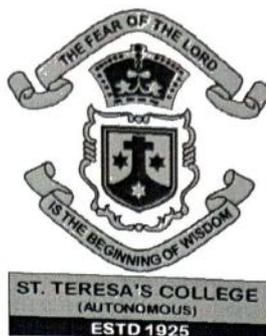


ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM



CERTIFICATE

This is to certify that the dissertation entitled, **FUZZY LOGIC AND IT'S APPLICATIONS** is a bonafide record of the work done by Ms. **NANDANA P JAYESH** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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PROJECT REPORT

THE RELATIONSHIP BETWEEN LOCUS OF CONTROL AND SELF-CRITICIZING /ATTACKING BEHAVIOR AMONG YOUNG ADULTS

Submitted by:

PARVATHY C SURESH

Register No:

SB19PSY057

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In partial fulfillment of the requirement for award of the degree of

B.Sc. PSYCHOLOGY



ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

Nationally Re-accredited at 'A++' level (4th
cycle) Affiliated to: Mahatma Gandhi University

MARCH 2022

CERTIFICATE

This is to certify that the project report entitled, “RELATIONSHIP BETWEEN LOCUS OF CONTROL AND SELF-CRITICIZING /ATTACKING BEHAVIOR IN YOUNG ADULTS”, is a bonafide record submitted by MS. PARVATHY C SURESH, Reg.no. SB19PSY057, in partial fulfillment of the requirements for the award of the Degree of Bachelor of Psychology during the academic year 2019-2022.



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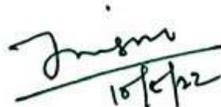
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DECLARATION

I, Parvathy C Suresh, hereby declare that the study presented in the dissertation entitled, “Relationship between locus of control and self-criticizing /attacking behavior in young adults”, which is submitted to the Department of Psychology, St. Teresa’s College, Ernakulam is a bonafide record of the research work carried out by me, under the supervision and guidance of Ms. Vishnupriya V, Assistant Professor, Department of Psychology, St. Teresa’s College, Ernakulam, in partial fulfillment of the requirements for the degree of Bachelor of Science in Psychology and has not previously formed the basis for the award of any degree, diploma, fellowship, title or recognition before.

Place: Ernakulam

Parvathy C Suresh

Date:

ACKNOWLEDGEMENT

It is not possible to prepare a project report without the assistance and encouragement of other people. This one is certainly no exception. I would like to express my deep heartfelt gratitude to the Department of Psychology, St. Teresa's College, Ernakulam for providing me with the opportunity to undertake the research.

I acknowledge my indebtedness and deep sense of gratitude to my research guide, Ms. Vishnupriya V, Assistant Professor, Psychology, for encouraging and guiding me throughout all the phases of my research.

I extend my sincere thanks to my parents, teachers and my friends who all have supported me throughout the time. I am grateful to each and every one who has given me guidance, encouragement, suggestions and constructive criticisms which has contributed immensely for this project.

Above all, I thank God Almighty for blessing me in all the stages of the project and for helping me complete the project successfully.

Thanking you

Parvathy C Suresh

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ABSTRACT

The aim of the research was to study the relationship between locus of control and self-criticizing / attacking in young adults. The FSCRS- The Forms of Self-Criticizing /Attacking & Self-Reassuring Scale and LCS- Rotter's Locus of Control Scale were the instruments that was used to measure these variables in the sample. The sample consisted of 304 participants of age ranging from 18 – 35. Spearman's Correlation Coefficient method and Mann-Whitney Test were used for statistical analysis. Results showed that there is a significant relationship between the variables. The findings of the study can be used to get a better insight about one's own cognitive and affective aspects in a situation which may lead to self-criticizing/attacking behavior.

Keywords: locus of control, self-criticizing/attacking behavior, self-reassuring behavior.

CHAPTER I
INTRODUCTION

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The study aims to understand the relationship between locus of control and self-criticizing/attacking behavior in young adults. Locus of Control refers to the extent to which individuals believe that they can control events that affect them. Locus of control can be classified into internal locus of control and external locus of control. Individuals with a high internal locus of control believe that events result primarily from their own behavior and actions. Those with a high external locus of control believe that powerful others, fate, or chance primarily determine events. Self-criticizing/ attacking behavior occurs when people criticize or hurt themselves, when things go wrong in ones lives or don't work out as he/she hoped, and feel they could have done better.

Individuals with a high internal locus of control have better control of their behavior and tend to exhibit more political behaviors than externals and are more likely to attempt to influence other people; they are more likely to assume that their efforts will be successful. However, individuals with high internal locus of control may also be quick to blame themselves when things do not go to plan. They can be overly self-critical and beat themselves up over their failings. Someone with an external locus of control might cope better with failure (at least in the immediate term) because they can pass the responsibility on to other factors and deflect criticism of their own performance. And when something bad does happen, they may be quicker to accept it and move on because they don't believe they could have influenced the outcome: it happened to them, not because of them. But when working in a team, they may be more likely to dole out praise for a job well done as they appreciate the influence of external players more than they do their own.

1.2 PROBLEM STATEMENT

The study aims at understanding the relationship between locus of control and self- criticizing/ attacking behavior. It also aims to understand the significance of self- criticizing/ attacking behavior among participants with internal locus of control and external locus of control. Since, these two variables haven't been studied in the past history, it would be critical in getting a better understanding on relationship between locus of control and self-criticizing/attacking behavior.

1.3 NEED AND SIGNIFICANCE OF THE STUDY

This research mainly focuses on relationship between locus of control and self-criticizing/ attacking behavior in young adults. This study also aims to explore, which type of locus of control influence self-criticizing/ attacking behavior more. This presents an opportunity to understand how a person's perception and belief about the amount of control he has over his life have an impact in the way he treats himself or

his thought patterns. This study might provide a foundation upon which research may build, and bring about fruitful avenues for future research.

The findings of the study can be used to get a better insight about one's own cognitive and affective aspects in a situation which may lead to self-criticizing/attacking behavior. Understanding the cause of a certain undesirable behavior may help a person to correct the issue easily, if the person wishes to change that behavior. The person can train themselves to think differently in a difficult situation if they have knowledge about how their mind would work in the situation.

1.4 SCOPE OF THE STUDY

Locus of control is a variable that reflects a person's beliefs about the degree of control they have over events in their lives that has been formally studied for more than 50 years in field of psychology. Early studies and research have demonstrated that locus of control was a significant predictor of various work-related outcomes, ranging from job attitudes and affect to motivation and behavior. Despite this, the majority of research has moved away from exploring the relationship between internal and external locus of control with respect to self-criticizing/ attacking behavior. This research mainly focuses on relationship between locus of control and self-criticizing/ attacking behavior in general population. This study also aims to explore, which type of locus of control influence self-criticizing/ attacking behavior more. This research study may be of great use that may lead to more insightful knowledge in understanding negative thinking patterns or negative schemas that may influence the behavior of a person under different context.

1.5 OBJECTIVES OF THE STUDY

- To understand if there is any relationship between locus of control and self-criticizing/attacking behavior among young adults.
- To understand if there is a significant difference in self- criticizing/ attacking behavior among the participants with internal locus of control and external locus of control.

1.6 LIMITATIONS OF THE STUDY

- The study was conducted using google forms, therefore the study was conducted with less supervision on the participants.
- The majority of the participants were females from age group 20; therefore, the study lacks gender and age diversity.
- The major part of the population is from a single state of India, i.e.; Kerala, so culture diversity is low for the study.
- The questionnaire is set in English, the native language for majority of the participants are not English which is a limitation for the study.

CHAPTER II
REVIEW OF LITERATURE

REVIEW OF LITERATURE

LOCUS OF CONTROL

Angela Roddenberry & Kimberly Renk in 2010 conducted a study on Locus of Control and Self-Efficacy: Potential Mediators of Stress, Illness, and Utilization of Health Services in College Students. The study focuses on the mediating effects of locus of control and self-efficacy in the relationships among stress, illness, and the utilization of health services in a sample of 159 college students. The findings suggest that participants who endorse higher levels of stress also endorse higher levels of illness, higher levels of external locus of control, and lower levels of self-efficacy. Moreover, locus of control appears to be a partial mediator in the relationship between stress and illness.

Wendy Kliever & Irwin N. Sandler in 1992 organized a study on Locus of control and self-esteem as moderators of stressor-symptom relations in children and adolescents. Locus of control and self-esteem were observed as moderators of links between negative life events and psychological symptoms in 238 young people 8 to 16 years old. Results showed that locus of control buffered the effects of stressors on psychological symptoms, and the pattern of buffering did not differ by age or gender. When faced with many negative life events, girls who have both an external locus of control and low esteem show the highest psychological maladjustment.

Robert C. Kanoy, Beth W. Johnson and Korrel W. Kanoy in 1980 conducted a study on Locus of control and self-concept in achieving and underachieving bright elementary students. This study studied a group of academically bright fourth-grade children for positive relationships of academic achievement with locus of control and self-concept. The results displayed that achievers had significantly higher self-concepts than underachievers on the intellectual and school status subscale. No sex differences were discovered for either self-concept or locus of control.

Loretta Brown Astry & Michael Langenbach in 2015 conducted a study on Locus of Control and Self-Responsibility for Behavior. This study investigated the variations in locus of control orientations that may result from training in self-regulating procedures to control behavior. Results showed that both the external and the self-regulating procedures were effective in increasing internal expectancies. Self-regulating procedures were effective in establishing and maintaining decreases in disruptive behaviors and, to a lesser extent, increases in constructive behaviors. Self-monitoring procedures are perceived as practical, efficient, and inexpensive methods of producing behavior changes.

Hallal, Janice C. in 1982 conducted a study on the relationship of health beliefs, health locus of control, and self-concept to the practice of breast self-examination in adult women. 207 women completed the Tennessee Self-Concept Scale, Multidimensional Health Locus of Control Scales, and a measure of the

perceived benefits of breast self-examination (BSE). Analysis revealed that the practice of BSE was correlated with higher perceived susceptibility to breast cancer, greater perceived benefits of BSE, and higher self-concept. Ss who practiced BSE tended to be less inclined to have a health locus of control that depended on a powerful other.

Judge, T. A., Erez, A., Bono, J. E., & Thoresen, C. J. on 2002 conducted a study on measures of self-esteem, neuroticism, locus of control, and generalized self-efficacy indicators of a common core construct. Meta-analytic results indicated that measures of the 4 traits were strongly related. Results also demonstrated that a single factor explained the relationships among measures of the 4 traits.

Seyede Golafrouz Ramezani¹, Abbas Gholtash on 2015 conducted a study on the relationship between happiness, self-control and locus of control. Data analysis involved multiple regression analysis and one-way analysis of variance. The results of this study indicated that, happiness is positively and significantly related to self-control. Furthermore, self-control was the strongest predictor for happiness.

Anthony Drago, David C. Rheinheimer, Thomas N. Detweiler on 2016 conducted a study on Effects of Locus of Control, Academic Self-Efficacy, and Tutoring on Academic Performance. Results of this study showed that LOC, tutoring, gender, and an ASE measure identified as self-assurance had positive and significant effects on academic performance as measured by students' total grade point averages. However, tutoring had no effect on LOC but had only a small moderating effect on one component of ASE.

Judge, Timothy A., Bono, Joyce E on 2001 conducted a study on Relationship of core self-evaluations traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability—with job satisfaction and job performance. Meta-analytic results of the relationship of 4 traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability (low neuroticism)—with job satisfaction and job performance. The results based on 274 correlations suggest that these traits are among the best dispositional predictors of job satisfaction and job performance.

Stephen I. Abramowitz on 1969 conducted a study on Locus of Control and Self-Reported Depression among College Students. The Internal-External Control, Guilford Depression, and Marlowe-Crowne Social Desirability Scales were administered to 69 university undergraduates to test the hypothesis that depression is associated with belief in external control. The results supported the hypothesis.

SELF-CRITICIZING/ ATTACKING BEHAVIOUR

Paul. Gilbert, Kirsten. McEwan, Chris. Irons, Rakhee. Bhundia, Rachael. Christie, Claire. Broomhead and Helen. Rockliff in 2010 conducted study the Self-harm in a mixed clinical population: The roles of self-criticism, shame, and social rank on 73 participants. The results showed that self-harm was suggestively

associated with forms and functions of self-criticism, shame, and feelings of inferiority (low social rank). The self-persecuting function of self-criticism was particularly linked to self-harm, depression, and anxiety. This study improves to a growing literature on the importance of recognizing the pathogenic effects of negative self-critical thoughts and feelings about the self and the value of distinguishing different types of self-criticism.

David C. Zuroff, D. S. Moskowitz and Stéphane Côté in 2010 conducted study on Dependency, self-criticism, interpersonal behaviour and affect: Evolutionary perspectives and assessed agentic (dominant-submissive) and communal (agreeable-quarrelsome) interpersonal behavior as well as affect in 119 employed adults over a time period 20 days. Evolutionary accounts of vulnerability to depression have focused either on the attachment system (Bowlby, 1980) or the social rank system (Gilbert, 1992; Price, 1972). Self-criticism forecast low levels of agency and low levels of communion. In the sample as a whole, agentic and communal behaviours were associated with pleasant affect, but highly self-critical participants experienced relatively less pleasant affect when they acted communally or agentially.

Zuroff, David C. Duncan, Neil in 1999 conducted a study on Self-criticism and conflict resolution in romantic couples on 120 heterosexual college student couples. In both girlfriends and boyfriends, self-criticism was associated with negative relational schemas and more negative cognitive-affective reactions during the conflict resolution task. Self-critical women displayed greater overt hostility towards their partners. It also showed that, in women, negative cognitive-affective reactions predicted overt hostility, which in turn predicted partners' distress and overt hostility. The results bolster cognitive interpersonal analyses of depression by illustrating how cognitive structures associated with a hypothesized vulnerability (self-criticism) can have important interpersonal correlates.

Catherine O'Neill, Daniel Pratt, Meryl Kilshaw, Kate Ward, James Kelly and Gillian Haddock in 2021 conducted study on the relationship between self-criticism and suicide probability on 101 participants. The present study assessed the relative contribution of self-criticism to suicide probability, alongside established predictors of suicidal ideation; hopelessness, depression, defeat and entrapment. Results demonstrated that self-attacking has a direct relationship with suicide probability, alongside established predictors; entrapment and hopelessness. Depressive symptomology was not found to be a significant predictor of suicide probability in this population.

A. Mills, P. Gilbert ,R. Bellew, K. McEwan and C. Gale on 2007 conducted study on paranoid beliefs and self-criticism in students on a total of 131 students. In this population, paranoid beliefs were associated with forms and functions of self-criticism, especially self-hating and self-persecution. Paranoid beliefs were negatively correlated with self-kindness and abilities to be self-reassuring. These variables were also associated with depression.

Katherine E. Wakelin, Gemma. Perman, Laura M. Simonds on 2021 conducted study on Effectiveness of self-compassion-related interventions for reducing self-criticism. A systematic search of the literature identified 20 randomized controlled trials (RCTs) that met the inclusion criteria. Meta-analysis findings indicated that self-compassion-related interventions produce a significant, medium reduction in self-criticism in comparison with control groups. The review provides promising evidence of the effectiveness of self-compassion-related interventions for reducing self-criticism.

Lucy.Serpell, Rebecca.Amey, Sunjeev K.Kamboj on 2021 conducted study on the role of self-compassion and self-criticism in binge eating behaviour. . The self-compassion strategy was associated with a greater improvement in positive and negative affect following the negative mood induction. The findings suggest that therapeutic strategies for cultivating self-compassion are associated with improved food-related self-regulation in the context of negative mood.

Theodore A. Powers, David C. Zuroff, Raluca A. Topciu on 2004 conducted study on Covert and overt expressions of self-criticism and perfectionism and their relation to depression. The results replicated previous reports that two factors, self-critical perfectionism and high personal standards, underlie existing measures of covert expressions. Self-critical perfectionism and overt self-criticism were shown to be independent predictors of depression, suggesting the importance of assessing the overt interpersonal, as well as the covert, manifestations of self-criticism.

P. Gilbert,M. Clarke,S. Hempel,J.N.V. Miles,C. Irons on 2010 conducted study on Criticizing and reassuring oneself: An exploration of forms, styles and reasons in female students. Mediation analysis suggested that wanting to harm the self may be particularly pathogenic and is positively mediated by the effects of hating the self and negatively mediated by being able to self-reassure and focus on one's positives. The findings suggested that self-criticism is not a single process but has different forms, functions, and underpinning emotions.

Duarte C., Stubbs J. , Pinto-Gouveia J. , Matos M., Gale C., Morris L. and Gilbert P. on 2017 conducted study on the Impact of Self-Criticism and Self-Reassurance on Weight-Related Affect and Well-Being in Participants of a Commercial Weight Management Programme. Path analysis suggested that self-criticism was significantly associated with decreased well-being, both directly and indirectly, mediated by increased negative and decreased positive weight-related affect. Self-reassurance had a stronger association with increased well-being by predicting lower negative and increased positive weight-related affect. The positive association between self-reassurance and well-being was stronger than the negative association between self-criticism and well-being.

RESEARCH GAP

There have been various researches done in the past regarding locus of control and self-esteem, self-efficiency, self-concept etc. in relation to adolescents, depression, stress etc. This research mainly focuses on relationship between locus of control and self-criticizing/ attacking behavior in general population which has not been done in the past. The study also lays foundation for future research in further understanding the correlation and impact of one on another. The study also helps in investigating which of the two types of locus of control have a more impact on self-criticizing behavior. The two types of locus of control, internal and external is separately studied with the 3 domain of self-criticizing/attacking behavior namely inadequate self, hated self and reassurance self.

CHAPTER III
THEORETICAL FRAMEWORK

THEORETICAL FRAMEWORK

Locus of control is the degree to which people believe that they, as opposed to external forces, have control over the outcome of events in their lives. The first recorded trace of the term Locus of Control comes from Julian B. Rotter's work (1954) based on the social learning theory of personality. It is a great example of a generalized expectancy related to problem solving, a strategy which applies to a wide variety of situations. It is speculated that Locus of Control may have come beforehand, as a term coined by a psychologist by the name of Alfred Adler. The evidence for this is lacking, however, so the main bulk of credit for the concept lies in Rotter and his understudies' early works. The Locus of Control Scale (LCS) is a 29-item questionnaire that measures an individual's level of internal versus external control of reinforcement.

When confronted with life difficulties and setbacks, the way one makes attributions of causality for those setbacks and the way we evaluate, judge, condemn or accept, and support ourselves has a major impact on our coping, resilience, recovery, and perseverance. Self-criticism, which involves negative self-labelling and harsh judgement, with negative emotions such as anger and contempt with the self. The forms of self-criticizing /attacking & self-reassuring scale (fscrs) was developed by Gilbert, Clarke, Hempel, Miles and Irons (2004).

THEORIES RELATED TO LOCUS OF CONTROL

- Self-efficacy theory

Self-efficacy, a concept proposed by social psychologist Albert Bandura (2010), is the measure of how capable an individual feels about achieving their goals. Bandura showed that no matter how talented a person may be, if they do not believe they are capable, this belief will have a strong effect on their ability to succeed. Individuals with high self-efficacy will have higher levels of persistence and give up less easily than those with low levels of self-efficacy (Schunk, 1990). Self-efficacy and locus of control are related, but they are not the same. An individual with an internal locus of control may feel their health outcomes are caused by their behavior, but they may not feel capable of achieving their goal.

- Attributional styles & locus of control

Attributional style is also a theory of behavior that includes locus of control as one of three potential causes (Weiner, 1986). Attribution theory includes other factors – whether the cause is global or specific, stable or unstable – in addition to whether the individual perceives that they have control over it. A global attribution means that the person believes the cause of the event is consistent across all contexts. A specific attribution is just the opposite: it only happens in a particular context. Whether an outcome is

stable or unstable describes if it is consistent across time or only attributable to a single point in time. If you attribute a person's behavior to internal, stable, and global causes, you perceive that their personality causes him to act this way in all contexts and all the time. If you attribute one's behavior to internal but unstable and specific causes, you may think that the person is in a foul mood, that this is out of character, and something must have set him off.

- Big Five Personality model

The Big Five personality traits (emotional stability, extraversion, openness, agreeableness, and conscientiousness) have each been shown to have varying levels of impact on outcomes in these realms. These traits have been examined for their relationship with locus of control and how the interaction may affect work-life and health. emotional stability (formerly known as neuroticism) and conscientiousness have strong positive relationships with an internal locus of control. Believing that their behavior contributes directly to the outcome of a situation will naturally lead to hard work if the individual also has the desire. Those with an external locus of control have been shown to have higher levels of stress and even depression (Benassi, Sweeney, & Dufour, 1988). It stands to reason that if someone feels they are at the mercy of outside forces and their life is not in their hands, this could lead to anxiety and learned helplessness.

THEORIES RELATED TO SELF-CRITICIZING/ ATTACKING BEHAVIOUR

- Aaron Beck's cognitive theory of depression

Cognitive theories of depression are among the most widely studied theories in the etiology of depression. One of the most influential of these theories was proposed by Aaron Beck in 1967. Beck's model argues that depression results from the activation of depressive self-schemas. These schemas refer to organized mental structures that, in the case of depression, are negatively toned representations of self-referent knowledge. Moreover, schemas guide appraisals and interact with information to influence selective attention, memory, and cognition. Although all person's evidence schemas, the schemas of depressed individuals are dysfunctional because they lead to negative perspectives about oneself, the world, and the future, or what Beck has termed, the negative cognitive triad.

- Albert Bandura's social cognitive theory

The unique feature of Social Cognitive Theory is the emphasis on social influence and its emphasis on external and internal social reinforcement. Social Cognitive Theory considers the unique way in which individuals acquire and maintain behavior, while also considering the social environment in which individuals perform the behavior. The theory takes into account a person's past experiences, which factor

into whether behavioral action will occur. These past experiences influence reinforcements, expectations, and expectancies, all of which shape whether a person will engage in a specific behavior and the reasons why a person engages in that behavior.

- Carl Rogers's humanistic theory

Carl Rogers (1902-1987) was a humanistic psychologist who agreed with the main assumptions of Abraham Maslow. However, Rogers (1959) added that for a person to "grow", they need an environment that provides them with genuineness (openness and self-disclosure), acceptance (being seen with unconditional positive regard), and empathy (being listened to and understood). Without these, relationships and healthy personalities will not develop as they should. Rogers believed that every person could achieve their goals, wishes, and desires in life. When, or rather if they did so, self-actualization took place.

CHAPTER IV
RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

4.1 OBJECTIVES

- To understand if there is any relationship between locus of control and self-criticizing/attacking behavior among young adults.
- To understand if there is a significant difference in self- criticizing/ attacking behavior among the participants with internal locus of control and external locus of control.

4.2 HYPOTHESIS

1. There is significant relationship between locus of control and self-criticizing/attacking behavior.
2. There is a significant difference in self- criticizing/ attacking behavior among the participants with internal locus of control and external locus of control.

4.3 RESEARCH DESIGN

The study involved descriptive and correlational design.

4.4 SOURCES OF DATA

The primary data collection was done through the use of questionnaire for this research study.

4.5 SAMPLE DESIGN

The sample population of the study focused on young adults between the ages 18 and 35.

4.6 SAMPLE SIZE

The sample size was 304 participants.

4.7 SAMPLING METHOD

Convenient sampling was used to collect data. A convenience sample is a type of non-probability sampling method where the sample is taken from a group of people easy to contact or to reach.

4.8 METHOD OF DATA COLLECTION

The study was administered through google forms on the specified population and spread through different social media platforms such as Instagram, WhatsApp, Emails., as it was more convenient method during the pandemic. Demographic details such as name, age, gender was also collected from the participants.

4.9 DRAFTING QUESTIONNAIRE

The data is collected through two questionnaires which has 51 items combining both the questionnaires (FSCRS- The Forms of Self-Criticizing /Attacking & Self-Reassuring Scale and LCS- Rotter's Locus of Control Scale).

FSCRS was developed by Gilbert, Clarke, Hempel, Miles and Irons (2004). It was developed to measure self-criticism and the ability to self-reassure. It is a 22-item scale. The items make up three components, there are two forms of self-criticalness; inadequate self, which focuses on a sense of personal inadequacy and hated self, and one form to self-reassure, reassure self. The responses are given on a 5-point Likert scale.

The Locus of Control Scale (LCS) is a 29-item questionnaire that measures an individual's level of internal-external control, in other words, the degree to which the individual interprets events as being a result of their own actions or external factors. These two questionnaires will help us to understand the relationship between locus of control and self-criticizing behavior.

4.4 DATA ANALYSIS TECHNIQUE

The questionnaire was analyzed using a statistical analysis software (IBM SPSS Statistics). The first objective (To find out whether there is significant relationship between locus of control and self-criticizing/attacking behavior among the young adults' population) was analyzed by performing a Spearman's rank correlation coefficient which measures the statistical relationship between two variables. The secondary objective of the study (To find which type of locus of control contribute more to self-criticizing behavior) was analyzed using Mann-Whitney Test.

Spearman's rank correlation

The Spearman rank-order correlation coefficient measures nonparametric data. The strength and direction of association that exists between two variables are measure in this method. It is denoted by the symbol r_s (or the Greek letter ρ , pronounced rho). The test is used for either ordinal variables or for continuous data that has failed the assumptions necessary for conducting the Pearson's product-moment correlation.

Mann-Whitney U Test

The Mann-Whitney U test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. Unlike the independent-samples t-test, the Mann-Whitney U test allows you to draw different conclusions about your data depending on the assumptions you make about your data's distribution.

CHAPTER V
DATA ANALYSIS

DATA ANALYSIS

This chapter deals with the data analysis and interpretation of the research data. The research data was analyzed using a statistical analysis software (IBM SPSS Statistics). Spearman's Correlation Coefficient method and Mann-Whitney Test were used for statistical analysis. The analyzed data is represented as tables and graph.

TABLE 5.1: *Results of Shapiro-Wilk Tests of Normality of locus of control and self-criticizing behavior (inadequate self, hated self, reassuring self)*

	Significance
Inadequate-self	.003
Reassurance-self	.009
Hated self	<.001
Locus of control	.003

Here we mainly focus on Shapiro-Wilk normality test. If the significance Value of the Shapiro-Wilk test is greater than 0.05, then the data follows normal distribution. If it is below 0.05, the data significantly deviate from a normal distribution. In this test, we can clearly see that both variables, locus of control and self-criticizing behavior (inadequate self, hated self, reassuring self) has a significance value that is below 0.05. Therefore, it is not a normative distribution.

Therefore, we use **Spearman's Correlation Coefficient method**.

TABLE 5.2: *Results of Spearman rank Correlation between self-criticizing behavior (inadequate self, hated self, reassuring self) and Locus of Control*

	Locus of Control		Inadequate-self	Reassurance-self	Hated-self
Spearman's rho	Internal	Correlation	0.142	-0.144	0.164
	Locus of Control	Coefficient			
		Sig.(2-tailed)	0.064	0.060	0.032

	N	172	172	172
External	Correlation	.084	-.066	-.041
Locus of	Coefficient			
Control	Sig. (2-tailed)	.338	.454	.641
	N	132	132	132

From the above table 5.2, Spearman's Rank Correlation test, the results indicated that there is positive correlation between internal locus of control and inadequate-self and internal locus of control and hated-self and, negative correlation between internal locus of control and reassuring-self. Also, it is found that there is a positive correlation between external locus of control and inadequate-self and negative correlation between external locus of control and reassuring-self and, external locus of control and hated-self.

MANN-WHITNEY TEST

The next objective of the study is to understand if there is a significant difference in self-criticizing behavior among participants with internal and external locus of control. This was analyzed using Mann-Whitney U Test.

Mann-whitney U test was conducted between locus of control and self-criticizing/attacking behavior. The self-criticizing/ attacking behavior was further divided into 3 components, namely inadequate self, hated self and reassurance self. The 3 components were separately compared with the locus of control. The hypothesis was to understand whether the 2 types of locus of control- internal locus of control and external locus of control showed significant difference when compared with each of the 3 components of self-criticizing/attacking behavior.

TABLE 5.4: *Results of Mann-Whitney U test*

	Inadequate-self	Reassurance-self	Hated-self
Asymp. Sig. (2-tailed)	0.068	0.703	0.528

- Relation between locus of control and inadequate self

The significance value for inadequate self from the table no. 5.4, is above the significance level 0.05 which indicates the rejection of the hypothesis that there is significant difference between the groups internal locus of control and external locus of control.

- Relation between locus of control and hated self

For hated self, the significance value is above 0.05 implying the rejection of the hypothesis that there is significant difference between the 2 groups of locus of control.

- Relation between locus of control and reassurance self

When the reassurance self and groups of locus of control was compared the significance value obtained was above 0.05 leading to rejection of hypothesis that there is significant difference between internal and external locus of control.

CHAPTER VI
FINDINGS

FINDINGS

The hypothesis that the data is not normally distributed is accepted if the P value is less than or equal to 0.05, and the hypothesis is rejected if P value is greater than 0.05. The significance values between the variables self-criticizing behavior (inadequate self, hated self, reassuring self) and Locus of Control (internal locus of control and external locus of control) is above 0.05. This indicates that the given hypothesis (i.e. that the data does not follows a normal distribution) is accepted. Hence, spearman rank correlation test is used. The objective of the study was to understand the relationship between locus of control and self-criticizing/attacking behavior in young adults. From the table 5.2, Spearman's Rank Correlation test, it can be understood that there is a correlation between internal locus of control and inadequate-self and, internal locus of control and hated-self. Which means that when internal locus of control increases, inadequate-self and hated-self increases and when internal locus decreases, inadequate-self and hated-self decreases. There is a negative correlation between internal locus of control and reassuring-self which means that when internal locus of control increases, reassurance-self decreases and when internal locus decreases, reassurances-self increases. There is a positive correlation between external locus of control and inadequate-self which means that when external locus of control increases, inadequate-self increases and when external locus decreases, inadequate-self decreases. There is a negative correlation between external locus of control and reassuring-self and, external locus of control and hated-self which means that when external locus of control increases, reassurance-self and hated-self decreases and when external locus decreases, reassurances-self and hated-self increases. Therefore, we can conclude that there is correlation between locus of control and self-criticizing/ attacking behavior. Mann-Whitney U test was conducted to compare the influence of internal and external locus of control on self-criticizing/attacking behavior. The self-criticizing/attacking behavior was further classified in three components which are inadequate self, hated self and reassurance self. From the Mann-Whitney U test it was found that there is no significant difference in self- criticizing/ attacking behavior among the participants with internal locus of control and external locus of control. Which implies that the hypothesis, is rejected. Which means that the influence of internal locus of control on self-criticizing/attacking behavior is similar to the influence of external locus of control on self-criticizing/attacking behavior.

CHAPTER VII
RECOMMENDATIONS

RECOMMENDATIONS

Many limitations were observed for the research conducted which may have influenced the final outcome of the research. The sample which was selected shows more female participants than participants from other gender categories. Even Though gender was not considered as a variable for the study it may have influenced the final outcome. Therefore, it is recommended to select almost equal number of participants from all the categories of gender.

Similar drawback was found when considering the age group, the majority of the participants are from the age group 20. The study was conducted for young adults, specifically from age group 18-35. The unequal distribution of participants from all the age group may have affected the study. Due to this reason, it should be noted, to select almost equal participants from the all the ages.

The native language of the majority participants of the sample was not English. The questionnaire was set it English which must have been a barrier and may have affected the study. It recommended to choose the sample according to language preference of the population.

The questionnaire used for the study consist of 51 items, this may lead to decrease in interest while answering the questionnaire. Also, since the questionnaire was distributed through online mode, there was lack of supervision on the participants during the test administration. Both these issues show a chance for giving inaccurate response. It is recommended to reduce the items if possible and to administer the study through offline mode.

CHAPTER VIII
CONCLUSIONS

CONCLUSIONS

The objective of the study was to understand if there existed any significant relationship between locus of control and self-criticizing/attacking behavior in young adults. The study was conducted on young adults from age 18 to 35. The findings of the study suggest that there is correlation between locus of control and self-criticizing/attacking behavior. It was also found that there is no significant difference in self-criticizing/ attacking behavior among the people with internal locus of control and external locus of control.

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APPENDIX

ROTTER'S LOCUS OF CONTROL SCALE

For each question select the statement that you agree with the most

- 1) a. Children get into trouble because their parents punish them too much.
b. The trouble with most children nowadays is that their parents are too easy with them.
- 2) a. Many of the unhappy things in people's lives are partly due to bad luck.
b. People's misfortunes result from the mistakes they make.
- 3) a. One of the major reasons why we have wars is because people don't take enough interest in politics.
b. There will always be wars, no matter how hard people try to prevent them.
- 4) a. In the long run people get the respect they deserve in this world
b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries
- 5) a. The idea that teachers are unfair to students is nonsense.
b. Most students don't realize the extent to which their grades are influenced by accidental happenings.
- 6) a. Without the right breaks one cannot be an effective leader.
b. Capable people who fail to become leaders have not taken advantage of their opportunities.
- 7) a. No matter how hard you try some people just don't like you.
b. People who can't get others to like them don't understand how to get along with others.
- 8) a. Heredity plays the major role in determining one's personality
b. It is one's experiences in life which determine what they're like.
- 9) a. I have often found that what is going to happen will happen.
b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.
- 10) a. In the case of the well-prepared student there is rarely if ever such a thing as an unfair test.
b. Many times exam questions tend to be so unrelated to course work that studying is really useless.
- 11) a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.
b. Getting a good job depends mainly on being in the right place at the right time.
- 12) a. The average citizen can have an influence in government decisions.
b. This world is run by the few people in power, and there is not much the little guy can do about it.
- 13) a. When I make plans, I am almost certain that I can make them work.
b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

- 14) a. There are certain people who are just no good.
b. There is some good in everybody.
- 15) a. In my case getting what I want has little or nothing to do with luck.
b. Many times we might just as well decide what to do by flipping a coin.
- 16) a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.
b. Getting people to do the right thing depends upon ability. Luck has little or nothing to do with it.
- 17) a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.
b. By taking an active part in political and social affairs the people can control world events.
- 18) a. Most people don't realize the extent to which their lives are controlled by accidental happenings.
b. There really is no such thing as "luck."
- 19) a. One should always be willing to admit mistakes.
b. It is usually best to cover up one's mistakes.
- 20) a. It is hard to know whether or not a person really likes you.
b. How many friends you have depends upon how nice a person you are.
- 21) a. In the long run the bad things that happen to us are balanced by the good ones.
b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.
- 22) a. With enough effort we can wipe out political corruption.
b. It is difficult for people to have much control over the things politicians do in office.
- 23) a. Sometimes I can't understand how teachers arrive at the grades they give.
b. There is a direct connection between how hard I study and the grades I get.
- 24) a. A good leader expects people to decide for themselves what they should do.
b. A good leader makes it clear to everybody what their jobs are.
- 25) a. Many times I feel that I have little influence over the things that happen to me.
b. It is impossible for me to believe that chance or luck plays an important role in my life.
- 26) a. People are lonely because they don't try to be friendly.
b. There's not much use in trying too hard to please people, if they like you, they like you.
- 27) a. There is too much emphasis on athletics in high school.
b. Team sports are an excellent way to build character.
- 28) a. What happens to me is my own doing.
b. Sometimes I feel that I don't have enough control over the direction my life is taking.
- 29) a. Most of the time I can't understand why politicians behave the way they do.
b. In the long run the people are responsible for bad government on a national as well as on a local level.

THE FORMS OF SELF-CRITICISING/ATTACKING & SELF-REASSURING

SCALE (FSCRS)

Read each statement carefully and circle the number that best describes how much each statement is true for you.

Please use the scale below.

Not at all like me A little bit like me Moderately like me Quite a bit like me Extremely like me
 0 1 2 3 4

When things go wrong for me:

1.	I am easily disappointed with myself.	0	1	2	3	4
2.	There is a part of me that puts me down.	0	1	2	3	4
3.	I am able to remind myself of positive things about myself.	0	1	2	3	4
4.	I find it difficult to control my anger and frustration at myself.	0	1	2	3	4
5.	I find it easy to forgive myself.	0	1	2	3	4
6.	There is a part of me that feels I am not good enough.	0	1	2	3	4
7.	I feel beaten down by my own self-critical thoughts.	0	1	2	3	4
8.	I still like being me.	0	1	2	3	4
9.	I have become so angry with myself that I want to hurt or injure myself.	0	1	2	3	4
10.	I have a sense of disgust with myself.	0	1	2	3	4
11.	I can still feel lovable and acceptable.	0	1	2	3	4
12.	I stop caring about myself.	0	1	2	3	4
13.	I find it easy to like myself.	0	1	2	3	4
14.	I remember and dwell on my failings.	0	1	2	3	4
15.	I call myself names.	0	1	2	3	4
16.	I am gentle and supportive with myself.	0	1	2	3	4
17.	I can't accept failures and setbacks without feeling inadequate.	0	1	2	3	4
18.	I think I deserve my self-criticism.	0	1	2	3	4
19.	I am able to care and look after myself.	0	1	2	3	4
20.	There is a part of me that wants to get rid of the bits I don't like.	0	1	2	3	4
21.	I encourage myself for the future.	0	1	2	3	4
22.	I do not like being me.	0	1	2	3	4

A study on
THE IMPACT OF COVID-19 ON EMPLOYMENT

Project Report

Submitted by

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Under the guidance of
SMT. JINI JUSTIN D’COSTA

In partial fulfillment of the requirement for the Degree of
BACHELOR OF COMMERCE



ST. TERESA’S COLLEGE ESTD 1925
ST. TERESA’S COLLEGE (AUTONOMOUS), ERNAKULAM
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CERTIFICATE

This is to certify that the project titled "A GENERAL STUDY ON COVID-19 IMPACT ON EMPLOYMENT" submitted to Mahatma Gandhi University in partial fulfillment of the requirement for the award of Degree of Bachelor in Commerce is a record of the original work done by Ms. Archana Sathyanath K, Ms. Gayathri Gokul, Ms. Parvathy Krishnan under my supervision and guidance during the academic year 2021-22.

Project Guide

Smt. Jini Justin D'Costa

(Head of the Department)

Department of Commerce (SF)

Viva/Voice Examination held on....



Smt. Jini Justin D'Costa

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Department of Commerce (SF)

External Examiner(s)

DECLARATION

We, Archana Sathyanath K, Gayathri Gokul and Parvathy Krishnan, final year B. Com students. Department of Commerce (SF), ST. Teresa's College (Autonomous) do hereby declare that the project report entitled A GENERAL STUDY ON COVID-19 IMPACT ON EMPLOYMENT submitted to Mahatma Gandhi University is a Bonafede record of the work done under the supervision and guidance of Smt. Jini Justin, Head of the Department of Commerce (SF), St. Teresa's College(Autonomous) and this work has not previously formed the basis for the award of any academic qualification, fellowship, or other similar title of any other university or board.

PLACE: ERNAKULAM

DATE: 29/04/2022

ARCHANA SATHYANATH K

GAYATHRI GOKUL

PARVATHY KRISHNAN

Acknowledgement

First of all, we are grateful to God Almighty for his blessings showered upon us for the successful completion of our project.

It is our privilege to place a word of gratitude to all persons who have helped us for the successful completion of the project. We are grateful to our guide Smt. **Jini Justin D'Costa**, Department of Commerce (SF) of St. Teresa's College (Autonomous), Ernakulam for her valuable guidance and encouragement for completing this work.

We would like to acknowledge **Dr. Lizzy Mathew**, Principal of Teresa's college (Autonomous), Ernakulam for providing necessary encouragement and infrastructure facilities needed for us.

We would like to thank **Smt. Jini Justin D'Costa**, Head of Department for her assistance and support throughout the course of this study for the completion of the project.

We will remain always indebted to our family and friends who helped us in completion of this project.

Last but not the least; we would like to thank the respondents of our questionnaire who gave their precious time from work to answer our questions.

Archana Sathyanath K

Gayathri Gokul

Parvathy Krishnan

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CHAPTER 1

INTRODUCTION

THE IMPACT OF COVID-19 ON EMPLOYMENT

1.1 INTRODUCTION

In April 2020, the International Labor Organization (ILO) estimated that nearly 2.5 crore jobs could be lost worldwide due to the COVID-19 pandemic in 2020. Undoubtedly the COVID 19 pandemic in India has very severely impacted, rather negatively, the employment figures of India. Further, it was observed that more than 40 crore informal workers in India may get pushed into deeper poverty due to the pandemic. Unemployment rate in urban areas rose to 20.9% during the April-June quarter of 2020, more than double the unemployment rate in the same quarter the previous year (8.9%). Thus, the estimated share of informal employment directly impacted by the first and the second lockdown periods represents 89.5 and 88 per cent of the total employment affected by the containment measures, respectively. Most of the affected informal employment (75 per cent) are employed in the informal sector, with 17.8 per cent in the formal sector and 7.2 per cent in private households. During the lockdown, severe restrictions were placed on the movement of individuals and economic activities were significantly halted, barring the activities related to essential goods and services. The most complicated socio-economic aspect in India is unemployment; the problem can't be removed by a golden touch instantly; the pressure on the unemployed could only be minimized by durable planning. There is a real danger that the crisis will increase poverty and widen inequalities, with the impact felt for years to come. Countries now need to do everything they can to stop this jobs crisis from turning into a social crisis. Reconstructing a better and more resilient labour market is an essential investment in the future and in future generation. Job seekers in India have new concerns about the job search process. About 51 per cent of jobseekers are interested in pursuing opportunities in industries they have worked with. When applying for a job, 55 per cent of professionals claim compensation is a major factor they look for. Job security is a major priority for 56 per cent of them following the pandemic. For half of the professionals (49 per cent), opportunities that will help them learn and develop is a high priority when considering a job. For 47 per cent of professionals, having a safe workplace environment is a high priority when considering a job.

1.2 STATEMENT OF THE PROBLEM

The covid-19 pandemic has triggered one of the worst job crises since the Great Depression. The unemployment rate will be around 12% at the end of May 2021 which translates into a loss of job by 1 crore people during the period due to the 2nd wave of corona pandemic. Income of 97% households have declined since the outbreak of the pandemic last year. The unemployment rate stands at 12.4%, urban 15.1% and rural 11.2% on 3rd June 2021. In April and May, the poorest 20 per cent of households lost their entire income and the richer households suffered losses of less than a quarter of their pre-pandemic incomes. This shows that covid-19 has a impact on individuals income. A majority of people prefer government jobs for employment security and higher salary, amid uncertainties due to the disruptions caused by COVID-19. There is a high need for the problem to be solved for the job security. Most of the employees are concerned about losing their job because there is no job security for private employees whereas there is a little chance that any Government employee will lose his job. This study helps us to suggest the organization that employees get a steady income, job security and raise the remuneration of employees after analyzing their knowledge, their ability and their skill.

1.3 SIGNIFICANCE

The most serious problem the country facing today is the problem of unemployment, as the planners have been much concerned about this in each plan the emphasis has been put forward to remove unemployment by increasing the growth rate. Our study primarily focuses on understanding the impact of covid 19 on employee's income, labor turnover in the organization and salary reduction faced by the employees during covid 19 outbreak. Through this study we will be able to understand the challenges faced by the employees like stress factor, changes in the working situations, organization's reaction during covid 19 situation. Our research will throw light on the post pandemic concern of employees working in Ernakulam city. This project helps us give a clear-cut idea regarding the pre and post covid effect differences.

1.4 OBJECTIVES

The study is directed by the following specific objectives:

- To analyze the impact of COVID-19 on employee's income.
- To study about the labor turnover rates before and during the pandemic.
- To identify the post pandemic concern faced by the employees during this period.
- To study about the challenges faced by employees during the COVID-19 outbreak.

1.5 RESEARCH METHODOLOGY

This was an observational, descriptive, community-based study which was conducted in a randomly selected group of employees working in and around Ernakulam. The study population consisted of employees between the age group 20-40. Sample size of our consisted of 70 employees. The study is based on both primary and secondary data. The primary data required for the study are gathered from employees using questionnaire. The secondary data was based on external sources such as journal articles and internet.

1.6 LIMITATIONS OF THE STUDY

1. The study was limited to Cochin city.
2. The responses may be biased.
3. The study was time bound and had time constraints.
4. Delay in getting responses from employees.

1.7 CHAPTERISATION

CHAPTER 1: Introduction

CHAPTER 2: Literature review and theoretical framework

CHAPTER3: Data analysis and interpretation

CHAPTER4: Findings, suggestions, conclusions

CHAPTER 2

**LITERATURE REVIEW
AND
THEORETICAL FRAMEWORK**

2.1 INTRODUCTION

The COVID 19 pandemic in India has very severely impacted, rather negatively, the employment figures of India since early 2020. We have seen so many scenarios since March 2020 like corona infection in huge number, corona testing, containment zone, safe home, quarantine, mask, sanitiser, PPE kits, rushing of ambulances, heltering-skeltering of the health personnel, i.e. doctors, nurses, paramedical staff, other support staff, police personnel and most shocking helpless deaths. Side by side, we have also seen another type of scenarios like lockdown in industrial units, a beeline of the job loser laborers with hungry children, women, elderly family members carrying belongings heading towards their native villages.millions of hapless migrant laborers including their families took to the street for their native places or unknown places. The purpose of this paper is to consider the influence, scope, limitations, barriers, and challenges imposed on employment by the ongoing coronavirus disease health crisis, along with its potential consequences in the near future and beyond. An in-depth literature review was conducted of the current COVID-19 crisis, along with similar pandemics in recent history, and the effect of such events on global un/employment, and economic activities. The research focuses primarily on the impact of COVID-19. This pandemic has brought difficult situations for citizens of nations across the world. The impact however, may be more severe for others in the Third World Countries, who are in desperate situations and whose conditions may well further deteriorate if not put into considerations. While this pandemic affects different dimensions of life.society in general, this paper examines the impact of the outbreak COVID-19 pandemic on Somaliland Economy and analyzes the need for mitigation measures. India being a densely populated country with inadequate medical facilities was left with no option but to follow the policy of lockdown. World economy is heading for a recession and India is no exception. The current pandemic is working its way through a highly globalized world with interconnected production networks and financial markets. The fall out of the COVID-19 on the Indian economy is going to be huge because of its own lockdown, which was necessary to contain the spread of coronavirus, and also because of India's integration with the rest of the world. Here is an assessment of the likely fall out of lockdown and restrictive policy measures owing to the pandemic on India's gross value added (GVA), manufacturing, trade and micro, small and medium enterprises (MSME) sector.

The ongoing COVID-19 pandemic is causing unprecedented disruptions to economic activities across countries, and India is no exception. The pandemic has severely affected and continues to disrupt global value chains (GVCs), domestic production network, trade, services and MSMEs thereby affecting overall growth and welfare. The current pandemic is working its way through a highly globalized world with interconnected financial markets and production networks. The complete lockdown and currently the ongoing partial lockdowns have both demand-side and supply-side effects on the Indian economy. On the supply side, the restrictions of movement of goods, services and personnel affects the production network.

Therefore, the economic impact of COVID-19 is expected on every sphere including growth, international trade, financial markets, unemployment, income, poverty and many more variables. The impact of the virus spread is expected to lead to a huge loss as global trade is severely affected. The Indian growth model depends on the export-led-growth and hence can experience massive impact on growth due to lockdown amidst the virus spread. On the international trade front, it is expected to plunge in a range of 13–32 per cent under optimistic and pessimistic scenarios, respectively noted the spill over effects of COVID-19 and hailed that the social distancing measure of virus controlling led to the shutdown of financial markets, corporate offices, businesses and events which in turn may have significant impact on economic growth. As per the International Labour Organization (ILO) estimation, the total value added of industrial enterprises in China declined by 13.5 per cent during the first 2 months of. There are many projections and estimations by institutions and scholars on the economic fallout of COVID-19 pandemic. Though there are variations in degree and magnitude of the fall out, now there is a reasonable amount of consensus that the economic impact would be severe on the world economy and also on Indian economic growth, much more than the global financial crisis (GFC) of 2008. With regard to the impact on employment and income, [ILO \(2020\)](#) estimated that global unemployment can range between 5.3 million and 24.7 million from a base level of 188 million in 2019 pushing these people towards below poverty line. Most of the existing studies have focused on global growth, trade and unemployment, a few are country specific, especially India.

Ravi Srivastava, former Professor of Economics at JNU stated in THE HINDU that:

With the government's sudden lockdown decision, wages for jobs already carried out remained unpaid. A large percentage of migrants remained saddled with debt taken as advances from their employers, contractors, or landlords. The government's announcement of a tepid relief package on March 26 did not address any of the concerns of this section as the frail social security net largely does not cover them. Crucially, the government side-stepped its major responsibility of paying compensatory wages to the informal workers for the lockdown, putting this onus on employers who are already hit hard by the lockdown.

- 1. Praveen kumar and Nilachala Acharya conducted a Periodic Labour Force Survey (PLFS) and stated that :** Approximately 470 million workers, 245 million were self-employed, 170 million were casual workers, and 107 million were regular workers, with median monthly earnings of ₹8,000, ₹5,000 and ₹10,000, respectively; such figures clearly indicate the fragile structure and overall vulnerability of the country's workforce.
- 2. Businessstoday.in India's unemployment rate in March rises to nearly 9%, highest in 43 months:** The number of unemployed people who were actively looking for a job was reported at 3.79 crore. This is the highest since October 2016, when 3.85 crore unemployed people were actively looking for a job. The unemployment rate largely remained under 8 per cent from April 2019 till February 2020, except in July and October.
- 3. Students of Azim Premji University who conducted the survey reported that:** Around two-thirds of respondents reported losing employment during the lockdown, and those that continued to be employed witness a sharp decline in earning. Almost 80 per cent of households experienced a reduction in food intake, more than 60 per cent did not have enough money for a week's worth of essentials.
- 4. Labour in India and the COVID-19 Pandemic: A study conducted by Manish Jain and Kiran Jha states that:** during the first couple of months after the lockdown, more than 120 million jobs were lost, that is, close to one-fourth of the workers had been deprived of their employment. In March–July 2020, from 117 to 126 million workers, whereas the estimated number of daily wage workers had come down from 127 million in March to 120 million in July.

2.2 Theoretical Framework

Employment Rate in India averaged 44.97 percent from 2012 until 2020, reaching an all-time high of 50.80 percent in the fourth quarter of 2012 and a record low of 36.40 percent in India has two broad groups of migrant laborers - one that migrates to temporarily work overseas, and another that migrates domestically on a seasonal and work available basis. The second quarter of 2020. Domestic migrant workers have been estimated to be about 4.2 million. These workers range from full-time to part-time workers, temporary or permanent workers. They are typically employed for remuneration in cash or kind, in any household through any agency or directly, to do the household work, but do not include any member of the family of an employer. Unemployment in India mainly refers to educated young people looking for jobs in the formal economy - although the informal economy employs 90% of the workforce and generates half the economic output. The more educated the person is, the more likely it is they'll remain jobless and unwilling to take up a low-paying informal job. On the other hand, the poor who have little access to education are compelled to take up whatever work comes their way.

Three-quarters of India's workforce is self-employed and casual, with no social security benefits. surveys show 45% of all salaried workers earn less than 9,750 rupees (\$130; £96) a month. unemployment is more in the urban areas as compared to the rural areas. Between 2019-20 and December 2021, the manufacturing sector has lost 9.8 million jobs; by contrast, agricultural jobs jumped by 7.4 million. The percentage of salaried people has dropped from 21.2 per cent in 2019-2020 to 19 per cent in 2021, which mean that 9.5 million people have left the salaried and become jobless or part of the informal sector. There are variations among Indian states, as per CMIE data, the unemployment rate in December 2021 was the highest in Haryana (34.1 per cent), followed by Rajasthan (27.1 per cent), Jharkhand (17.3 per cent) and Bihar (16 per cent). There are also variations age-wise. Based on the data from CEDA-CMIE (between January 2019 and July 2021), the year 2020-21 saw 42.4 per cent fewer 15-19-year-olds employed in comparison to 2019-20. The age group of 20-29-year-olds saw the average monthly employment numbers go down by 15.6 per cent. According to CMIE, of the 35 million unemployed who were actively looking for work in December 2021, 23% or 8 million were women.

At the same time, of the 17 million who were passively unemployed, 53% or 9 million women were willing to work although they were not actively looking for work. Unemployment in India was highest in May 2021, when it touched 11.84 per cent.

According to a 30-day moving average, the unemployment rate on January 2, 2022, is 7.8 per cent. Urban unemployment was as high as 9.2 per cent. Among the states, the unemployment rate was highest in Haryana at 34.1 per cent. It was followed by Rajasthan with 27.1 per cent unemployment. Jharkhand ranked third in the list with a 17.3 per cent unemployment rate. From early April 2020 onwards, a large number of field-based reports started generating estimates of the likely loss of work and their consequences; although the sample size of most of these reports are relatively small, they provide very powerful insights into the huge adversities confronted by those at the bottom of the pyramid, that is, the informal workers constituting more than 90% of the workforce.

Factors influencing employment

The four main factors influencing employment are:

1. Increased population growth

Increases in population have been considerable over the half-century. The country's overall population is made up of more than 1.3 billion people, second only to that of China. Moreover, India's population is [predicted](#) to exceed China's by the year 2024; it will, furthermore, probably be the most populous country for the entirety of the 21st century. As the country's economic growth cannot keep up with population growth, this leads to a larger share of the society being unemployed.

2. Ineffective economic planning

This is a major source of unemployment in India. Problematically, there were no nationwide plans to account for the significant gap between labour supply (which is abundant) and labour demand (which is notably lower). It is crucial that the supply and demand of labour be in balance to ensure

that those who need jobs are able to get them; otherwise, many individuals will compete for one job.

3. Slow economic growth

The Indian economy is relatively underdeveloped, economic growth is considerably slower than it might otherwise be. This means that as the population increases, the economy cannot keep up with demands for employment and an increasing share of people are unable to find work. The result is insufficient levels of employment nationwide.

4. Slow industrial growth

Industrialization has been considerable its rate of growth is nevertheless fairly slow. There is a major emphasis on industrialization nationwide, which has elevated the Indian economy; however, industrial growth continues to generate relatively few new jobs overall as compared to increases in population.

Importance of employment in India

Employment opportunities for citizens in India can help to reduce corruption, remove terrorism. And it plays the biggest role in poverty alleviation. Employment improves the quality of living standard when an employed person gets money. It's because the employed person works hard to achieve his/her goals. That help to improves the business of his/her employer or improve the productivity of any company. Then it speeds up business transactions and new investment comes in the market.

Employment directly gives security and financial stability to people below poverty line. Indirectly when someone is on the job they learn to live and survive. They got a group of people in which many explore new ideas and daily life finance handling methods. When anyone below poverty line people learn from other in working atmosphere then they become able to educate their children to become successful and respectful in the society. They become inspiring for their kids. That's the difference employment create in the life of people

CHAPTER 3

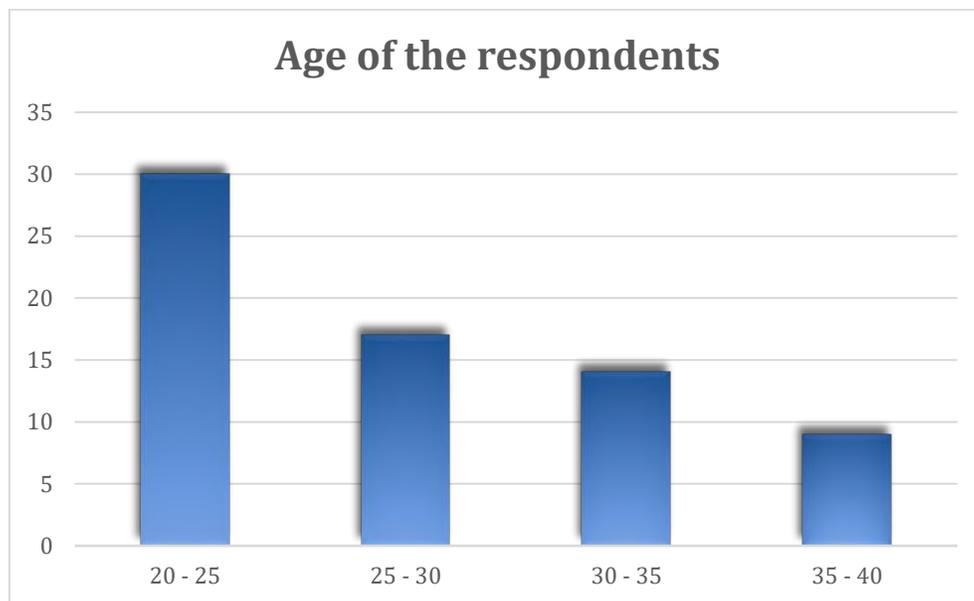
DATA ANALYSIS AND INTERPRETATION

3.1 AGE OF THE RESPONDENT

Age of the respondent	Number of respondents	Percentage of respondents
20 - 25	30	30
25 - 30	17	17
30 - 35	14	14
35 - 40	9	9

SOURCE: Primary Data

Figure 3.1



INFERENCE

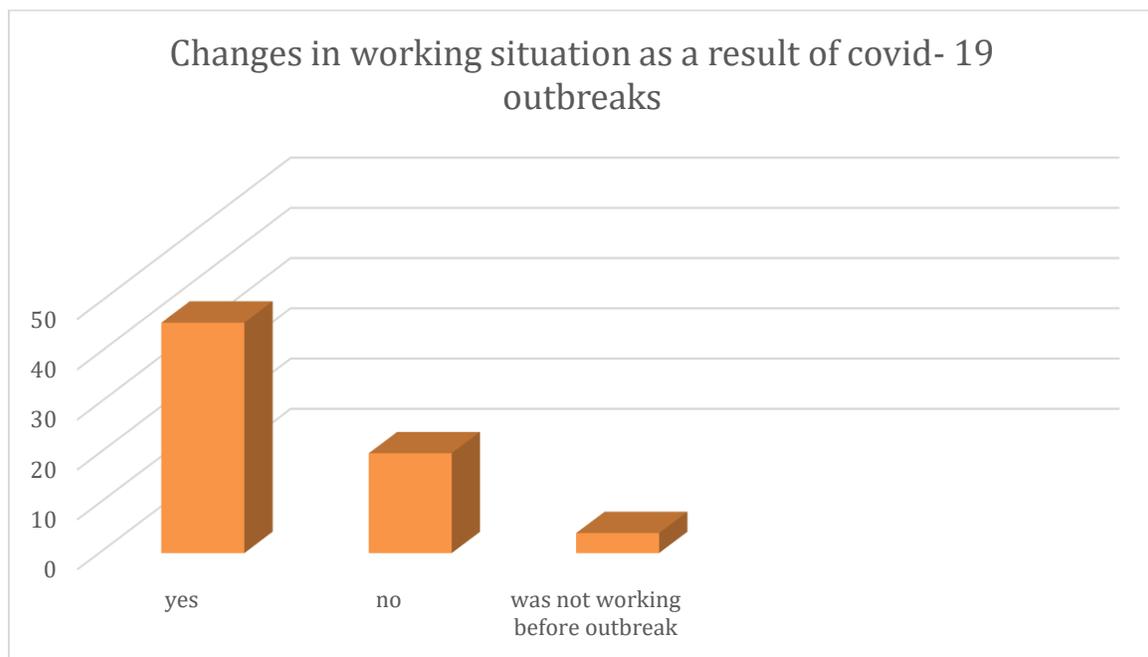
Of the total samples taken majority belongs to the category of people who are within the age limit of 20 – 25

3.2 CHANGES IN WORKING SITUATION AS A RESULT OF COVID OUTBREAK

Changes in working Situation as a result of Covid outbreak	Number of respondents	Percentage of respondents
Yes	46	65.7
No	20	20.6
Was not working before outbreak.	4	5.7

SOURCE: Primary Data

Figure 3.2



INFERENCE

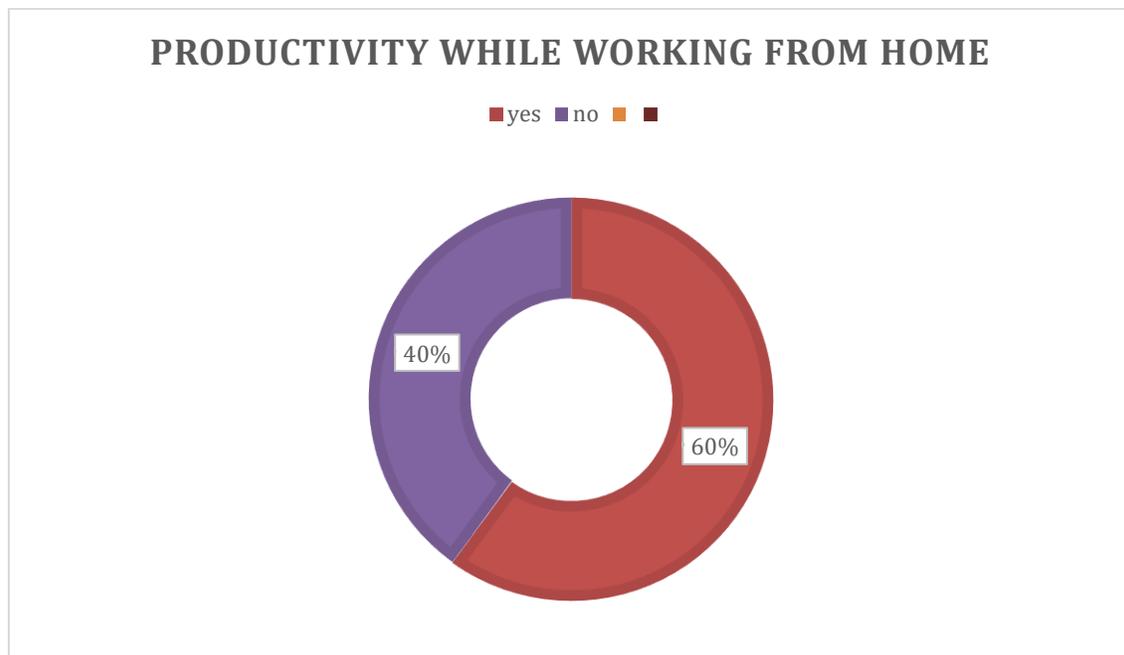
As per response collected 65.7% of the population have experienced changes in working situation as a result of covid – 19 outbreaks.

3.3PRODUCTIVITY WHILE WORKING FROM HOME

Equally as productive, less productive or more productive while working from home	Number of respondents	Percentage of respondents
Yes	42	60
No	28	40

SOURCE: Primary Data

Figure3.3



INFERENCE

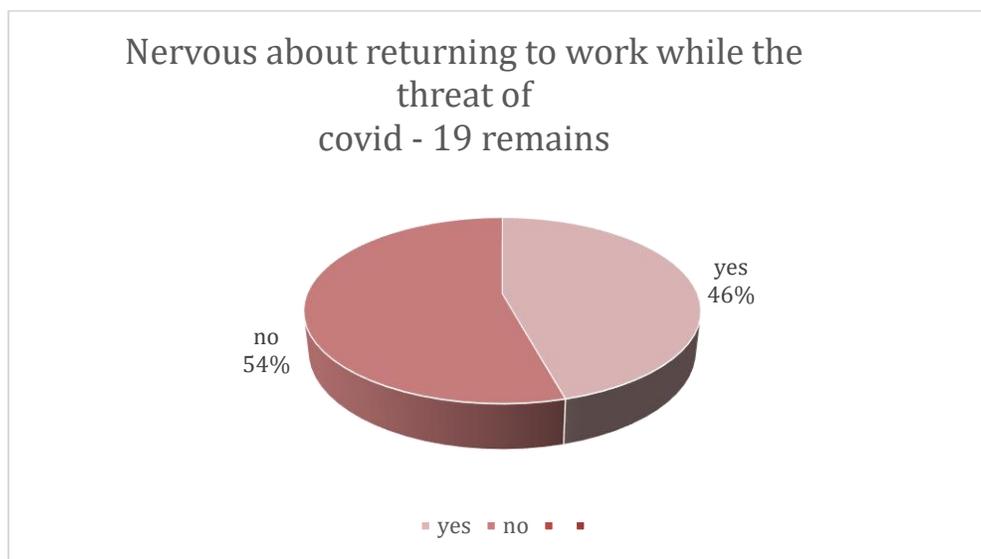
As per the pie chart 60% of population have been productive while working from home whereas 40% of population thinks that they are not productive while working from home.

3.4 Nervous about returning to work while the threat of Covid-19 remains

Nervous about returning to work while the threat of covid – 19 remains	Number of respondents	Percentage of respondents
Yes	32	45.7
No	38	54.3

SOURCE: Primary Data

Figure3.4



INFERENCE

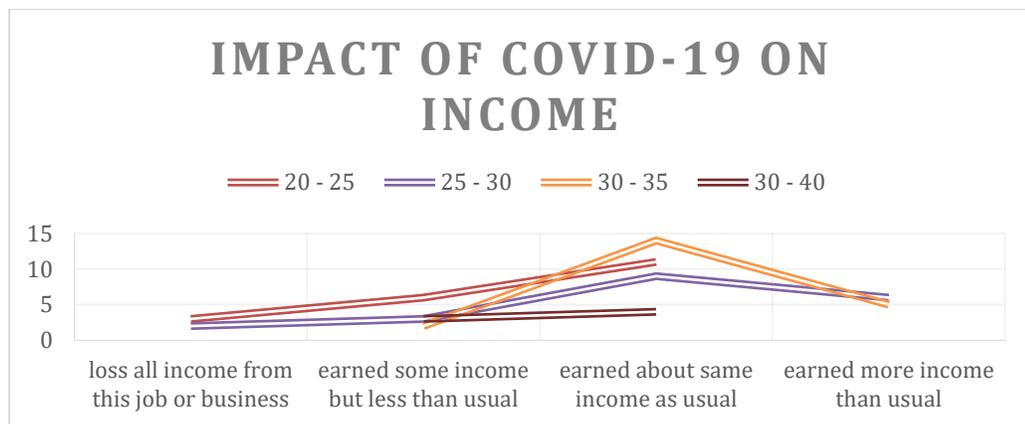
As per the pie chart 54% of population are not anxious about returning to work due to covid-19 and rest 46% of population are anxious about returning to work.

3.5 Impact of covid – 19 on income

Impact of Covid 19 on income	Number of respondents	Percentage of respondents
Lose all income from this job or business	5	7.1
Earned some income but less than usual	16	22.9
Earned about same income as usual	38	54.3
Earned more income than usual	11	15.7

SOURCE: Primary Data

Figure3.5



INFERENCE

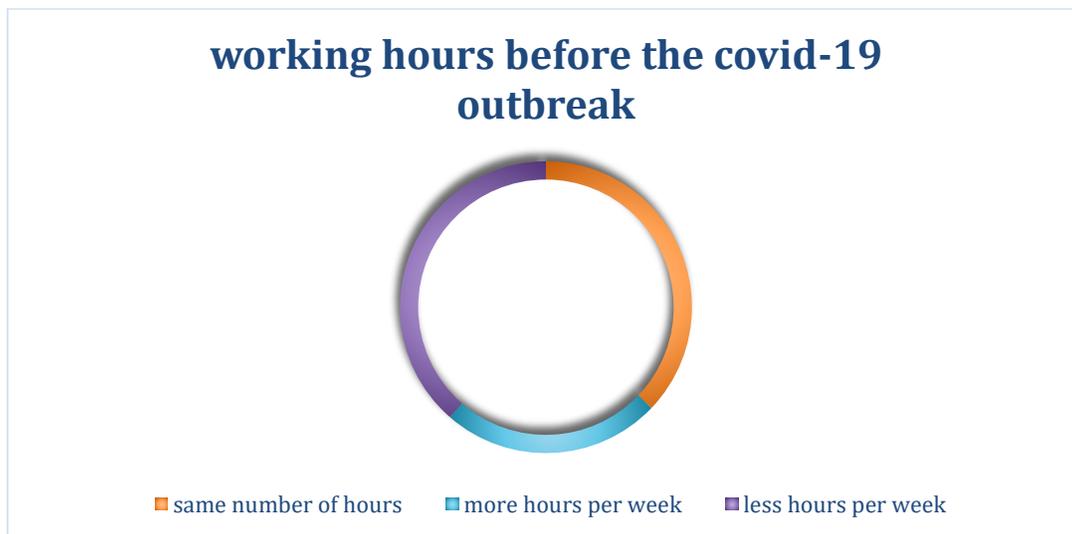
As per the chart 54% of sample earned about same income as usual, 23% earned some income less than usual, 15% earned more income than usual and 7% lost all income from business.

3.6 Working hours before covid – 19 outbreak

Working hours before covid- 19	Number of respondents	Percentage of respondents
Same number of hours per week	26	37.1
More hours per week	17	24.3
Less hours per week	27	38.6

SOURCE: Primary Data

Figure3.6



INFERENCE

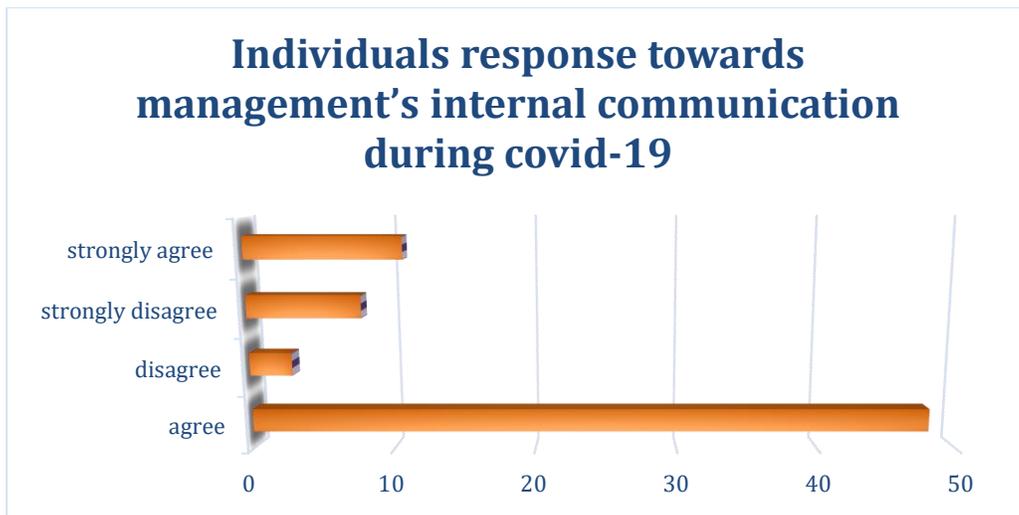
As per the data collected 38% of the population were working less hours in a week and 37% of the population were working same number of hours in a week and rest 17% of the population were working more hours in a week

3.7 Individuals response towards management's internal communication during covid-19

Individuals response towards management's internal communication during covid-19	Number of respondents	Percentage of respondents
Agree	48	68
Disagree	3	4.3
Strongly disagree	8	11.4
Strongly agree	11	15.7

SOURCE: Primary Data

Figure3.7



INFERENCE

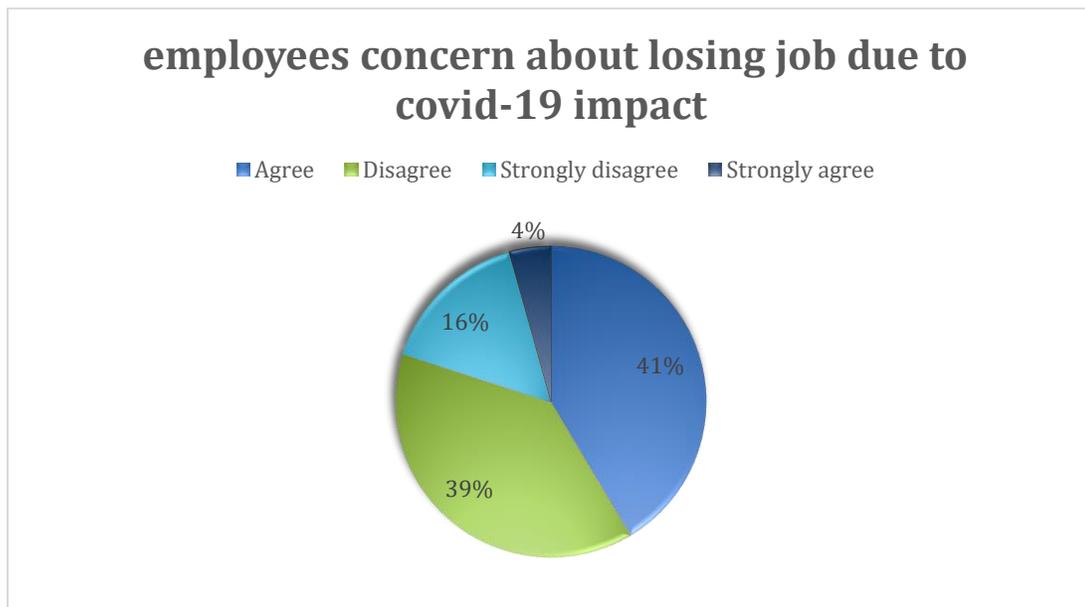
As per the chart 68% of the sample agrees that their management has done a great job with internal communication during covid-19.

3.8 Employees concern about losing job due to covid-19 impact

Employees concern about losing job due to covid 19 impact	Number of respondents	Percentage of respondents
Agree	29	41.4
Disagree	27	38.6
Strongly agree	3	4.3
Strongly disagree	11	15.7

SOURCE: Primary Data

Figure3.8



INFERENCE

As per the pie chart 41% of the sample are concerned about losing job due to covid-19 and 39% of the sample are not concerned about losing job due to covid-19.

3.9 Salary deduction during covid-19 outbreak

Salary deduction during covid-19 outbreak	Number of respondents	Percentage of respondents
High reduction	6	8.6
Medium reduction	11	15.7
Low reduction	10	14.3
No change	43	61.4

SOURCE: Primary Data

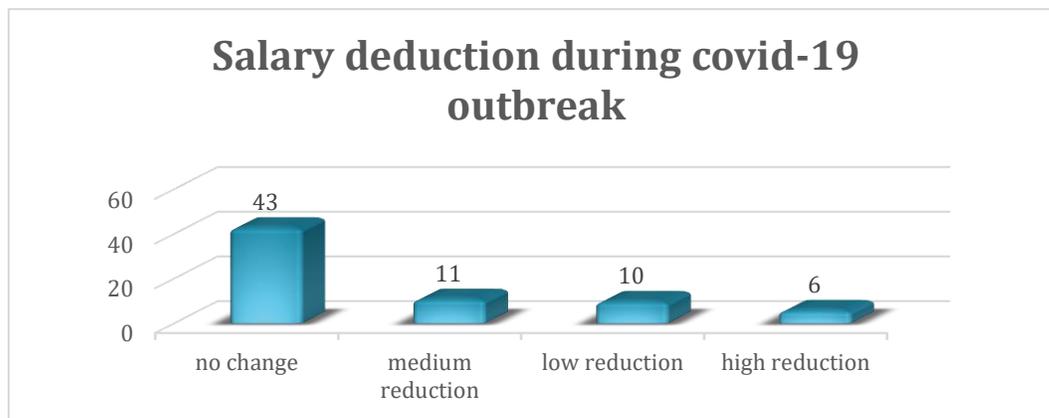


Figure3.9

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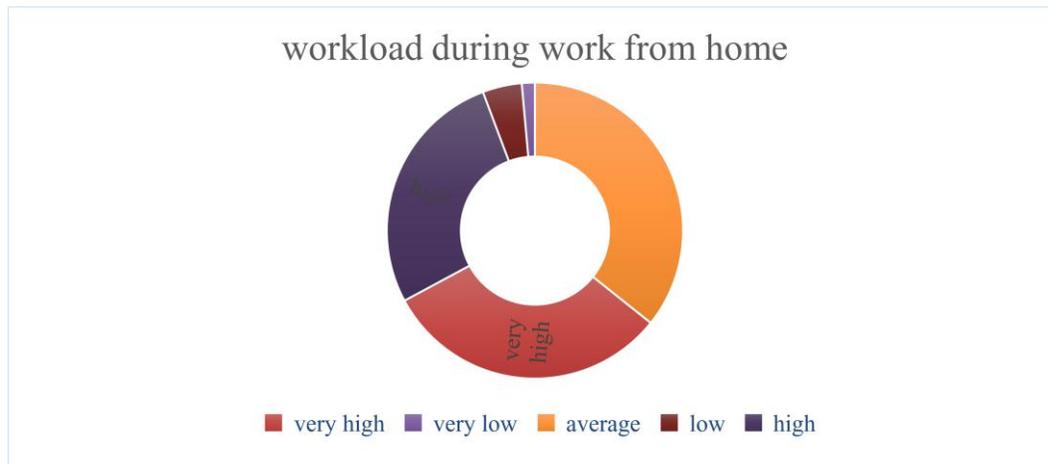
Only 61% of the population reported that there was no salary deduction during covid-19, 15% faced medium reduction, 14% low reduction and rest 8% faced high reduction of salary.

3.10 Work load during work from home

Work load during work from home	Number of respondents	Percentage of respondents
Very high	22	31.4
Very low	1	1.4
Average	25	35.7
Low	3	4.3
High	19	27

SOURCE: Primary Data

Figure3.10



INFERENCE

As per the report around 31% of the respondents went through a very high increase in work load during work from home , 35% went through an average increase and around 4% went through a lower increase in work load.

3.11 LABOUR TURNOVER IN THE ORGANIZATION

Labour turnover in the organization	Number of respondents	Percentage of respondents
Yes	29	41.4
No	12	17.1
Slight change	26	37.1
No change	3	4.3

SOURCE: Primary Data

Figure3.11



INFERENCE

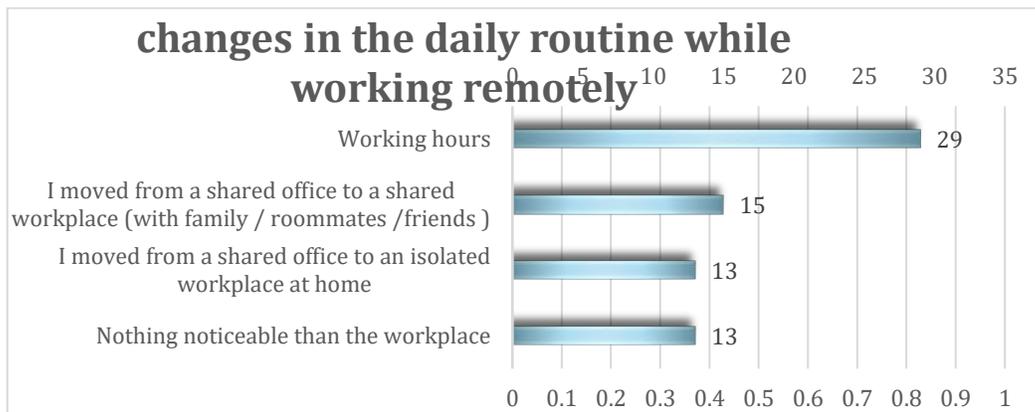
Through this data we can clearly understand that around 41% of the respondents agree there has been sudden labor turnover during this period, while 37% claim there was only a slight change and the rest 4% believe there wasn't any change.

3.12 CHANGES IN THE DAILY ROUTINE WHILE WORKING REMOTELY

Changes in the daily routine while working from home	Number of respondents	Percentage of respondents
Nothing noticeable than the workplace	13	18.6
I moved from a shared office to an isolated workplace at home	13	18.6
I moved from a shared office to a shared workplace (with family / roommates /friends)	15	21.4
Working hours	29	41.4

SOURCE: Primary Data

Figure3.12



INFERENCE

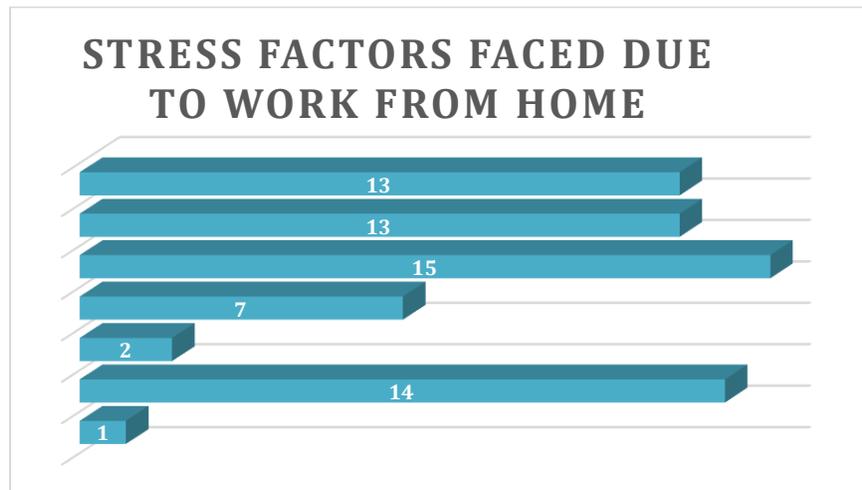
It is clearly noticeable that around 42% of respondents faced an increase in working hours while working remotely, 18% of them had to move to an isolated workplace from a shared office, 21% of them worked around family and roommates and the other 18% faced no change other than the workplace.

3.13 STRESS FACTORS FACED DUE TO WORK FROM HOME

Stress factors faced due to work from home	Number of respondents	Percentage of respondents
I have to work in a different place than where I live / my family lives e.g. in another country...	5	7.1
I live away from the ones who need special care (children living separately...	1	1.4
Separating work and family life	14	20
Not enough space to work	2	2.9
Lack of privacy	7	10
Over working	15	21.4
Network issues	13	18.6
All of the above	13	18.6

SOURCE: Primary Data

Figure3.13



INFERENCE

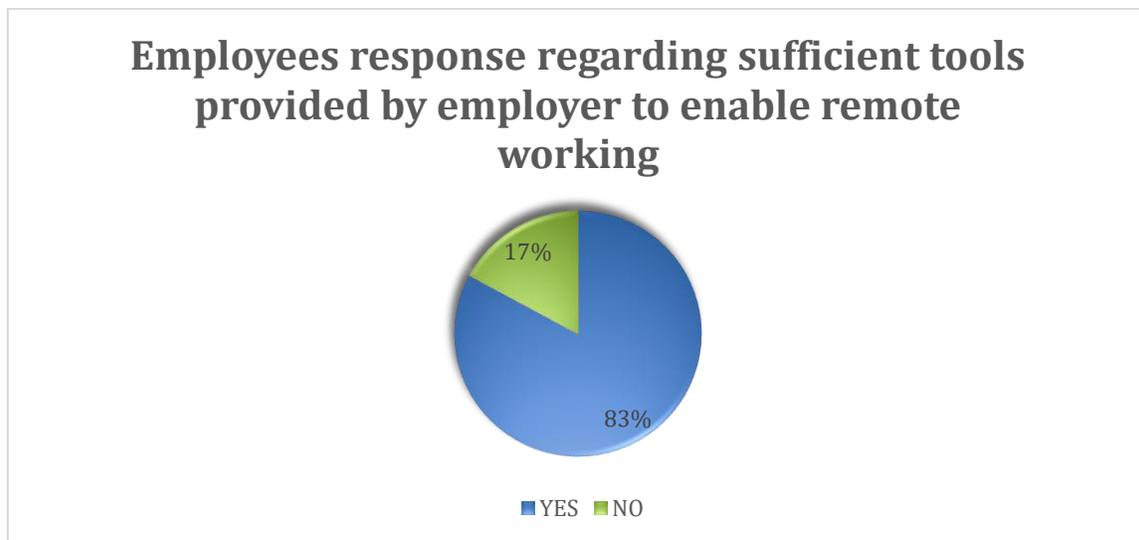
As per the chart 21% of the population thinks that over working is the stress factor faced during work from home, 20% separating work and family life, 18% network issues and 13% all of the above.

3.14.EMPLOYEES RESPONSE REGARDING SUFFICIENT TOOLS PROVIDED BY EMPLOYER TO ENABLE REMOTE WORKING

Employees response regarding sufficient tools provided by employer to enable remote working	Number of respondents	Percentage of respondents
Yes	58	82.9
No	12	17.1

SOURCE: Primary Data

Figure3.14



INFERENCE

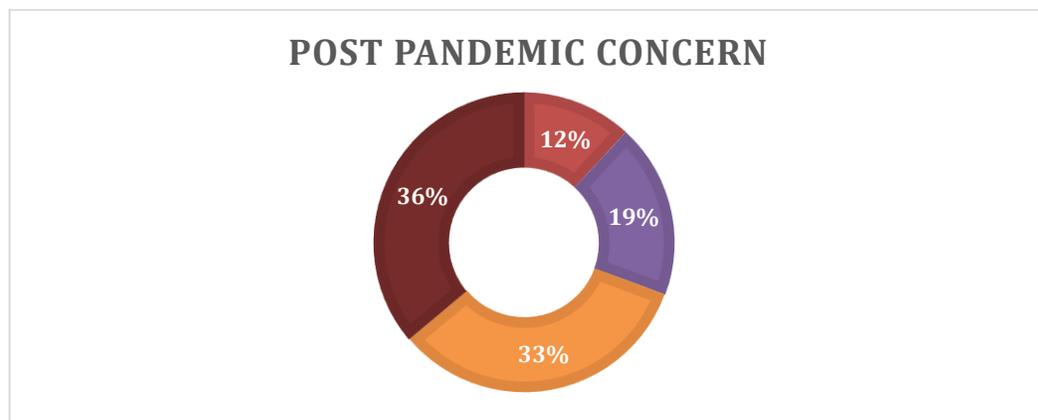
As per the pie chart 83% of the population thinks that their employer has provided sufficient tools to enable remote working and 17% thinks that employer has not provided sufficient tools to enable remote working.

3.15 POST- PANDEMIC CONCERN

Post- pandemic concern	Number of respondents	Percentage of respondents
Losing your job	9	12.9
Financial stagnation / recession of your company	13	18.6
Social anxiety (including coping with grief related to loss of family members)	23	32.9
Not being able to work remotely afterwards	25	35.7

SOURCE: Primary Data

Figure3.15



INFERENCE

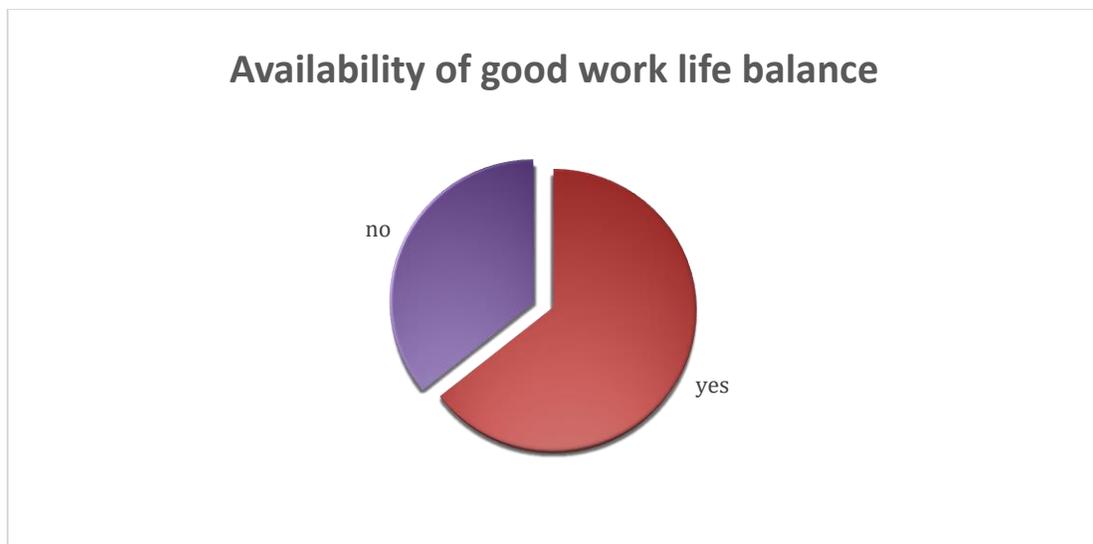
An analysis made on the post pandemic concern shows that around 12% of the respondents feared losing their job, 18% worried about the financial stagnation of their company, 32% of them had to go through social anxiety while the other 35% worried about not being able to work remotely afterwards.

3.16 AVAILABILITY OF GOOD WORK LIFE BALANCE

Good work life balance	Number of respondents	Percentage of respondents
Yes	45	65.3
No	25	35.7

SOURCE: Primary Data

Figure3.16



INFERENCE

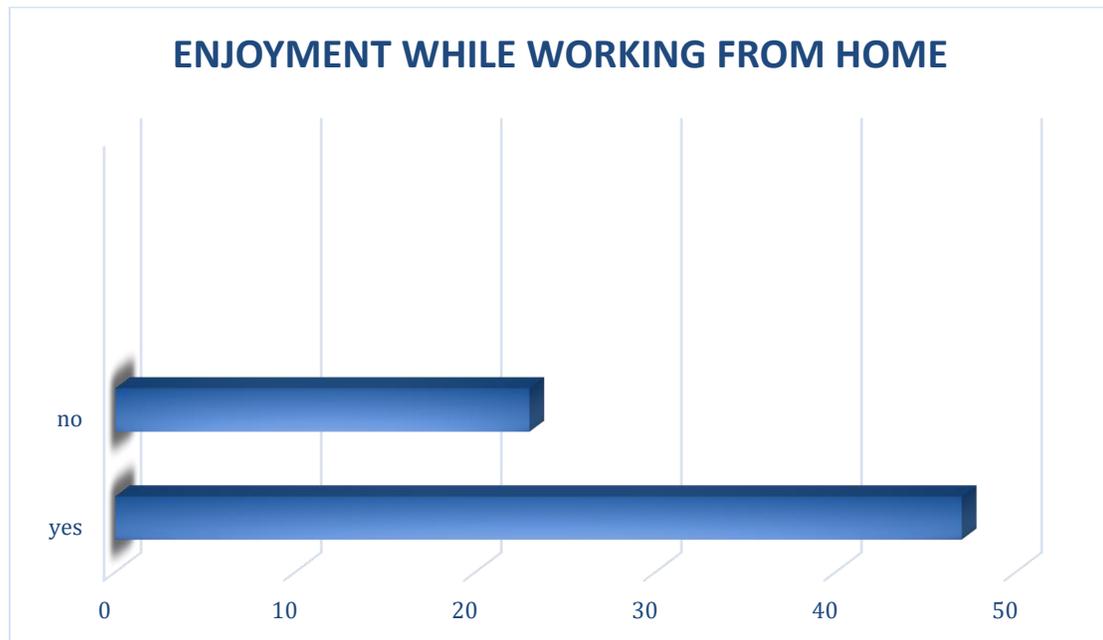
From the above pie chart, we can find a good work life balance among 65% of the respondents whereas the remaining 35% did not agree with it.

3.17 ENJOYMENT WHILE WORKING FROM HOME

Enjoyment while working from home	Number of respondents	Percentage of respondents
Yes	47	67.1
No	23	32.9

SOURCE: Primary Data

Figure3.17



INFERENCE

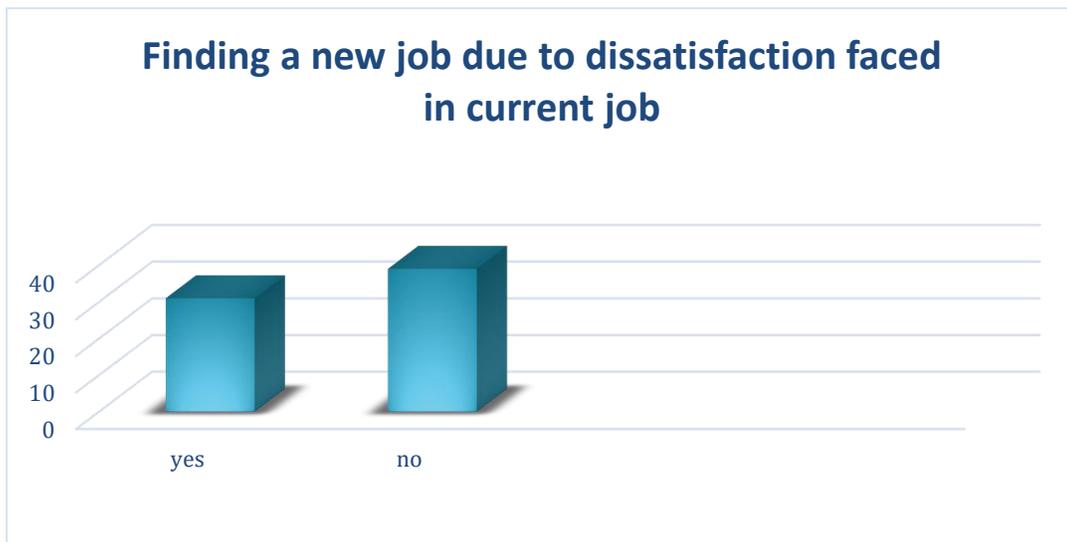
It is clear from the above data that around 67% of the respondents enjoyed working from home and only the remaining 32% did not enjoy it.

3.18 FINDING A NEW JOB DUE TO DISSATISFACTION FACED IN CURRENT JOB

Finding a new job due to dissatisfaction faced in current job	Number of respondents	Percentage of respondents
Yes	31	44.3
No	39	55.7

SOURCE: Primary Data

Figure3.18



INFERENCE

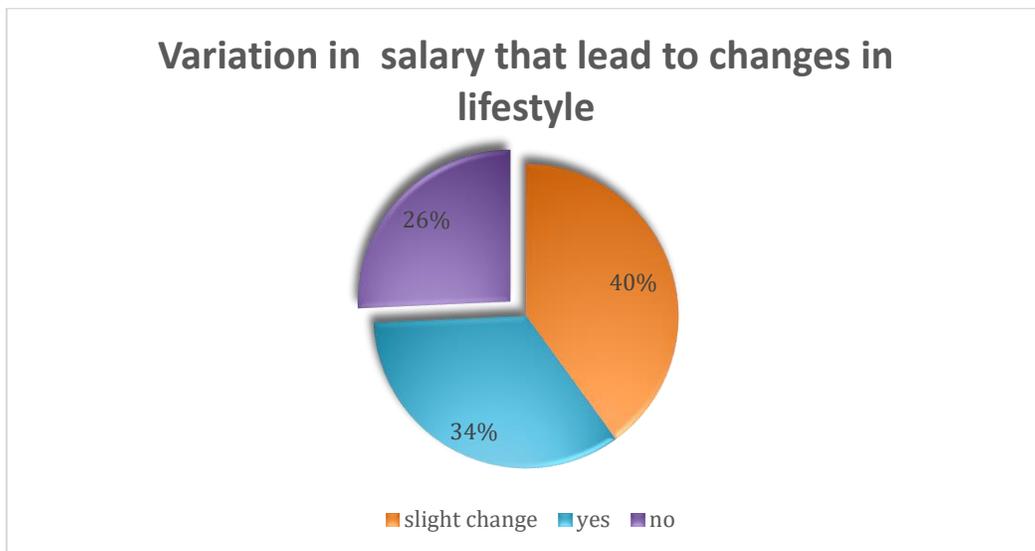
It is observed that around 44% of the respondents were dissatisfied with the present job and was looking for a new one while the other 55% of them had no issues in their current job.

3.19 VARIATION IN SALARY THAT LEAD TO CHANGES IN THE LIFESTYLE

Variation in salary that lead to changes in the lifestyle	Number of respondents	Percentage of respondents
Yes	24	34.3
No	18	25.7
Slight change	28	40

SOURCE: Primary Data

Figure3.19



INFERENCE

As per the pie chart 34% of the population faced fluctuation on the salary that lead to changes in their lifestyle, 40% slight change and rest 26% faced no fluctuation on the salary.

3.20 LEVEL OF SATISFACTION WITH ORGANIZATION’S RESPONSE TO COVID-19 AND SAFETY MEASURES

Level of satisfaction with organization response to covid-19 and safety measures	Number of respondents	Percentage of respondents
Satisfied	38	54.3
Dissatisfied	7	10
Neutral	25	35.7

SOURCE: Primary Data

Figure3.20



INFERENCE

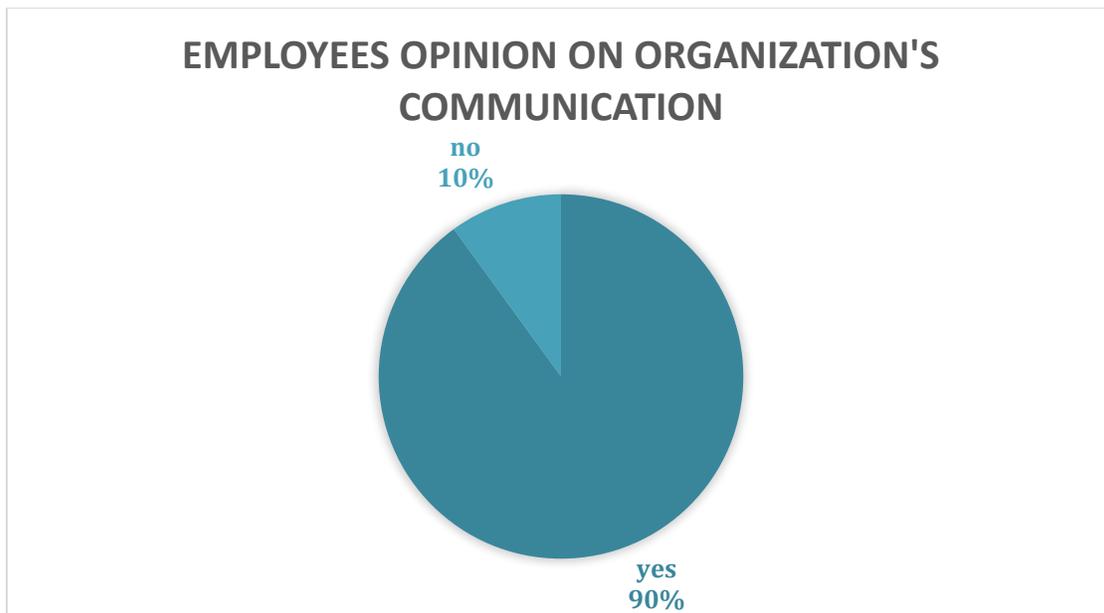
As per the data collected 54%of the sample collected are satisfied regarding organization’s response to covid-19 and employee safety,10% dissatisfied and rest 36% are unbiased.

3.21 EMPLOYEES OPINION ON ORGANIZATION'S COMMUNICATION WITH THEM

Employees opinion on organization's communication	Number of respondents	Percentage of respondents
Yes	63	90
No	7	10

SOURCE: Primary Data

Figure3.21



INFERENCE

As per the data collected 90% of the sample thinks that the organization has communicated with them during this period and rest 10% does not agree.

3.22.LEVEL OF SATISFACTION WITH THE ORGANIZATION'S MANAGEMENT.

Level of satisfaction with organization's management	Number of respondents	Percentage of respondents
Satisfied	47	67.1
Neutral	15	21.4
Not satisfied	8	11.4

SOURCE: Primary Data

Figure3.22



INFERENCE

As per the chart 67%of the population are satisfied with the organization's management in it's business and people during covid-19, 8% of the population are dissatisfied and rest 15% of the population are unbiased.

3.23 EMPLOYEES RESPONSE TOWARDS THE ORGANISATION'S INTEREST IN EMPLOYEES WHILE MAKING BUSINESS DECISION DURING WORK FROM HOME

Employees response towards the organization's interest in employees while making business decision during work from home	Number of respondents	Percentage of respondents
Yes	37	52.9
No	7	10
Maybe	26	37.1

SOURCE: Primary Data

Figure3.23



INFERENCE

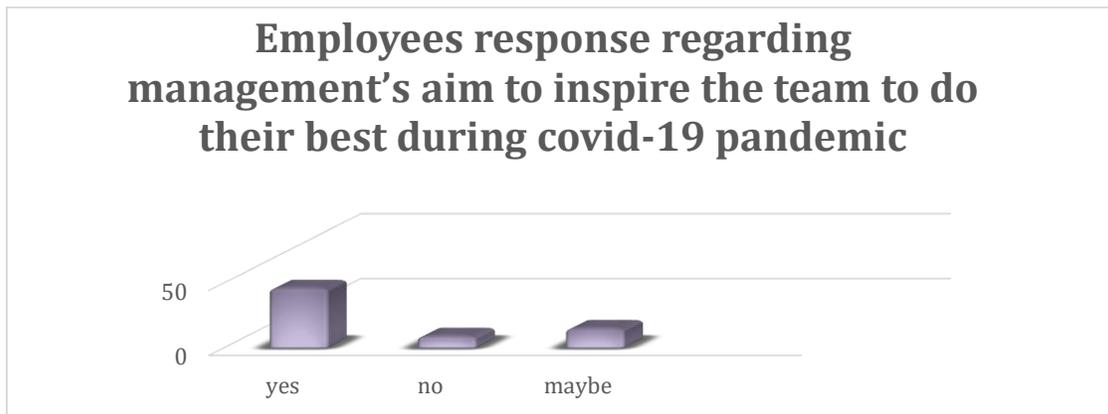
As per the chart 53% of the respondents thinks that their organization has interest in employees while making business decision during work from home , 37% maybe and rest 10% no.

3.24. EMPLOYEES RESPONSE REGARDING MANAGEMENT’S AIM TO INSPIRE THE TEAM TO DO THEIR BEST DURING COVID-19 PANDEMIC.

Employees response regarding management’s aim to inspire the team to do their best during covid-19 pandemic	Number of respondents	Percentage of respondents
Yes	46	65.7
No	9	12.9
Maybe	15	21.4

SOURCE: Primary Data

Figure3.24



INFERENCE

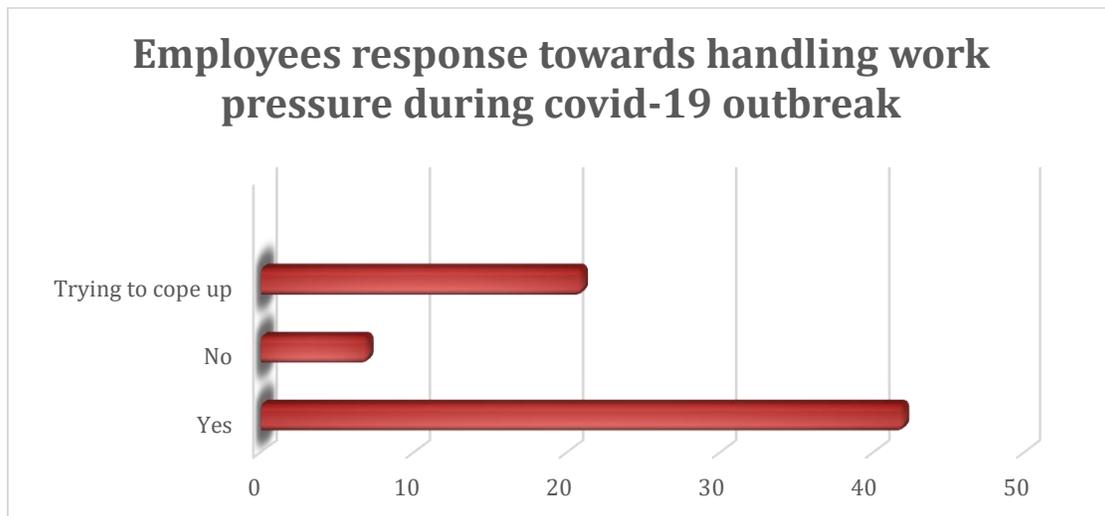
As per the chart 66% of the respondents said yes towards management’s aim to inspire the team to do their best work during covid-19 outbreak , 21% maybe, 13% said no.

3.25 EMPLOYEES RESPONSE TOWARDS HANDLING WORK PRESSURE DURING COVID-19 OUTBREAK

Employees response towards handling work pressure during covid-19 outbreak	Number of respondents	Percentage of respondents
Yes	42	60
No	7	10
Trying to cope up	21	30

SOURCE: Primary Data

Figure3.25



INFERENCE

As per the chart majority of the sample collected are able to handle work pressure during covid-19 outbreak,30% are trying to cope up and rest 10% are not able to handle work pressure.

CHAPTER 4

FINDINGS, SUGGESTIONS AND CONCLUSIONS

FINDINGS

- Most of our respondents fall under the age group of 20-25
- Majority of the respondents have experienced changes in working situation as a result of covid-19 outbreak.
- Most of the respondents are productive while working from home
- As per the data collected majority of the respondents are not anxious about returning to work due to covid-19
- Majority of the employees earned about same income as usual during covid-19 outbreak.
- Most of the respondents were working less hours in a week before covid-19.
- Nearly all our participants agrees that their organization has done a great job with internal communication during covid-19.
- Majority of the employees are concerned about losing job.
- There was no reduction in salary during covid-19
- Most of the respondents went through an average increase in work load during work from home.
- From data analysis, there was a sudden labour turnover in the organization during covid-19.
- Working hours is the factor faced by most of the respondents.
- Majority of the employees stress factor is over working during work from home.
- The employer has provided sufficient tools to most of the employees to enable remote working.
- Most of the respondent's post-pandemic concern was not being able to work remotely afterwards and social anxiety.

- There was a good work life balance available to most of our participants.
- Majority of the respondents enjoyed working from home.
- From data analysis, it was observed that most of the respondents have no issues in their current job.
- Due to variation in the salary most of the employee's have experienced slight change in their lifestyle.
- Most of the respondents are satisfied with the organization's response to covid-19 and safety measures.
- Nearly all of the respondent's experienced that the organization has maintained adequate communication with it's employee's.
- Majority of the respondents are satisfied with organization's management during covid-19.
- Most of the respondents said yes regarding organization's interest in employee's while making business decision while working from home.
- From data analysis, sufficient number of employees have experienced that the organization inspire them to do their best work during this covid-19 outbreak.
- Almost all of the employee's were able to handle workload during this period.

SUGGESTIONS

- ❖ The employers should make sure that the employees are being productive while working.
- ❖ The employees should be given a friendly work environment when they return to work.
- ❖ The employers should study the current market situation and raise the remuneration of the employees accordingly so that they have a better livelihood.
- ❖ There should be better internal communication in the organization with the employees.
- ❖ The organization should ensure that the employees get a steady income and job security for better performance of the employees.
- ❖ The employers should avoid giving heavy work load to the employees while working from home.
- ❖ The employees should be motivated and should be encouraged to be productive so that there will be less labour turnover.
- ❖ The working hours should be minimized and the employees mental health should be considered.
- ❖ Over working should be avoided.
- ❖ The employees should be provided sufficient tools for better performance and timely completion of work.
- ❖ The employees should have a good work life balance.
- ❖ The employees find difficulties in their current jobs which leads to job switch so factors affecting their working situation should be analysed.
- ❖ The organization should take into consideration the employees interest for better management.

CONCLUSION

The COVID-19 pandemic has altered every aspect of our work and life. The impact of coronavirus pandemic in India has been largely disruptive in terms of economic activity as well as loss of human lives. Almost all the sectors have been adversely affected. Among these, the employment sector went through a drastic change as well.

From the study conducted we could analyze that during the Covid-19 outbreak there was a sudden emergence in WFH (Work from home) where people were shifted from working from their workplace to their homes. It was evident that some of the respondents faced a change in their working situation. While we could see that some others felt that they were more productive working from home than from office. Some respondents also had to go through change in working hours from usual to more or less. The study also showed change in income varying from more to less and even usual.

One of the greatest disadvantage of working from home was the excess work load which is clearly seen in the study, the work pressure during this period varied from average to very high among the employees. Existence of high rate of labour turnover also made it difficult for the employees to work during this period. Our study also highlights the work life balance seen among the employees as well as the stress factors that hindered their job.

We could also find out that there existed dissatisfaction of job among certain employees that provoked them to look for new ones while another portion of respondents also had the constant fear of losing their current job during this period.

So we can understand that through this study conducted by taking responses of different working individuals and other sources, working during this Covid-19 era was difficult indeed. It has drastically, one or the other way affected the living standards of the people as well as their mental health. Taking into account the satisfaction level of employees on how the management has played a major role in providing them sufficient tools to work and taking decisions according to the employee's best interest can make us conclude that even the organisations, institutions along with their employees are coping through this hard time together.

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Annexure

QUESTIONNAIRE

1. Age of the respondent

- 20-25
- 25-30
- 30-35
- 35-40

2. Have you experienced any changes in your working situation as a result of the [COVID-19 outbreak]?

- 1. YES
- 2. NO
- 3. WAS NOT WORKING BEFORE OUTBREAK

3. Have you been equally as productive, less productive, or more productive while working from home?

- YES
- NO

4. Are you nervous about returning to work while the threat of Covid-19 remains?

- YES
- NO

5. As a result of the [COVID-19 outbreak], did you...?

- 1. Lose all income from this job or business
- 2. Earned some income but less than usual
- 3. Earned about the same income as usual
- 4. Earned more income than usual

6. Before COVID-19 outbreak were you working...?

- 1. The same number of hours per week
- 2. More hours per week
- 3. Less hours per week

7. I feel my organization has done a great job with internal communication regarding the coronavirus/COVID-19.

- Agree
- Disagree
- Strongly disagree
- Strongly agree

8. I don't feel concerned about losing my job after covid 19 outbreak.

- Agree
- Disagree
- Strongly disagree
- Strongly agree

9. Have you experienced any salary deduction during covid 19 outbreak?

- High reduction
- Medium reduction
- Low reduction
- No change

10. What is your opinion regarding workload during work from home?

- Very high
- Very low
- Average
- Low
- High

11. Was there a sudden fluctuation in the employee turnover during the covid outbreak?

- Yes
- No
- Slight change
- No change

12. What has changed in your daily routine while working remotely?

- Nothing noticeable than the workplace
- I moved from a shared office to an isolated workplace at home
- I moved from a shared office to a shared workplace (with family / roommates / friends)
- Working hours

13. What are the stress factors you face due to work from home?

- I have to work in a different place than where I live / my family lives e.g. in another country.
- I live away from the ones who need special care (children living separately, relatives in need of care).
- Separating work and family life
- Not enough space to work
- Lack of privacy
- Strain on family relationships
- Over-working
- Feeling isolated
- Lack of self-discipline / self-management
- Network issues
- All of the above

14. Do you think your employer has provided you sufficient tools to enable remote working?

- Yes
- No

15. What is your biggest post-pandemic concern?

- Losing your job
- Financial stagnation / recession of your company
- Social anxiety (including coping with grief related to loss of family members)
- Not being able to work remotely afterwards

16. Do you feel you have a good work-life balance?

- Yes
- No

17. Do you enjoy working from home

- Yes
- No

18. Did you feel like looking for a new job due to the dissatisfaction faced in your current job because of the covid outbreak?

- Yes
- No

19. Did the fluctuation on the salary (if any) lead to change in your lifestyle/living standards?

- Yes
- No
- No change in salary

20. How satisfied are you with your organization's response to COVID-19 and employee safety?

- Satisfied
- Not satisfied
- Neutral

21. Has your organization maintained adequate communication with all of its employees during the employees?

- Yes
- No

22. Are you satisfied with the way your organization has managed both its business and people during this time?

- Satisfied
- Not satisfied

23. Do you believe the organization has your best interests in mind when making business decisions during work from home?

- Yes
- No

24. Does your team inspire you to do your best work during this stressful period?

- Yes
- No

25. Have you been able to handle your workload during the transition?

- Yes
- No
- Trying to cope up

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CERTIFICATE

This is to certify that the project titled "A GENERAL STUDY ON COVID-19 IMPACT ON EMPLOYMENT" submitted to Mahatma Gandhi University in partial fulfillment of the requirement for the award of Degree of Bachelor in Commerce is a record of the original work done by Ms. Archana Sathyanath K, Ms. Gayathri Gokul, Ms. Parvathy Krishnan under my supervision and guidance during the academic year 2021-22.

Project Guide

Smt. Jini Justin D'Costa

(Head of the Department)

Department of Commerce (SF)

Viva/Voice Examination held on....



Smt. Jini Justin D'Costa

(Head of the Department)

Department of Commerce (SF)

External Examiner(s)

DECLARATION

We, Archana Sathyanath K, Gayathri Gokul and Parvathy Krishnan, final year B. Com students. Department of Commerce (SF), ST. Teresa's College (Autonomous) do hereby declare that the project report entitled A GENERAL STUDY ON COVID-19 IMPACT ON EMPLOYMENT submitted to Mahatma Gandhi University is a Bonafede record of the work done under the supervision and guidance of Smt. Jini Justin, Head of the Department of Commerce (SF), St. Teresa's College(Autonomous) and this work has not previously formed the basis for the award of any academic qualification, fellowship, or other similar title of any other university or board.

PLACE: ERNAKULAM

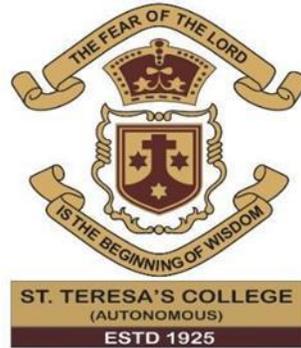
DATE: 29/04/2022

ARCHANA SATHYANATH K

GAYATHRI GOKUL

PARVATHY KRISHNAN

A CONTEMPORARY STUDY ON EKPHRASTIC POETRY



Project submitted to St. Teresa's College (Autonomous) in partial fulfilment of the requirement for the degree of BACHELOR OF ARTS in English Language and Literature

By

PARVATHY M P

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March 2022

DECLARATION

I hereby declare that this project entitled “A Contemporary Study On Ekphrastic Poetry” is the record of bona fide work done by me under the guidance and supervision of Dr. Jisha John, Assistant Professor, Department of English.

Parvathy M P

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March 2022

CERTIFICATE

I hereby declare that this project entitled “A Contemporary Study On Ekphrastic Poetry” by Parvathy M P is a record of bona fide work carried out by her under my supervision and guidance.

Dr. Jisha John

Department of English

Ernakulam

St Teresa’s College (Autonomous)

March 2022

Ernakulam

An Abstract of the Project entitled

A Contemporary Study On Ekphrastic Poetry

By

Parvathy M P

BA English Language and

Literature St Teresa's

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Ernakulam

Register Number: AB19ENG016

(2019-22)

March 2022

Supervising Teacher: Dr. Jisha John

Poetry, is the literature in which language is chosen and arranged for its meaning, sound etc. It conveys thought or describes a scene in simple forms or lyrical forms and it is the highest form of literature. Each of us like it may be through the concepts, forms, styles of the poem. But there are different types of poetry such as sonnets, haiku, elegy, ballad etc. But we didn't give much importance to a particular kind of poetry, that is 'Ekphrastic Poetry'. Ekphrastic Poetry is poetry that describes another work of art like paintings, sculptures, drawings or any visual art. The word 'Ekphrasis' means 'description' in Greek. Today, the word ekphrastic is referred to any literary detailing to a non-literary work. Each poetry has its own specialities, such as Ekphrastic Poetry also has. The aim of this study to bring out the specialities of this poetry, the creative processes, techniques. To strengthen the study, I chose three best Ekphrastic poems which in the 20th century. They are, *When It Is Over It Will Be Over*, by Paisley Rekdal (2016), *Replica of 'The Thinker'*, by Matthew Olzmann (2016) and *Dinosaurs in the Hood*, by Danez Smith (2017).

ACKNOWLEDGEMENT

I would like to thank God for giving me proper guidance throughout the process of crafting this project.

I would like to show my appreciation to Dr. Lizzy Mathew, Principal, St Teresa's College (Autonomous) and Rev Dr. Sr. Vinitha (CSST), Provincial Superior and Manager for their support.

I am deeply indebted to my guide, Dr. Jisha John, Department of English, St Teresa's College (Autonomous), who has acted as a constant pillar of support from the very beginning; without whose guidance and constructive feedback I would have never completed this project.

I am greatly thankful for Dr. Latha R Nair, Head of Department of English, St Teresa's College (Autonomous) for her constant encouragement and motivation.

I am grateful for Ms. Lakshmipriya B, who has given us a strong base on Research Methodology and all other faculty members of the department for their help and encouragement.

Parvathy M P

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INTRODUCTION

Poetry, the literature in which language is chosen and arranged for its meaning, sound etc. It conveys thought or describes a scene in simple forms or lyrical forms and it is the highest form of literature. We all love Poetry, right? Who doesn't love Poetry? Each of us like it may be because of the concepts, forms or styles of the poem etc.

But there are different types of poetry such as sonnets, haiku, elegy, ballad etc. But we didn't give much importance to a particular kind of poetry, that is 'Ekphrastic Poetry'. Ekphrastic Poetry is poetry that describes another work of art like paintings, sculptures, drawings or any visual art. Even poetry that describes dance and music are also known as Ekphrastic Poetry. In his work "The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction", Baugher writes, "The primary genre for ekphrasis has been poetry. One reason is the ease of designation. When a poem takes an artwork, it is natural to call the work "ekphrastic poetry". Contrarily, while prose might feature artwork and treat that subject descriptively, rarely does an entire prose piece revolve around a work-of-art" (155). The poem "The Starry Night" by Anne Sexton was inspired by the art of Vincent Van Gogh, then "Ode on a Grecian Urn" by John Keats, he wrote this after visualizing a vase named 'Sosibios Vase'. etc. are notable examples of Ekphrastic poems. The word 'Ekphrasis' means 'description' in Greek. But a common literary definition of Ekphrasis is writing which concerns itself with the art. Another definition of Ekphrasis is in the work, "Museum of Words", James A.W. Heffernan writes, "the verbal representation of visual representation" (3). Today, the word ekphrastic is referred to any literary detailing to a non-literary work. Ekphrasis is a method by which writers can exist outside themselves. Turning to the visual arts as creative fodder can allow writers to detach from their individual narratives. In "The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction", Baugher says that Writers with ekphrastic leanings might attempt to investigate their immobility by jotting

down the unutterable, using words to stab at the worldlessness of that feeling. Aesthetics is the ekphrastic writer's work. Ekphrastic writers wish to stun their eyes into getting precisely what the artists behold, to align themselves physically with them, to lean over their shoulders close enough to smell the paint (29).

There are so many such things we don't know about / we didn't try to know about this particular poetry.

Each poetry has its specialities, such as Ekphrastic Poetry also has. So, I intended to do my project on "A CONTEMPORARY STUDY ON EKPHRASTIC POETRY", the specialities of this poetry, the creative processes, tools and techniques which used from the beginning itself through the primary text named *The Ekphrastic Writer: Creating Art-Influenced Poetry, Fiction and Nonfiction* by Janeé J. Baugher and also to strengthen the study I chose three Ekphrastic poems. They are, *When It Is Over It Will Be Over*, by Paisley Rekdal (2016), "Replica of 'The Thinker'," by Matthew Olzmann (2016) and "Dinosaurs in the Hood," by Danez Smith (2017).

CHAPTER-1

A THEORETICAL FRAMEWORK

Ekphrastic Poetry, it's one of the different types of poetry. But we didn't look into it that much. Because nowadays ekphrastic poetry is not that much used. But some way or the other social media has taken it seriously and on some of the sites on the internet, we can see they conduct monthly ekphrastic poetry competitions. In his work "The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction", Baugher writes, "Ekphrastic poetry is poetry that verbally describes a visual art or the detailed literary description of any object, real or imagined" (15). Art includes paintings, drawings, sculptures etc. In this work "The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction", Baugher writes, "A common literary definition of ekphrasis is writing which concerns itself with the arts" (15). The word ekphrasis itself means: "Describe". Many previous ekphrasis reviewers have only looked at the text, moving away from the image to the verbal and then commenting on the works without a philosophical and/or genuine perspective, and this tradition leaves readers only with superficial and text centred criticism. Of course, this does not mean that texts on ekphrasis before the twentieth century have little or no value; rather they are as precious as the theoretical works which themselves rely on such prior critics as Horace, Plutarch, Quintilian, James Harris, and Joachim Wincklemann.

So, we can take a deep look into some ekphrastic poems which belongs to the 21st century, and study about it's specialities, how they describe the art? and examines the relationship between the text's ideas and its form, between what the text says and the way it says. To study all these, I hereby choose the Formalist literary theory, also called Russian Formalism which is led by Viktor Shklovsky and the Other members of the groups included Osip Brik, Boris Eikhenbaum, Yury Tynianov, and Boris Tomashevsky. The poems that I have taken are: "When It Is Over It Will be Over" by Paisley Rekdal, "Replica of 'The

Thinker’,” by Matthew Olzmann and “Dinosaurs in the hood,” by Danes Smith. The characteristic of the poem is that it is very well expressed by the critic of its other qualities. The Formalists based their assumptions partly on the linguistic theory of Ferdinand de Saussure and partly on Symbolist notions. The Formalists located an “emphasize on the medium”. They stressed the importance of form and technique over content. They looked for the specificity of literature as a self-reliant verbal art. They studied the diverse functions of “literariness” as ways to associate poetry and fictional narrative from alternative forms of discourse.

Formalism attempts to treat each work as its own distinct piece, clear from its environment, era, and even author. Formalists assume that the keys to understanding a text exist within "the text itself". The name "Formalism" derives from anecdotic of the cardinal tenets of Formalist idea: That the form of a work of literature is inherently a part of its content. Literature is self-reliant from extraneous conditions in the sense that literary language is distinct from ordinary uses of language, not least because it is not entirely approachable. Literature has its own history, a history of innovation in formal structures, and is not determined by external, material history. By applying the theory, it helps to emphasize the explications of the work itself. Asserts that the goal of literature is not the pursuit of sincerity or authenticity, but subtly, unity, and integrity.

By applying the theory overall, I intended to analyse these three poems which describe three various arts. The poem “When It Is Over It Will be Over” by Paisley Rekdal, describes a drawing. The next one is “Replica of ‘The Thinker’,” by Matthew Olzmann which describes a statue/sculpture of “The Thinker”. The third poem is “Dinosaurs in the hood,” by Danes Smith which talks about the films ‘Jurassic Park’, Friday and The pursuit of Happiness and empowers the Black Afro- American men to fight against the negative

representation in media. These three poems are of different types and forms. So, through the thesis application, it helps to find how these poems explain each idea ekphrastically.

CHAPTER-2

DETAILING THE EKPHRASIS POEMS – THE PROCESS AND THE TECHNIQUES

Ekphrasis poems are an extended and detailed literary description of any object, real or imagined, sometimes we can include real-life situations by comparing that piece of art. In this work “The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction”, Baugher writes, “While ekphrasis is a type of experiment anchored in visual imagery, it is not forensics. Interpretation is antithetical to ekphrasis. So, Ekphrasis is a method by which writers can exist outside themselves. Turning to the visual arts as creative fodder can allow writers to detach from their individual narratives” (2convent). In this work “The Ekphrastic Writer, Creating Art-Influenced Poetry, Fiction and Nonfiction”, Baugher says, “The primary genre for ekphrasis has been poetry. One reason is the ease of designation. When a poem takes an artwork as its subject and dedicates much time to describing the artwork, it is natural to call the work “Ekphrastic Poetry”” (155). In ekphrasis, what is excluded from the artwork might seem an unlikely place on which to focus your attention. That approach can lead to surprising moments for both the writer and the reader. Ekphrastic writing is a creative writing form that invites dynamic descriptions and personal interpretations of visual art. So, here I've chosen three ekphrastic poems to know more about each poem's characteristics. The process of writing an ekphrastic poem is:

- Choose a piece of art: the work can be from any period and take any form, such as a painting, sculpture, mural, etc.
- Write down what we see: simply write what we see, narrate the events, and describe the colours, tone, medium, and characters in the piece of art.
- Pick a form: Ekphrastic poems can take on many forms. Our work might be a sonnet, a haiku, or a longer poem with multiple stanzas written in free verse.

No matter the form, ekphrastic poems exist to respond to a piece of art critically, analytically, and reverentially.

- Write from a specific point of view: how your poem responds to the chosen art depends on your angle.

Then focus on some other points that should be noted in an ekphrastic poems like; Write about the scene or subject being depicted in the artwork, write in the voice of a person or object shown in the work of art, write about your experience of looking at the art, relate the work of art to something else it reminds you of, imagine what was happening while the artist was creating the piece, write in the voice of the artist, write a dialogue among characters in a work of art, speak directly to the artist or the subject(s) of the piece, write in the voice of an object or person portrayed in the artwork, imagine a story behind what you see depicted in the piece, speculate about why the artist created this work.

An ekphrastic poem can be written in many ways that've proven by many ekphrastic poets earlier, the some of the techniques/the way of conveying the ekphrasis nature through the poems are; Through Description, describe – and do no more. This is always the poet's initial desire, to put into words what has caught our attention visually. Describe but imagine, beyond the frame. Through Ventriloquism; Make Objects Speak, Make the Artist Speak. Through Interrogation of the Figure(s)/of the Artist/ of Yourself, Interestingly, ekphrastic poems need not always stand in awe of the work. Through Giving an Account of Your Encounter of Gallery Visitors/of Others. Come at a Tangent. Finally, the ekphrastic moment can be presented as if an after-thought, or illustration of a poem already half composed.

Let's take a look at those three poems which we've taken and analyse the above processes and techniques in those poems.

The first poem "When it is Over, it Will be Over" takes its title from a pen-and-ink drawing by the artist Troy Passey of a line from Edna St. Vincent Millay's poem "Endings." The poet came across Passey's drawing five years ago while in Boise, where the Boise Art Museum had a show up of Passey's art. The poem is constructed by the description of that painting but at the same time with some imagination. Then she was immediately struck by Passey's stark, gestural paintings. "When it is Over" is a window-sized, ever-tightening spiral of words, Millay's phrase worked into what looks, from a distance, like a hurricane of slapdash hatches in white and black. Passey is an artist whose work focuses primarily on words, usually, snippets of poems and novels that most of us have had (whether accidentally or deliberately) drilled into us over our education. One recent series, "library," includes black and white paintings of phrases like "wine-dark sea" and "nothing gold can stay": the irony being that the pieces call up colours that the viewers are forced to imagine, thus we "overwrite" Passey's otherwise spare phrases with our own emotional and imaginative palettes. Passey's artworks in much the same way that books do, allowing me to create vibrant worlds out of plain black and white. That day in the museum before his "When it is Over," she was, of course, thinking of Millay, and thinking too of Passey's spiral of black word-hatches, but she couldn't help but be drawn by association also into her own memories of a dwindling romance, of spoken and unspoken words, of a spiral of minnows she once found herself caught inside while swimming. When we look at the first four stanzas of this poem, we can see that the poet describes the art of work.

The poet uses the hurricane as the simile to the endless circle in the painting. Paisley starts to describe a glimpse of her life by comparing the art of Troy Passey. As we can see the painting is like a looped one, when we analyse the text alone is clear that the poem gives life to the art work by the similies, figure of speeches that used in it. The poet relates the art work to reality and it has definite point of view. So, as in this ekphrastic response to Passey's

painting, she wanted her poem to be one long, paratactic, and hallucinatory sentence that destabilized the reader's own senses and memories while also heightening them.

In the second poem which is by Olzmann is an example of ekphrastic poetry is exciting and unique as it is written from the persona's interpretation while being in the shoes of the statues. This poem is also structured in the manner of description but with imagination. The narration shifts from the statue's point of view to the personal experiences and memories of the persona. Olzmann's prologue poem is titled, with wit and terror, "Replica of The Thinker." Think of what that image means to someone giving his life to thinking and to art. Rather than praising the way in which the statue was sculpted, Olzmann writes The Thinker's brain into life: 'he only wants to think dignified thoughts, important thoughts, thoughts that will imprint like an artist's signature on the memory of mankind.' The use of enjambment and repetition creates a stream of consciousness which in turn characterises the statue for what it is: a man caught in thinking about the meaning of life. However, Olzmann does more than this. Looking at the artwork sitting 'by the doorstep of The Museum' generates an emotional response in the poetic "I" who sees his father (and also himself) in the statue's lineament and appearance: 'The Replica digs his right elbow into his left thigh, his chin into his right fist, and then he thinks as his maker will allow.' To be a copy of a great original, which itself was only a likeness of thinking, is to be a faked thinker, faking thought.

The poem contains four stanzas, in that the very first stanza Olzmann describes the sculpture/replica and about the kind of thoughts that man should've thought. Then Olzmann shares that have also felt like that. Then he gives the perfect example for the thoughts of the replica that is a photocopy of a photocopy. In the last two stanzas of the poem, Olzmann tells that his father also has sat like this, to pretend that we are not frauds. The poet refers to his father in most part of this poem. Here he uses Replica as the similitude to father, such as there

are many literary elements used in this poem. Throughout the poem, we can sense the wit and the terror in the thoughts.

The last poem by Smiths in the poem, “Dinosaur in the Hood” by Danez Smith, he discusses most stereotypes that happen within movies and explains how they are portrayed. And he also talks about how blacks are portrayed in the movies. In this poem the poet constructed it through ventriloquism, ie; the poet makes the artist/object speaks. Danez Smith is one of these modern fighters in his free verse poem “Dinosaurs in the Hood.” As Smith uses his words to create a poetic trailer for this stereotype-free movie, he tells the story of a young African American boy. Danez Smith, the poet of ‘Dinosaurs in the hood’ uses sarcasm in most of the parts of the poem to present the fundamental message to the audience and readers. The overall message aims at explaining how black individuals are beyond the cultural depiction developed in the films. The poem is a masterpiece collection of literary and poetic devices in presenting the thematic concerns and development of the characters. The author uses satire as the principal technique for thinking of the perceptions represented by different images and films that represent as thuggish, stupid and less than what they are. In addition, the author stresses the names of different directors and actors who appear to depict the picture of Black men in stereotypic terms. Also, Smith uses imagery terms to paint vivid pictures to the readers of various movie scenes presented. The poet makes a wise choice of words and literary devices to seek understanding and support of view in his poem from the audience. Smith starts the poem with a communal invitation to make a new movie. He uses juxtapositions to show the mood of the film is when “Jurassic Park meets Friday meets The Pursuit of Happyness,” meaning a suspenseful creature movie with the influence of “hood boys.” Smith goes on in the fourth stanza to say this is the story of minorities that save themselves standing next to the addicts, exiles, and children of slaves. It is the broken people that are the heroes of this story. A shift is noticeable beginning in the fourth stanza because

the poem changes from what the poet wants the movie to be to what elements the movie is prohibited to have. As we can see throughout the poem Smith raises his voice against bullying the people in order of their race. At the of the poem he mentions that “I want to make this for that first scene anyway: the little black boy on the bus with a toy dinosaur, his eyes wide & endless his dreams possible, pulsing, & right there”. Through these lines, the poet creates emotions of blacks that are carved from the three movies and we can understand that smith wants to make aware of the society that blacks are also should be treated normally.

CHAPTER-3

A THEORETICAL APPROACH - ANALYSING THE FORMS OF EKPHRASTIC POEMS

As we looked into the analysis of the poem, let's examine each poem closely through the formalist view. The first poem "When it is over it will be over", here Rekdal, in the first four stanzas describes an art using the word 'hurricane of feeling', as we saw the picture it's a looped one. So, the loop is represented in the poem as 'hurricane of feeling'. Rekdal, used the rhyme scheme as follows, ABCDEFFGF... it gives the poem a pattern. As formalist looks through the literary devices here Rekdal, uses similes such as hurricane, freckle, scattering of diamond etc. it also helps to maintain the pattern and it highlights the form of the poem. By using the figure of speeches she combines the meaning of the poem vividly. As such when read the poem, the meaning of the poem can't be determined by it's affects on the readers. Thus Affective Fallacy is not appeared here. It follows form as well. Throughout reading the poem we observe that the poet tries to share some feelings of her and it fits well to the form of the poem. The poem follows the theme of 'feelings of mind' we can see that through the synonyms, figure of speeches used here, like collapse, gesture, canvas, etc. Rekdal, tried to maintain the connection between the form and the content. So, when we read the poem without even looking at the painting which Rekdal inspires to write this poem, the poem itself gives a vivid idea about what the poem is. The creative techniques and form made that more simpler.

When we look at the other poem which is written by Olzmann, it's a four stanza structured poem. In this poem also we can see the Olzmann uses the figure of speech simile, here uses the replica as the simile to his father. So, throughout the poem Olzmann, reflects the theme 'memory'. By the usage of effective words to develop the theme, it maintains a pattern throughout the poem. Here also we can see that the meaning of the poem can't be

predicted by the it's affects on the reader. Thus there is no affective fallacy. The usage of particular words celestial, X+Y, crossword etc. in the third stanza makes the poem more standardize. The poem itself has a meaning and form even without looking at the painting which Olzmann inspired. In the third poem by Smith, is also an ekphrastic poem with a powerful voice and subject-matter. The use of colloquialism and slang only fuels the voice with more authority, shaping the poem into a manifesto that calls for fair and equal representation of black actors in films. In his version, the boy plays with a gun, the metaphor: black boys toy with their own lives, the foreshadow to his end, the spitting image of his father. The ample usage of figure of speeches throughout the poem helps to maintain a form.

It is a six-seven stanza structured poem and it's a free verse poem, with no affective fallacy. Here there is no such powerful usage of words but instead of words here Smith, uses some names of known persons, the important part is here he uses juxtapositions to show the mood of the poem and the things explained in the poem. The poem itself has a self-value. The text itself has meaning and it maintains a form throughout of it.

CONCLUSION

As we analysed the above three different ekphrastic poems, now we understood how an ekphrastic poem looks like, how each poet describes each piece of art. We understood how an ekphrastic poem works. When we write ekphrastically we can improve our creative imagination because ekphrasis means the *description of art*, so when we give a piece of art to a bunch of writers to describe that art, we can see the difference in each ekphrastic work. In each poem, we can see that each poet describes the particular artwork and they implemented their own life experiences by using it as a simile, metaphors and other figures of speech. They convey their ideas ekphrastically. Each poem has a common creative technique it uses simile in the poem. By visualizing an art we can make another kind of art with meaningful parts in it. This is because each of us has different creative imagination, so the way we describe an art will also be different.

So, in this era reading and understanding an Ekphrastic poem, writing ekphrastically will improve their language, imaginative skills. The most interesting part is the way they approach, the way they analyse an art will improve. When we look on some of the social media sites we can see that there are some groups of people still out there who promote ekphrastic writings. They will provide a piece of art on their site, they will give a period of time to work on that art (*ekphrastically*) and they've also provided a submission box to submit the ekphrastic works that people have done. Hence, approaching a work ekphrastically, writing ekphrastic works in this generation is a valid thing to do for ourselves, for improving our creative skills.

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Project Report

On

MATHEMATICS IN FORENSIC SCIENCE

Submitted

in partial fulfilment of the requirements for the degree of

BACHELOR OF SCIENCE

in

MATHEMATICS

by

PARVATHY VENU

(Register No. AB19AMAT024)

Under the Supervision of

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APRIL 2022



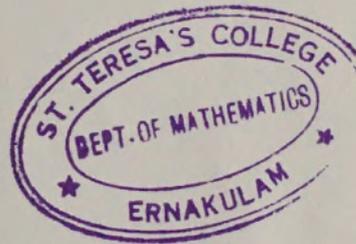
CERTIFICATE

This is to certify that the dissertation entitled, **MATHEMATICS IN FORENSIC SCIENCE** is a bonafide record of the work done by Ms. **PARVATHY VENU** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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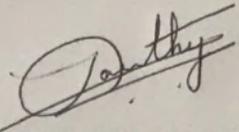
2:

DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of Dr.URSALA PAUL, Assistant Professor, Department of Mathematics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.

Date: 06.08.2022



PARVATHY VENU

AB19AMAT024

ACKNOWLEDGEMENT

I would like to express my special thanks to our project guide and HOD Dr. Ursala Paul for her able guidance and support in completing my project. Also I would like to thank all my teachers for the constant support. Their continuous invaluable knowledgeable guidance throughout the course of this study helped me to complete the work up to this stage

I am very grateful to all the police officers of Harbour Janamithri police station who provided all the useful data for the case study of our project.

Ernakulam.

Date: 06.03.2022

PARVATHY VENU

AB19AMAT024

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Chapter 1

Forensic Mathematics

1.1 Introduction

Forensic science is a branch of science used to analyze crime scene evidence. All science uses mathematical concepts and equations, and forensic scientist are well educated in mathematical concepts they uses to analyze evidence from crime scenes.

Without mathematics it is impossible to analyze forensic evidence scientifically. One of the main things investigators do at the crime scene is to collect, measure and document evidence. This data help investigators to perform calculations and determine the facts of a crime. Mathematics shows proof of what ever happened during a crime in data and number.

The court ask the significance of evidence in the context of the crime and, as an expert witness the forensic scientist should be able to respond appropriately to such a challenge. Methods based on Bayesian statistic utilizing probability arguments may facilitate both the comparison of the evidence type and the weight that should be attach to each by the court.

The discussion and presentation of the data within the report submitted to the court by the expert witness must be prepared with rigour and clarity that can only come from a sound understanding of the essential mathematical and statistical method applied within forensic science.

1.2 Forensic Science

Forensic science is the application of science to criminal and civil, as governed by the legal standards of admissible evidence and criminal procedure. Forensic science is an ever growing field of science that can be further subdivided into toxicology, anthropology, serology and many others. Forensic scientist collect, preserve and analyze scientific evidence during the course of an investigation. While some forensic scientist travel to the scene of the crime to collect the evidence themselves and others occupy a laboratory role, performing analysis on object brought to them by other individuals.

1.3 Forensic Mathematics

One of the main thing crime scene investigators do is, collect, measure and document evidence. Their data help forensic scientists to perform calculation and determine the facts of a crime. Mathematics is the main key to analyze forensic evidence scientifically it is impossible to carry on without mathematics. For example, for pathologist calculus is need to estimate the time of death of victims. Overall, calculus has many application in the field forensic science. Mathematics make it possible to show the proof of what occurred during a crime in data and numbers.

1.3.1 Measurements:

One area of mathematics that is crucial for forensic science is take precise measurement at a crime scene. Knowing the exact length of shoe print from the crime scene help to rule out crime suspects whose shoe are the wrong size.

Forensic scientist need exact measurements of everything at a crime scene in order to perform scientific calculation properly. Investigators

spend a great deal of time measuring distance, weight, temperature, volume and other aspects of evidence to get the number correct.

1.3.2 Proportion:

Forensic scientist use not only measurements but proportions in their analysis. If a human leg bone is discovered in an unmarked grave forensic scientist use mathematical equations to determine what proportion or percentage of persons overall height of the leg bone would be. Once they know that they can determine how tall the person was and whether it was a child or an adult. Proportions are one way mathematics is involve in forensic science.

1.4 Applications of Mathematics in forensic Science

Forensic scientists analyze the evidence and search around crime scenes for clues pointing to possible suspects. Mathematics can be used to determine time of death, how crime are committed, when they were committed and who committed them. Some of the application of mathematics in various field of forensic science are given below :

- Psycho physical detection Monitoring pulse rate, blood pressure, and breathing patterns.
- Heights and distance Footprints in dirt and mud, length of objects.
- Bullet trajectories Geometry and trigonometry.
- Entomology Time of death.
- Trigonometry and industry physics can be used to reverse calculate height.
- To find an elevation consistent with two blood drops.
- Can be used to determine the height of the blood when it exceed to the body.

- Examining skid mark can help to reconstruct the accident. Marks are caused by the speed of the car, braking force, frictional force of the road and impacts with other vehicles.
- Newton's law of cooling describes the cooling of a warmer object to the cooler temperature of its environment.

1.4.1 Trigonometry

Trigonometry is very useful in forensic science. Knowledge about trigonometry is absolutely necessary for many crime scene reconstruction. Blood stain pattern analysis (BPA) is one of the several specialists in the field of forensic science. It involves the study and analysis of blood stain at a known or suspected violent crime scene. Blood stain evidence is most often associated with violent acts such as assault, homicide, abduction, suicide or even accidents. Pythagoras theorem, trigonometry function, trigonometric rules are application of trigonometry in forensic science. Trigonometric function related to non right angled triangles and can be used to find an unknown angle or side.

1.4.2 Probability

In forensic science, empirical probabilities are particularly important and examples may be derived from data on height, fingerprint class, blood group, allele frequencies in DNA profiles or shoe size among the population. Some examples involving the use of empirical data like the matching of hair evidence and analysis of human teeth mark are discussed later.

Forensic science uses several approaches for DNA statistics with computer programs such as match probability, exclusion probability, likelihood ratios, Bayesian approaches, and paternity and kinship testing.

Random match probabilities (RMP) are used to estimate and express the rarity of a DNA profile. RMP can be defined as the probability that someone else in the population, chosen at random, would have the same genotype as the genotype of the contributor of the forensic evidence. RMP is calculated using the genotype frequencies at all the loci, or how

common or rare the alleles of a genotype are. The genotype frequencies are multiplied across all loci, using the product rule, to calculate the RMP. This statistic gives weight to the evidence either for or against a particular suspect being a contributor to the DNA mixture.

Chapter 2

Ballistics and Ricochet analysis

2.1 Ricochet Analysis of the bullet

Ricochet occurs when the incident angle is below the critical angle for the surface, a bullet after impact bounces off a solid surface at a glancing angle after impact and then continues its trajectory, otherwise the bullet will either fragment on the impact or penetrate the solid surface.

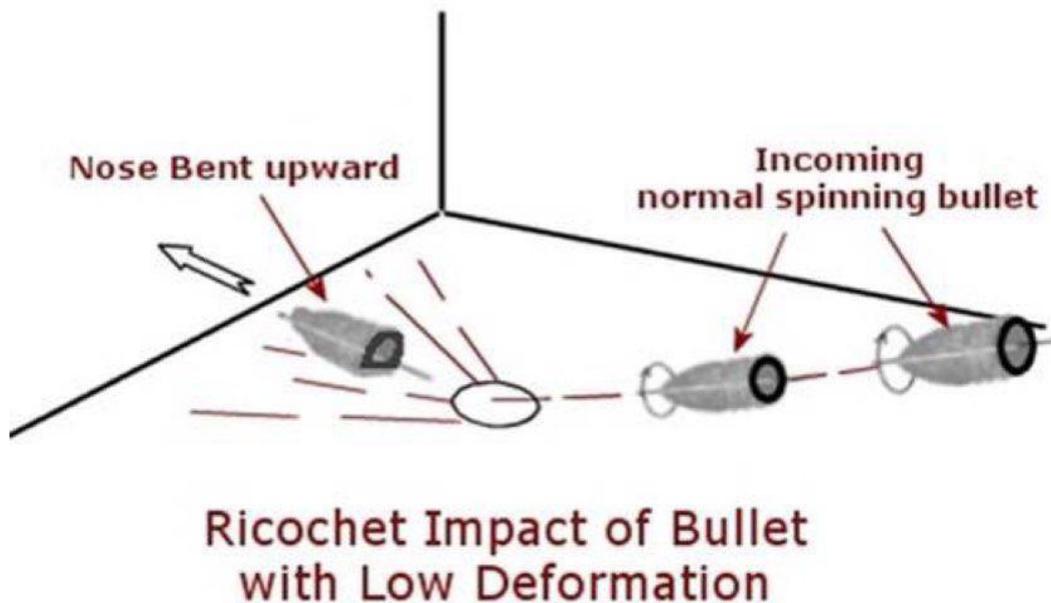


Figure 2.1:

For soil and water the critical angle is very low, at around $6-7^\circ$, whereas for hard surfaces this value will be much larger.

In almost all cases the ricochet angle θ_r at which the bullet leaves

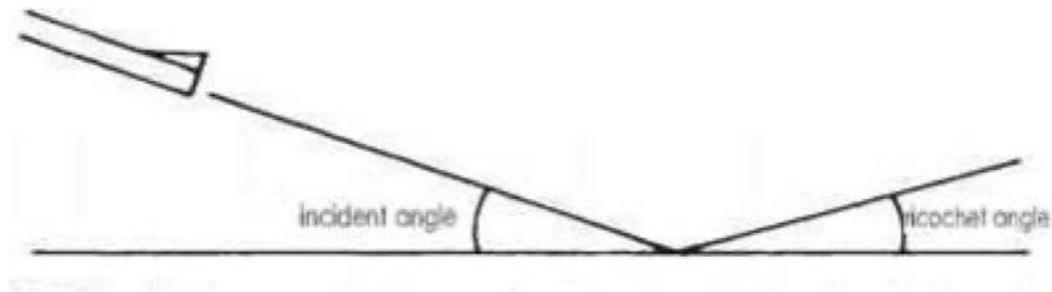


Figure 2.2: Incident and Ricochet angle

the surface is lower than the incident angle θ_i and these parameters are linked approximately by the equation

$$\tan \frac{\theta_r}{\theta_i} = C$$

where C is a constant dependent on the surface and the bullet involved.

θ_r : Ricochet angle

θ_i : Incident angle

C : constant

2.2 Aspects of ballistics

The effect of angle and the measurement of angle are important in understanding the trajectories followed by missiles such as bullets, arrows and cricket balls etc. All missiles start their motion with some initial speed and a specific launch angle from the initial force comes from the explosive charge in a rifle, the elastic energy in a tensioned string or human arm muscles strength. Once set on its trajectory, the only force acting on a missile is the vertically downward acting gravity. This is called the vacuum trajectory assumption. Horizontal component of the velocity remains unchanged. The result is that the missile follows a curved path, reaching a maximum height when the gravitational deceleration has reduced its upward velocity component to zero. It then descends with increasing downward vertical speed and constant horizontal speed until it impacts on the ground. (Fig 3)

If it is launched horizontally, for example from an elevated window, roof or cliff-top, it follows the downward part of this trajectory. (Fig 2.2)

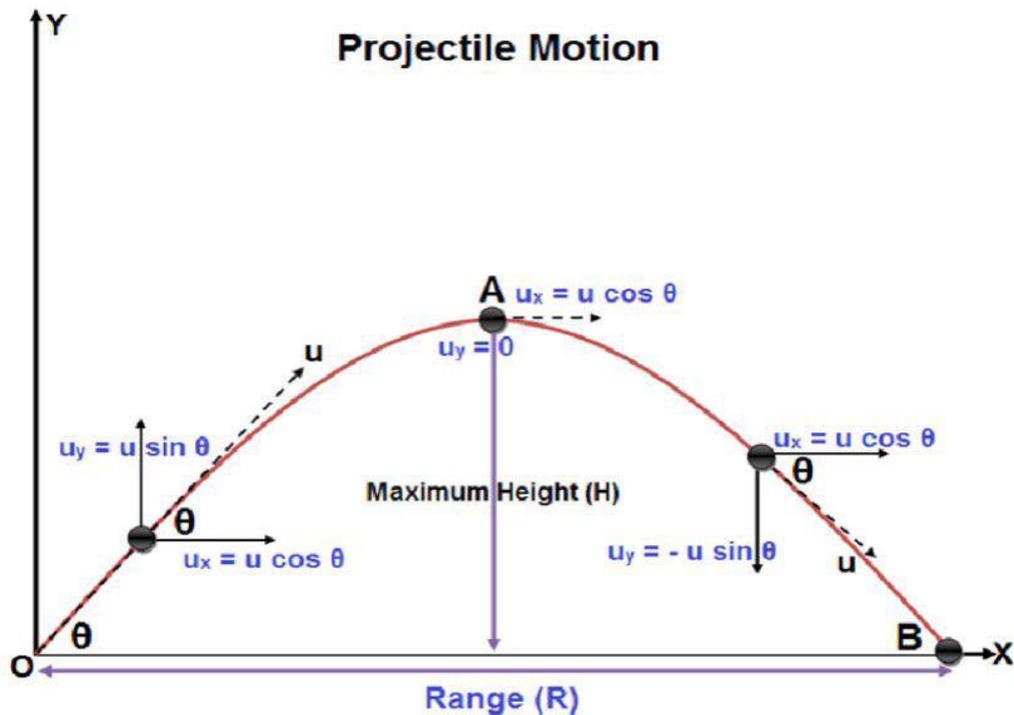


Figure 2.3:

The trajectory of a missile launched with speed u at an angle of θ to the horizontal is given by

$$y = \tan \theta x - \frac{g}{2u^2 \cos^2 \theta} x^2$$

where y is the height at any particular horizontal distance x and $g = 9.81 \text{ m/s}^2$ is the acceleration due to gravity.

In the equation ($y = (\tan \theta)x$) represents the straight line obtained in the absence of gravity by following the launch angle i.e. the line-of-sight path and the next term calculates how much the gravitational acceleration moves the projectile path downwards from this straight line. For specific initial conditions defined by u and θ , this equation is similar to the quadratic form:

$$y = Ax - Bx^2$$

This function represents a parabola with maximum altitude at $x = \frac{A}{2B}$

$$y_{max} = A\left(\frac{A}{2B}\right) - B\left(\frac{A}{2B}\right)^2 = \frac{A^2}{4B} = \frac{\tan^2 \theta}{4g} 2u^2 \cos^2 \theta = \frac{u^2 \sin^2 \theta}{2g}$$

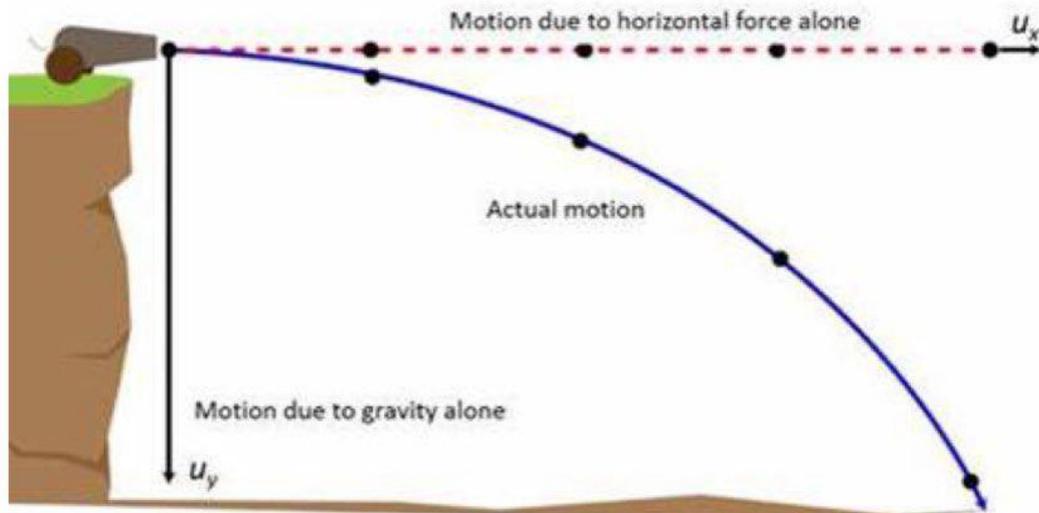


Figure 2.4:

The parabola is a symmetric shape, so if both initial and impact points are at the same height, the initial launch angle is the same as the angle at which the missile lands and also the speed with which it impacts on the same level surface is equal to the launch speed. e.g. a level surface. The horizontal range of the projectile occurs when horizontal distance

$$y = 0$$

$$(\tan \theta)x - \frac{g}{2u^2 \cos^2 \theta} x^2 = 0$$

$$x \left(\tan \theta - \frac{gx}{2u^2 \cos^2 \theta} \right) = 0$$

therefore either $x = 0$, which is the initial position, or :

$$\tan \theta - \frac{gx}{2u^2 \cos^2 \theta} = 0$$

$$x_{max} = \frac{2u^2 \cos^2 \theta \tan \theta}{g} = \frac{2u^2 \sin \theta \cos \theta}{g} = \frac{u^2 \sin 2\theta}{g}$$

Hence the maximum value of the sine function occurs when the angle is equal to 90° , the maximum range will occur here when $\theta = 45^\circ$.

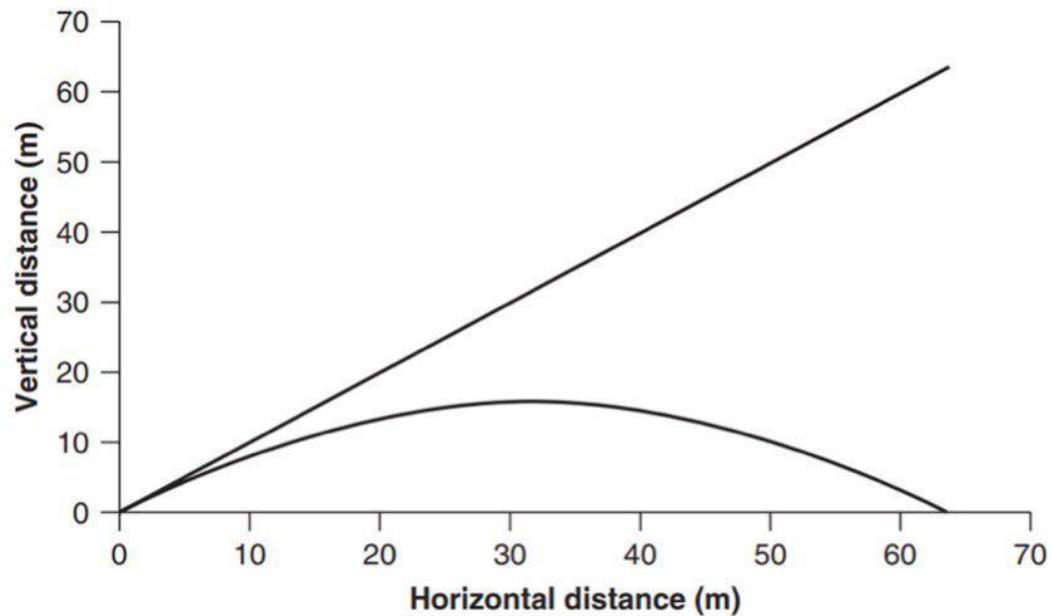


Figure 2.5:

2.2.1 Worked out example

Example :

An amateur archer who has the best launch speed of 25 m/s stands 20 m from a 5 m high wall and launches an arrow horizontally from a height of 1.6 m above the ground and at an angle of 20° horizontally, towards the wall from her standing position. Determine whether the arrow will clear the wall and if cleared by what distance? How much distance away from the other side should onlookers stand in order to be outside her range?

Solution :

Calculate the height attained over a horizontal distance of 20 m under the given launch conditions using :

$$\begin{aligned}
 y &= (\tan \theta)x - \frac{g}{2u^2 \cos^2 \theta}x^2 = (\tan 20 \times 20) - \frac{9.81 \times 20^2}{2 \times 25^2 \cos^2 20} \\
 &= 7.28 - 3.55 = 3.73 \text{ m}
 \end{aligned}$$

Since the arrow was launched 1.6 m above the ground the net height will be 5.33m and hence the height of the wall 5m is given, hence the wall will be cleared by 0.33 m.

The horizontal range is given by the sum of two calculations. The distance travelled until it is again at launch height (1.6 m) above the ground is given by :

$$x_{max} = \frac{u^2 \sin 2\theta}{g} = \frac{25^2 \sin 40}{9.81} = 41.0m$$

The remaining distance taken from a height of 1.6m, travelling at the same speed but this time on a negative launch angle of 20/degree below the horizontal, down to ground level. This distance x is given as the solution of the equation :

$$\begin{aligned} -1.6 &= (\tan(-20))x - \frac{9.81}{2 \times 25^2 \cos^2(-20)}x^2 \\ 0.00889x^2 + 0.364x - 1.6 &= 0 \end{aligned}$$

Thus we evaluate the positive root of this quadratic equation.

$$x = \frac{-0.364 \pm \sqrt{0.364^2 + 4 \times 0.00889 \times 1.6}}{2 \times 0.00889} = \frac{-0.364 \pm 0.435}{0.0178} = 4.0m$$

Hence the total range of the arrow until it hits the ground is 45.0 m, which represents 25.0 m from the wall on the far side. The negative root is not taken, as it gives the distance below ground level which is against our assumption.

Chapter 3

Determination of fall type

3.1 Introduction

In a culture that value life , explaining the death in a public forum is crucial for many reasons . The examination of a death scene and collection of potential evidential material requires special and advanced skill, knowledge, aptitude and attitude. If a body is pronounced dead at the scene, many death investigation systems require a scene investigation. Others have many protocols as to which case types absolutely require a scene investigation (whether the body is present at the scene or not). Case types that should have a scene investigation include all confirmed or suspected homicides, suicides, accidents, traffic-related deaths, in-custody deaths, and workplace-related deaths. In this chapter we are going to see whether a death is suicide ,accident ,or murder using the relationship between the height above the ground(say y) and horizontal distance travelled(say x).

3.2 Suicide,accident or murder?

Studies have shown that the distance from the wall of a building at which a body is found can help us to establish how the fall from a height originated. This is because the initial conditions of launching differ according to whether the person simply loses his balance and falls or deliberately launches himself from the tall building by jumping or even running or jumping. In the former case i.e. accidental case,

the launch angle will be zero and the initial velocity will be minimal, whereas in the latter situation the jumping action will lead to a high launch angle and larger initial speed. It has been suggested that a launch speed of 2.7 m/s or greater can be used to indicate suicide and the jump angles likely to be between 21° and 38° . For the third possible scenario of murder by pushing the victim over the edge, the launch angle may be expected to be very low with the initial velocity higher than that achieved in case of accidental fall.

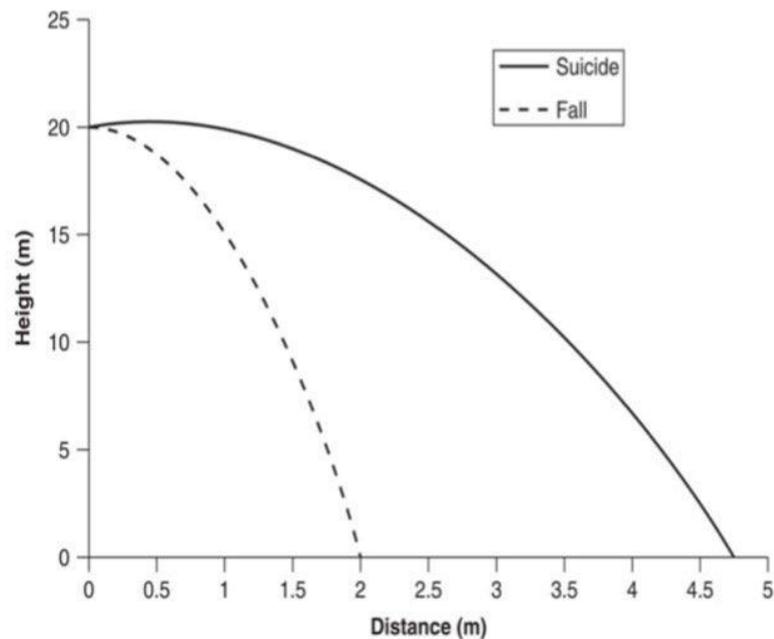


Figure 3.1:

The basic trajectory of the body is given by the same equation as before. If the ground level is set at $y = 0$ then we should simply add the fall height h , to give the relationship between y (the height above the ground) and x (horizontal distance travelled):

$$y = h + \tan \theta x - \frac{g}{2u^2 \cos^2 \theta} x^2$$

Typical trajectories, corresponding to accident or suicide, are given in the below graph. These have been calculated by assuming $\theta = 0^\circ$, $u = 1\text{ m/s}$, in the former case and $\theta = 35^\circ$, $u = 3\text{ m/s}$, in the latter case.

It can be seen that the impact distance for suicide is over twice that for accident. This result is supported by experimental data including an allowance for variation in the launching conditions.

3.3 Worked out example

Example : A woman jumps from the top of a vertical cliff-top 100m high

a) At what distance from the base of the building will the body land assuming initial launch conditions of $\theta = 35$ and $u = 3m/s$?

b) Compare this distance with the distance calculated on the basis of an accidental fall: $\theta = 0$ and $u = 1m/s$

Solution: a) This problem requires us to calculate x where all other parameters are known. This results in a quadratic equation:

$$0 = 100 + \tan 35x - \frac{9.8}{2 \cdot 3^2 \cdot \cos^2 35} x^2$$

$$0.812x^2 - 0.70x - 100 = 0$$

This is solved using the standard equation for the solution of quadratic equations:

$$x = \frac{0.7 + \sqrt{0.49 + 324.5}}{1.62} = 11.6m$$

b) The method is the same with these parameters; however, as the coefficient of the linear term in x is zero the solution is found more quickly:

$$0 = 100 + \tan 0x - \frac{9.8}{2 \cdot 1^2 \cdot \cos^2 0} x^2$$

$$4.90x^2 - 100 = 0$$

$$x = \sqrt{\frac{100}{4.90}} = 4.5m$$

The former result is clearly different to the latter.

3.4 Program to check the fall type

```
#import required modules
import math
class Project:
#Get user input through the constructor
def _init_(self)
self.height = float(input("Enter height of the building in meters: "))
self.theta=float(input("Enter the angle: "))
self.gravity=9.81
self.velocity=float(input("Enter the velocity in m/s: "))
print("-----")
)
# calculate the distance from the building for each type of fall
def calculateDistance(self,type):
if type=="Maximum Accidental":
self.theta=0
self.velocity=1
if type=="Minimum Suicide":
self.theta=38
self.velocity=2.7
# make the quadratic equation ax2-bx-c=0
x1 = 2 * (self.velocity * *2) * (math.cos(math.radians(self.theta)) * *2)
a=self.gravity/x1
b=math.tan(math.radians(self.theta))
c=self.height
# calculate the discriminant
d = (b * *2) + (4 * a * c)
```

```

# find the solutions
sol1 = (b - math.sqrt(d))/(2 * a)
sol2 = (b + math.sqrt(d))/(2 * a)
# print the distance calculated
if((sol1.real) > 0.0):
print(type+' distance from the building is ', format(sol1.real))
return(sol1.real)
else:
print(type+' distance from the building is ', format(sol2.real))
return(sol2.real)
# print the findings
def printFindings(self,Actual,Accidental,Suicide):
if(Actual>=Suicide):
print("The fall is SUICIDE!!")
elif(Actual>Accidental):

else:
print("The fall is ACCIDENTAL!!")
print("\n")
print("-----")
")
#creating an object with the class
obj=Project()
#call methods
Actual=obj.calculateDistance("Actual")
Accidental=obj.calculateDistance("Maximum Accidental")
Suicide=obj.calculateDistance("Minimum Suicide")
obj.printFindings(Actual,Accidental,Suicide)

```

Output of the program

Enter height of the building in meters: 100

Enter the angle: 36

Enter the velocity in m/s: 5

Actual distance from the building is 19.516519331513965

Maximum Accidental distance from the building is 4.515236409857309

Minimum Suicide distance from the building is 9.974033289332445

The fall is SUICIDE!!

Chapter 4

Case Study

4.1 Introduction

Our group visited the Harbour Janamithri Police Station, Willington Island on 20 th December 2021 to collect data on a case based on Chapter 3(determination of fall type) of our project. There we checked some case files and found a case where an employer during the construction work of Dhruv complex were found dead due to the fall of a screw jack on his head. We got the measurements such as building height and measurements giving the exact position of the body.By examining the position of the body we came to a conclusion that the screw jack fell by accident.



4.2 Case Details

FIR No : 0948

Section : 174

Name : Benoy

Age : 41

Height :169cm

Date : 30.09.2021

Place:INS Venduruthy



A man named benoy was found dead on the ground($y=0$) near the constructing Dhruv complex after a screw jack fell on his head. The body was found 4.5m (say x) away from a tall building. The screw jack was said to be in the 6 th floor of the building i.e. approximately 22.4m high. According to the witness statement the screw jack fell by accident and the police conclude the case with the same

According to our study the impact angle and initial velocity should be minimal for an accidental fall. The body was lying at a short distance , 4.5m away from the building which would only be possible when the initial conditions i.e. initial velocity u and initial launge angle θ is minimal. Hence from our studies, we concluded that the fall was accidental.

i.e. $y=0$

$h=22.4m$

$g=9.8$

$x=4.5$

are the measurements obtained.

From the eqn

$$y = h + \tan \theta x - \frac{g}{2u^2 \cos^2 \theta} x^2$$

we usually calculate x which is used to determine the fall type provided u is minimal and $\theta = 0$ in the case of accidental fall. But here $x=4.5\text{m}$ is already obtained without the calculation which is very small which implies u and θ are minimal. Hence the fall is accidental.



Chapter 5

Bloodstain shape analysis

5.1 Introduction

Correlating the basic shape of a bloodstain with the impact conditions of the droplet involves trigonometric functions. There are two types of bloodstain formation :

1. Bloodstain formation from a stationary source
2. Bloodstain formation from a moving source

5.2 Bloodstain formation from a stationary source

Blood droplets in free-fall through the air under gravity adopt a spherical shape, surface tension forces act on the blood droplet to minimize the surface energy leading to a surface with minimum area.

On perpendicular impact of blood on a surface, it will spread out equally in all directions, then circular stain is formed. If the impact is less than 90° , the blood spreads out at the same rate in all directions. On impact the spherical blood droplet will intersect the surface in an elongated fashion in the direction of travel of the victim, then the stain is in elliptical state. The long axis (L) lies in the direction of impact along the surface and the short axis (W) is in transverse direction. By measuring the dimensions of the blood stain, the impact angle can be calculated using their ratio :

$$\sin \theta = \frac{W}{L}$$

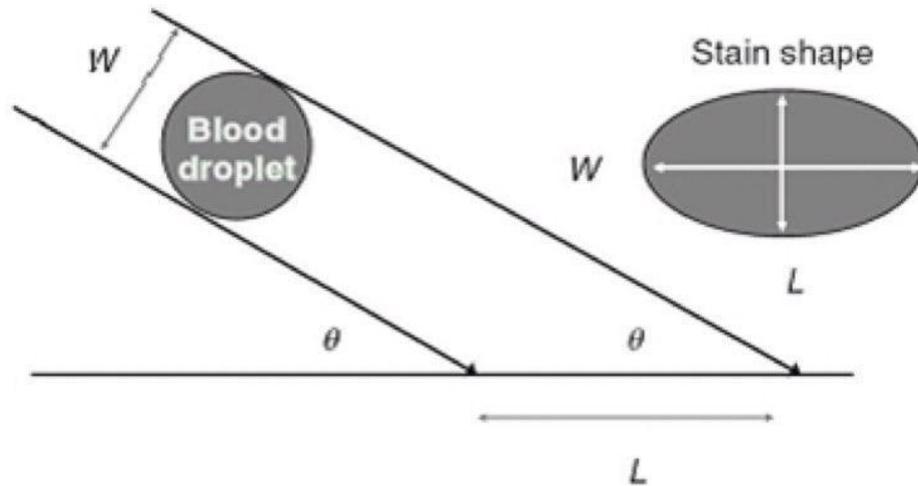
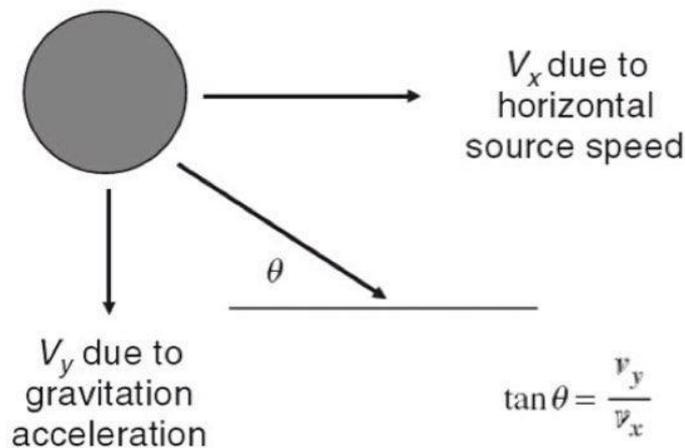


Figure 5.1: Angular impact of a blood droplet on a surface

5.3 Bloodstain formation from a moving source

Consider blood droplets falling from a moving source, the droplet under gravity starts falling vertically, it possesses a horizontal component of velocity due to the moving source and when it impacts on the ground surface, its actual impact is not 90° and it depends on the relative values of these two components.



Impact on the ground of a blood droplet from a moving source

Figure 5.2:

The above diagram shows the relation between the velocity components as impact angle vectors. These components, from a right angled triangle, which are perpendicular to each other, includes the effective impact angle, θ . Inspection of this triangle gives:

$$\tan \theta = \frac{V_y}{V_x}$$

This equation enables us to calculate the walking speed of the victim V_x , from the measurement of the impact angle θ . The vertical velocity component V_y is calculated using the drop height h :

$$V_y = \sqrt{2gh}$$

In the above equation it is assumed that the air resistance has no significant effect, which will be true for large droplets of blood falling over relatively short distance.

5.3.1 Worked out example

Example: An assailant walks away from a crime scene, blood dripping from a wound to his hand. The elliptical bloodstain has a length of 7 mm and a width of 6 mm. Calculate his walking speed assuming that his hand is moving with the same velocity as his body.

Solution impact angle is calculated using the dimensions of the stain.

$$\begin{aligned}\sin \theta &= \frac{6}{7} \\ \theta &= \sin^{-1} \frac{6}{7} = 59\end{aligned}$$

Estimation of drop distance of the blood droplet. Assuming a hand wound, this would be around 1 m; the vertical impact speed is given by:

$$V_y = \sqrt{2 \cdot 9.8 \cdot 1} = 4.43 \text{ m/s}$$

the horizontal speed is calculated using:

$$\tan 59 = 4.43/v_x$$

$$v_x = 4.43/1.664 = 2.66 \text{ m/s}$$

5.4 Program to calculate walking speed of assailant

```

#import required modules
#import math
class Project:
#get user input through the constructor
def _init_(self):
self.length=float(input("Enter the length of the bloodstain: "))
self.width=float(input("Enter the width of the bloodstain: "))
self.height=1.0
self.gravity=9.81
print("-----")
#calculate the impact angle
def calculateVelocity(self):
x=self.width/self.length
self.theta=math.asin(x)
self.theta=math.degrees(self.theta)
#calculate the velocity of the assailant from a crime scene
a=2*self.gravity*self.height
vy=math.sqrt(a)
b=math.tan(math.radians(self.theta))
vx=vy/b
return vx,vy
#print the findings
def printFindings(self,vx,vy):
print("The impact angle=",self.theta)
print("The vertical impact speed=",vy)
print("The walking speed of the assailant=",vx)
print("\n")
print("-----")
#creating an object with the class
obj=Project()
vx,vy=obj.calculateVelocity()

```

obj.printFindings(vx,vy)

5.4.1 Output of the program

Enter the length of the bloodstain:7

Enter the width of the bloodstain: 6

The impact angle= 58.997280866126005

The vertical impact speed= 4.4294469180700204

The walking speed of the assailant= 2.6617663308412336

Chapter 6

Probability in forensic science

6.1 Introduction

The term probability is given to a proper measure of the certainty that a specific event or outcome will occur. In each case of probability the result's based on unbiased outcomes where every possible result's equally likely.

In forensic science, empirical probabilities are particularly important and example could also be derived from data on height, fingerprint class, blood group, allele frequency in DNA.

6.2 Calculating Probability

The most common assumption in probability is that every event has the same random chance of happening. For instance, once we toss a coin, either the tail can come up or head can. Both these events can't be predicted.

$$Probability = \frac{\text{Number of selected outcomes}}{\text{Total number of outcomes}}$$

6.2.1 RULES OF COMBINING PROBABILITIES:

We use some ground rules to combine probabilities of various situations. We can do that only when the events are independent of each other. When the outcome of one event doesn't depend upon the result of the other, the events are said to be independent.

RULE 1:

The probability of specified outcomes A and B occurring is given by:

$$P(\text{A and B}) = P(A) \times P(B)$$

RULE 2:

The probability of specified outcomes A or B occurring, where both A and B cannot occur together (mutually exclusive), is given by:

$$P(A \text{ or } B) = P(A) + P(B)$$

In some applications it is possible that both A and B occur together (e.g. A and B aren't mutually exclusive). In such cases we should always exclude this possibility to obtain:

$$P(\text{A or B}) = P(A) + P(B) - P(\text{A and B})$$

For example, some witnesses have claimed that a criminal has long, fair hair and data is out there that says that 10 cannot compute the probability of somebody having both these attributes ($P(\text{A and B})$) from this data alone as we do not know the probability of occurrence of one without the other $P(\text{A or B})$, e.g. long hair that is not fair and fair hair that is short. In other words, having long hair and having fair hair aren't mutually exclusive.

In cases where we've to seek out the probability of an event not occurring, for example, the probability that a coin wouldn't land on head when tossed. Such an event is notated by ("A'") and therefore the following applies:

$$P(A') = 1 - P(A)$$

Note that this suggests certainty – a probability of unity – that either the event will occur or it'll not!

6.2.2 Worked out examples

Example 1: A violent incident leads to a multicolored vase being broken at a crime scene into very many small pieces. Half the ceramic pieces are white and the rest are coloured either red or blue in equal proportions. A CSI is tasked with retrieving pieces of this evidence randomly. Calculate the probability of:

- selecting a white piece
- not selecting a red piece
- selecting a white piece and a blue piece in either order
- selecting one among each color in three attempts.
- What assumption have you made in calculations (c) and (d)?

Solution:(a) Half the pieces are white so:

$$P(\text{white}) = \frac{1}{2} = 0.5$$

(b) A quarter of the pieces are red so:

$$P(\text{not red}) = 1 - \frac{1}{4} = 0.75$$

(c) The probability of choosing white then blue or blue then white is:

$$P(\text{w and b or b and w}) = \frac{1}{2} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{2} = \frac{2}{8} = 0.25$$

(d) Similarly, we extend the calculation to three selections, in any order. Note that there are six different orders during which the three differently coloured pieces could also be selected, e.g. white, red, blue; white, blue, red etc. Each of these has the same probability.

$$P(\text{all three colours}) = \left(\frac{1}{2} \times \frac{1}{4} \times \frac{1}{4}\right) \times 6 = 0.1875$$

(e) In these calculations we've assumed that the removal of a couple of pieces does not change the total number significantly, i.e. it is very

large.

Example 2:The percentage distribution of shoe sizes for 2001 is given in Table

(a) Calculate the probability that a man selected at random will have

- (i) a shoe size of 10
- (ii) a shoe size of 8 or less.

(b) If two men are randomly selected from a really large population, what's the probability

- (i) that both will have size 9 shoes
- (ii) that both have identical shoe size.

Table:Distribution of men's shoe sizes

SIZE	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	>12
%	1	1	2	4	7	11	13	15	14	12	9	6	3	2	1

Solution : (a) .(i) Out of each hundred men, nine have this shoe size and then the proportion and thus the probability is given by:

$$P(10) = \frac{9}{100} = 0.09$$

(ii) Here we need the number of men who have shoe sizes of 8 or less.

Using the data from the table gives:

$$P(\leq 8) = \frac{1 + 1 + 2 + 4 + 7 + 11 + 13}{100} = \frac{39}{100} = 0.39$$

(b) .(i) This probability is given by combining the probability that the first man has size 9 shoes and that the second has size 9 as well:

$$P(\text{size 9 and size 9}) = \frac{14}{100} \times \frac{14}{100} = \frac{196}{10000} = 0.0196$$

(ii) If both men have identical size then we would like to sum up, over all sizes, the individual probabilities that both have a specific size:

$$P(\text{same size}) = \frac{1}{100} \times \frac{1}{100} + \frac{1}{100} \times \frac{1}{100} + \dots + \frac{2}{100} \times \frac{2}{100} + \frac{1}{100} \times \frac{1}{100}$$

$$P(\text{same size}) = 0.0001 + 0.0001 + 0.0004 + 0.0016 + 0.0049 + 0.0121 + 0.0169 + 0.0225 + 0.0196 + 0.0144 + 0.0081 + 0.0036 + 0.0009 + 0.0004 + 0.0001 = 0.1057$$

The probability of two men having the same shoe size, based on this data, is therefore 0.1057

6.3 Program

```
shoes=5:1,5.5:1,6:2,6.5:4,7:7,7.5:11,8:13,8.5:15,9:14,9.5:12,10:9,10.5:6,11:3,11.5:2,12:1
option=0
while(option!=3):
print("\n=====MENU=====")
print("1. Probability that a random man selected will have a given shoe
sizes ")
print("2. Probability when two men are selected ")
print("3. Exit")
print("=====")
option=int(input("Enter the option :"))
if(option==1):
sizes=map(float,input("Enter the shoe sizes :").rstrip().split())
p=0
for size in sizes:
p+=shoes[size]/100

    print("Probability is",round(p,4))
elif(option==2):
print("\n=====")
print("1.Probability that the have a given size")
print("2.Probability that they have same size")
print("=====")
option2=int(input("Enter the option :"))
if(option2==1):
size=float(input("Enter the size:"))
p=(shoes[size]/100)**2
print("Probability is",round(p,4))
elif(option==2):
p=0
```

```
percent=shoes.values()
for value in percent:
p+=(value/100)**2
print("Probability that they have same size is",round(p,4))
```

6.3.1 Output of the program

```
=====MENU=====
1. Probability that a random man selected will have a given shoe sizes
2. Probability when two men are selected
3. Exit
=====
Enter the option :1
Enter the shoe sizes :9
Probability is 0.14
```

```
=====MENU=====
1. Probability that a random man selected will have a given shoe sizes
2. Probability when two men are selected
3. Exit
=====
Enter the option :2
```

```
=====
1.Probability that the have a given size
2.Probability that they have same size
=====
Enter the option :1
Enter the size:9
Probability is 0.0196
```

```
=====MENU=====
1. Probability that a random man selected will have a given shoe sizes
```

2. Probability when two men are selected

3. Exit

=====

Enter the option :2

=====

1. Probability that they have a given size

2. Probability that they have same size

=====

Enter the option :2

Probability that they have same size is 0.1057

CONCLUSION

From the above it can be concluded that mathematics is a subject which can be incorporated in all types of sciences including the various branches of forensic science such as forensic biology, forensic chemistry, forensic physics, forensic ballistics, etc.

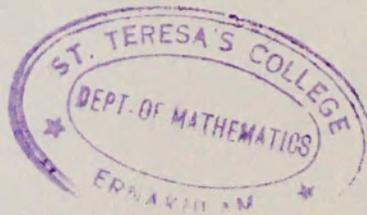
Mathematics has a wide scope in forensic science because it deals with the analysis of the evidence obtained from a crime scene followed by its interpretation and followed by mathematical calculations.

Moreover, only with the mathematics interpretation, it is possible to determine the findings such as height from which a blood drop has originated, or the angle at which a blood drop has struck a target surface resulting in the formation of bloodstains, or the probability that the blood types of any two randomly chosen individuals would match with each other and much more.

As it is clearly understood that mathematical calculations have a wide range of applications in forensic science. So, for a forensic expert, it is important to possess excellent knowledge of mathematics and statistics along with the principles and theory of different sciences to solve a crime efficiently and effectively.

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SYNTHESIS AND CHARACTERIZATION OF ZINC FERRITE NANOPARTICLES

PROJECT REPORT

SUBMITTED BY

PAULINE JESNA JOSEPH

REG NO: AM20PHY012

Under the guidance of

Dr. MARIYAM THOMAS

**Submitted to Mahatma Gandhi University, Kottayam
In partial fulfillment of the requirements for the award of the degree of**

MASTER OF SCIENCE IN PHYSICS



DEPARTMENT OF PHYSICS AND CENTRE FOR RESEARCH

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM, KOCHI-682011

2020-2022

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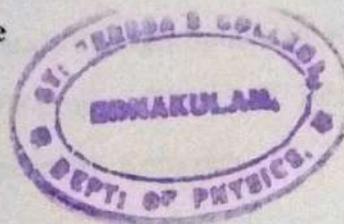


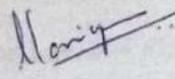
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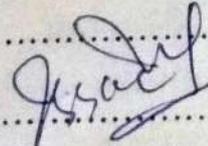

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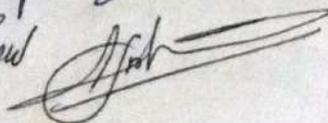



Dr. Mariyam Thomas
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Submitted to the Examination of Master's Degree in Physics

Date : 14.06.2022

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CERTIFICATE

This is to certify that the project work entitled "SYNTHESIS AND CHARACTERIZATION OF ZINC FERRITE NANOPARTICLES" is the work done by **PAULINE JESNA JOSEPH**, Register Number **AM20PHY012** under the guidance of **Dr. MARIYAM THOMAS**, Assistant Professor, Department of Physics and Centre for Research, St. Teresa's College, Ernakulam in partial fulfilment of the award of the Degree of Master of Science in Physics St. Teresa's College, Ernakulam affiliated to Mahatma Gandhi University, Kottayam


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CERTIFICATE

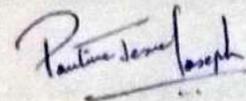
This is to certify that the project work entitled "**SYNTHESIS AND CHARACTERIZATION OF ZINC FERRITE NANOPARTICLES**" is the work done by **PAULINE JESNA JOSEPH**, Register Number **AM20PHY012** **under** my guidance in the partial fulfilment of the award of the Degree of Masters of Science in Physics at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam.

A handwritten signature in blue ink, appearing to read "Mariyam Thomas", is positioned above the printed name.

Dr. Mariyam Thomas
Assistant professor
Supervising Guide

DECLARATION

I hereby declare that the project work entitled "**SYNTHESIS AND CHARACTERIZATION OF ZINC FERRITE NANOPARTICLES**" submitted to Department of Physics and Centre for Research, St. Teresa's College (Autonomous) affiliated to Mahatma Gandhi University, Kottayam, Kerala is a record of an original work done by me under the guidance of **Dr. MARIYAM THOMAS**, Assistant Professor, Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam . This project work is submitted in the partial fulfillment of the requirements for the award of the Degree of Master of Science in Physics.



PAULINE JESNA JOSEPH

ACKNOWLEDGEMENTS

The success and final outcome of this project required a lot of guidance and assistance from many people and we are extremely grateful to have got this all along the completion of my project work. Whatever we have done is due to such guidance and assistance and we would not forget to thank them.

Primarily, we thank God almighty for being with us throughout all the days and helping us complete the project successfully.

We respect and thank our project guide Dr. Mariyam Thomas Assistant Professor, Department of Physics, St. Teresa's college (Autonomous) Ernakulum, for her valuable and enlightened guidance and the support and suggestions which helped us in completing the project.

We extend our sincere gratitude to Dr. Priya Parvathi Ameena Jose, Head of Physics Department, St. Teresa's College (Autonomous), Ernakulum, for providing us with all the facilities and support to meet our project requirements.

We also express our heartfelt gratitude to Dr. Vinitha CSST, Director, St. Teresa's College (Autonomous), and Dr. Lissy Mathew, Principal, St. Teresa's College (Autonomous), Ernakulum, for their extended support and co-operation during our project work.

We thank all the teachers and non-teaching staff of the Department of Physics, St. Teresa's college (Autonomous), Ernakulum for their support and co-operation during our entire project work. And I would like to acknowledge the immense help and support given by Ms. Anakha M, M. Phil student of Physics Department, St Teresa's college Ernakulam.

We also like to extend our sincere thanks to Central Sophisticated Instrumentation Facility, University of Calicut for their assistance in XRD measurements. And Chemistry Department of University of Calicut for their assistance in FTIR measurements.

We would like to express our gratitude towards our parents and friends for their kind co- operation and encouragement which helped us in the completion of the project.

**SYNTHESIS AND CHARACTERIZATION OF
ZINC FERRITE NANOPARTICLES**

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO FERRITES

Ferrites are magnetic ceramic-like materials that are derived from iron-oxides. Mostly, they are ferrimagnetic compounds that are hard and brittle. They are also polycrystalline and poor conductors of electricity. They have the chemical formula AB_2O_4 where A and B are metal cations in which one cation is Fe^{2+} . An important example of Ferrite is the iron ore magnetite (Fe_3O_4) in which the cations are Fe^{2+} and Fe^{3+} . [2]

They have several applications in many electronic devices like isolator, circulator, phase-shifter, filters, voltage-controlled oscillators, impedance matching networks, because of their small electrical conductivity due to which they have negligible eddy current losses at high frequencies.

Their contribution can be seen in other fields like automobile industry, telecommunication, memory chip, magnetic recording etc. They are also used as permanent magnets.

Ferrites can be classified based on magnetic properties, crystal-structure, chemical composition of metal ions.

1.1.1 CLASSIFICATION BASED ON MAGNETIC PROPERTIES

Here, Ferrites can be classified as Soft Ferrites, Semi-hard Ferrites and Hard Ferrites based on their magnetic coercivity or resistance to get demagnetized.

1.1.1.1 SOFT FERRITES

These are Ferrites composed of iron oxide with divalent metal oxides e.g. zinc, cobalt nickel etc. Soft ferrites are inverse spinel and belong to the cubic crystal system^[1]. They exhibit a homogenous cubic spinel crystalline structure. They have low coercivity because of which their hysteresis losses upon reversal of direction of magnetization is less and high resistivity because of which the eddy current losses in the core is less at high frequencies. So they are used as temporary magnets in RF transformers, inductor cores, filters, and switched-mode power supplies, antennas.^[2]

1.1.1.2 SEMI-HARD FERRITES

^[2]Their magnetic nature is in between soft magnetism and hard magnetism. An example for this material is Cobalt Ferrite CoFe_2O_4 ($\text{CoO} \cdot \text{Fe}_2\text{O}_3$). It exhibits magnetostrictive effect^[4] which is due to magneto-elastic coupling i.e. coupling between magnetic energy and mechanical energy under the influence of an external magnetic field .They can convert magnetic energy into kinetic energy, and vice-versa because of which they have many applications in thin-films, sensors and actuators .They have great research potential.

1.1.1.3 HARD FERRITES

^[2]Hard Ferrites have crystal structure as cubic blocks with spinel structure and hexagonal blocks containing the metal ions. Magnetic structure characterized by a close packing of oxygen metal ions with Fe atoms at the interstitial position. They have high coercivity or very low tendency to become demagnetized. So they are permanent magnets and are used in refrigerators, telecommunication, microwave, magneto-optic media etc. They mainly contain iron oxide, barium oxide, and strontium carbonate.

1.1 FERRITE STRUCTURE WITH UNIT CELL

1.2.1 CLASSIFICATION BASED ON CRYSTAL STRUCTURE

There are 4 types of Ferrites based on crystal structure: Spinel (cubic), Hexagonal, Garnet and Orthoferrites

1.2.1.1 SPINEL FERRITES

Spinel structure was first found out by Bragg and Nishikawa. Spinel ferrite crystal has cubic crystal structure. The general formula for spinel ferrites is MFe_2O_4 where M is a divalent metal cation of Cu, Mn, Mg, Co, Zn etc. In ferrites Fe is the trivalent ion and in the general spinel structure Fe can be replaced with any trivalent ions like Al, Cr, Ga.

A spinel unit cell is composed of 8 FCC unit cells ^[3]. The anions or the oxide ions (O^{2-}) occupy the FCC lattice points, 32 O^{2-} ions forming the spinel unit cell framework. The metal ion and the Fe^{3+} ions are distributed among two types

of lattice sites-sites having tetrahedral and octahedral oxygen coordination, also called tetrahedral sites (A) and octahedral sites (B) respectively ^[6]. The divalent cations occupy 1/8th of the tetrahedral voids and the trivalent cations occupy 1/2 of the octahedral voids. Also, we know that in 1 FCC lattice unit cell, the effective number of atoms occupying the lattice points is 4, the effective number of tetrahedral voids is 8 and that of octahedral voids is 4 ^[3]. Thus in the normal spinel structure, the number of anions occupying the fcc lattice points of 8 fcc unit cells is 32, the number of divalent cations occupying 1/8th of tetrahedral voids is 8 and the number of trivalent cations occupying 1/2 of the octahedral voids is 16. The ratio of the number of divalent cations to the trivalent cations to the oxide ions in the spinel unit cell thus becomes 1:2:4 which agrees with the formula of normal spinels. The distribution of cations within the A and B sites depends on the ionic radius and their electronic configuration and also on the electrostatic energy of the lattice.

Spinel Ferrites show high electrical resistivity, high magnetic permeability and low magnetic losses and are hence used as substitutes to metallic magnets like iron. They are further classified into normal, inverse, random spinel Ferrites.

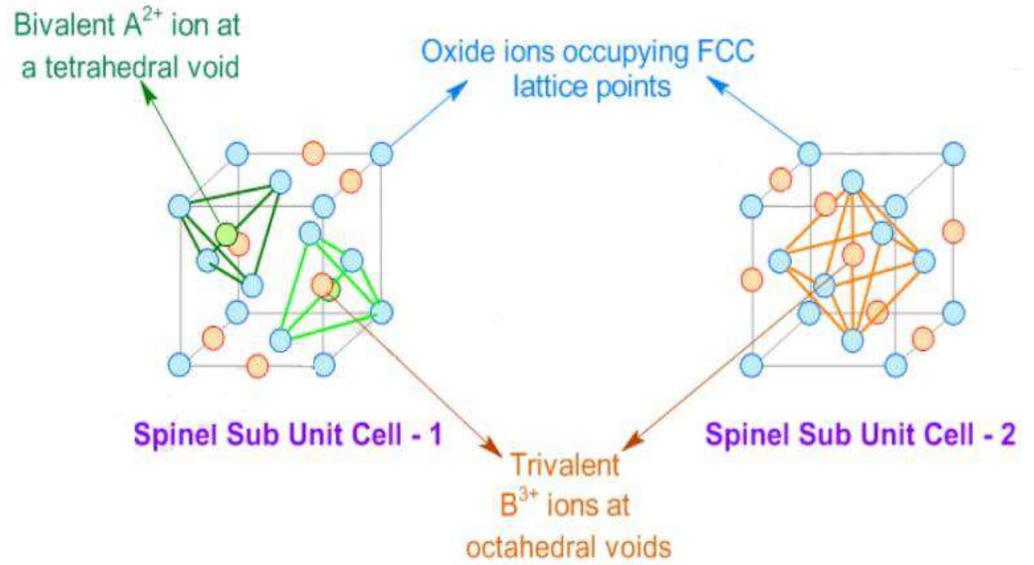


Figure 1.1 : Spinel Sub Unit Cell

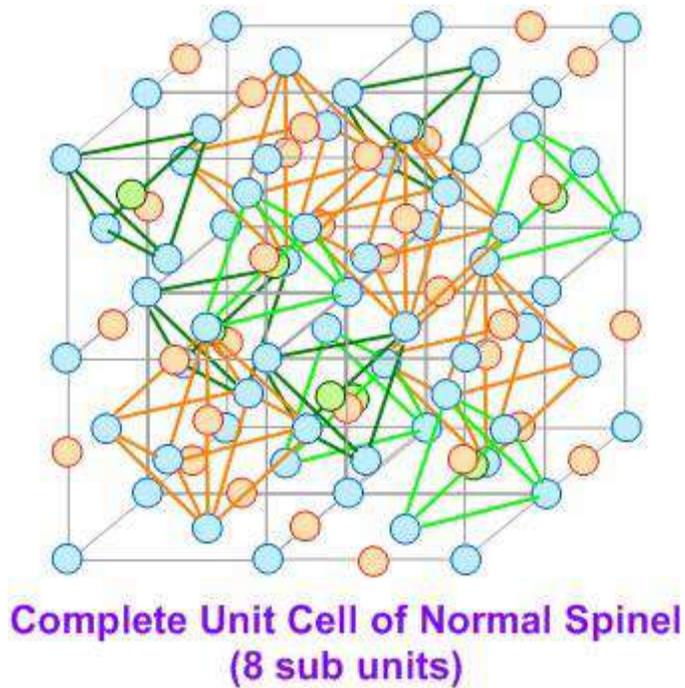


Figure 1.2 : Complete unit cell

1.2.1.1.1 NORMAL SPINEL FERRITE

The divalent cation occupies the tetrahedral sites and the trivalent ion occupies the octahedral sites. The cation distribution can be represented as $(M^{2+})[Fe^{3+} Fe^{3+}] O_4^{2-}$ [5]. Zinc Ferrite is an example for Spinel Ferrite represented by $(Zn^{2+})[Fe^{3+} Fe^{3+}]$. The cation distribution in the octahedral sites is given in the square brackets.

1.2.1.1.2 INVERSE SPINEL FERRITE

The divalent ions occupy the 1/4th of octahedral voids, and half of trivalent ions occupy the 1/8th of tetrahedral sites and the other half occupy 1/4th of octahedral sites [3]. The cation distribution can be represented as $(Fe^{3+})[M^{2+} Fe^{3+}] O_4^{2-}$. An example of inverse Spinel Ferrite structure is Cobalt Ferrite given by the formula $(Fe^{3+})[Co^{2+} Fe^{3+}] O_4^{2-}$ [5].

1.2.1.1.3 RANDOM SPINEL FERRITE

The divalent and trivalent cations occupy both sites given by the chemical formula $M^{2+}_{1-\delta} Fe^{3+}_{\delta} [M^{2+}_{\delta} Fe^{3+}_{2-\delta}] O_4^{2-}$ where δ is the degree of inversion. $MnFe_2O_4$ has this structure with degree of inversion $\delta = 0.2$. $Mn^{2+}_{0.8} Fe^{3+}_{0.2} [Mn^{2+}_{0.2} Fe^{3+}_{1.8}] O_4^{2-}$ [7]

1.2.1.2 HEXAGONAL FERRITES

They have a close-packed hexagonal crystal structure, showing the superposition of S, R, and T blocks along c-axis. S block is spinel block consisting of two oxygen layers (O₄ - O₄) with Fe₆O₈ composition. R is a three oxygen layer block (O₄ - BaO₃ - O₄) with BaFe₆O₁₁ composition. T block has four layers of oxygen ions (O₄ - BaO₃ - BaO₃ - O₄) with Ba₂Fe₈O₁₄ composition. Based on the arrangement of S, R, T blocks there are several subclasses of Hexagonal Ferrites. Their general formula is MFe₁₂O₁₉. Examples are barium ferrites and Strontium Ferrites. They have high coercivity and high uni-axial magneto crystalline anisotropy making it useful as permanent magnets in microwave devices ^[5].

1.2.1.3 GARNET FERRITES

They have many uses in microwave, acoustic, optical, magneto-optical fields. They have the general formula where X₃ Fe₅O₁₂ is a rare earth metal like Sm, Eu, Gd, Tb, Dy, Y etc. They are minerals having dodecahedral sites (12- coordinated sites) together with tetrahedral and octahedral sites. They are magnetically hard. Example for Garnet Ferrite is Yttrium Iron Ferrite Y₃Fe₅O₁₂. ^[5]

1.2.1.4 ORTHO FERRITES

They find applications in communication technology, optical internet and sensor technology. They have orthorhombic crystal structure, are weakly ferromagnetic. They have the general formula MFeO₃ where M is a rare earth

element. Examples are LaFeO_3 (lanthanum orthoferrite), gadolinium orthoferrite (GdFeO_3), and DyFeO_3 (dysprosium orthoferrite) ^[5].

1.3 CLASSIFICATION BASED ON CHEMICAL COMPOSITION OF METAL IONS

On this basis, Ferrites can be classified into Simple Ferrites, Mixed Ferrites and substitutional Ferrites

1.3.1 SIMPLE FERRITES

They are formed when the ferrous ion in Fe_3O_4 is replaced by any divalent cation like Zn, Cu, Ni, Cd etc. to obtain ZnFe_2O_4 , NiFe_2O_4 , CuFe_2O_4 , and CdFe_2O_4 .

1.3.2 MIXED FERRITES

They are formed by the replacement of ferrous ion in Fe_3O_4 by two different divalent cations like Zn, Cu, Ni, Cd etc. without changing the stoichiometry.

Ex: $\text{Mg}_x\text{Ni}_{1-x}\text{Fe}_2\text{O}_4$

1.3.3 SUBSTITUTIONAL FERRITES

They are formed by the replacement of divalent and trivalent ions by magnetic or nonmagnetic metal ions in the spinel structure

Ex: $\text{Ni}_x\text{Mg}_{1-x-y}\text{Ti}_y\text{Fe}_{2-2y}\text{O}_4$

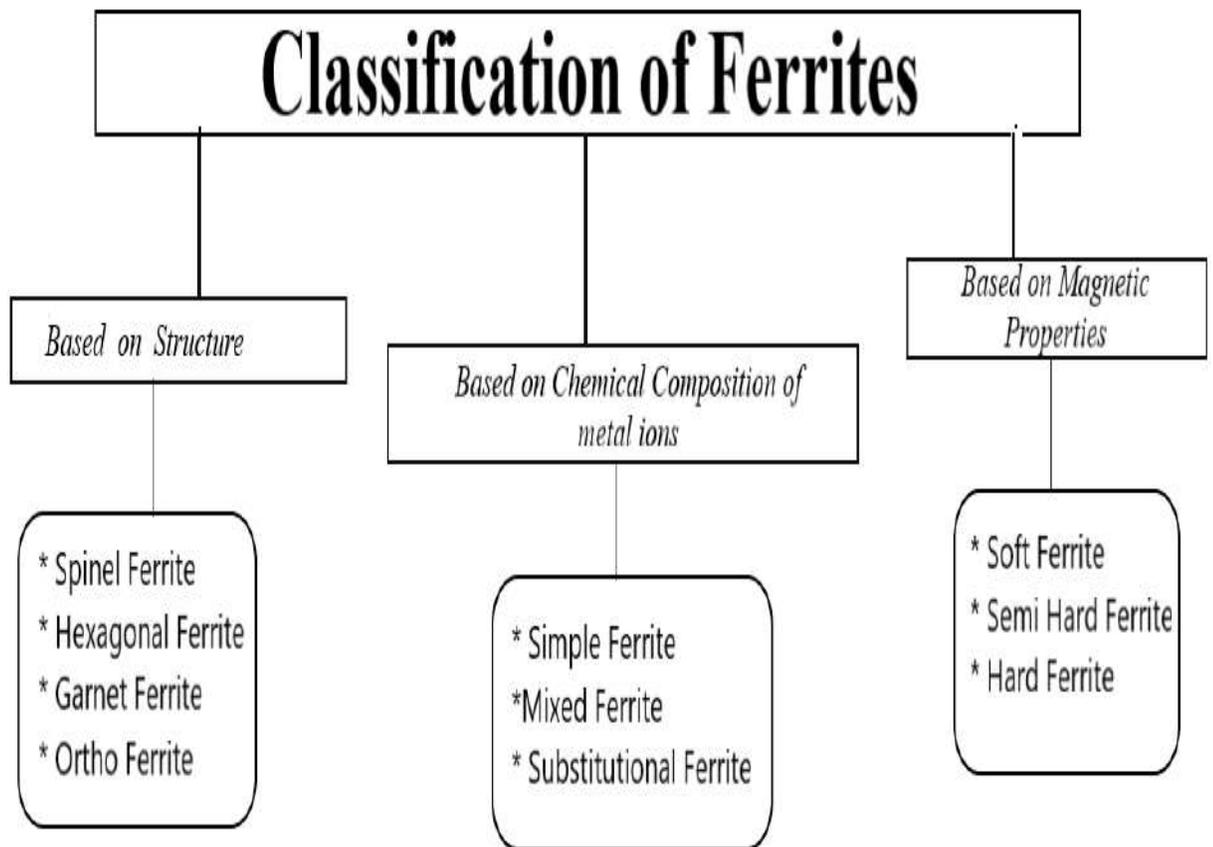


Figure 1.3 : Flowchart-Classification Ferrites

1.4 PROPERTIES AND APPLICATION OF FERRITES

Ferrites has strong electric and magnetic properties. Low conductivity, low eddy current, dielectric losses are some of their unique properties [7]. Ferrite suffer from less ohmic loss since they have nonmagnetic media. Ferrites are electrically non- conductive so they are insulators and ferrimagnetic in nature. Ferrites shows strong ferromagnetism since they possess electrons of metal and oxygen ions on lattice site with opposite spin arrangement. Net resultant magnetization result from the unequal antiparallel spin moments. Ferrites have high resistivity than ferromagnetic metals due to their intrinsic atomic level interaction between oxygen and metal ions. Most of the Ferrites have an ability to get completely magnetized along an axis on applying a magnetic field [8]. They can behave as semiconductors when subjected to an applied electric field. Ferrites have either thin hysteresis loop or square loop [8]. Soft Ferrites results in low eddy current losses over wide frequency range and high magnetic permeability and stability over wide temperature range [9]. Soft Ferrites having thin hysteresis loop used in devices such as transformers and inductors. While Hard Ferrites having square hysteresis loop are used in memory devices and switching devices. Ferrites are extensively used for commercial applications because of their stable chemical structure with high surface area, controllable magnetic, optic and electrical properties. Besides, their low cost and abundance make Ferrites suitable for commercial interests. High permeability, ability to show various redox states and electrochemical stability make Ferrites suitable electrode materials for electrochemical super capacitors [10]. Ferrite based gas sensors have wide acceptance now a days. Electron transfer process takes place between gas molecules and Ferrite surface due to chemical reaction. This leads to the change in electrical conductivity or resistivity. This property enables Spinel Ferrites apt for gas sensor. Ferrite based gas sensors are relatively inexpensive and have excellent sensing capabilities [11]. Different type of Ferrites has been used for sensing today.

Current research in incorporating Ferrites into smart devices for remote sensing is also in progress. Properties such as economic feasibility, effective catalytic activity, wide bandgap into visible spectrum, corrosion resistance, redox activity and ability to store oxygen on its crystal lattices ^[12] encourage them to be used as photocatalyst for hydrogen production as it is considered to be the next generation energy carrier. Polycrystalline Spinel Ferrites at nanoscale exhibits humidity sensing properties. Their contribution can be seen in other fields like automobile industry, telecommunication, memory chip, magnetic recording etc. They are also used as permanent magnets.

1.5 SYNTHESIS METHOD

1.5.1 CO-PRECIPIATION METHOD

Coprecipitation is one among the convenient approach to synthesis magnetic nanoparticles. In this process desired aqueous metal salt solutions are added in stoichiometric ratio. Then subjected to continuous and vigorous stirring in an alkaline solution (NaOH or NH₄OH). These precipitates are subsequently calcinated at appropriate temperature to yield the powdered sample. pH value, appropriate precursors, temperature, stirring speed, concentration of the solutions all are important factors of getting high quality material as the final product. Main advantages of coprecipitation method are that its less time consuming, more cost effective, has high mass production and provide materials with almost uniform particle size

1.5.2 PRINCIPLE OF CO-PRECIPIATION METHOD

Coprecipitation reactions involve the formation of simultaneous stages such as nucleation, growth in a homogeneous solution and agglomeration. Nanomaterials are formed from aqueous solution or by

reduction from nonaqueous solution. Nucleation process allows to form large number of small particles. Post nucleation process takes place due to Ostwald ripening processes that leads to aggregation of the particles. This secondary process mainly affect the size, morphology and other properties of the final products. Products gained as an insoluble species under the condition of supersaturation and supersaturation helps to induce precipitation at the reaction scale ^[13]. pH is maintained throughout mixed salt solutions and the base solutions are simultaneously added drop wise in order to maintain solution. Nuclei formed at the beginning undergo crystal growth in course of time than those formed toward the end of the mixing process. This results the distribution of crystalline sizes. Typical coprecipitation techniques involve metals formed from aqueous solutions by reduction from non-aqueous solution, electrochemical reduction and decomposition of metal organic precursors, oxides formed from aqueous and nonaqueous solutions ^[13]

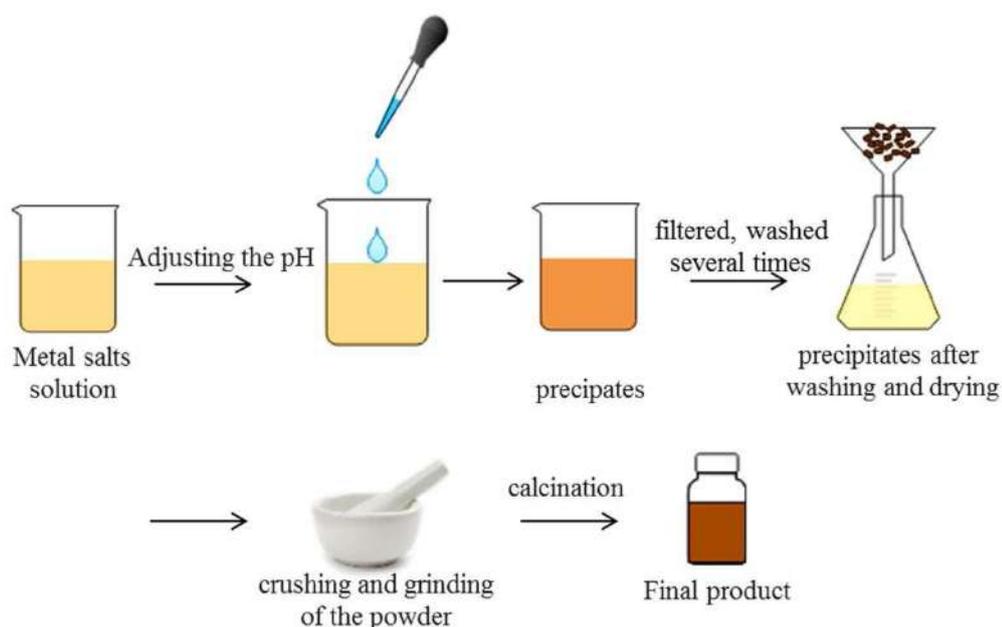


Figure 1.4: Schematic representation of co-precipitation method

1.5.3 ADVANTAGES OF CO-PRECIPIATION METHOD

- Radiotoxic dust is less generated ^[14]
- Availability of reactants is quite easy
- Co-Precipitation Method is simply flexible to glove box operation ^[14]
- Widely used technique to synthesize nanoparticles
- Method can be carried out in ordinary laboratory conditions
- Free from solid wastes
- Cost effective and fast process
- Nanoparticles can be formed with high purity
- Eco-friendly synthesize route
- No requirement of hazardous organic solvents
- No requirement of high pressure and temperature
- Easily Transposable on a large scale for industrial applications ^[15]
- Multi components can be synthesized through intermediate precipitate

1.6 LITERATURE SURVEY

^[20] Salar Hafez et al synthesized Zinc Ferrite nanoparticle magnetite nanoparticles using hydroethanolic extract of Citrus Aurantium flowers. Aim of the work was production of Zn nanoparticless without adding any chemicals. Hydroethanolic plant extract was used as the precipitating agent. pH measurement is an important parameter for synthesis of required nanoparticle.

^[21] Muhammad Imran et al investigated the photocatalysis performance of Zinc Ferrite nanoparticles by carrying out the degradation reaction of methylene blue under sunlight. Zn-NPs were synthesized using aqueous seed extract of piper nigrum through microwave assisted

hydrothermal method. Temperature and pressure are the important parameters for the production of required nanoparticle. From the investigation it is concluded that synthesized nanoparticle exhibits excellent photocatalytic performance in the degradation of the methylene blue solution. Recycling of Zn-NPs gives higher photocatalytic potential for the number of cycles.

[18] V.Lakshmi Ranganatha et al investigated the photocatalytic activity, electrical properties and microbial applications of synthesized Zinc Ferrite nanoparticles using aegle Marmelos extract as fuel through solution combustion method. Extract can act as an alternative biofuel to chemicals. Calcination temperature, pH and volume are the important parameters to carry out the procedure for production of Zn-NPs. From the study it is concluded that synthesized nanoparticles exhibits photocatalytic activity when subjected to the degradation of methylene blue.

[19] E. Sarala et al investigated the magnetic and anticancer activity against breast cancer (MCF-7) cell lines of lawsonia inermis mediated Zinc Ferrite nanoparticle using sol gel method. Temperature and pH are the important parameters for the production of desired nanoparticle. Magnetic properties of the as synthesized NPs depend on the parameters such as synthesis method, cation distribution and annealing temperature. From the studies ferromagnetic behavior of Zinc- Ferrite NPs were recognized. In addition to this, formation of homogeneous and agglomerated nanoparticles were also identified. Anticancer activity reveals a gradual decrease in the cell viability with the increase in the concentration of Zinc Ferrite nanoparticle and thus concluded synthesized nanoparticle exhibit agreeable anticancer activity against the breast cancer (MCF-7) cell lines. Synthesis of lawsonia inermis mediated Zinc Ferrite

nanoparticles was successful.

^[17]M.Balasubramanian et al investigated the photocatalytic activity of flower extract of *nyctanthesarbor-tristis* mediated Zinc Ferrite nanoparticle. Photocatalytic activity of as synthesized Zinc Ferrite ($ZnFe_2O_4$) nanoparticle is studied by measuring the degradation rate of Rhodamine B (RhB) dye solution under the sunlight illumination. Single phase spinel $ZnFe_2O_4$ was successfully synthesized from the flower extract of *nyctanthesarbor-tristis*. Calcination temperature, pH of the solution, amount of dye were the important factors for examining the photocatalytic activity. From the further investigation it is clear that photocatalytic performance of nanoparticles synthesized through biosynthesis route are worthy of comparison to the solution combustion synthesized powder.

^[22] K.Kombaiah et al investigated the optical, magnetic and catalytic applications of *Optunia delenii* haw mediated multifunctional Zinc Ferrite ($ZnFe_2O_4$) nanoparticles using conventional heating and microwave heating method. Synthesis of nanoparticles were carried out at different calcination temperatures. Photoluminescence, magnetic properties, effect of temperature and time plays a vital role in the synthesis and properties of the synthesized nanoparticles and catalytic activity were examined for all samples and the results were compared. From the investigation it is confirmed that microwave heating technique produces nanoferrites with high yield, low crystalline size and uniform morphology properties than conventional heating method. Also catalyst synthesized by microwave heating method exhibits higher catalytic activity.

^[23]M.Madhukara Naik et al investigated photocatalytic and antibacterial activities of Zinc Ferrite nanoparticles synthesized by

microwave assisted green method using *Limonia acidissima* juice. Preparation was conducted at high magnetic saturation and calcinated at 600⁰C. Photocatalytic activity examined from the degradation of EB and MB dyes under visible light. Studies revealed a decrease in the absorbance of EB and MB dyes solution with increase in time of irradiance in the presence of Zinc Ferrite photocatalyst. Antibacterial activity was carried out by agar well diffusion method against pathogenic bacterial strains. Nanoparticles exhibited an impressive antibacterial activity. Besides, significant cell inhibition against bacterial strains compared to antibiotics is also noted. From the investigation it's clear that the synthesized nanoparticles are suitable materials for medical devices against the microbes.

^[24]Aubrey Makofane et al investigated the photocatalytic degradation of methylene blue and sulfisoxazole from water using biosynthesized Zinc Ferrite ($ZnFe_2O_4$) nanoparticles. Nanoparticles were synthesized using hydrothermal route using the nitrate salts. The synthesized nanoparticles showed an effective photocatalytic performance towards methylene blue dye degradation at optimum conditions. Photocatalytic degradation of sulfisoxazole using the synthesized nanoparticles as a catalyst under UV light irradiation was examined. It is understood that the value of pH, dosage, concentration and time determines the rate of degradation. Studies confirmed that it is possible to synthesize eco-friendly photocatalyst that can be used in both the textile and pharmaceutical industry for wastewater treatment.

^[25]R. Raeisi et al investigated the magnetic properties of super paramagnetic Zinc Ferrite nanoparticles synthesized via coprecipitation method at different temperatures of 20-80 ⁰C. The preparation was carried out without any subsequent calcination. Effect of range of precipitation

temperature on the structural and magnetic properties of the synthesized nanoparticles were examined.

^[26]Edilan S. Lima et al investigated the influence of glycerol as structure directing and stabilizing agent in the synthesis of Zinc Ferrite (ZnFe_2O_4) nanoparticle via co-precipitation method and examined the chelating capacity and oxidation properties of Zinc Ferrite sample with and without the addition of glycerol. The results concluded that Zinc Ferrite crystal synthesized in the presence of glycerol is bigger than the other without the presence of glycerol. Studies confirm that glycerol can act directly over the size and morphology of the sample and thus modify the synthesis route.

1.7 SUMMARY OF THE PROJECT

This project aims to synthesize Zinc Ferrite nanoparticles using bioreducers present in a suitable bioextract and to make their characterization studies using techniques like XRD and FTIR. We use the coprecipitation method for the biosynthesis, in which we add the bio extract to a mixture of Zinc Nitrate Hexahydrate $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ and iron nitrate ($[\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}]$) maintained at a suitable basic pH. The bioreducers were used to assist the precursors in the synthesis procedure.

We focus on the biosynthesis method for synthesizing the nanoparticles as it can be very advantageous over the traditional methods of synthesis. It is economical and eco-friendly. Its biocompatibility ensures less toxicity towards nature and towards us when we are exposed to them. Other advantages include less time expenditure, large scale synthesis, simple laboratory conditions with no need of high temperature and

pressure.

An important feature of the synthesized nanoparticles is its magnetic nature due to which it has wide range of applications. They can have many biomedical applications as in MRI and spintronic devices. Also they have research potential in biomedicine, in treatment of cancers and bioengineering such as cell-separation, hyperthermia, detoxification of biological fluids and tissue regeneration. It is useful in diagnostic techniques like biosensors, cellular labelling and gene therapy. It has other applications like as adsorbent material for hot gas desulphurisation, potential semiconductor photocatalyst in photo induced transformer and in photoelectrochemical cells and in elimination of other toxic gases from coal gas.

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CHAPTER 2

EXPERIMENTAL TECHNIQUES

2.1 SYNTHESIS METHOD WITH PROCEDURE

We employ the coprecipitation method to synthesize the samples. The precursor solutions of Zinc Nitrate Hexahydrate [$\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$] and Ferric Nitrate [$\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$] in distilled water were prepared and mixed them to form a mixture solution and add the mixture solution and the extract simultaneously to distilled water. We make it basic by the addition of ammonium hydroxide with continuous stirring. Then, the sample is sealed and kept overnight for settling. The sample is washed to reduce its pH to neutral, filtered and dried in the oven and then calcinated at 400°C .

2.2 CHARACTERIZATION TECHNIQUES

2.2.1 X-RAY DIFFRACTION TECHNIQUE

X-ray diffraction technique is most important characterization tool used for the qualitative and quantitative analysis of materials at atomic level. It is used to study the crystalline size, lattice parameter, crystal structure, phase identification and can provide information on unit cell dimensions.

2.2.1.1 PRINCIPLE OF XRD TECHNIQUE

In 1912, Max Von Laue discovered that crystalline substances could act as three dimensional diffraction gratings for X-Ray wavelengths and X-Ray

diffraction can be used to study atomic spacing and crystal structures. Identically arranged crystal planes act as diffraction grating. When the wavelength of the propagating beam is order of the interplanar distances for that particular crystal, diffraction pattern can be observed. X-ray diffraction pattern is a resultant of constructive interference of monochromatic x-rays reflected from a crystalline sample.

Typical X-rays used for the diffraction are electromagnetic waves with wavelength in the range of 0.05 to 0.25 nm. The X-ray beam is made monochromatic by filtering using graphite, collimated, focused and directed towards the sample. The interaction of the incident rays with the sample produced constructive interference for suitable angles of incidence. This is governed by the well-known Bragg's law

$$n\lambda = 2d\sin\theta$$

relating the wavelength of electromagnetic radiation to the diffraction angle and the lattice spacing in a crystalline sample.

The XRD pattern is the graph between the intensities of diffracted X-rays and angles of incidences. To record the XRD pattern the sample to be scanned through a range of 2θ angles. Since the samples in powder form its present it all possible diffraction direction to the beam. Peak in the diffractogram indicates a series of planes facing the X-ray beam at the correct angle to satisfy Bragg's condition^[1].

The size of the nanoparticle can be calculated from the XRD data using Debye- Scherrer formula

$$D = \frac{k\lambda}{\beta\cos\theta}$$

Where D is the particle size of the nanoparticle, λ is the wavelength of X-ray beam, β is the full width at half maximum (FWHM) in radians and θ is the angle of diffraction. The analysis of the diffraction pattern help to identify the phase of the sample.

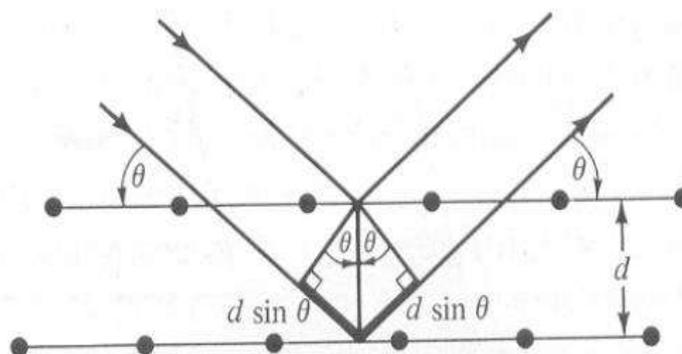


Figure 2.1: X-ray reflection in different planes satisfying Bragg's condition

For a cubic crystal lattice constant 'a' is calculated from the equation

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

2.2.1.2 INSTRUMENTATION

The XRD instrument consist of an X-ray source, specimen and detector. X-rays are generated from the cathode ray tube by heating a filament to produce the electrons. These electrons collide with a target material by the application of voltage. As a result inner shell electron of the target material gets ejected. These vacancies are filled by the outer electrons. The vacancies created by the outer electron result in the release the characteristic X-rays spectra. The wavelength of the X-rays are characteristics of the target material. Commonly used target material is copper with Cu-K α radiation having the wavelength $\lambda = 1.5418 \text{ \AA}$

2.2.2 FOURIER TRANSFORM INFRARED SPECTROSCOPY

Fourier-transform infrared spectroscopy is a method used to detect

infrared spectrum for absorption or emission of solids, liquids or gases ^[2]. The FTIR spectrometer simultaneously collects spectral data with high accuracy over a wide spectral range. It identifies the presence of organic and inorganic compounds in the sample. The specific molecular groups in the sample will be determined through spectrum data in the automated software of spectroscopy. It has very high sensitivity. It can detect slight variation in absorbance of magnitude 10^{-3} .

2.2.2.1 APPLICATIONS ^[6]

FTIR has applications in geology, chemistry, materials and biology research fields.

- Microscopy and imaging

The spectra can be measured from regions as small as 5 microns and the distribution of different chemical species within the sample can be seen in the images generated

- Detector in chromatography
- Used to analyze water content in plastics and composites
- Nano FTIR: Performs spectroscopy when the sample is in the nanoscale like viruses and protein complexes with 10- 20 nm resolution.

2.2.2.2 PRINCIPLE

FTIR spectroscopy is based on how infrared light absorption changes dipole moments in molecules with a specific vibrational energy. Vibrational energy of the molecule depends on reduced mass and spring constant of the bond. Each functional group has different atoms and bonding, so vibrations are characteristic to functional groups ^[3]. The frequencies of the radiation are measured as wave numbers mostly in the range $4000 - 600 \text{ cm}^{-1}$ ^[2]. Thus, the absorption or transmittance peaks obtained during spectroscopy can be used for identification by comparing with sample databases in standard libraries ^[2].

2.2.2.3 COMPONENTS AND WORKING

The FTIR spectrometer includes IR source, cell sample, detector, amplifier, A / D converter, and computer. There is a beam splitter in the interferometer which divides the incoming beam from the source into two beams. The path length for one beam is fixed whereas for the other beam, it is constantly changing as its mirror moves. The signal exiting the interferometer is the resultant beam caused by the interference of these two beams and is called the interferogram. Every data point which makes up the interferogram is a function of position of the moving mirror. The signal reaches the detector where it is amplified and converted to a digital signal by the A / D converter and amplifier. Since we need a frequency spectrum for analysis the signal is transmitted to the computer where the Fourier conversion is performed ^[2]. The sample cells or pellets we use are made of KBr for hydrophobic samples as it is 100% optically transparent to IR radiation ^[5]. For hydrophilic samples we use ZnSe cells ^[5].

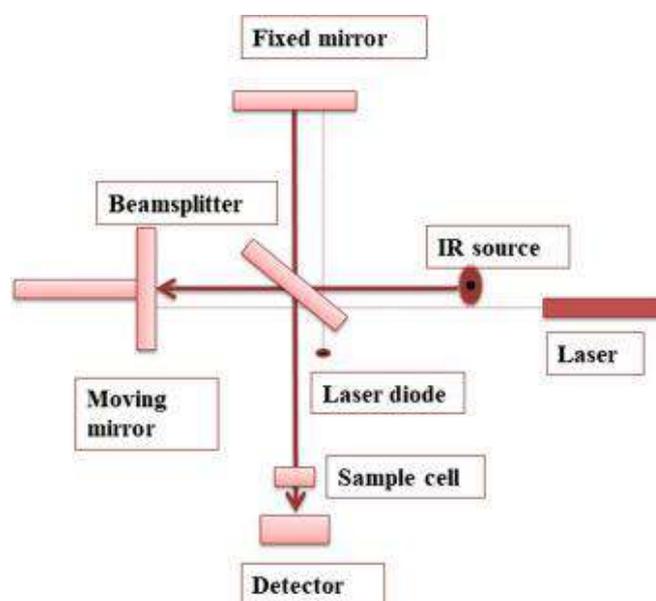


Figure 2.2: Block diagram of FTIR spectrometer

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[4] <https://crridom.gov.in/fourier-transform-infrared-spectroscopy-ftir>

[5]<https://www.researchgate.net/post/Why-we-use-KBr-in-FTIR>

[6] https://en.wikipedia.org/wiki/Fourier-transform_infrared_spectroscopy

CHAPTER 3

RESULT AND DISCUSSION

3.1 XRD ANALYSIS

The XRD pattern of the sample C was taken and compared with the standard JCPDS file (JCPDS entry: 01-089-1011). The obtained peaks are represented by their corresponding miller indices. The most intense peak is at angle 2θ equal to 35.23° and it is from the crystal plane whose miller indices are (311). The observed peaks were at 2θ values 29.91° , 56.64° and 62.21° and the corresponding planes were (220), (511) and (440). The sharpness of the XRD peaks indicate the degree of crystallinity of the synthesized nanoparticles. The other prominent peaks also confirm the face-centered cubic spinel structure of Zinc Ferrite nanoparticles.

The crystallite size of the nanoparticle is calculated using the Debye-Scherrer equation as $D = \frac{k\lambda}{\beta \cos\theta}$

$$D = \frac{0.89 \times 0.154}{\left(1.057 \times \frac{\pi}{180}\right) \times \cos\left(\frac{35.23}{2} \times \frac{\pi}{180}\right)} = 7.42\text{nm}$$

$$D = \frac{0.89 \times 0.154}{\left(0.997 \times \frac{\pi}{180}\right) \times \cos\left(\frac{29.91}{2} \times \frac{\pi}{180}\right)} = 7.87\text{nm}$$

$$D = \frac{0.89 \times 0.154}{\left(1.435 \times \frac{\pi}{180}\right) \times \cos\left(\frac{56.64}{2} \times \frac{\pi}{180}\right)} = 5.47\text{nm}$$

$$D = \frac{0.89 \times 0.154}{\left(1.391 \times \frac{\pi}{180}\right) \times \cos\left(\frac{62.21}{2} \times \frac{\pi}{180}\right)} = 5.64 \text{ nm}$$

2θ (Degree)	β (Degree)	D (nm)
35.23	1.057	7.42
29.91	0.997	7.87
56.64	1.435	5.47
62.21	1.391	5.64

Table 3.1: Calculation of crystallite size

The average crystallite size is found to be 6.6 nm

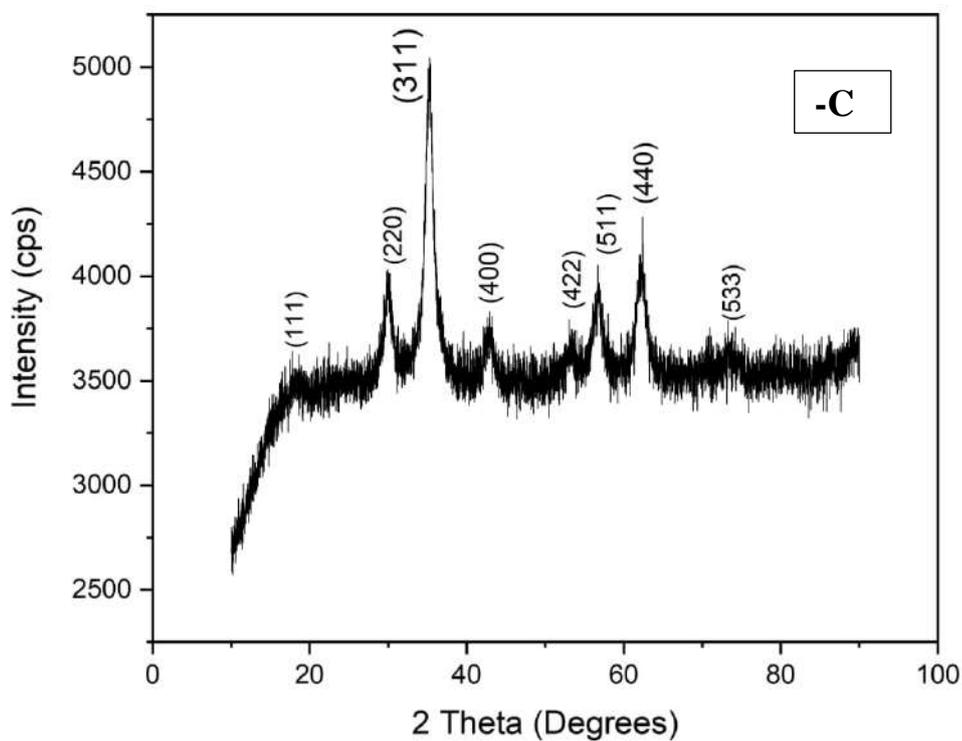
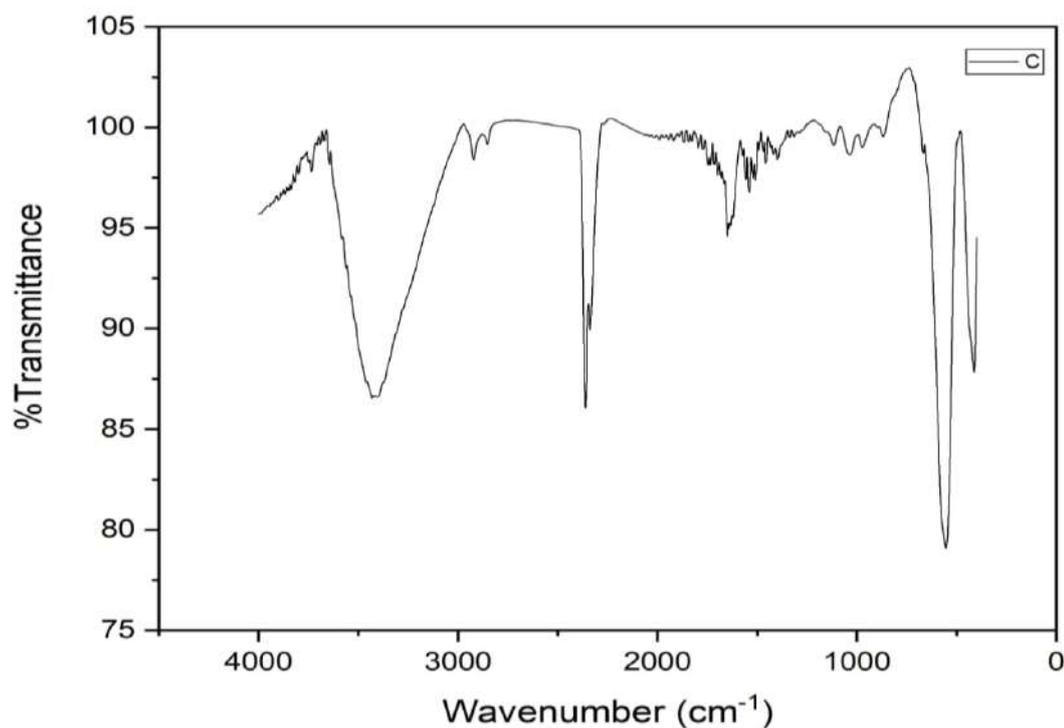


Figure 3.1: X-Ray pattern of bio extract mediated Zinc Ferrite nanoparticle

3.2 FTIR ANALYSIS

FTIR spectrum of ZnFe_2O_4 nanoparticles was recorded in a frequency range of $4000 - 400 \text{ cm}^{-1}$. From the spectrum, information regarding the functional groups present in the synthesized nanoparticle was obtained. IR peak around 3420 cm^{-1} indicates formation of OH bond in the prepared sample^[1]. Peak around 2357 cm^{-1} indicates the presence of C=C double bond stretching vibration^[2]. Peak about 1649 cm^{-1} indicates stretching vibration of C=O bonds^[3]. Peak around 1035 cm^{-1} indicates the carbon hydrogen bond stretching^[1]. IR peak around 415 cm^{-1} is for the lattice vibration of Zn-O stretching bond in the tetrahedral sites. And peak around 551 cm^{-1} indicates the lattice vibration of Fe-O stretching bond in the octahedral sites^[1]. Strong absorption peak observed in the range of $415 - 551 \text{ cm}^{-1}$ conforms the presence of ZnFe_2O_4 nanoparticles in the synthesized material and also reveals the formation of spinel structure^[1].

Figure 3.2: FTIR spectrum of bio extract mediated Zinc Ferrite nanoparticles



3.3 CONCLUSION

In this study, Zinc Ferrite nanoparticles were synthesized using the biosynthesis method which is different from the conventional methods of synthesis. This method has several advantages like being a very simple, inexpensive and eco-friendly method. The by-products are less toxic to the environment as well as us. The bioreducers were used to assist the precursors in the synthesis procedure. Also, characterization studies were carried out using XRD and FTIR. The FTIR studies showed the presence of functional groups and bonds like C=C, C=O, O-H etc. and also confirmed the vibrational stretching of tetrahedral Zn^{2+} and octahedral Fe^{3+} of spinel Zinc Ferrite structure. The XRD studies confirmed the crystalline structure of the synthesized nanoparticles. The synthesis of nanoparticles using the biosynthesis technique is found to be very efficient though it has certain limitations

3.4 FUTURE SCOPE

The biosynthesis technique for the production of nanoparticles is being carried now only in the laboratory scale. Extensive research and studies are required to bring this technique to large scale of production in par with the conventional methods of synthesis. The cost for producing nanoparticles using the biosynthesis method will be considerably lower as the chemicals involved are reduced compared to the conventional methods of synthesis. Zinc Ferrite nanoparticles can be of great use in medical fields due to its biocompatibility. It can be used in various fields. It can be used to enhance the antimicrobial properties of substances. It can also have applications in photocatalysis, Li ion batteries, gas sensors etc. Because of its wide range of possibilities and easy production, studies can be carried out for making use of the biosynthesis technique to its maximum.

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**“A COMPARITIVE STUDY ON EFFECTS OF THERMAL AND
NON-THERMAL PROCESSING METHODS ON NUTRITIONAL
AND ORGANOLEPTIC ASPECTS OF SPIRULINA BASED
SNACK PRODUCTS”**

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*In partial fulfillment of requirements for the award of degree of
Bachelor of Vocational studies*

B. Voc FOOD PROCESSING TECHNOLOGY



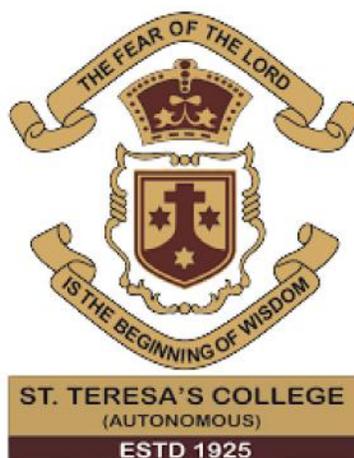
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University Kottayam-686560
2022**

**DEVELOPMENT, STANDARDIZATION AND
ACCEPTABILITY OF NUTRITIOUS BARLEY MORINGA
BREAD FOR DIABETIC PATIENTS**

Dissertation submitted to

ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM



Affiliated to

MAHATMA GANDHI UNIVERSITY, KOTTAYAM

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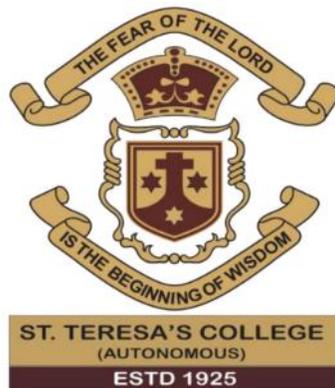
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**HEALTH AND WELL-BEING OF LONG COVID
PATIENTS IN ERNAKULAM DISTRICT OF KERALA**

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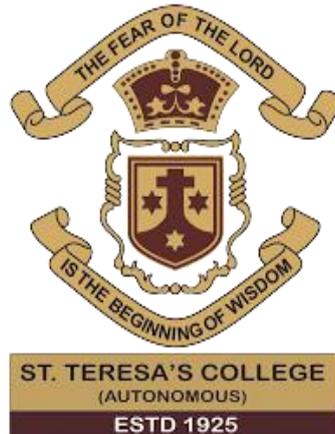
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COVID AFFECTED INDIVIDUALS IN AROOR**

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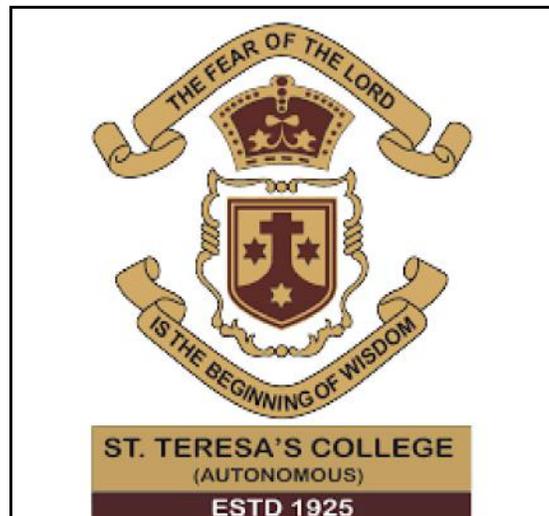
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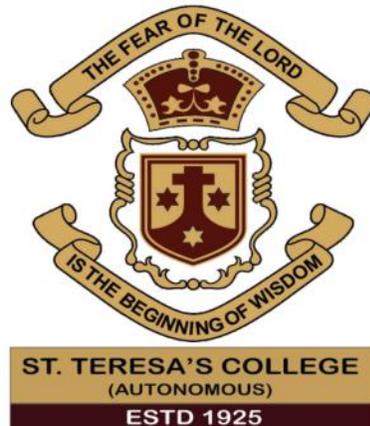
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June 2022

**DEVELOPMENT OF VALUE-ADDED PRODUCTS
FROM MANGO KERNEL FLOUR**

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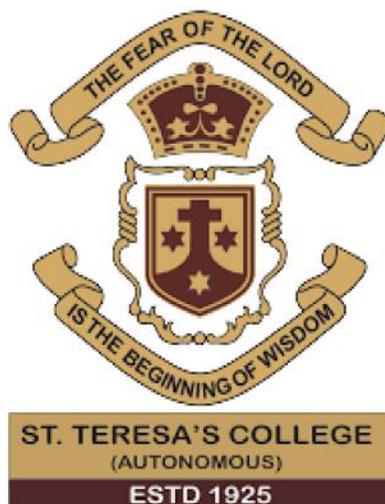
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June 2022

THE IMPACT OF COVID19 ON DIET AND LIFESTYLE AMONG SPORTS STUDENTS

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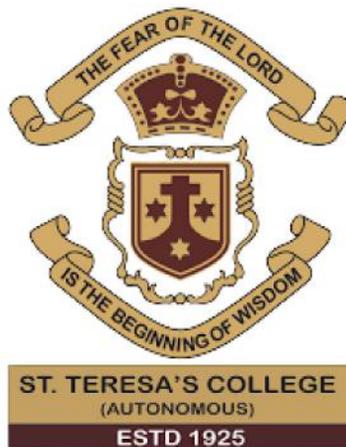
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June 2022

IMPACT OF NUTRITION AND LIFESTYLE ON THE OCCURRENCE OF COVID 19

Dissertation submitted to

ST. TERESA'S COLLEGE (AUTONOMOUS)
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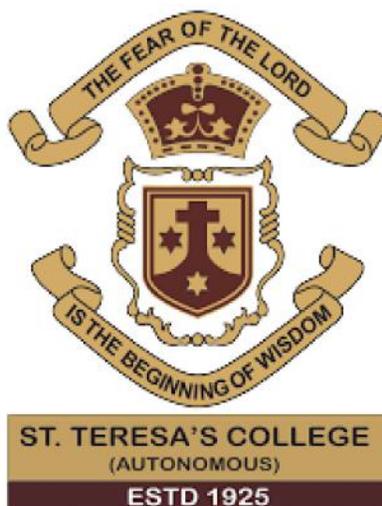
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June 2022

DEVELOPMENT OF VALUE-ADDED PRODUCTS FROM PUMPKIN SEED FLOUR

Dissertation submitted to

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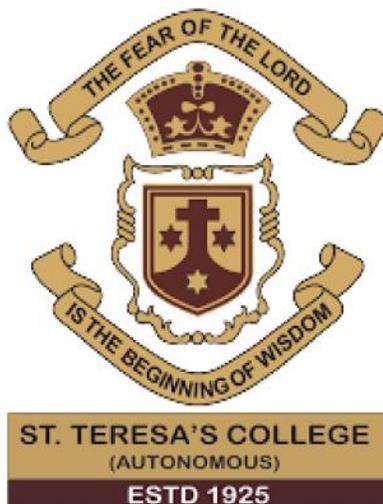
June 2022

STANDARDIZATION OF TUBER BASED NUTRITIONAL BREADS USING YAM AND TARO

Dissertation submitted to

ST. TERESA'S COLLEGE (AUTONOMOUS)

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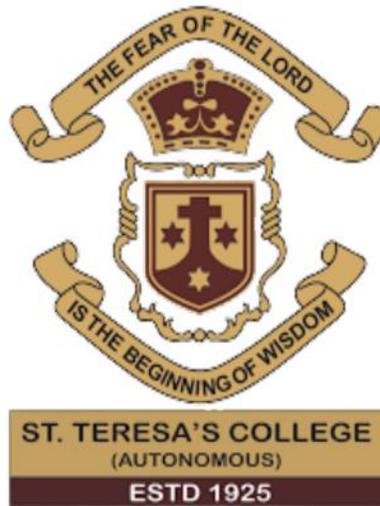
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June 2022

**EVALUATION OF BIOACTIVE ANTIMICROBIAL AND
ANTIOXIDANT PROPERTIES OF ROSE APPLE AND
DEVELOPMENT OF VALUE-ADDED PRODUCTS**

Dissertation submitted to

ST. TERESA'S COLLEGE (AUTONOMOUS)
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**HEALTH AND WELLBEING OF LONG COVID PATIENTS IN
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ST. TERESA'S COLLEGE (Autonomous)
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IN

FOOD SCIENCE AND NUTRITION

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**HOUSE HOLD FOOD SECURITY AMONG BELOW
POVERTY LINE BENEFICIARIES OF PUBLIC
DISTRIBUTING SYSTEM DURING COVID-19 PANDEMIC
PERIOD**

Dissertation submitted to

ST. TERESA'S COLLEGE (AUTONOMOUS)
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Project Report

On

**DATA ANALYSIS ON COVID-19
VACCINATION PROGRESS IN INDIA**

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

APPLIED STATISTICS AND DATA ANALYSIS

by

ANNABEL ANJALA DAVID

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Under the Supervision of

MS.SREELAKSHMI. M. S



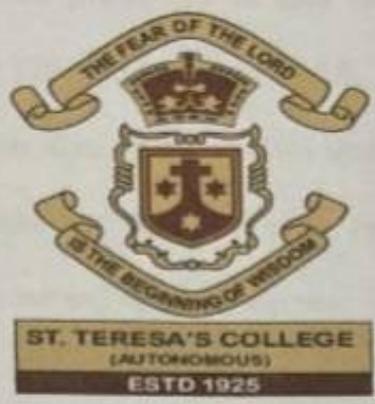
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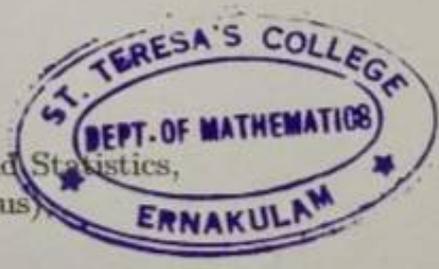


CERTIFICATE

This is to certify that the dissertation entitled, **DATA ANALYSIS ON COVID-19 VACCINATION PROGRESS IN INDIA** is a bonafide record of the work done by Ms. **ANNABEL ANJALA DAVID** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Applied Statistics and Data Analysis** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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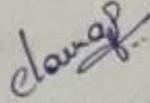
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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of MS. SREELAKSHMI. M. S, Assistant Professor, Department of Mathematics and Statistics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.


ANNABEL ANJALA DAVID

Date: 9.05.2022

SM20AS003

ACKNOWLEDGEMENTS

Primarily I would thank God for helping me to complete this project with success.

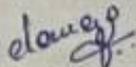
I am very grateful to my project guide Ms.Sreelakshmi M. S for the immense help during the period of work and also giving me a great opportunity to excel in my learning through this project

I have achieved a good amount of knowledge through the research. Also I acknowledge with thanks to faculty, teaching and non-teaching staff of the department and Colleagues.

Apart from this, I would like to express special thanks to my parents who have supported me and helped me out in my project despite their busy schedules.

Ernakulam.

Date: 09/05/2022


ANNABEL ANJALA DAVID

SM20AS003

ABSTRACT

Coronavirus disease 2019 (COVID-19) is a contagious disease caused by a virus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first known case was identified in Wuhan, China, in December 2019. The disease has since spread worldwide, leading to pandemic. Several COVID-19 vaccines have been approved and distributed in various countries, which have initiated mass vaccination campaigns. India began administration of COVID-19 vaccines on 16 January 2021. Covishield, Covaxin and Sputnik V are the vaccines administered in India. Even though several effective vaccines have been introduced there exist small proportion of vaccine hesitancy among people. Study is focused on Covid-19 vaccination progress in India using Exploratory Data Analysis (EDA) using Indian state-wise data and Time series analysis using Indian vaccination data recorded from 16th January 2021 to 7th January 2022. As a result, about 20 vaccination rate has been successfully forecasted using Fb Prophet.

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Chapter 1

Introduction

Coronavirus disease 2019 (COVID-19) is a contagious disease caused by a virus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first known case was identified in Wuhan, China, in December 2019.

In early December 2019, an outbreak of coronavirus disease 2019 (COVID-19), caused by a novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), occurred in Wuhan City, Hubei Province, China. On January 30, 2020 the World Health Organization declared the outbreak as a Public Health Emergency of International Concern. As of February 14, 2020, 49,053 laboratory-confirmed and 1,381 deaths have been reported globally. The disease has since spread worldwide, leading to an ongoing pandemic.

Symptoms of COVID 19 are variable, but often include fever, cough, headache, fatigue, breathing difficulties, loss of smell, and loss of taste. Symptoms may begin one to fourteen days after exposure to the virus. At least a third of people who are infected do not develop noticeable symptoms. Of those people who develop symptoms noticeable enough to be classed as patients, most (81 percentage) develop mild to moderate symptoms up to mild pneumonia, while 14 percentage develop severe symptoms like dyspnea, hypoxia, or more than 50 percentage lung involvement on imaging, and 5 percentage suffer from critical symptoms such as respiratory failure, shock, or multiorgan dysfunction. Older people are at a higher risk of developing severe symptoms.

Some people continue to experience a range of effects (side effects or long COVID) for months after recovery, and damage to organs has been observed.

COVID 19 transmits when people breathe in air contaminated by droplets and small airborne particles containing the virus. The risk of breathing these in is highest when people are in proximity, but they can be inhaled over longer distances, particularly indoors. Transmission can also occur if splashed or sprayed with contaminated fluids in the eyes, nose, or mouth, and, rarely, via contaminated surfaces. People remain contagious for up to 20 days and can spread the virus even if they do not develop symptoms.

Several COVID-19 vaccines have been approved and distributed in various countries, which have initiated mass vaccination campaigns. Other preventive measures include physical or social distancing, quarantining, ventilation of indoor spaces, covering coughs and sneezes, hand washing, and keeping unwashed hands away from the face. The use of face masks or coverings has been recommended in public settings to minimize the risk of transmission.

The first cases of COVID-19 in India were reported on 30 January 2020 in three towns of Kerala, among three Indian medical students who had returned from Wuhan, the epicenter of the pandemic. As of 2 April 2022, according to official figures, India has the second-highest number of confirmed cases in the world.

A COVID 19 vaccine is a vaccine intended to provide acquired immunity against severe acute respiratory syndrome coronavirus 2 (SARS CoV 2), the virus that causes coronavirus disease 2019 (COVID 19). The COVID 19 vaccines are widely credited for their role in reducing the severity and death caused by COVID 19. Many countries have implemented phased distribution plans that prioritize those at highest risk of complications, such as the elderly, and those at high risk of exposure and transmission, such as healthcare workers.

India began administration of COVID-19 vaccines on 16 January 2021. As of 3 April 2022, India has administered over 1.8 billion doses over-

all, including first, second and precautionary (booster) doses of the currently approved vaccines. In India, 91 percentage of the eligible population (12+) has received at least one shot, and 77 percentage of the eligible population (12+) is fully vaccinated. India initially approved the Oxford–AstraZeneca vaccine manufactured under license by Serum Institute of India under the trade name Covishield and Covaxin a vaccine developed locally by Bharat Biotech. They have since been joined by the Sputnik V.

A brief study about Covid-19 vaccination hesitancy among people in India is done. Exploratory Data Analysis is used in Indian state-wise vaccination data to perform data analysis also to get an overview about the vaccination distribution among various states and union territories in India. FBProphet of Time series Analysis is used for forecasting Covid-19 vaccination progress in India.

1.1 OBJECTIVES

Data analysis on Covid-19 vaccination progress in India using both National and State-wise data.

1.1.1 Exploratory Data Analysis-EDA

1.1.2 Time Series Analysis

Chapter 2

Literature Review

Forecasting the spread of the COVID-19 pandemic in Saudi Arabia using ARIMA prediction model under current public health interventions (April 2020) by Saleh et al published by Biomedical Engineering Department, College of Engineering, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31451, Saudi Arabia. In this article they use various mathematical and machine learning-based prediction models to estimate the future trend Covid-19 pandemic. Here they employed the Autoregressive Integrated Moving Average (ARIMA) model to forecast the expected daily number of COVID-19 cases in Saudi Arabia in the next four weeks. Initially performed four different prediction models; Autoregressive Model, Moving Average, a combination of both (ARMA), and integrated ARMA (ARIMA), to determine the best model fit, and found out that the ARIMA model outperformed the other models. The forecasting results showed that the trend in Saudi Arabia will continue growing and may reach up to 7668 new cases per day and over 127,129 cumulative daily cases in a matter of four weeks if stringent precautionary and control measures are not implemented to limit the spread of COVID-19.

The COVID-19 Vaccines: Recent Development, Challenges and Prospects by Yuxin Yan 1 et al published in China (April 2021) discussed about the current world pandemic: The highly infectious coronavirus disease

2019 (COVID-19) associated with the pathogenic severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This journal reflects the crucial role of Covid-19 Vaccine for the world to return to the pre-pandemic normalcy and a collective global effort has been invested into protection against SARS-CoV-2. It shows that as of March 2021, thirteen vaccines have been approved for application whilst over 90 vaccine candidates are under clinical trials. This review focuses on the development of COVID-19 vaccines and highlights the efficacy and vaccination reactions of the authorized vaccines. The mechanisms, storage, and dosage specification of vaccine candidates at the advanced stage of development are also critically reviewed together with considerations for potential challenges.

Time series forecasting of Covid-19 using deep learning models: India-USA comparative case study by Sourabh Shastri and Vibhakar Mansotra (November 2020). This study predicts the future conditions of novel Coronavirus to recede its impact using deep learning based comparative analysis of Covid-19 cases in India and USA by taking datasets of confirmed and death cases of Covid-19 into account. The recurrent neural network (RNN) based variants of long short term memory (LSTM) such as Stacked LSTM, Bi-directional LSTM and Convolutional LSTM are used to design the proposed methodology and forecast the Covid-19 cases for one month ahead. Convolution LSTM outperformed the other two models and predicts the Covid-19 cases with high accuracy and very less error for all four datasets of both countries along with upward/downward trend of forecasted Covid-19 cases are also visualized graphically.

Predicting intention to receive COVID-19 vaccine among the general population using the health belief model and the theory of planned behavior model by Liora Shmueli (2021). This study aims to explore the

intentions, motivators, and barriers of the public to vaccinate against COVID-19, using both the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) model. An online survey was conducted among Israeli adults aged 18 years based on socio-demographic and health-related questions, questions related to HBM and TPB dimensions, and intention to receive a COVID-19 vaccine. Associations between questionnaire variables and COVID-19 vaccination intention were assessed by univariate and multivariate analyses. The results are 80 percentage of 398 eligible respondents stated their willingness to receive COVID-19 vaccine.

Correlates and Disparities of COVID-19 Vaccine Hesitancy by Timothy Callaghan, Jennifer A. Lueck, Peter J. Hotez (August 2020). The objective of the study is to understand the correlates of COVID-19 vaccine hesitancy in the American public and the reasons why individuals intend to refuse a COVID-19 vaccine. Here they rely on a demographically representative survey of 5,009 American adults and then analyzed the influence of demographic factors, political ideology, and COVID-19 experiences on COVID-19 vaccine hesitancy. The results are about 31.1 percentage of Americans do not intend to pursue getting vaccinated when a COVID-19 vaccine becomes available. People who are more concerned about COVID-19 were less likely to refuse the vaccine. The two most cited reasons for refusal are concerns about vaccine safety, and effectiveness in which women are most likely to be hesitant.

Time Series Analysis: Forecast COVID-19 Vaccination Rate by dayanabenny (2021). The article surveyed about the current progress of tracking Coronavirus vaccinations around the world. It came to know that more than 950 million times COVID-19 vaccine doses have been administered all over the world and it is about 12 doses for every 100 folks. They conducted a research study regarding the country-wise forecast-

ing of vaccination rate to determine when all the people in the country will be vaccinated. ARIMA model of time series analysis was used for forecasting.

COVID-19 World Vaccination Progress Using Machine Learning Classification Algorithms by Nasiba M et al The study was focus on the COVID-19 World Vaccination Progress using Machine learning classification Algorithms. The findings of the paper showed which algorithm is better for a given dataset. Weka is used to run tests on real-world data, and four output classification algorithms Decision Tree, K-nearest neighbors, Random Tree, and Naive Bayes were used to analyze and draw conclusions. The comparison was based on accuracy and performance period, and it was discovered that the Decision Tree outperforms other algorithms in terms of time and accuracy.

COVID-19 vaccine hesitancy – reasons and solutions to achieve a successful global vaccination campaign to tackle the ongoing pandemic by Kuldeep Dhama, Khan Sharun, Ruchi Tiwari (April 2021). The article shows the importance of coronavirus disease (COVID-19) vaccination drive which aims to achieve global vaccination coverage that will help to control the pandemic. Therefore, the individuals who are reluctant to be vaccinated or forego COVID-19 vaccination can delay the progress of overall vaccination coverage, leading to slower vaccination rates and may create obstacles in global efforts to control the circulation of SARS-CoV-2 as unvaccinated individuals can act as reservoirs of SARS-CoV-2 and could drive further outbreaks. Vaccine hesitancy is one of the major threats that directly impact global health as it challenges our ability to eradicate infectious diseases and achieve significant herd immunity through vaccination. One of the strategies to counter vaccine hesitancy is to follow a multisectoral approach that involves the collaboration between various stakeholders, such as government,

private companies, religious groups, and other agencies, to leverage the knowledge, expertise, and resources, thereby enabling the creation of longstanding public trust of vaccines.

Chapter 3

DATA DESCRIPTION AND PREPROCESSING

3.1 DATA DESCRIPTION

3.1.1 INDIAN STATE-WISE VACCINATION DATA

The data has a total of thirty-seven observations with six response variables. Thirty-seven observations are Indian States and Union Territories namely, Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Chhattisgarh, Dadra and Nagar Haveli, Daman and Diu, NCT of Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Ladakh, Lakshadweep, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Puducherry, Punjab, Rajasthan, Sikkim, Tamil Nadu, Telangana, Tripura, Uttar Pradesh, Uttarakhand, West Bengal.

1	State_or_UT	Population	Dose_1	Dose_2	Cumulative_Dose	Atleast_1dose_Percentage	Fully_Vaccinated
2	Andaman and Nicobar	380581	14934	5068	20002	3.92	1.33
3	Andhra Pradesh	49577103	1643888	328146	1972034	3.16	0.66
4	Arunachal Pradesh	1383727	58119	17474	75593	4.2	1.26
5	Assam	31205576	716328	120799	837127	2.3	0.39
6	Bihar	104099452	1835841	409195	2245036	1.76	0.39
7	Chandigarh	1055450	59614	9719	69333	5.65	0.92
8	Chhattisgarh	25545198	1197167	291767	1488934	4.69	1.14
9	Dadra and Nagar Haveli	343709	9682	2166	11848	2.82	0.63
10	Daman and Diu	243247	10884	1606	12490	4.47	0.66
11	NCT of Delhi	16787941	874509	219920	1094429	5.21	1.31
12	Goa	1458545	84491	14521	99012	5.79	1
13	Gujarat	60439692	3759854	621960	4381814	6.22	1.03
14	Haryana	25351462	1070888	142762	1213650	4.22	0.56
15	Himachal Pradesh	6864602	325647	87548	413195	4.74	1.28
16	Jammu and Kashmir	12267032	537307	124190	661497	4.38	1.01
17	Jharkhand	32988134	1130183	213445	1343628	3.43	0.65
18	Karnataka	61095297	2631127	398417	3029544	4.31	0.65
19	Kerala	33406061	2260396	358455	2618851	6.77	1.07
20	Ladakh	274000	39015	6146	45161	14.24	2.24
21	Lakshadweep	64473	4411	2052	6463	6.84	3.18
22	Madhya Pradesh	72626809	2453554	478784	2932338	3.38	0.66
23	Maharashtra	113274333	4343646	671138	5014784	3.85	0.66

fig:3.1

State or UT: Indian States and Union Territories.

Population: Population of each state or union territories.

Dose 1: Number of people who have received Dose 1 vaccination in each State or Union Territories.

Dose 2: Number of people who have received Dose 2 vaccination in each State or Union Territories.

Cumulative Dose: Total number of vaccinations administered in each State or Union Territories.

At least 1dose Percentage: Percentage of number of people who have received at least Dose 1 vaccination.

Percentage Fully Vaccinated: Percentage of number of people who have received Dose 1 and Dose 2 vaccinations.

3.1.2 INDIAN VACCINATION DATA

The data consist of 358 observations and ten variables. Observations are taken starting from the date 15th January 2021 to 7th January 2022.

	A	B	C	D	E	F	G	H	I	J	K	L
1	date	total_vacc	people_v	people_fu	daily_vacc	daily_vacc	total_vacc	people_v	people_fu	daily_vaccinations_per_million		
2	15/01/2021	0	0				0	0				
3	16/01/2021	191181	191181		191181	191181	0.01	0.01		137		
4	17/01/2021	224301	224301		33120	112150	0.02	0.02		80		
5	18/01/2021	454049	454049		229748	151350	0.03	0.03		109		
6	19/01/2021	674835	674835		220786	168709	0.05	0.05		121		
7	20/01/2021	806484	806484		131649	161297	0.06	0.06		116		
8	21/01/2021	1043534	1043534		237050	173922	0.07	0.07		125		
9	22/01/2021	1390592	1390592		347058	198656	0.1	0.1		143		
10	23/01/2021	1582201	1582201		191609	198717	0.11	0.11		143		
11	24/01/2021	1615504	1615504		33303	198743	0.12	0.12		143		
12	25/01/2021	2023809	2023809		408305	224251	0.15	0.15		161		
13	26/01/2021	2029480	2029480		5671	193521	0.15	0.15		139		
14	27/01/2021	2355979	2355979		326499	221356	0.17	0.17		159		
15	28/01/2021	2928053	2928053		572074	269217	0.21	0.21		193		
16	29/01/2021	3500027	3500027		571974	301348	0.25	0.25		216		
17	30/01/2021	3744334	3744334		244307	308876	0.27	0.27		222		
18	31/01/2021	3758843	3758843		14509	306191	0.27	0.27		220		
19	01/02/2021	3950156	3950156		191313	275192	0.28	0.28		197		
20	02/02/2021	4138918	4138918		188762	301348	0.3	0.3		216		
21	03/02/2021	4449552	4449552		310634	299082	0.32	0.32		215		
22	04/02/2021	4959445	4959445		509893	290199	0.36	0.36		208		

fig:3.2

date: Dates of vaccinations administrated in India.

total vaccinations: Total number of vaccinations administrated including dose 1 and dose 2.

people vaccinated: Number of people who have received vaccinations.

people fully vaccinated: Number of people who have received both the vaccinations.

daily vaccinations raw: Number of people who have received vaccinations on a particular day.

daily vaccinations: Number of daily vaccinations.

total vaccinations per hundred: Total number of vaccinations administered on a scale of 100.

people vaccinated per hundred: Number of people who have received vaccinations on a scale of 100.

people fully vaccinated per hundred: Number of people who have received both the vaccinations on a scale of 100.

Daily vaccinations per milion: Number of daily vaccinations per milion.

3.2 DATA PREPROCESSING

One of the important steps in information discovery is data preprocessing. Data preprocessing is a data mining technique which is used to transform the raw data in a useful and efficient format. It can also refer to manipulation or dropping of data before it is used in order to ensure or enhance performance, and is an important step in the data mining process. Analyzing data that has not been carefully screened for preprocessing can produce misleading results. Thus, the representation and quality of data is first and foremost before running any analysis. Often, data preprocessing is the most important phase of a machine learning project. Data preprocessing is performed If there is much irrelevant and redundant information present or noisy and unreliable data, then knowledge discovery during the training phase is more difficult. It may affect the way in which outcomes of the final data processing can be interpreted. This aspect should be carefully considered when interpretation of the results is a key point.

Data preprocessing is done by importing the necessary libraries like numpy, panda and matplotlib. The dataset has been imported and checked for the missing values and noised.

3.2.1 DATA 1: Indian State-wise Vaccination dataset

Checking for null values

```
[ ] dataset.isnull().sum()

State_or_UT          0
Population           0
Dose_1               0
Dose_2               0
Cumulative_Dose     0
Atleast_1dose_Percentage 0
Percentage_Fully_Vaccinated 0
dtype: int64
```

fig:3.3

There are no null values

Indian state-wise vaccination dataset was already preprocessed by previous researchers for other analysis. So, to perform exploratory data analysis the dataset is free of noises.

3.2.2 Data 2: Indian vaccination Progress dataset

In the case of Indian vaccination progress dataset, initially it was world vaccination progress dataset with almost 40,000 observations of several countries. Here the problem under study is forecasting Indian vaccination progress. So, the observations of other countries are noises. The Indian vaccination progress dataset also has noises like time format was not in standard form, need to sorting Indian vaccination observations from world dataset, lots of irrelevant data and missing values.

Changed time format to standard form using pandas

fig:3.4

Sorted India from data using pull data function in google sheets

Cleaning data by removing unwanted columns manually

- (1) Iso code because in this every iso code value is India
- (2) Country column
- (3) Source name because all details are from Government of India site
- (4) Website which is irrelevant
- (5) Vaccine name because due to irrelevance.

Checking for null values

There are various null values in the data set. Null values are filled using `data.fillna("0")` function.

```

▶ data.isnull().sum()

date                0
total_vaccinations 11
people_vaccinated   11
people_fully_vaccinated 40
daily_vaccinations_raw 22
daily_vaccinations  1
total_vaccinations_per_hundred 11
people_vaccinated_per_hundred 11
people_fully_vaccinated_per_hundred 40
daily_vaccinations_per_million  1
dtype: int64
    
```

fig:3.5

```

[ ] df=data.fillna("0")
df
    
```

	date	total_vaccinations	people_vaccinated	people_fully_vaccinated	daily_vaccinations_raw	daily_vaccinations	tot
0	2021-01-15	0	0	0	0	0	0
1	2021-01-16	191181	191181	0	191181	191181	191181
2	2021-01-17	224301	224301	0	33120	112150	112150
3	2021-01-18	454049	454049	0	229748	151350	151350
4	2021-01-19	674835	674835	0	220786	168709	168709
...
353	2022-01-03	1.46453e+09	8.52571e+08	6.11955e+08	7.93994e+06	6.58272e+06	6.58272e+06
354	2022-01-04	1.47233e+09	8.57789e+08	6.14542e+08	7.8041e+06	6.60864e+06	6.60864e+06

fig:3.6

Chapter 4

EXPLORATORY DATA ANALYSIS

Exploratory data analysis is an approach of analyzing data sets to summarize their main characteristics, often using statistical graphics and other data visualization methods. A statistical model can be used or not, but primarily EDA is for seeing what the data can tell us beyond the formal modeling or hypothesis testing task.

Indian State-wise vaccination data is used for analysis. Here comparison between different states of India has been done to get an insight about the vaccination progress.

Fig.4.1 gives the graphical representation of distribution of first dose of vaccine among each state and union territories.

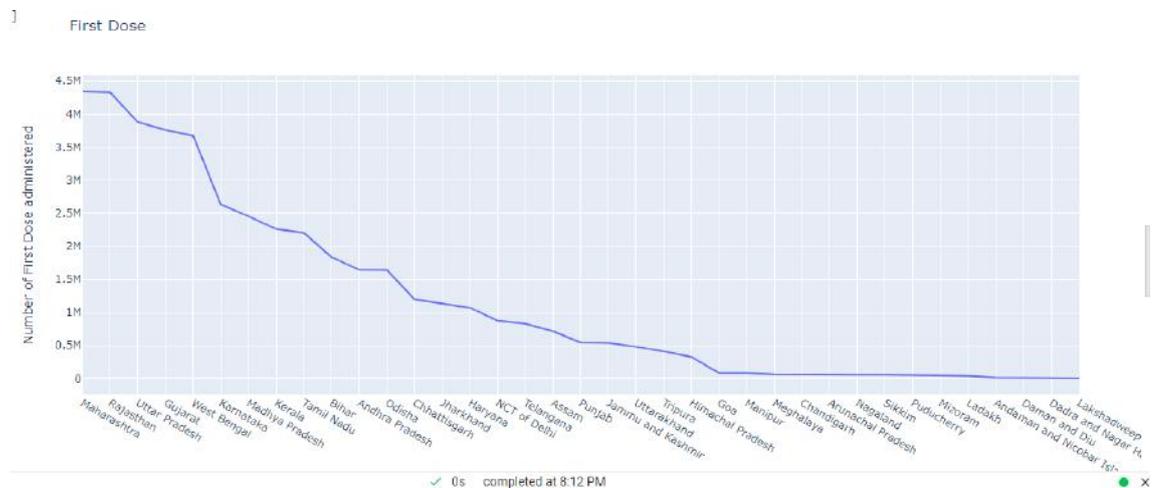


fig:4.1

The graphical representation of distribution of Second dose of vaccine among each state and union territories are shown in fig.4.2

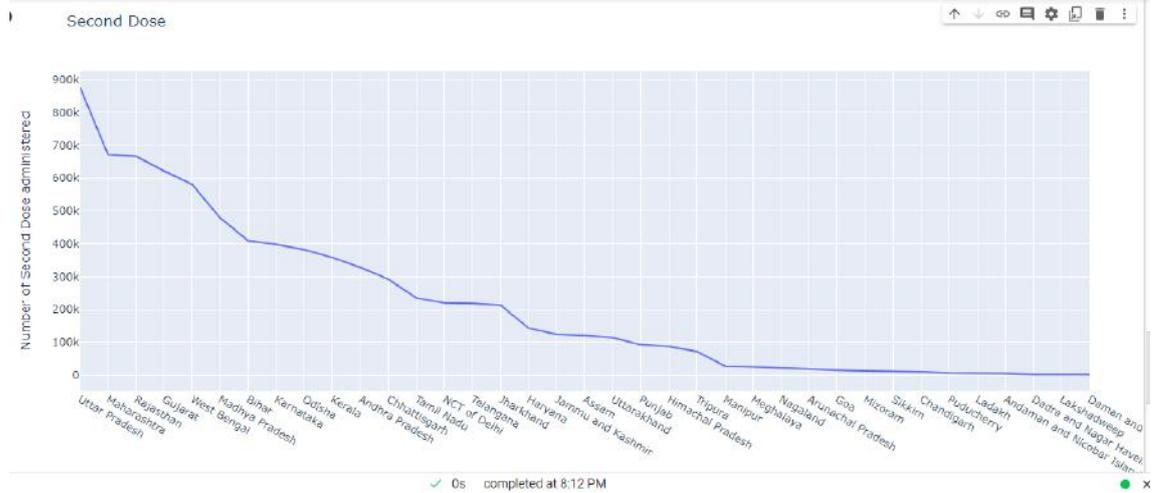


fig:4.2

The following figure (fig.4.3) gives the comparison between first dose and second dose of vaccination within country.

It is clear that the Maharashtra has the administrated highest number of Dose-1 vaccination and in the case of Dose-2 vaccination Uttar Pradesh stand's first.

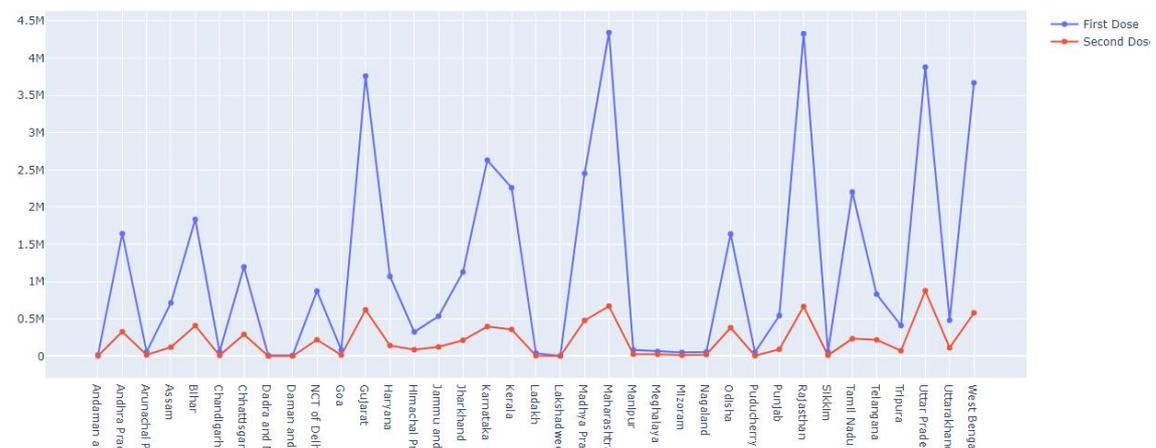


fig:4.3

Top ten states or union territories with highest vaccination drive

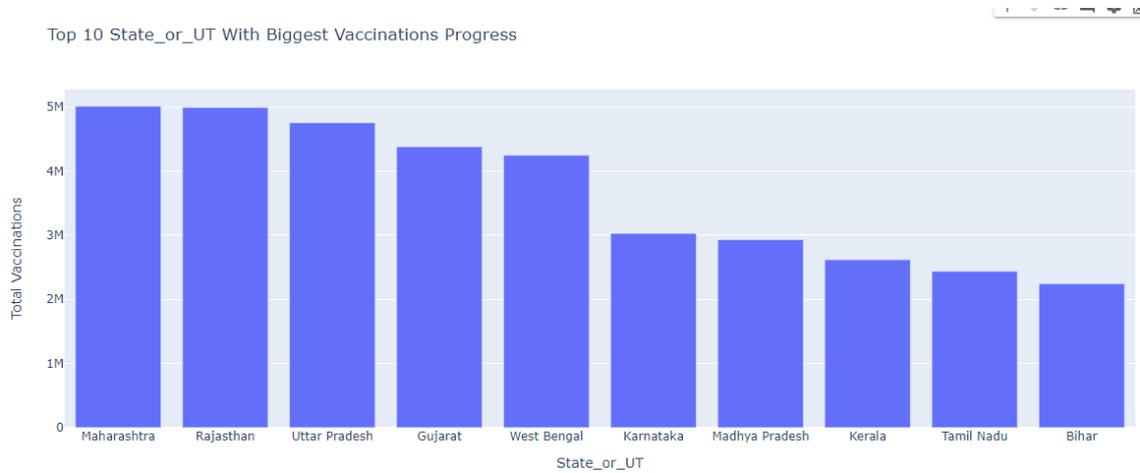


fig:4.4

	State_or_UT	Cumulative_Dose
20	Maharashtra	5014774
29	Rajasthan	4994574
34	Uttar Pradesh	4756799
10	Gujarat	4381814
36	West Bengal	4250140
15	Karnataka	3029544
19	Madhya Pradesh	2932338
16	Kerala	2618851
31	Tamil Nadu	2438253
4	Bihar	2245036

fig:4.5

Maharashtra, Rajasthan, Uttar Pradesh, Gujarat, West Bengal, Karnataka, Madhya Pradesh, Kerala, Tamil Nadu, and Bihar are the states or union territories with highest vaccination progress.

Top ten states or union territories with lowest vaccination drive

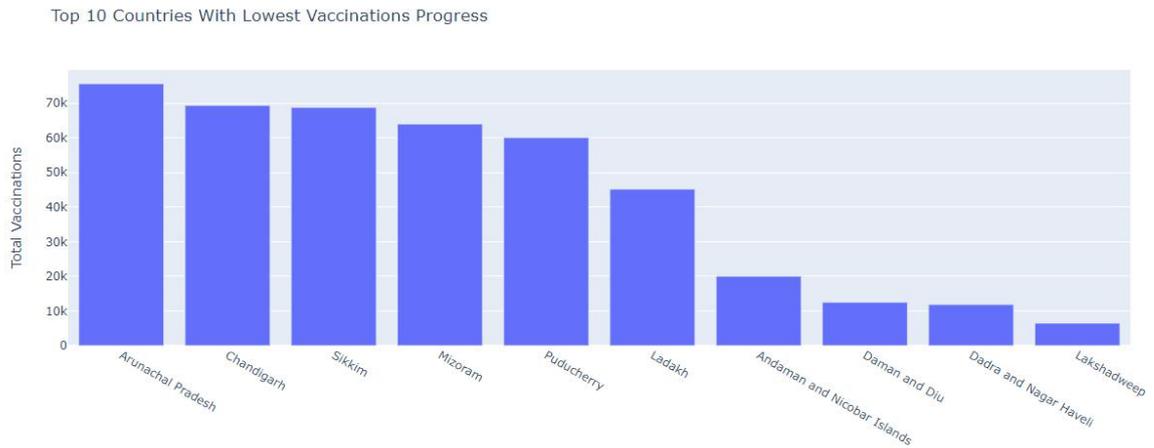


fig:4.6

	State_or_UT	Cumulative_Dose
2	Arunachal Pradesh	75593
5	Chandigarh	69333
30	Sikkim	68762
23	Mizoram	63939
27	Puducherry	60041
17	Ladakh	45161
0	Andaman and Nicobar Islands	20002
8	Daman and Diu	12490
7	Dadra and Nagar Haveli	11848
18	Lakshadweep	6463

fig:4.6

States or union territories with lowest vaccination progress are Arunachal Pradesh, Chandigarh, Sikkim, Mizoram, Puducherry, Ladakh, Andaman and Nicobar Islands, Daman and Diu, Dadra and Nagar Haveli and Lakshadweep.

Chapter 5

TIME SERIES FORECASTING

5.1 FORECASTING USING FB PROPHET

Time series analysis is a specific way of analyzing a sequence of data points collected over an interval of time. In time series analysis, analysts record data points at consistent intervals over a set of time rather than just recording the data points intermittently or randomly. Time-series data is a kind of data that has data points indexed or sequenced in time-based order. Time-series forecast itself is one of the methods to create a model for predicting future values based on current and historical time series data.

Someone with less knowledge of time-series forecasting skill can do time series forecasting. That's why Facebook open-sourced its package called FBProphet. It's a tool intended to do time series forecasting.

FBProphet uses decomposable time series model with 3 main components: seasonal, trends, holidays or events effect and error which are combined into this equation:

$$f(x) = g(x) + s(x) + h(x) + e(t)$$

In this project time series forecast using FBProphet is done by taking Indian vaccination progress dataset with variable under consideration is total vaccination. The observations are taken from 15th January 2021 to 7th January 2022. Forecasting is done for about 20 days.

In this study time series analysis and forecast is performed in python

using FBProphet. Indian Vaccination data is used for forecasting. From 16th January 2021 to 1st December 2021 is taken to train the dataset. Forecasting is done for twenty days that is till 27th January 2022. There is no large variation between predicted value and actual value.

FBProphet predicts that as of 27th January 2022 about 924244879 that is about 65 percentage people in India have been vaccinated and attained immunity against COVID-19 pandemic.

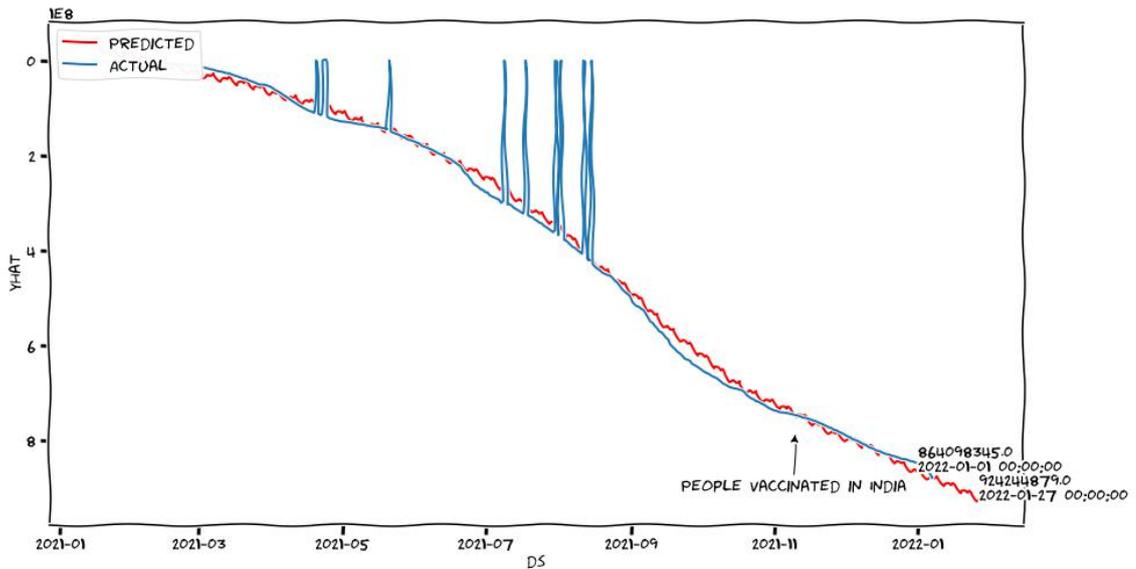


fig:4.1

Taking total number of vaccination administered in India, it is clear from figure 4.2 that there is no large variation between actual value and predicted value. So, we can conclude that by 27th January 2022 almost 1626840637 people in India will be vaccinated.

The forecast is shown below

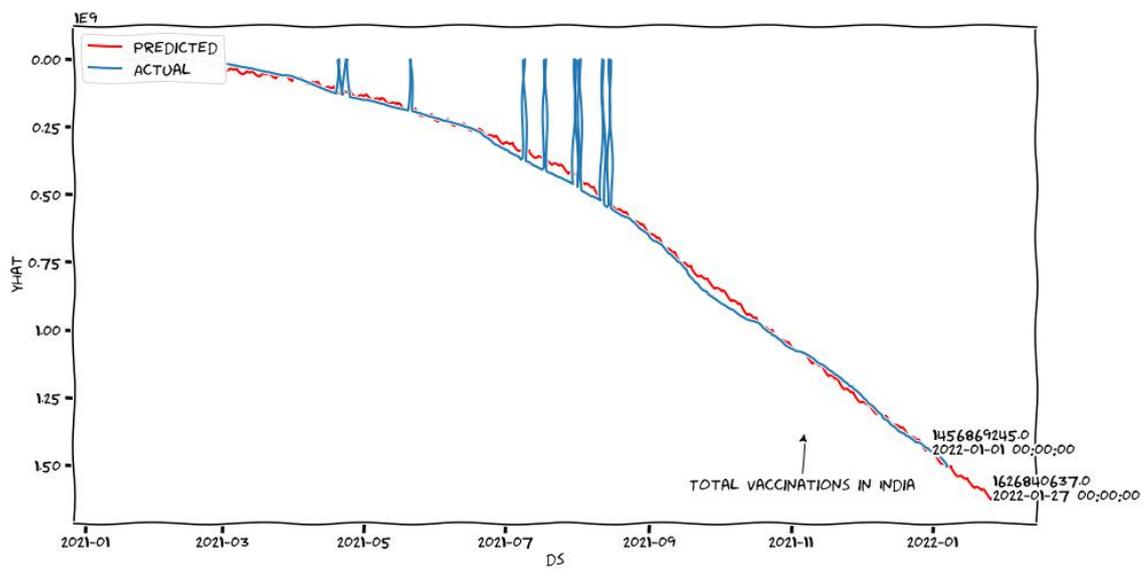


fig:4.2

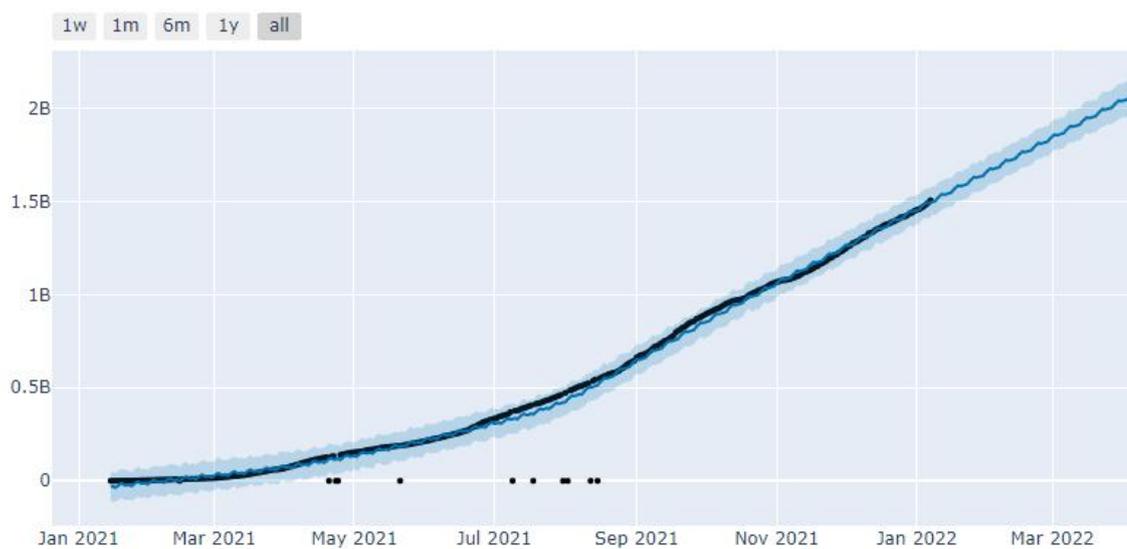


fig:4.3

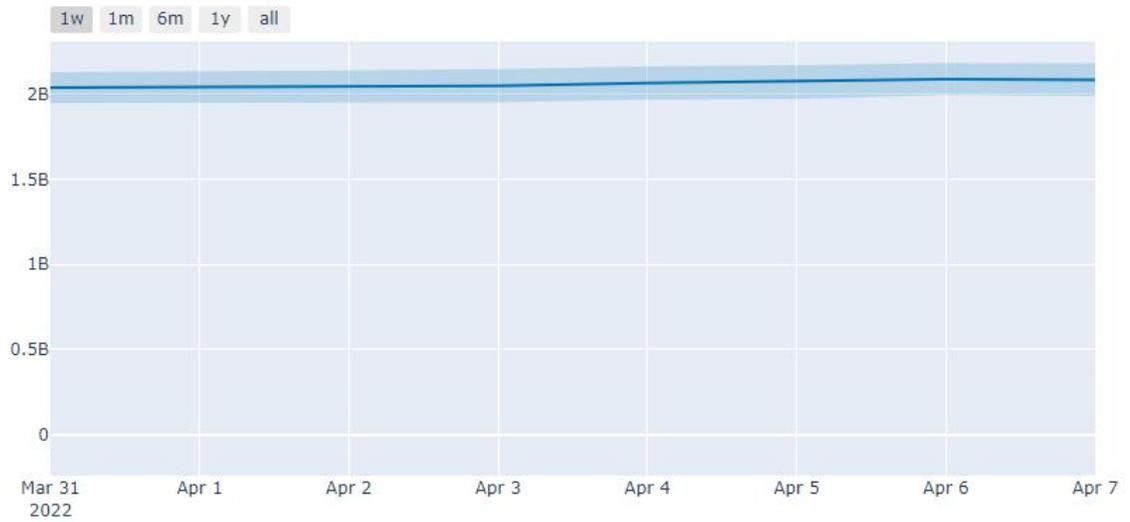


fig:4.4

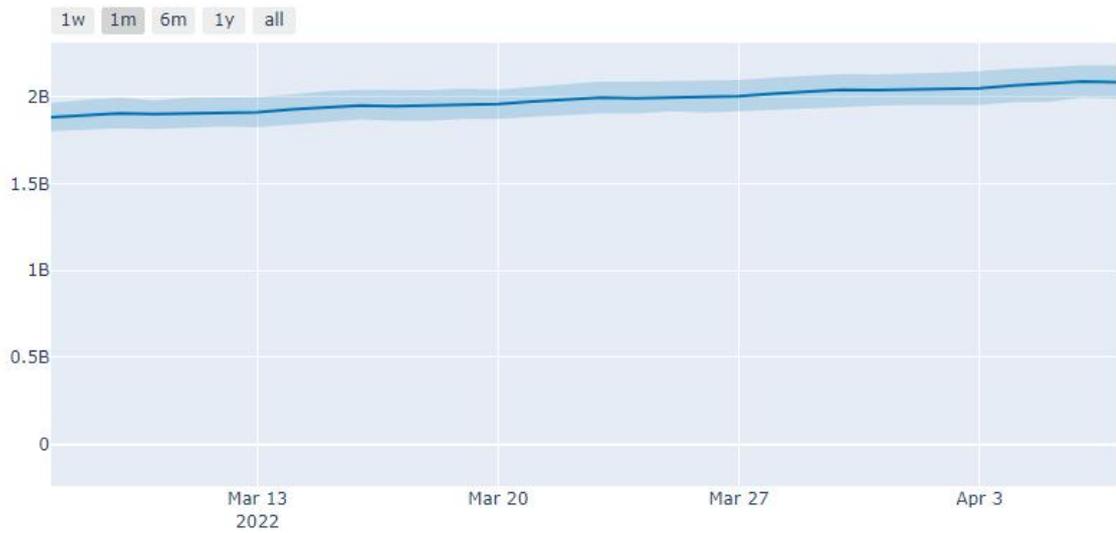


fig:4.5

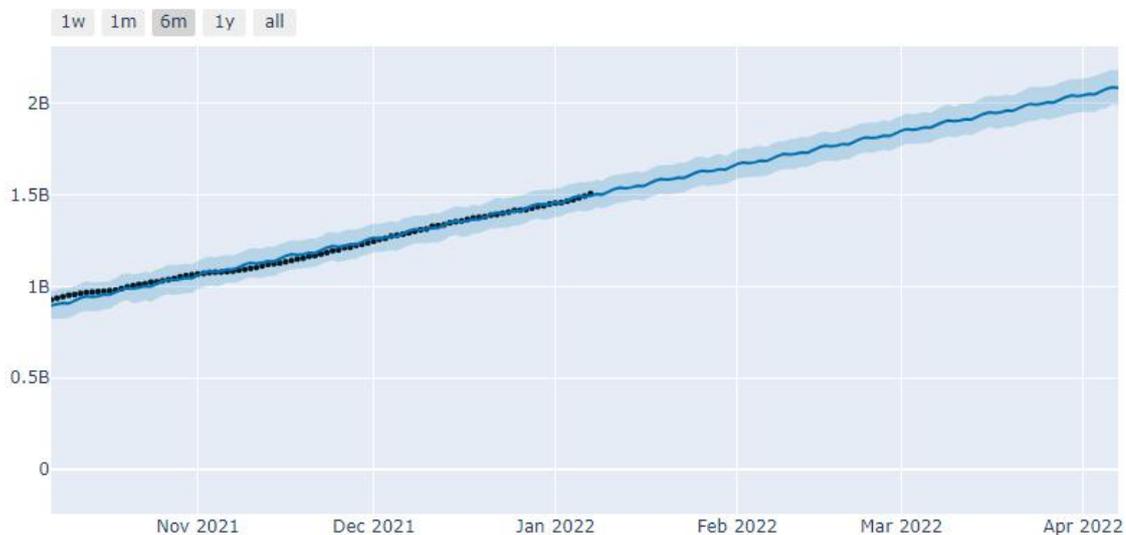


fig:4.6



fig:4.7

Chapter 6

CONCLUSION

Analysis and forecasting of Covid-19 vaccination progress is an important part in this current pandemic. Vaccination against Covid-19 is particularly important to attain herd immunity.

Exploratory data analysis gives the clear picture about the state-wise vaccination progress in India. Maharashtra, Rajasthan, Uttar Pradesh, Gujarat, West Bengal, Karnataka, Madhya Pradesh, Kerala, Tamil Nadu, and Bihar are the states or union territories with highest vaccination progress.

Arunachal Pradesh, Chandigarh, Sikkim, Mizoram, Puducherry, Ladakh, Andaman and Nicobar Islands, Daman and Diu, Dadra and Nagar Haveli and Lakshadweep are the states or union territories with lowest vaccination progress. Maharashtra has the highest vaccination progress whereas Lakshadweep has the lowest.

Time series forecasting using FBProphet gives the forecast for 20 days during the month of January 2022. It says that by 27th January 2022 almost 65 percentage people in India will be vaccinated against COVID-19 Vaccination. India will attain herd immunity if 75 percentage of the population are vaccinated against covid-19.

This is the phase where we can say that Indian are partially safe from covid-19 pandemic.

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Project Report

On

MATERNAL HEALTH RISK ANALYSIS

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

APPLIED STATISTICS AND DATA ANALYTICS

by

NAVYA SUSAN THOMAS

(Register No. SM20AS017)

(2020-2022)

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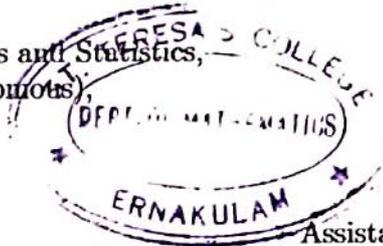


CERTIFICATE

This is to certify that the dissertation entitled, **MATERNAL HEALTH RISK ANALYSIS** is a bonafide record of the work done by Ms. **NAVYA SUSAN THOMAS** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Applied Statistics and Data Analytics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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External Examiners

1: *Kunankon*

2: *m/4/13/22*
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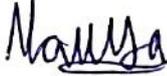
26/05/2022

DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of **SREELAKSHMI M S** , Assistant Professor, Department of Mathematics and Statistics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.

Date: 09/05/2022


NAVYA SUSAN THOMAS

SM20AS017

ACKNOWLEDGEMENTS

I would like to mention my teachers, friends and family for their continuous invaluable and knowledgeable guidance throughout the course of this study. It helped me to complete the work upto this stage.

I am very grateful to my project guide Ms.Sreelakshmi M.S for the immense help during the period of work.

In addition, the very energetic and competitive atmosphere of the Department had much to do with this work. I acknowledge with thanks to the faculty, teaching and non-teaching staff of the department and my colleagues.

I am also very thankful to the HoD for her valuable suggestions, and critical examination of work during the progress.

Ernakulam.

Date: 09/05/2022


NAVYA SUSAN THOMAS
SM20AS017

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Chapter 1

Introduction

The project topic is Maternal Health Risk Analysis. Maternal health refers to the health of women during pregnancy, childbirth and the postnatal period. Crores of pregnant women are dying due to maternal mortality in India especially the women in village,rural areas.

In this project we are going to use a particular maternal health risk data set that we have obtained.We are going to analyze and classify the data to find out which attributes contribute to high risk during pregnancy so as to provide medical care accordingly. Women living in the rural areas have lack of transportation facilities, nearby hospitals with proper medical facilities.This contributes to maternal mortality as they are unable to get proper medical care at the right time.Keeping track of the important vitals that influence healthy pregnancy is very essential.

If we can identify the attributes that indicate high risk then we can reduce mortality rates by alerting the medical authorities.

1.1 Objectives

Our main aim is to reduce maternal mortality rate. This is achieved by taking care of pregnant women once we identify the risk parameters associated with pregnancy.Then the women can treat those risk parameters accordingly and keep them in check.

1.1.1 Specific objectives

- 1) To classify risk intensity level in pregnant women using support vector machine and logistic regression multi class classification algorithm.**
- 2) To compare the performance analysis of both the models.**

Chapter 2

Literature Review

Some of the literature reviews done are

In ‘Review and Analysis of Risk Factor of Maternal Health in Remote Area Using the Internet of Things’, Marzia Ahmed, Sabira Khatun, Mostafijur Rahman et al.(,2020) sheds light on an important topic. This paper demonstrates effective monitoring of pregnant women mostly in a rural area of a developing country, with the help of wearable sensing enabled technology, which also notifies the pregnant women and her family about the health conditions. This research intends to use machine learning algorithms for discovering the risk level on the basis of risk factors in pregnancy.

In this research, an existing dataset (Pima-Indian-diabetes dataset) has been used for the analysis of risk factor and comparison of some machine learning algorithm shows that Logistic Model Tree (LMT) gives the highest accuracy in case of classification and prediction of the risk level.

Regardless, few selected pregnant women’s data have been collected (through IoT enabled devices) and the same process also applied for this dataset also by using LMT. Comparison results show that the prediction of risks is the same for the existing and real dataset.

The software tool used for data mining is Waikato Environment for Knowledge Analysis (Weka) It is developed by University of Waikato in New Zealand, which contains a large number of algorithms and imagining tools for data preprocessing and predicting the accuracy of the new

model. It supports data mining tasks such as classification, regression, visualization, clustering, and feature selection.

In this paper they utilize IoT to obtain LMT as the model with highest accuracy of 97 using Weka.

In IoT Based Risk Level Prediction Model For Maternal Health Care In The Context Of Bangladesh , Marzia Ahmed , Mohammad Abul Kashem et al.(,2020) mainly focus on the prediction of risk level parameters . Internet of Things (IoT), a new paradigm has extensive applicability including healthcare and numerous areas. In this research, a system has been developed for effective monitoring and predicting risk level of pregnant women, in the context of Bangladesh. This system will analyse the health data and risk factors of pregnant women to identify the risk intensity level. The United Nations goal is primarily concern about improving maternal health, reducing maternal and child mortality by 2030; however the rate is not declining up to the indication. This research intended to use respective analytical tools and machine learning algorithms for discovering the risk level on the basis of risk factors in pregnancy. In this research, a maternal health data set has been prepared from different sources (IoT device, Web portal, Hospitals in Bangladesh).

For the analysis of risk factors, categorize and classifying approaches has been used according to the intensity of risk. After comparing among some groups of the machine learning algorithm, in case of classification and prediction of the risk level shows that Modified Decision Tree Algorithm gives the highest accuracy and the numeric value of this accuracy is 97. A web application has also been developed as a crowdsourced platform to get feedback on different important suggestions and recommendations from corresponding stakeholders, which can also create as test data for further use.

Chapter 3

Dataset and Features

The dataset comprises of 1014 data with 6 attributes and 1 target variable. The source of the dataset is secondary. There are no null values in the dataset and no missing values are found. The features under consideration are: Age Systolic BP Diastolic BP Blood Sugar Heart Rate Body Temperature The target variable is Risk level

A picture of a portion of the dataset is given below:

	A	B	C	D	E	F	G	H
1	Age	SystolicBP	DiastolicBP	BS	BodyTemp	HeartRate	RiskLevel	
2	25	130	80	15	98	86	high risk	
3	35	140	90	13	98	70	high risk	
4	29	90	70	8	100	80	high risk	
5	30	140	85	7	98	70	high risk	
6	35	120	60	6.1	98	76	low risk	
7	23	140	80	7.01	98	70	high risk	
8	23	130	70	7.01	98	78	mid risk	
9	35	85	60	11	102	86	high risk	
10	32	120	90	6.9	98	70	mid risk	
11	42	130	80	18	98	70	high risk	
12	23	90	60	7.01	98	76	low risk	
13	19	120	80	7	98	70	mid risk	
14	25	110	89	7.01	98	77	low risk	
15	20	120	75	7.01	100	70	mid risk	
16	48	120	80	11	98	88	mid risk	
17	15	120	80	7.01	98	70	low risk	
18	50	140	90	15	98	90	high risk	
19	25	140	100	7.01	98	80	high risk	
20	30	120	80	6.9	101	76	mid risk	
21	10	70	50	6.9	98	70	low risk	
22	40	140	100	18	98	90	high risk	
23	50	140	80	6.7	98	70	mid risk	
24	21	90	65	7.5	98	76	low risk	
25	18	90	60	7.5	98	70	low risk	
26	21	120	80	7.5	98	76	low risk	
27	16	100	70	7.2	98	80	low risk	

Age: age in years when a woman is pregnant

The range in our dataset is from 10-70 years

Systolic BP: upper value of blood pressure in mmHg. Its range is from 70-160

Diastolic BP: lower value of blood pressure in mmHg. Its range is from 49-100

BS: blood glucose levels is in terms of a molar concentration; m mol/L. Its range is from 6-19.

Heart rate: A normal resting heart rate in beats per minute. Its range is from 7-90

Body temperature: It is a measure of how well body can make and get rid of heat. Its unit is in Fahrenheit. Range is from 98-103.

The target variable is risk level:It is the predicted risk intensity level during pregnancy considering the previous attribute.It is classified into low risk, mid risk and high risk.

Chapter 4

Exploratory Data Analysis

In statistics, exploratory data analysis is an approach of analyzing data sets to summarize their main characteristics, often using statistical graphics and other data visualization methods. A statistical model can be used, but primarily EDA is for seeing what the data can tell us beyond the formal modeling and thereby contrasts traditional hypothesis testing.

The exploratory data analysis was done in python

The mean value of the attributes are as follows

Age : 29.871795

SystolicBP : 113.198225

DiastolicBP: 76.460552

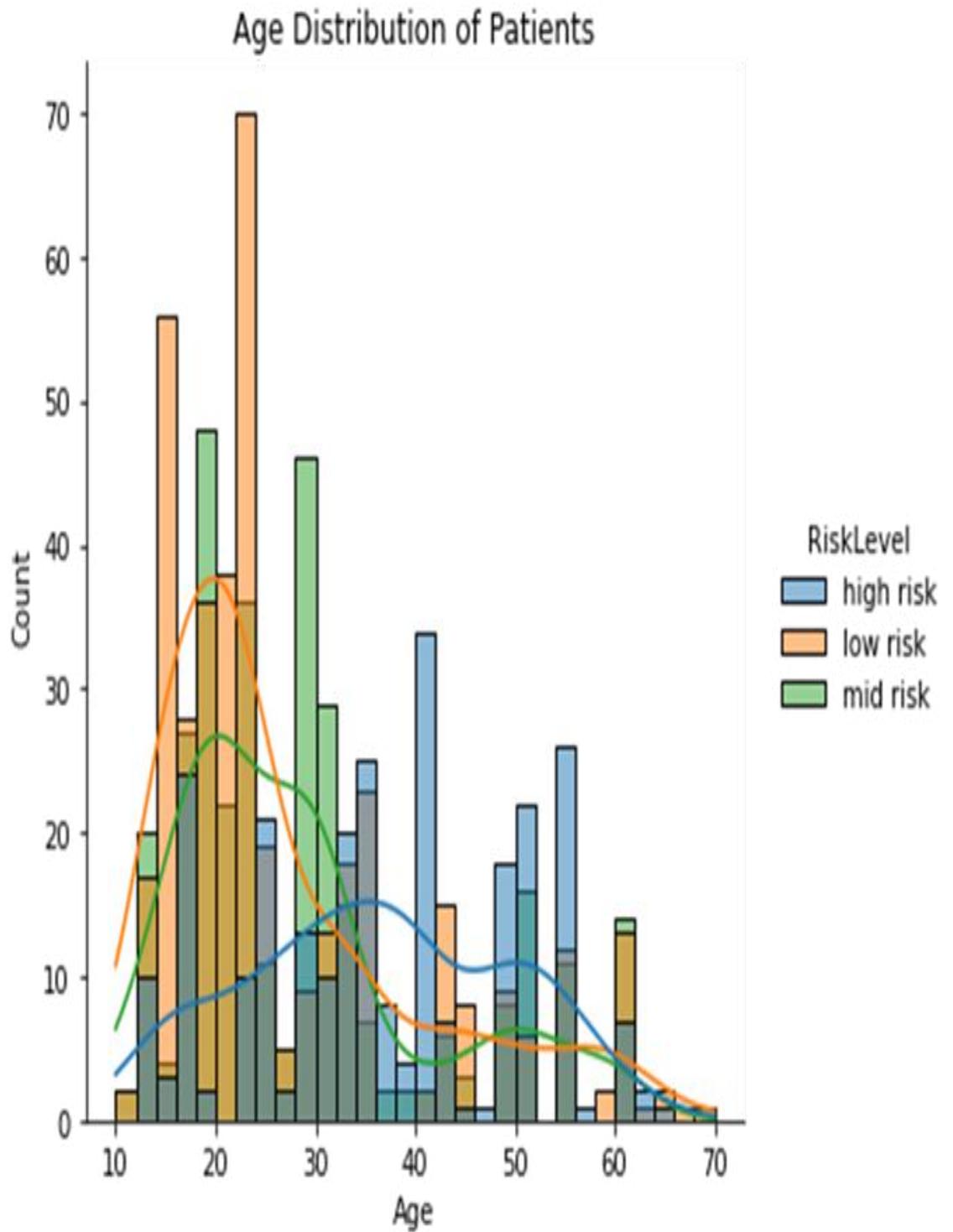
BS : 8.725986

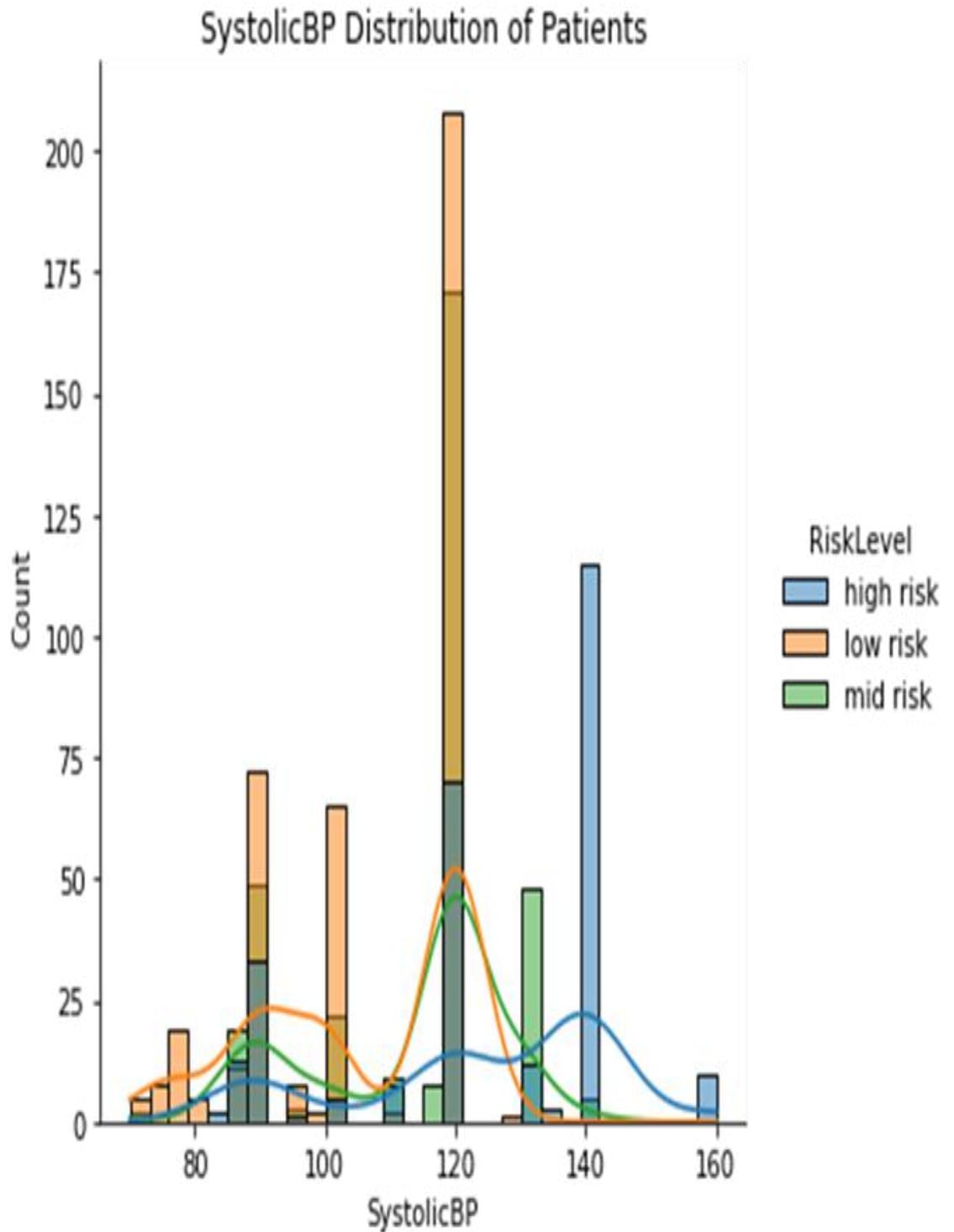
BodyTemp : 98.665089

HeartRate : 74.301775

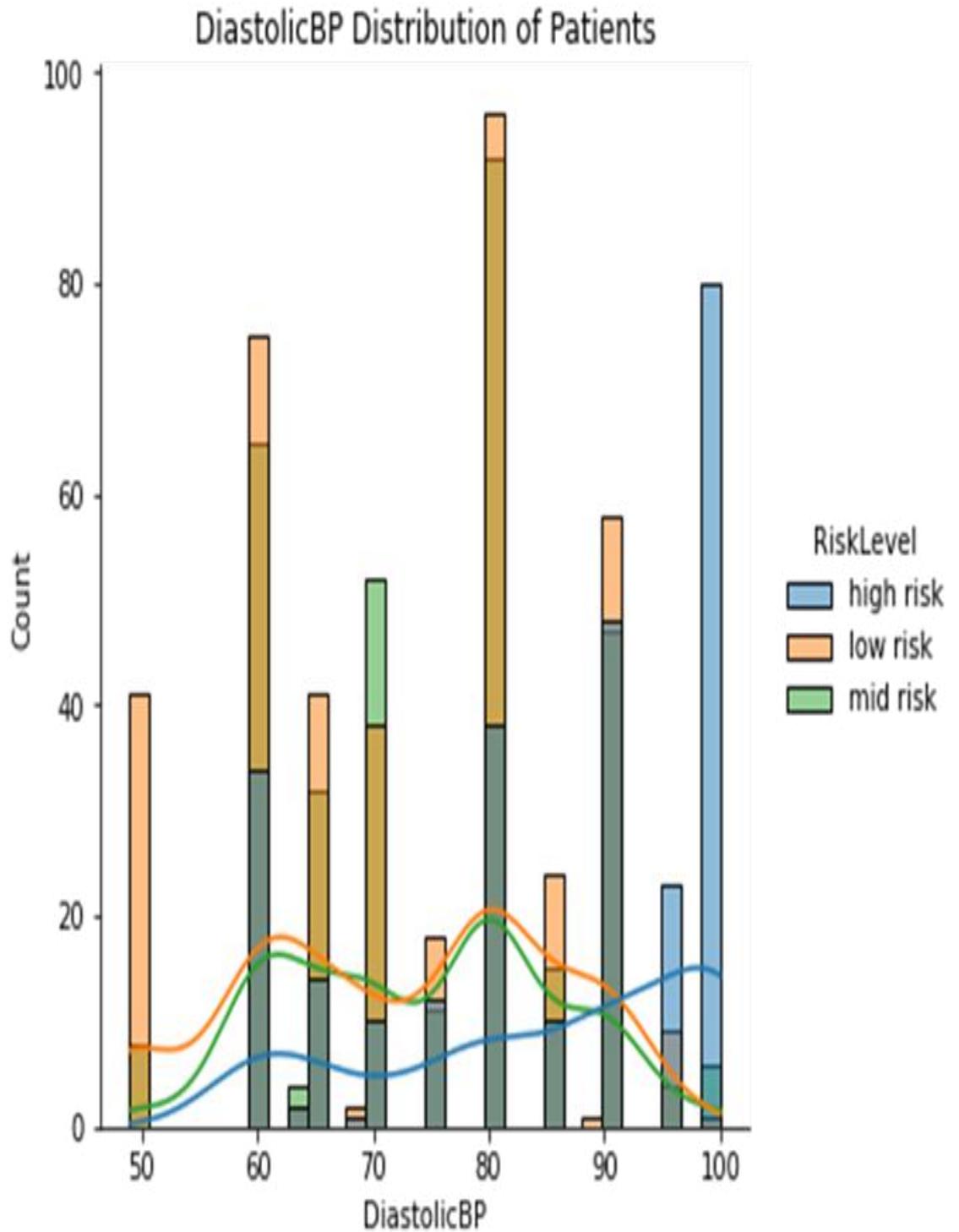
The following figures show how each feature has been distributed

with respect to the risk level.

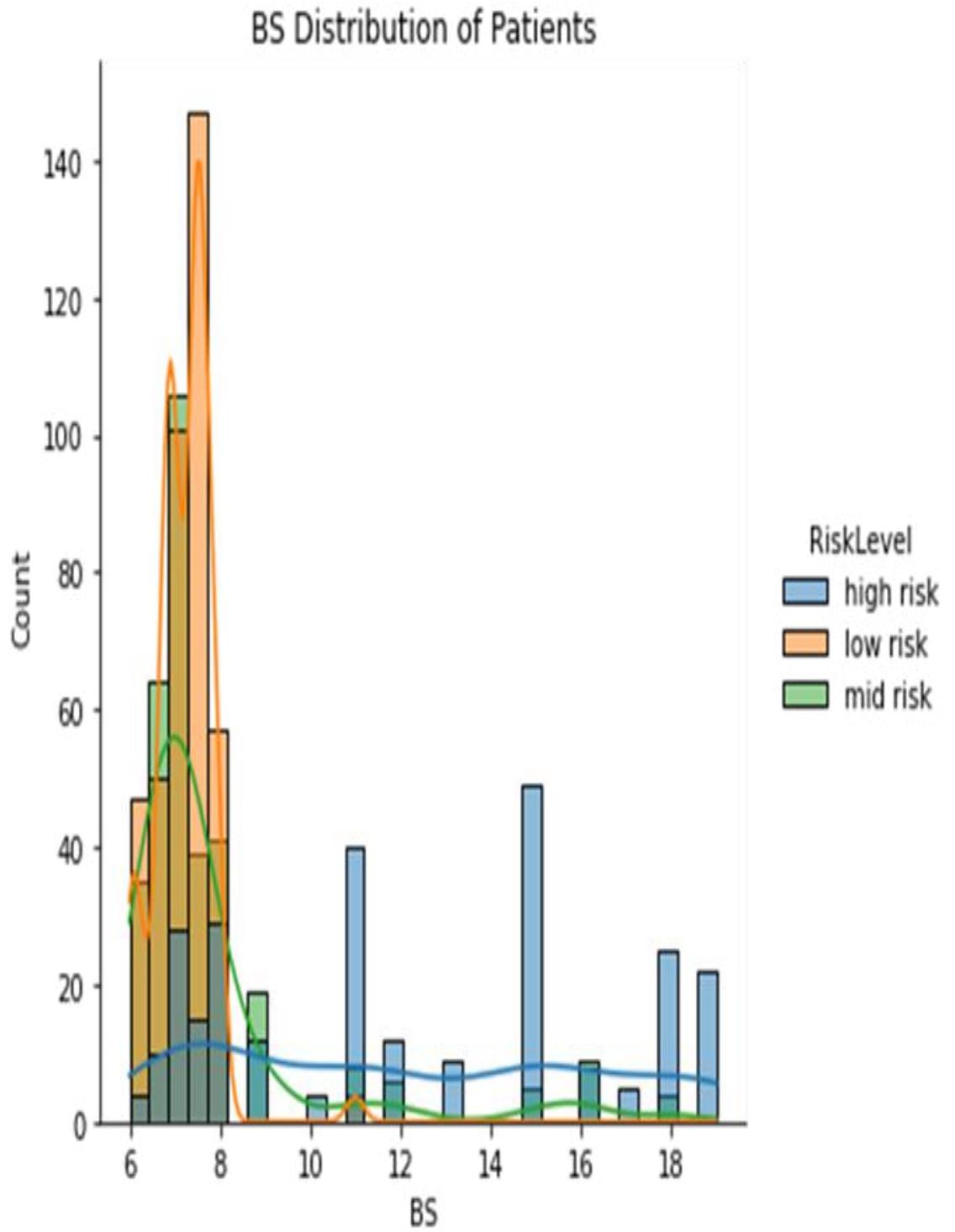


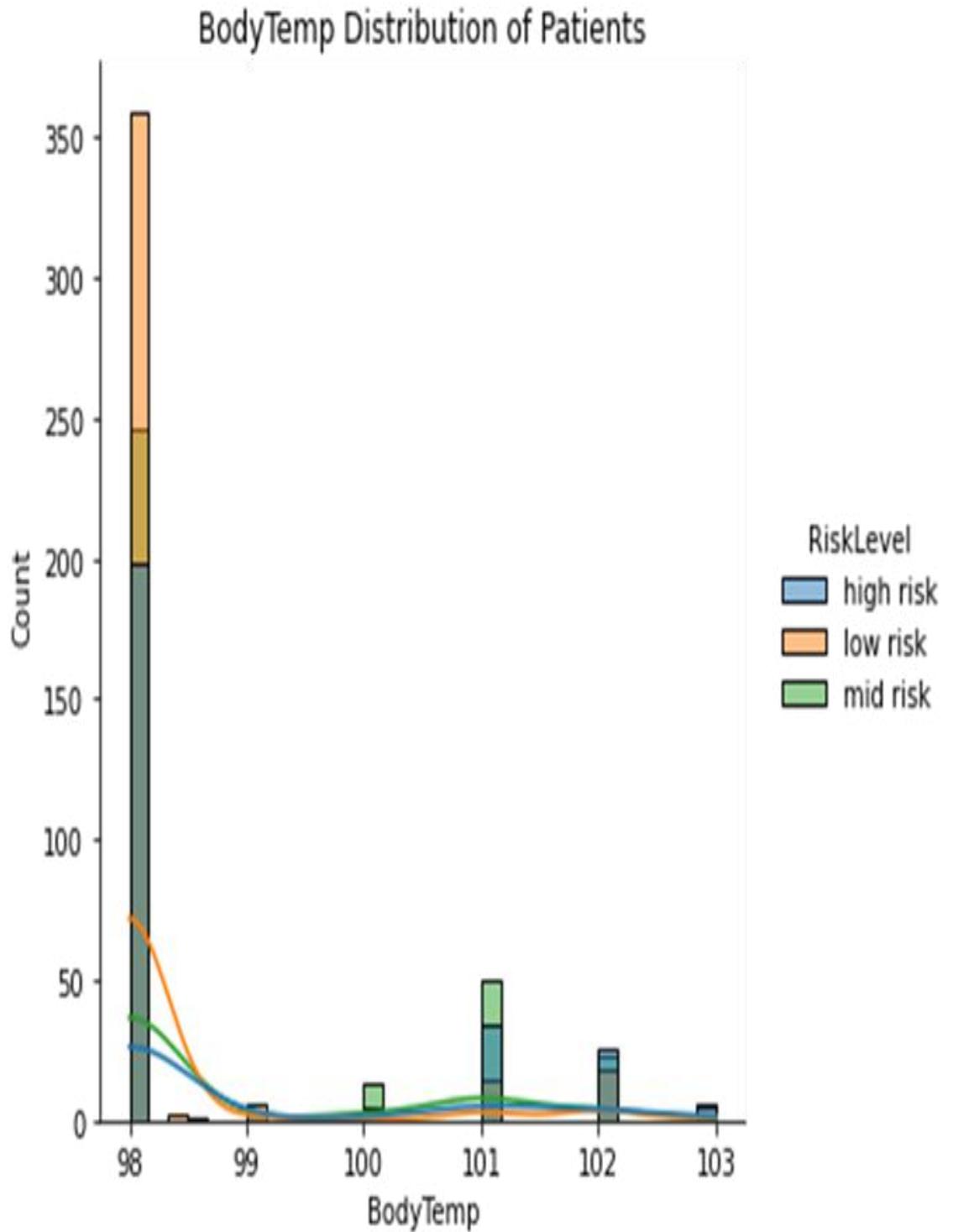


Here we can observe that for high values of Systolic Bp , the risk level observed is very high ; indicating that Systolic Bp is a key attribute during pregnancy .

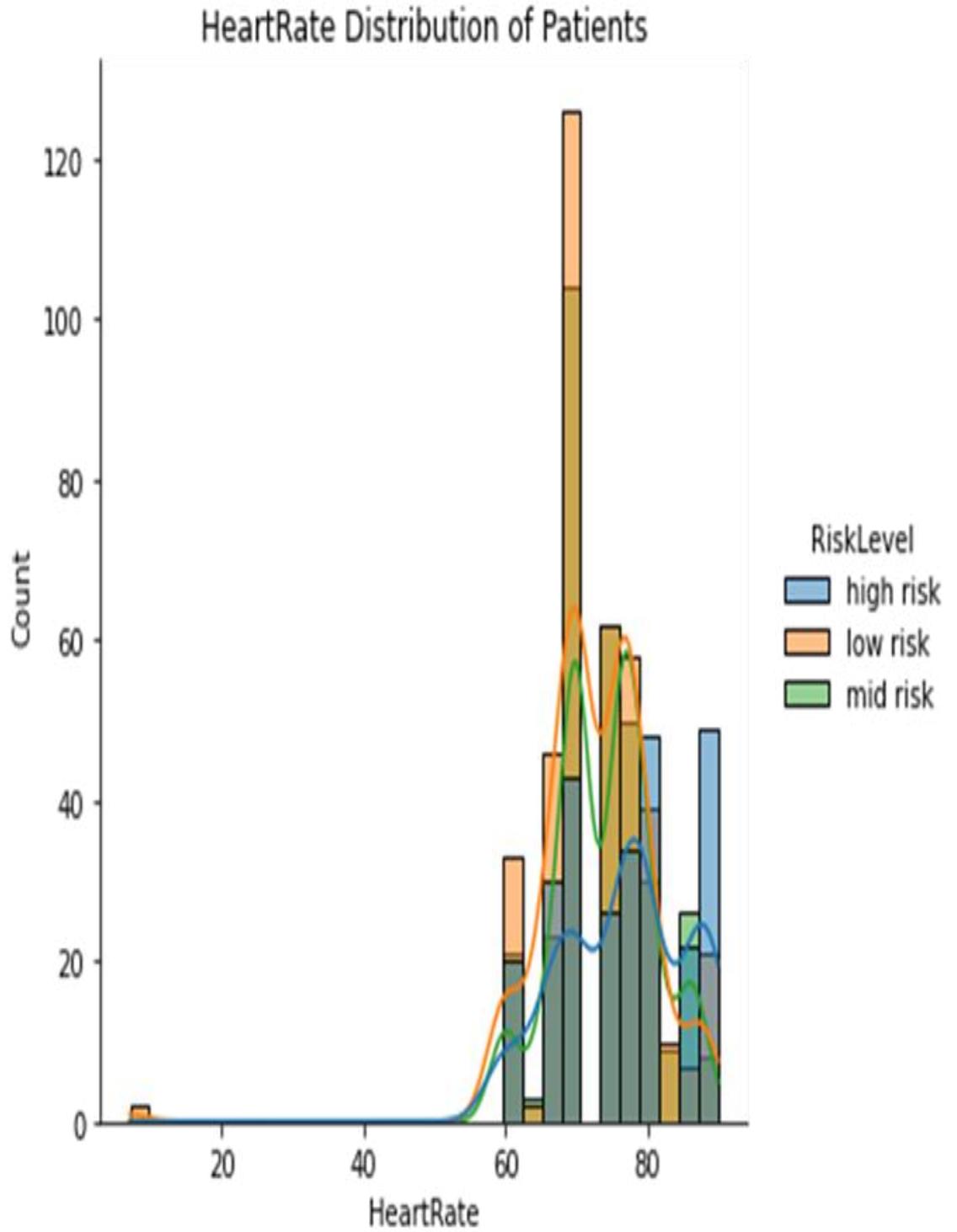


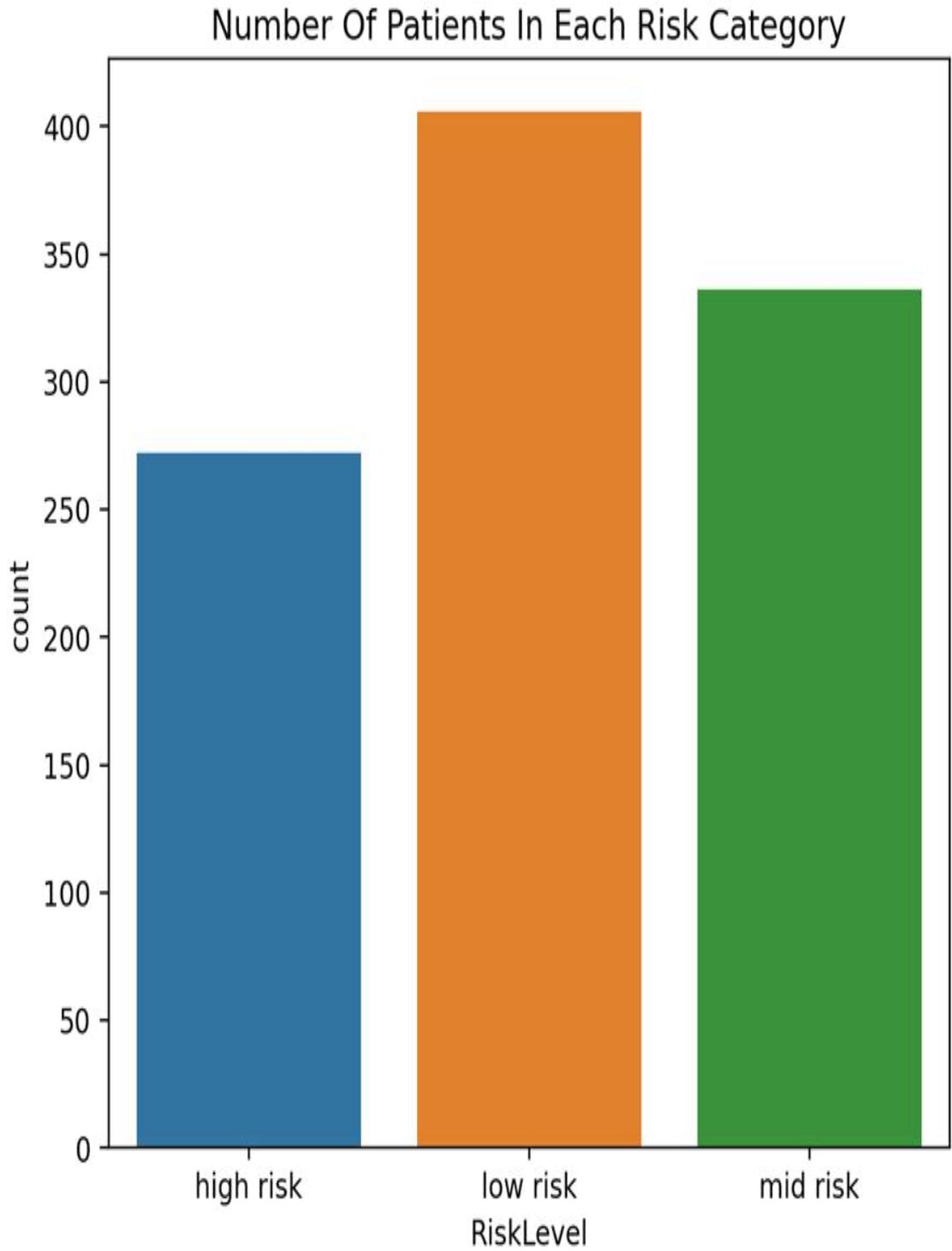
Similarly here also we can observe that for high values of Diastolic Bp, the risk level observed is very high; indicating that Systolic Bp is a key attribute during pregnancy.



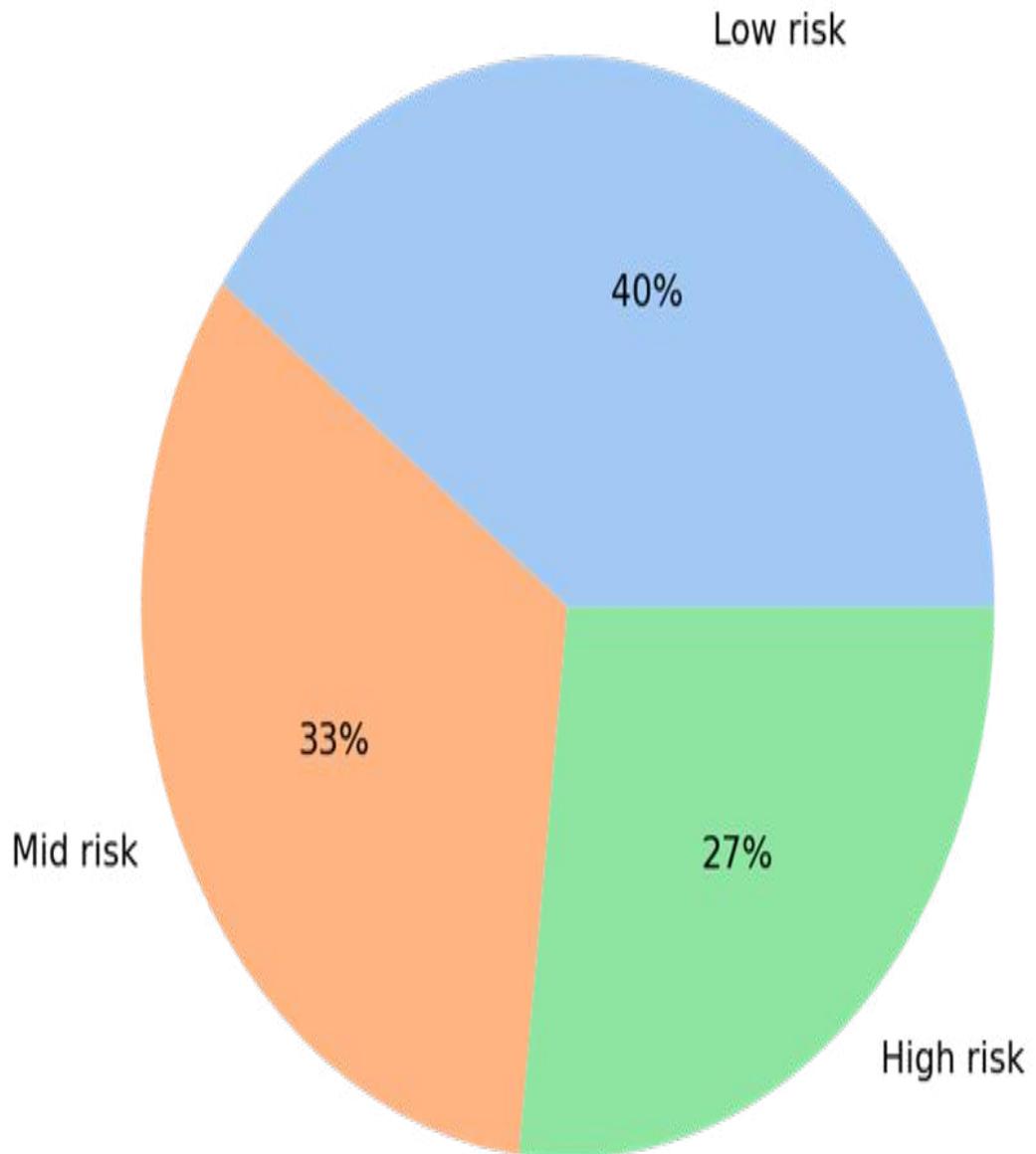


Here we can understand that body temperature is not a very dangerous feature in maternal health risk.

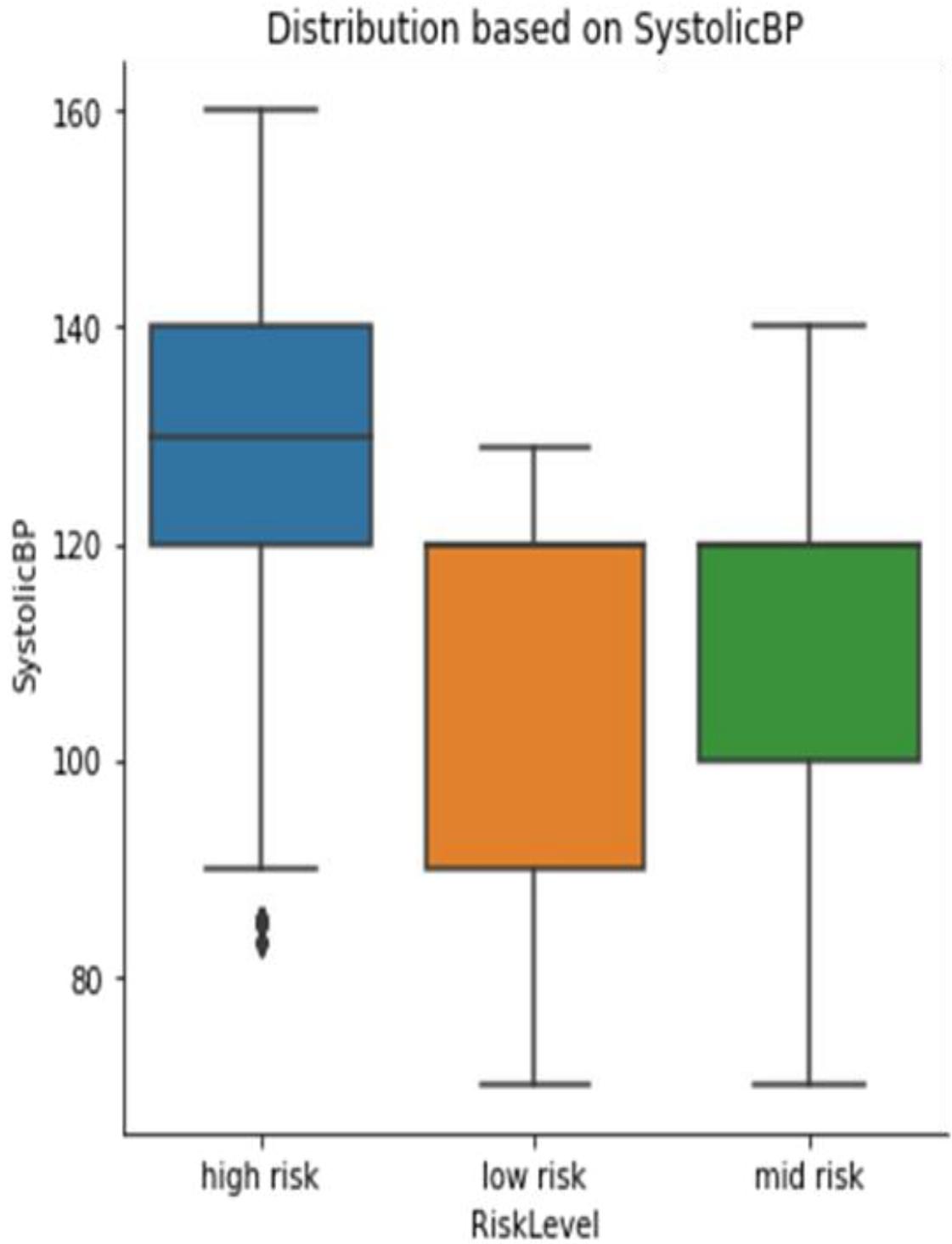


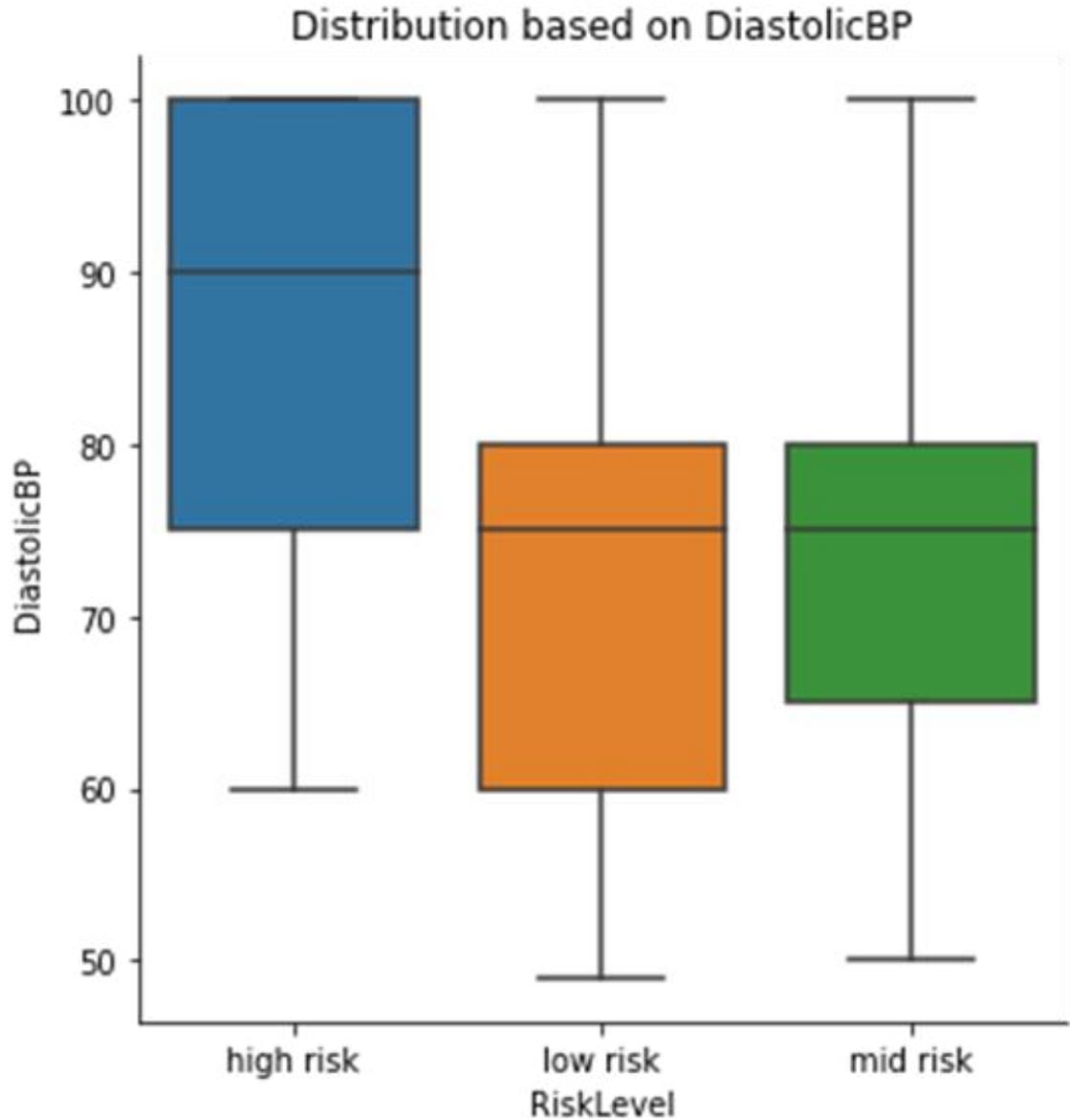


Analysis On Risk

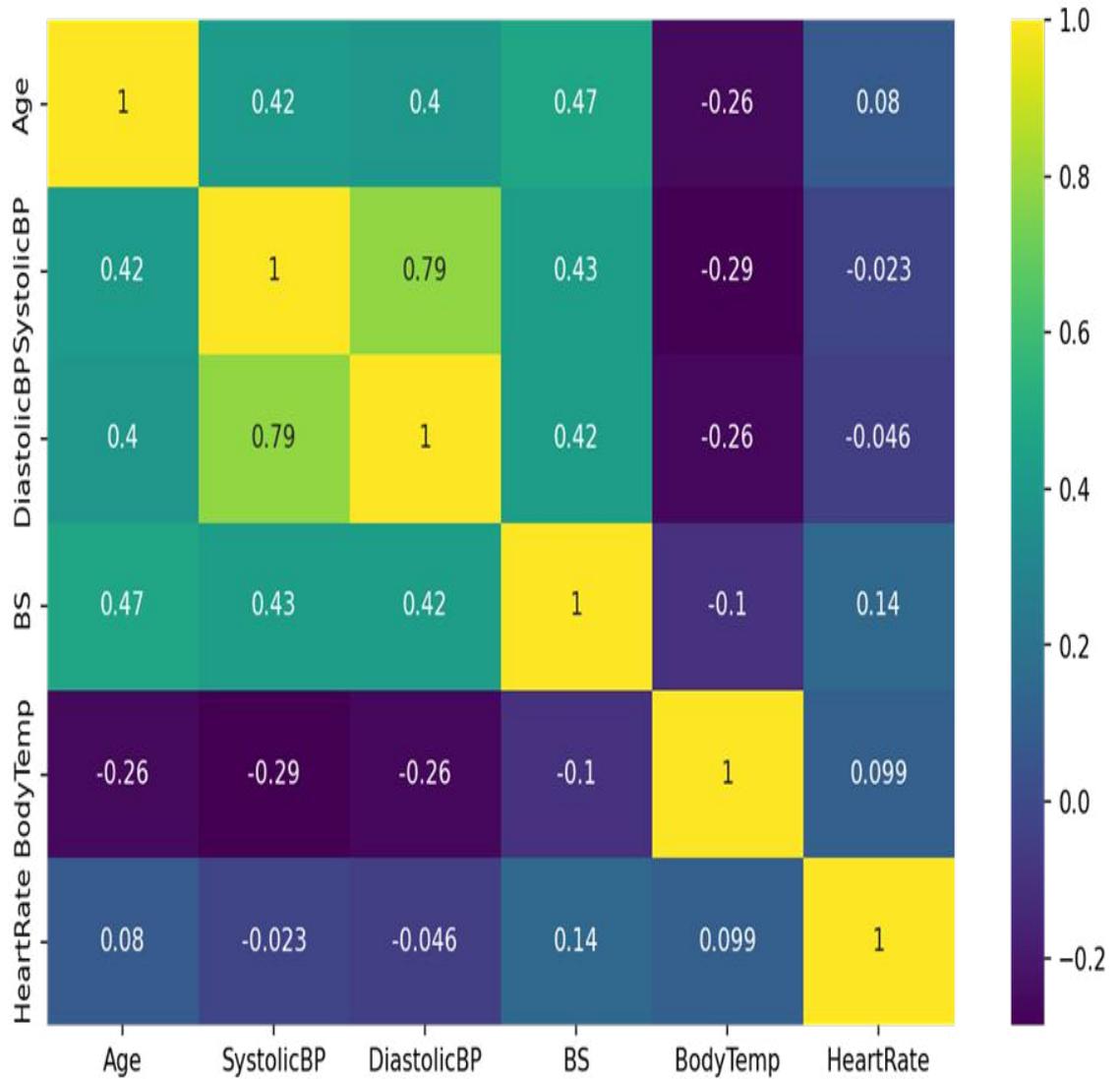


We can see here that the difference among the classes are not that high; thereby we can understand that the classes are balanced





The below figure is called Heat Map. It represents the pairwise correlation between the attributes under consideration.



From the above matrix we can understand that there is high correlation between systolic and diastolic blood pressure. Other than that there is not much correlation between any other attributes. So we gather that feature engineering technique is not needed here as there are not much attributes that we can drop, in such a way that there would be least change in the accuracy of the algorithms used.

Chapter 5

Algorithms used and performance analysis

5.1 MACHINE LEARNING

Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.

Supervised machine learning algorithm Supervised machine learning algorithms are trained using labeled data. Supervised learning is a process of providing input data as well as correct output data to the machine learning model. The aim of a supervised learning algorithm is to find a mapping function to map the input variable(x) with the output variable(y).

Logistic Regression

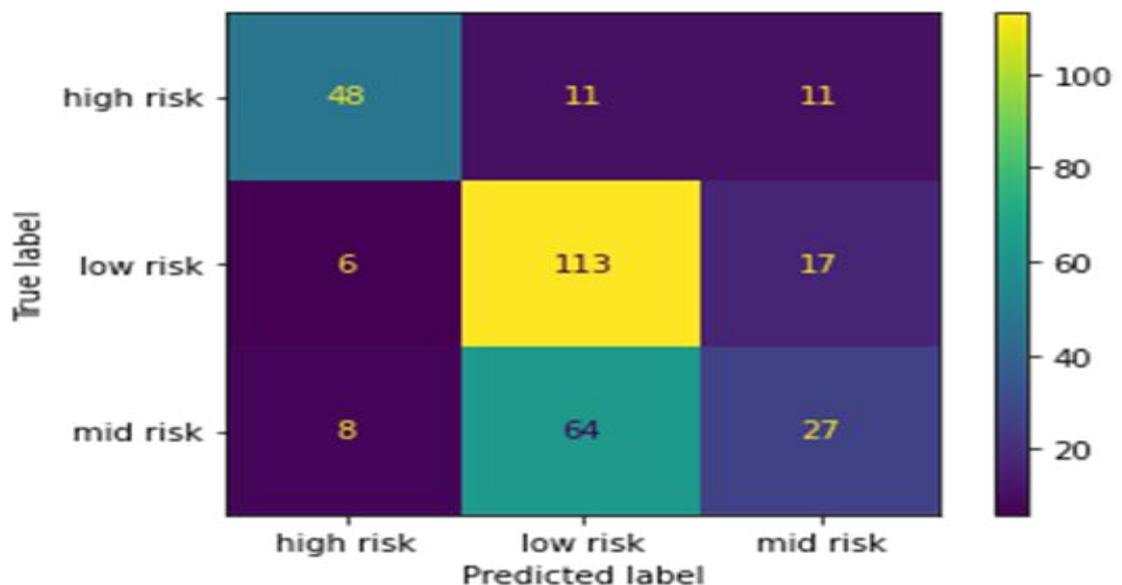
It is a type of supervised machine learning algorithm. In statistics, the (binary) logistic model (or logit model) is a statistical model that models the probability of one event (out of two alternatives) taking place by having the log-odds (the logarithm of the odds) for the event be a linear combination of one or more independent variables (predictors). In regression analysis, logistic regression (or logit regression) is estimating the parameters of a logistic model (the coefficients in the

linear combination). It is used for predicting the categorical dependent variable using a given set of independent variables. Logistic regression predicts the output of a categorical dependent variable.

Logistic Regression Multiclass Classification

The algorithm that we use is the logistic regression multiclass classification. It is also called Multinomial logistic regression. In statistics, multinomial logistic regression is a classification method that generalizes logistic regression to multiclass problems, i.e. with more than two possible discrete outcomes. That is, it is a model that is used to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables (which may be real-valued, binary-valued, categorical-valued). Multinomial logistic regression algorithm is an extension to the logistic regression model that involves changing the loss function to cross-entropy loss and predict probability distribution to a multinomial probability distribution to natively support multi-class classification problems. We will treat each class as a binary classification problem. This approach is called the one vs all method. In the one vs all method, when we work with a class, that class is denoted by 1 and the rest of the classes becomes 0.

The confusion matrix is given below



From the matrix we can understand that low risk label has been predicted correctly mostly compared to the other risk levels, followed by high risk and low risk levels. A confusion matrix is a table that is often used to describe the performance of a classification model on a set of test data for which the true values are known.

The performance measure of the algorithm is given by

	Precision	recall	f1-score	support
High risk	0.77	0.69	0.73	70
Low risk	0.60	0.83	0.70	136
Mid risk	0.49	0.27	0.35	99
Accuracy		0.62	305	
Macro avg	0.62	0.60	0.59	305
Weighted avg	0.61	0.62	0.59	305

The accuracy of logistic regression multiclass classification model is obtained as 61.64

Support Vector Machine Classification

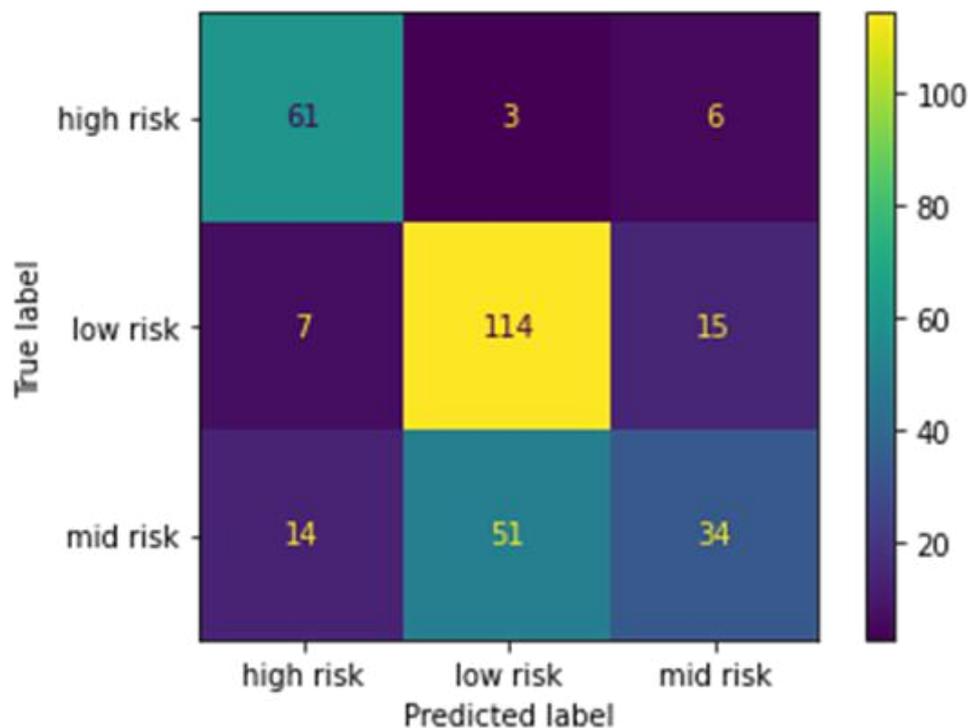
The other algorithm used is called Support vector machine classification. It is a supervised learning algorithm. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n -dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane. SVM chooses the extreme points/vectors that help in creating the hyperplane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine.

Hyperplane: There can be multiple lines/decision boundaries to seg-

regate the classes in n-dimensional space, but we need to find out the best decision boundary that helps to classify the data points. This best boundary is known as the hyperplane of SVM. The dimensions of the hyperplane depend on the features present in the dataset, which means if there are 2 features then hyperplane will be a straight line. And if there are 3 features, then hyperplane will be a 2-dimension plane. We always create a hyperplane that has a maximum margin, which means the maximum distance between the data points.

Multiclass Classification using Support Vector Machine SVM are applied on binary classification, dividing data points either in 1 or 0. For multiclass classification, the same principle is utilized. The multiclass problem is broken down to multiple binary classification cases, which is also called one-vs-one.

The confusion matrix obtained is given below



We can observe that here also, most of the lowrisk class has been predicted correctly followed by high risk level and low risk level.

The performance measure is given by

	Precision	recall	f1-score	support
High risk	0.74	0.87	0.80	70
Low risk	0.68	0.84	0.75	136
Mid risk	0.62	0.34	0.44	99
Accuracy		0.69		305
Macro avg	0.68	0.68	0.66	305
Weighted avg	0.67	0.69	0.66	305

The accuracy of support vector machine classification model is obtained as 68.52 .

Chapter 6

Result and conclusion

6.1 Result

We have obtained the following results

From exploratory data analysis we inferred that body temperature is not a very risky factor in maternal health risk analysis compared to the other attributes.

There is high correlation between Systolic and Diastolic blood pressure.

We found that Systolic blood pressure, Diastolic blood pressure and blood sugar level are important risk factors in maternal health risk analysis. These attributes need to be constantly kept in check for maintaining the maternal health and thereby; the health of the fetus.

From our modelling, we obtained that logistic regression multiclass classification has a performance accuracy of 61.64 and support vector machine algorithm gave an accuracy of 68.52 .

CONCLUSION

We have classified the risk intensity level in pregnant women using logistic regression multi class classification and support vector machine.

We can conclude that support vector machine has better performance as it has higher accuracy compared to logistic regression multiclass classification.

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Project Report

On

TRAFFIC PREDICTION AND TIME SERIES ANALYSIS

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

APPLIED STATISTICS AND DATA ANALYTICS

by

SOWMYA MOHAN

(Register No. SM20AS020)

(2020-2022)

Under the Supervision of

MS.VRINDA MURALEEDHARAN



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APRIL 2022

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM



CERTIFICATE

This is to certify that the dissertation entitled, **TRAFFIC PREDICTION AND TIME SERIES ANALYSIS** is a bonafide record of the work done by Ms. **SOWMYA MOHAN** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Applied Statistics and Data Analytics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of MS.VRINDA MURALEEDHARAN, Assistant Professor, Department of Mathematics and Statistics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

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ACKNOWLEDGEMENTS

I express my deep gratitude to Ms.Vrinda Muraleedharan,Assistant Professor, Department of Mathematics and Statistics, St.Teresa's College, Ernakulam for always motivating and encouraging me to learn and research everything independently.

I am also extremely grateful to all the teachers of our department who provided us with the necessities for the completion of the project.

In addition, very energetic and competitive atmosphere of the Department had much to do with this work. I acknowledge with thanks to faculty, teaching and non-teaching staff of the department and Colleagues.

Above all, I thank God almighty and my parents for giving me the blessings to take over this project.

Place:Ernakulam.

Date: 9-5-22



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ABSTRACT

Traffic congestion affects travel costs, travel time, mobility, accessibility, and productivity, and also impacts the environment such as air pollution and global warming. Accurate traffic flow information is crucial for the management and deployment of intelligent transportation systems. Over the past few years, many existing models have been designed for traffic flow prediction. A variety of methods were used to predict traffic volume including methods in Machine Learning, Artificial Intelligence, Neural Networks. etc. In this project, I propose to predict the traffic volume using the best model among the 4 Machine Learning models which are Linear Regression, XGBoost Regressor, Random Forest, and Decision Tree regressor. We find the cross-validation scores to compare and evaluate the best model and then predict the traffic volume. This project not only predicts traffic volume using ML models but also does a deep study on time series analysis, its different concepts, and popular models in time series analysis which includes AR, ARIMA, FBPROPHET, and LSTM models.

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Chapter 1

INTRODUCTION

1.1 Introduction

Traffic congestion has a direct and indirect impact on a country's economy and its dwellers' lifestyles. Traffic congestion causes massive losses every day in terms of opportunity, cost and fuel consumption. It affects on an individual level as well. Time loss, especially during peak hours, mental stress, and the added pollution to global warming are also some factors caused by traffic congestion. The major requirements for the development of a country are ensuring economic growth and the road users' comfort which is impossible without smooth traffic flow. With the development in the transportation sector by collecting traffic information, authorities can pay more attention to traffic congestion monitoring.

Traffic congestion prediction provides the authorities with the required time to plan the allocation of resources to make the journey smooth for travelers. Traffic forecasting is an essential activity for the services in charge of traffic management and user information. These studies also allow road infrastructure managers to ensure better road viability by allocating adequate resources. Traffic flow prediction relies heavily on historical and real-time systems and models that already exist, most of them use shallow traffic models and are still somewhat unsatisfactory.

This prompts us to rethink the traffic flow prediction problem based on deep architecture models. Recently, deep learning, which is a type of machine learning method, has attracted much academic and industrial interest.

1.2 Machine Learning Models

In this particular project, the main focus is on the prediction of traffic volume using the 4 popular machine learning models, which include 3 Regression models-Linear Regression, Random Forest and Decision Tree regressor, and XGBoost. The cross-validation score is found and the best model is evaluated to proceed further with the prediction of traffic volume.

Linear regression is a linear model, i.e., a model that assumes a linear relationship between the input variables (x) and the single output variable (y). More specifically, y can be calculated from a linear combination of the input variables (x).

A random forest algorithm can be used for both classifications and regression tasks. It provides higher accuracy through cross-validation. A random forest classifier will handle the missing values and maintain the accuracy of a large proportion of data. A Random Forest Regression model is powerful and accurate. It usually performs great on many problems, including features with non-linear relationships.

Decision Tree is one of the most commonly used, practical approaches for supervised learning. It can be used to solve both Regression and Classification tasks with the latter being put more into practical application. It is a tree-structured classifier with three types of nodes- the *Root Node*, *Interior Nodes* and the *Leaf Nodes*.

Extreme Gradient Boosting (XGBoost) is an open-source library that

provides an efficient and effective implementation of the gradient boosting algorithm. Gradient boosting refers to a class of ensemble machine learning algorithms that can be used for classification or regression predictive modeling problems. Regression predictive modeling problems involve predicting a numerical value such as a dollar amount or a height. XGBoost can be used directly for regression predictive modelling.

1.3 Time Series Analysis

An attempt is made to study time series analysis models like AR, ARIMA, FBProphet and LSTM on the dataset. The dataset taken into consideration for this study is an open dataset from Kaggle.

Autoregression is a time series model that uses observations from previous time steps as input to a regression equation to predict the value at the next time step. It is a very simple idea that can result in accurate forecasts on a range of time series problems.

Auto Regressive Integrated Moving Average (ARIMA) models are among the most widely used time series forecasting techniques. ARIMA is a form of regression analysis that indicates the strength of a dependent variable relative to other changing variables. The final objective of the model is to predict future time series movement by examining the differences between values in the series instead of through actual values.

The FBProphet is a procedure for forecasting time series data based on an additive model where non-linear trends are fit with yearly, weekly, and daily seasonality, plus holiday effects. It works best with time series that have strong seasonal effects and several seasons of historical data. Prophet is robust to missing data and shifts in the trend, and typically handles outliers well. Prophet is an open-source software released by Facebook's Core Data Science team.

LSTM (Long Short-Term Memory) is a Recurrent Neural Network (RNN) based architecture that is widely used in natural language processing and time series forecasting. The LSTM rectifies a huge issue that recurrent neural networks suffer from which is short memory. Using a series of 'gates,' each with its own RNN, the LSTM manages to keep, forget or ignore data points based on a probabilistic model. LSTMs also help solve exploding and vanishing gradient problems.

1.4 Objectives

1. DATA EXPLORATION: To explore the data and find out the hidden details from the data and visualize them using graphs, DATA VISUALIZATION.

2. Prediction using machine learning models – regression models-Linear Regression, XGBoost Regressor, Random forest, Decision tree Regressor. Also to find the cross-validation score to confirm which model to proceed with for prediction.

3. A study on Time Series Analysis and models like AR, ARIMA, LSTM FBProphet. An attempt to forecast using AR, ARIMA and fbprophet.

Chapter 2

LITERATURE REVIEW

The literature review for this work comprises the study of available literature on the methods previously used for traffic forecasting, their challenges, scope for improvement and then the study of the latest advances in the field, especially with reference to time-series analysis and artificial intelligence.

B. Karthika, N. Uma Maheswari & R. Venkatesh [1] discusses deep learning algorithms to forecast real-world traffic data. When traffic data becomes big data, some techniques to improve the accuracy of traffic prediction are also discussed. Mahmuda Akhtar's and Sara Moridpour [3] systematically summarizes the existing research conducted by applying the various methodologies of AI, notably different machine learning models in forecasting traffic congestion.

Deekshetha H R, Shreyas Madhav A V, and Amit Kumar Tyagi [6] deals with traffic prediction that can be done in intelligent transportation systems which involves the prediction between the previous year's data set and the recent year data which ultimately provides the accuracy and mean square error. Kevin Irawan, Rahadian Yusuf & Ary Setijadi Prihatmanto [8] discuss various methods related to traffic flow prediction in ITS that will eventually lead to a proposed method which is a traffic prediction method that combines dynamic real-time information prediction (short-term prediction) and time series analysis pre-

diction (long-term prediction).

Real-time traffic information prediction with ANN and SVR are applied for developing an effective and efficient traffic prediction by B. Rajendra Kumar, Naveen Kumar Chikkakrishna & Teja Tallam [10]. This study develops the model for the prediction of traffic volume for the Nizampet road stretch, an urban area by analyzing the measured data in the city of Hyderabad. In this study, the artificial neural network model is best suited to the Nizampet road stretch as the R-square value is 0.89 and performance measures are less compared with the SVR model. Yaguang Li & Cyrus Shahabi [14] first introduce traffic forecasting and the challenges, and then introduce different approaches for modeling the temporal and/or spatial dependencies, finally discussing several important directions for the future research.

Gaurav Meena, Deepanjali Sharma & Mehul Mahrishi [18] uses machine learning, genetic, soft computing, and deep learning algorithms to analyze the big-data for the transportation system with much-reduced complexity. Also, Image Processing algorithms are involved in traffic sign recognition. Hongxin Shao & Boon-Hee Soong [20] explored the application of Long Short-Term Memory Networks (LSTMs) in short-term traffic flow prediction. They conclude that both RMSE and MAPE increased when more LSTM layers were added to their model.

Nadia Slimani, Mustapha Amghar and Nawal Sbiti [21] has discussed and employed several methods of machine learning algorithms and time series analysis to design an accurate model to predict daily road traffic data and development of four models of traffic prediction: CNN, LSTM, SARIMAX and a hybrid model called CNN-LSTM, while Xueyan Yin, Genze Wu, Jinze Wei, Yanming Shen, Heng Qi, and Baocai Yin [23] provides a comprehensive survey on deep learning-based approaches in traffic prediction from multiple perspectives, including approaches, applications, datasets, experiments, analysis and future directions.

Chapter 3

METHODOLOGY

3.1 DATASET

The dataset considered for this particular study is a secondary data collected from Kaggle.com. The dataset is divided already into train and test data. Train dataset contains 33750 rows and the test data for which we predict has 14454 rows. It has 15 variables/attributes, given by,

1. *date_time*: Date, time, and hour of the data that is collected in the local IST time.
2. *is_holiday*: The categorical variable that describe whether the time the data were collected was in a holiday or not.
3. *air_pollution_index*: Air Pollution Index on that day from 10 to 300.
4. *Humidity*: The humidity measured in Celsius.
5. *wind_speed*: The wind speed measured in miles per hour.
6. *wind_direction*: The Cardinal wind direction (0-360 degree)
7. *visibility_in_miles*: The visibility radius measured in miles.
8. *dew_point*: The dew point measured in Celsius.
9. *temperature*: The average temperature on that day measured in Kelvin.
10. *rain_p_h*: The rain intensity measured in millimeters.
11. *snow_p_h*: The snow intensity measured in millimeters.
12. *clouds_all*: The percentage of cloud cover on that day.
13. *weather_type*: The weather in brief description on that day.

14. *weather_description*: The weather in full description on that day.

15. *traffic_volume*: Numeric hourly traffic volume

The train data has 15 variables and the test data has 14 variables.

The *traffic_volume* is the target variable in this study. Using the train dataset, we predict the values of the target variable in the test dataset.

But since the *wind_direction* is not useful in our prediction, we do not consider them.

Fig.1 & 2 given below shows a sample of the dataset.

date_time	is_holiday	air_pollution_index	humidity	wind_speed	wind_direction	visibility_in_miles	dew_point
2012-10-02 09:00:00	None	121	89	2	329	1	1
2012-10-02 10:00:00	None	178	67	3	330	1	1
2012-10-02 11:00:00	None	113	66	3	329	2	2
2012-10-02 12:00:00	None	20	66	3	329	5	5
2012-10-02 13:00:00	None	281	65	3	329	7	7

Fig.1

temperature	rain_p_h	snow_p_h	clouds_all	weather_type	weather_description	traffic_volume
288.28	0.0	0.0	40	Clouds	scattered clouds	5545
289.36	0.0	0.0	75	Clouds	broken clouds	4516
289.58	0.0	0.0	90	Clouds	overcast clouds	4767
290.13	0.0	0.0	90	Clouds	overcast clouds	5026
291.14	0.0	0.0	75	Clouds	broken clouds	4918

Fig.2

The implementation was done on Google Colab. First, the required

libraries like NumPy, pandas, seaborn, matplotlib. etc. are imported. And the dataset is loaded.

3.2 DATA PRE-PROCESSING

The dataset is checked for null values. This particular dataset (both the train and test data) has no null values.

Fig.3(a) and 3(b) depict the same.

date_time	False	date_time	False
is_holiday	False	is_holiday	False
air_pollution_index	False	air_pollution_index	False
humidity	False	humidity	False
wind_speed	False	wind_speed	False
wind_direction	False	wind_direction	False
visibility_in_miles	False	visibility_in_miles	False
dew_point	False	dew_point	False
temperature	False	temperature	False
rain_p_h	False	rain_p_h	False
snow_p_h	False	snow_p_h	False
clouds_all	False	clouds_all	False
weather_type	False	weather_type	False
weather_description	False	weather_description	False
traffic_volume	False	weather_description	False
dtype: bool		dtype: bool	

Fig.3(a),3(b)

3.3 EXPLORATORY DATA ANALYSIS

We do the Exploratory Data Analysis(EDA) on the train data. We first split the *date_time* variable into 5 different variables for ease of study. The following are the new variables extracted: year, month, day, day of week, and hour.

3.3.1 VISUALIZATIONS:

We do some visualizations to obtain some basic insights from the traffic dataset, as to which hours of the day or which days in a week have

observed a higher traffic volume. etc. The figures illustrated below will give us some idea regarding the same.

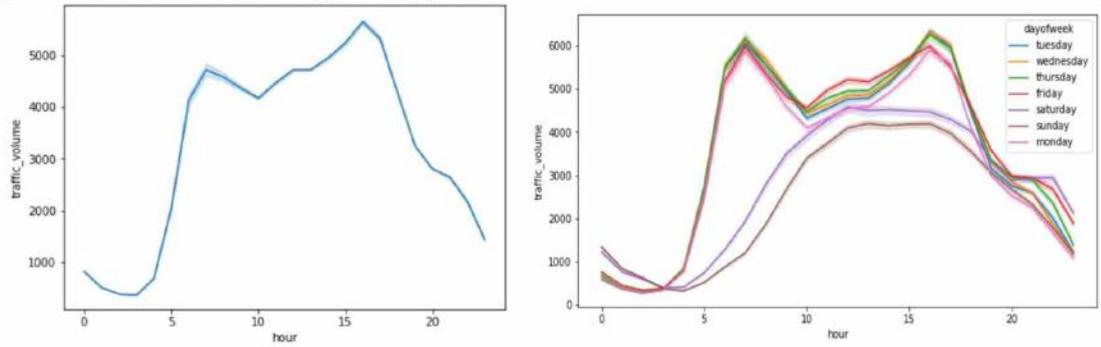


Fig.4(a), Fig.4(b)

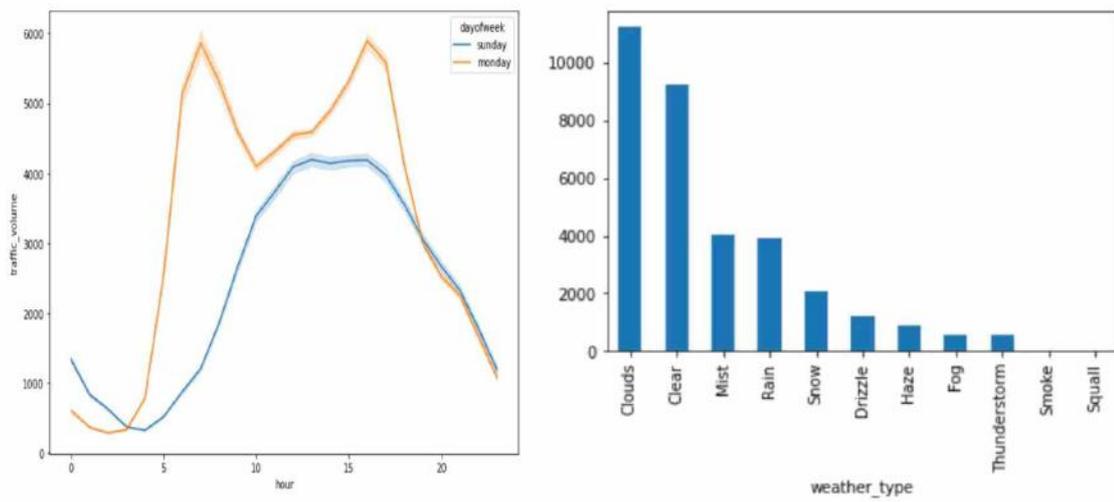


Fig.4(c), Fig.5

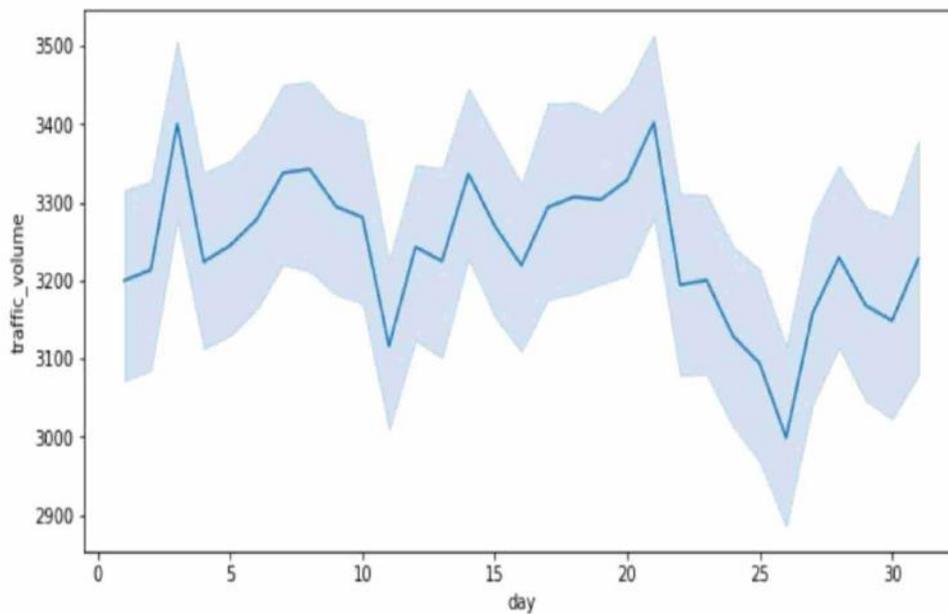


Fig.6(a)

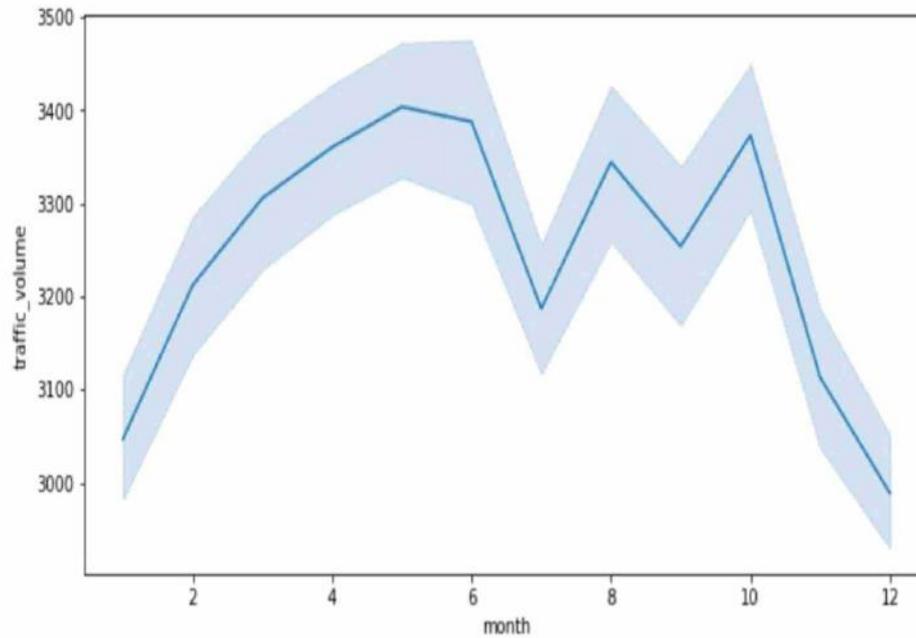


Fig.6(b)

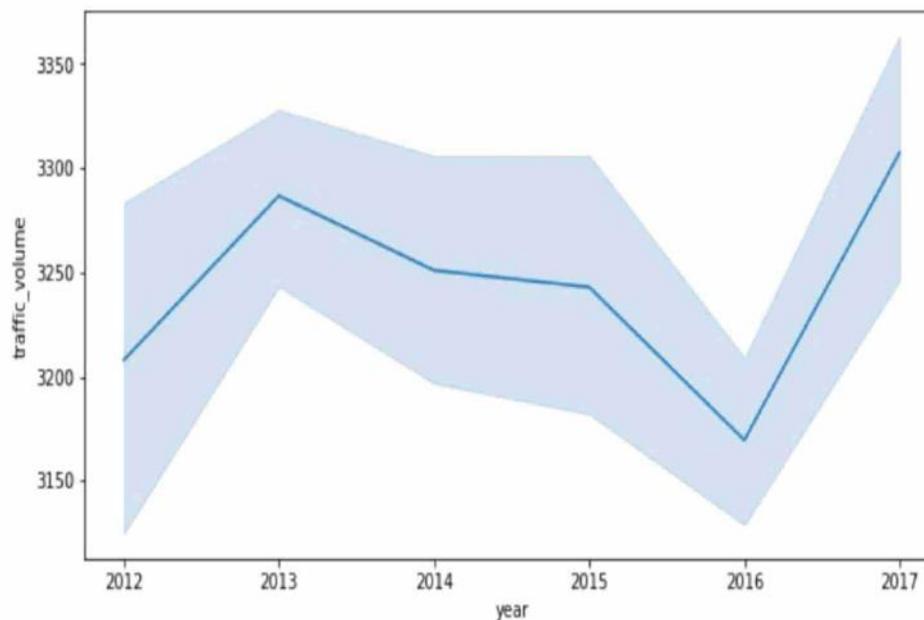


Fig.6(c)

Insights:

1. From Fig.4(a), we can see that the traffic volume is high during the day, especially in the rush hour (from 6 to 9 and from 16 to 18). Traffic volume is at the lowest point during the dusk, and then increases gradually when the day is started. Traffic peaks occur during these hours since it's the time when people go to work and return back.

2. From Fig.4(b), it's clear that during the weekends, people usually don't go to work, so the traffic volume in the morning is not as high as during the daytime. We can also see that during the weekday, there are 2 peaks: the morning rush hour and the evening rush hour. The traffic volume doesn't show a significant difference in the afternoon and after the evening rush hour.
3. Fig.4(c) clearly shows the difference in traffic volume during the weekend and weekdays.
4. Fig.5 indicates that most of the time, the weather is cloudy or clear. There are very few thunderstorms, smoke, or squall at that place.
5. From Fig.6(a),6(b),6(c), it can be concluded that there is no significant increase or decrease on a daily, monthly or yearly basis.

Also, by plotting a scatter plot, it's clear that the *dew_point* and the *visibility_in_miles* are highly correlated. So we will be using one of them in our models. The graph also shows that *temperature* and *rain_p_h* have outliers. We will replace those data points with the median of each variable.

3.3.2 OUTLIER HANDLING:

The outliers occur mainly in *temperature* and *rain_p_h*. We replace outliers using the following command:

```
df['rain_p_h'] = df['rain_p_h'].replace(df['rain_p_h'].max(),df['rain_p_h'].median())
sns.distplot(a=df['rain_p_h'])
```

```
df['temperature'] = df['temperature'].replace(df['temperature'].min(),df['temperature'].median())
sns.distplot(a=df['temperature'])
```

And the results obtained can be illustrated as in Fig.7(a),7(b)

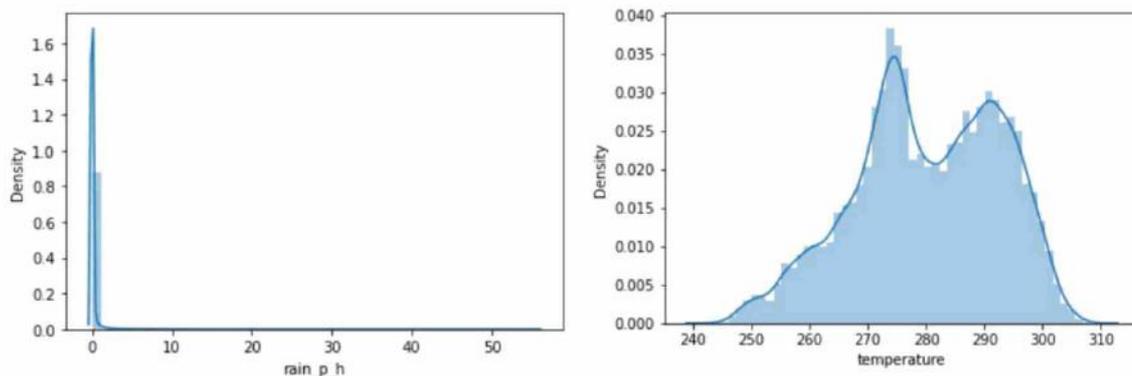


Fig.7(a), Fig.7(b)

After some outlier-handling processes, we are ready to build the model. The predictor variable chosen is all of them except *date_time*, *is_holiday*, *weather_description*, *year*, *month*, *day*, *dew_point*. Then I set the response variable to *traffic_volume*.

3.4 MODEL BUILDING

We split the data into training data and the testing data (on the train data!). We set 70% of the data as training data (23625) and the rest as testing data (10125). After splitting, we use 4 different models to see which model we choose for the final prediction of test data. As mentioned earlier, the models are Linear Regression, XGBoost, Decision tree regressor and Random Forest. Before moving on to the 4 different models, let's first take a look at what is cross-validation score.

3.4.1 CROSS-VALIDATION SCORE:

To overcome over-fitting problems, we use a technique called Cross-Validation. Cross-Validation is a resampling technique with the fundamental idea of splitting the dataset into 2 parts- training data and test data. Train data is used to train the model and the unseen test data is used for prediction. If the model performs well over the test data and gives good accuracy, it means the model hasn't overfitted the training data and can be used for prediction. Here, we have used the Hold out method for cross-validation, also referred to as a train-test

split. In Python, we can easily use the Scikit-Learn module to set up and execute this operation.

Model performance will be evaluated using mean squared error (MAE). It is to be noted that MAE is made negative in the Scikit-Learn library so that it can be maximized. As such, we can ignore the sign and assume all errors are positive. Once evaluated, we can report the estimated performance of the model when used to make predictions on new data for this problem.

The command for train and test split is given below in fig.8.

```
X_train, X_valid, y_train, y_valid = train_test_split(X,y,test_size=0.3,random_state=1)
```

Fig.8

3.4.2 ML MODELS

1.Linear Regression:

Linear regression is one of the easiest and most popular Machine Learning algorithms. It is a statistical method that is used for predictive analysis. The linear regression algorithm shows a linear relationship between a dependent (y) and one or more independent (x) variables, hence called linear regression. Linear regression shows the linear relationship, that is, it finds how the value of the dependent variable changes according to the value of the independent variable. In simple words, Linear Regression is the supervised Machine Learning model in which the model finds the best fit linear line between the independent and dependent variable i.e.it finds the linear relationship between the dependent and independent variable.

The linear regression model provides a sloped straight line representing the relationship between the variables.

Linear regression can be expressed mathematically as:

$$y = a_0 + a_1x + \epsilon$$

Here,

Y=Dependent Variable (Target Variable), X = Independent Variable (Predictor Variable), a_0 =intercept of the line (Gives an additional de-

gree of freedom), a_1 =Linear regression coefficient (scale factor to each input value) and ϵ =random error.

The values for x and y variables are training datasets for Linear Regression model representation.

In our study, we find the cross-validation score of linear regression model and the cross-validation score obtained is 1570.781696478441.

2.XGBoost:

Extreme Gradient Boosting (XGBoost) is an open-source library that provides an efficient and effective implementation of the gradient boosting algorithm. Regression predictive modeling problems involve predicting a numerical value such as a dollar amount or a height. XGBoost can be used directly for regression predictive modeling.

Gradient boosting refers to a class of ensemble machine learning algorithms that can be used for classification or regression predictive modeling problems.

Ensembles are constructed from decision tree models. Trees are added one at a time to the ensemble and fit to correct the prediction errors made by prior models. This is a type of ensemble machine learning model referred to as boosting. It is designed to be both computationally efficient (e.g., fast to execute) and highly effective, perhaps more effective than other open-source implementations.

The two main reasons to use XGBoost are execution speed and model performance. XGBoost dominates structured or tabular datasets on classification and regression predictive modeling problems.

The cross-validation score obtained for the XGBoost regressor for our dataset is 381.2516431451223. It gives us a significantly better result than linear regression. Let's check the cross-validation score for the remaining 2 models too to finally stick onto a model.

3.Decision Tree Regressor:

Decision Tree is one of the most commonly used, practical approaches for supervised learning. It can be used to solve both Regression and

Classification tasks with the latter being put more into practical application.

It is a tree-structured classifier with three types of nodes. The Root Node is the initial node that represents the entire sample and may get split further into further nodes. The Interior Nodes represent the features of a data set and the branches represent the decision rules. Finally, the Leaf Nodes represent the outcome. This algorithm is very useful for solving decision-related problems.

With a particular data point, it is run completely through the entire tree by answering *True/False* questions till it reaches the leaf node. The final prediction is the average of the value of the dependent variable in that particular leaf node. Through multiple iterations, the Tree is able to predict a proper value for the data point. Decision trees have an advantage that it is easy to understand, lesser data cleaning is required, non-linearity does not affect the model's performance and the number of hyper-parameters to be tuned is almost null. However, it may have an over-fitting problem, which can be resolved using the *Random Forest* algorithm.

The cross-validation score for Decision Tree Regressor for the study is 386.4901164021164.

4. Random Forest:

The Decision Tree is an easily understood and interpreted algorithm and hence a single tree may not be enough for the model to learn the features from it. On the other hand, Random Forest is also a "Tree"-based algorithm that uses the qualities features of multiple Decision Trees for making decisions.

Therefore, it can be referred to as a '*Forest*' of trees and hence the name "Random Forest". The term '*Random*' is due to the fact that this algorithm is a forest of '*Randomly created Decision Trees*'. The Decision Tree algorithm has a major disadvantage in that it causes *over-fitting*. This problem can be limited by implementing the Random Forest Regression in place of the Decision Tree Regression. Addi-

tionally, the Random Forest algorithm is also very *fast* and more *robust* than other regression models. The Random Forest Algorithm merges the output of multiple Decision Trees to generate the final output. The cross-validation score obtained for the Random Forest regressor is 287.8708507936508.

Therefore, if we compare the cross-validation scores of the 4 models, it's obvious that Random Forest is a better model to proceed with our prediction.

The codes used for finding the cross-validation score are given below in the following figures.

```
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error

linreg = LinearRegression()
linreg.fit(X_train,y_train)
print('Cross Validation Score: ',-1*cross_val_score(linreg,X_train,y_train,cv=5,scoring='neg_mean_absolute_error').mean())
```

Fig.9(a)

```
from xgboost import XGBRegressor
warnings.simplefilter("ignore",UserWarning)
xgb = XGBRegressor(objective='reg:squarederror')
xgb.fit(X_train,y_train)
print('Cross Validation Score: ',-1*cross_val_score(xgb,X_train,y_train,cv=5,scoring='neg_mean_absolute_error').mean())
```

Fig.9(b)

```
from sklearn.tree import DecisionTreeRegressor

dt = DecisionTreeRegressor()
dt.fit(X_train,y_train)
print('Cross Validation Score: ',-1*cross_val_score(dt,X_train,y_train,cv=5,scoring='neg_mean_absolute_error').mean())
```

Fig.9(c)

```

from sklearn.ensemble import RandomForestRegressor

rf = RandomForestRegressor()
rf.fit(X_train,y_train)
print('Cross Validation Score: ',-1*cross_val_score(rf,X_train,y_train,cv=5,scoring='neg_mean_absolute_error').mean())

```

Fig.9(d)

So, we proceed to predict the traffic volume using Random Forest Regressor. But before we implement it, we should tune the parameters so that the mean absolute error is minimal.

The command used for tuning the hyperparameters is as follows:

```

hasil=[]
j=[]
for i in range(10,310,10):
    rf = RandomForestRegressor(n_estimators=i)
    rf.fit(X_train,y_train)
    pred = rf.predict(X_valid)
    hasil.append(mean_absolute_error(pred,y_valid))
    j.append(i)
score = pd.DataFrame({'Mean Absolute Error':hasil},index=j)
score.plot.line()

```

The resulting graph obtained is given below in Fig.10

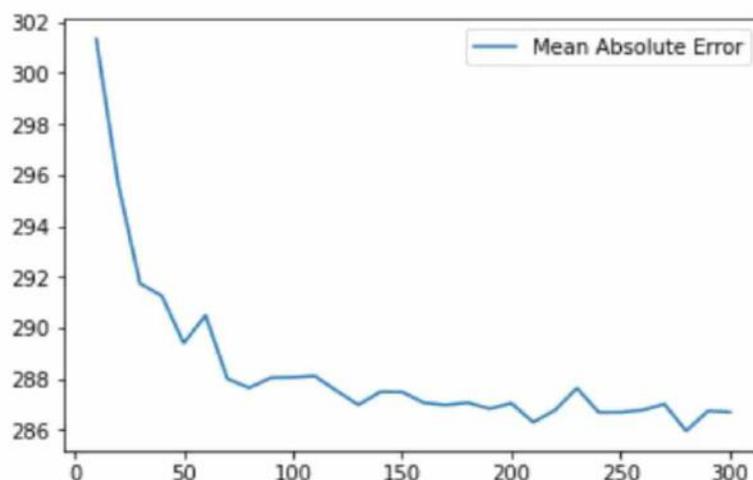


Fig.10

As we can see on the graph, the mean absolute error isn't changing when the parameter is 150 or more. So, we will tune the *n_estimators*

to 150 to get the result.

Therefore, we will use the Random Forest class and call it with the fit method to train the tree. We will have a random forest with 150 decision trees. After fitting, we predict using the 'pred' function and find the mean absolute error. The mean absolute error obtained is 288.24573497942384.

The command used is given below.

```
rf = RandomForestRegressor(n_estimators=150)
rf.fit(X_train,y_train)
pred = rf.predict(X_valid)
print('MAE: ',mean_absolute_error(pred,y_valid))
```

The final prediction is made on the train dataset after finding out the most important variables for predicting traffic volume, and they are *hour*, *dayofweek*, *temperature*, and *wind_direction*. We reconstruct our X and Y variables and then repeat fitting the model for prediction as done before, giving the mean absolute error value equals 297.08187456790125, using the following command.

```
X=df[['hour','dayofweek','temperature','air_pollution_index','wind_direction']]
y=df['traffic_volume']
X=pd.get_dummies(X)
X_train, X_valid, y_train, y_valid=train_test_split(X,y,test_size=0.3,random_state=1)
rf=RandomForestRegressor(n_estimators=150)
rf.fit(X_train,y_train)
pred = rf.predict(X_valid)
print(mean_absolute_error(pred,y_valid))
```

Then, the final prediction is done on the test data. The resulting prediction is saved as an excel file named result.xlsx.

That is all about my project. But before concluding, let's do a quick brief study on time series analysis and a few models: AR, ARIMA, LSTM and FBProphet, which was tried using the same dataset as a part of my study. Let's see some basic concepts of time series analysis.

Chapter 4

TIME SERIES ANALYSIS

4.1 Autocorrelation and Partial Autocorrelation

The coefficient of correlation between two values in a time series is called the autocorrelation function (ACF) For example the ACF for a time series y_t is given by:

$$\text{Corr}(y_t, y_{t-k}).$$

This value of k is the time gap being considered and is called the lag. A lag 1 autocorrelation (i.e., $k = 1$ in the above) is the correlation between values that are one time period apart. More generally, a lag k autocorrelation is the correlation between values that are k time periods apart.

The ACF is a way to measure the linear relationship between an observation at time t and the observations at previous times. If we assume an $\text{AR}(k)$ model, then we may wish to only measure the association between y_t and y_{t-k} and filter out the linear influence of the random variables that lie in between

(i.e., $y_{t-1}, y_{t-2}, \dots, y_{t-(k-1)}$), which requires a transformation on the time series. Then by calculating the correlation of the transformed time series we obtain the partial autocorrelation function (PACF).

The PACF is most useful for identifying the order of an autoregressive model. Specifically, sample partial autocorrelations that are significantly different from 0 indicate lagged terms of y that are useful

predictors of y_t . In a plot of ACF versus the lag, if you see large ACF values and a non-random pattern, then likely the values are serially correlated. In a plot of PACF versus the lag, the pattern will usually appear random, but large PACF values at a given lag indicate this value as a possible choice for the order of an autoregressive model.

The ACF and PACF PLOTS obtained from our data with lags equals to 25 and the command used is given below in Fig.11 & Fig.12(a),12(b) respectively.

```
from statsmodels.graphics.tsaplots import plot_pacf, plot_acf
pacf=plot_pacf(df['traffic_volume'],lags=25)
acf=plot_acf(df['traffic_volume'],lags=25)
```

Fig.11

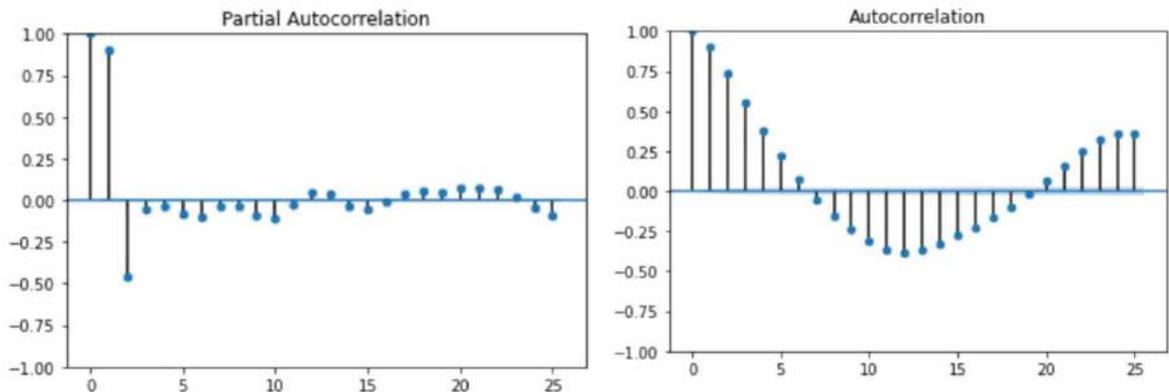


Fig.12(a),Fig.12(b)

4.2 Dickey-Fuller test

for testing stationarity

When we make a model for forecasting purposes in time series analysis, we require a stationary time series for better prediction. So, the first step to work on modeling is to make the time series stationary. Testing for stationarity is a frequently used activity in autoregressive modeling. We can perform various tests like the KPSS, Phillips–Perron, and Augmented Dickey-Fuller. We focus on the Augmented Dickey-Fuller test.

ADF (Augmented Dickey-Fuller) test is a statistical significance test which means the test will give results in hypothesis tests with null and alternative hypotheses. As a result, we will have a p-value from which we will need to make inferences about the time series, whether it is stationary or not.

To perform the ADF test in any time series package, statsmodel provides the implementation function `adfuller()`.

Function `adfuller()` provides the following information.

1. p-value
2. Value of the test statistic
3. Number of lags for testing consideration
4. The critical values

Here in the results given below in Fig.13, we can see that the p-value for time series is lesser than 0.05, and we can say we reject the null hypothesis and the time series is stationary.

```
from statsmodels.tsa.stattools import adfuller

dfctest=adfuller(df['traffic_volume'],autolag='AIC')
print("ADF=",dfctest[0])
print("p-value=",dfctest[1]) #lesser the p-value, the data becomes stationary.
print("No. of lags=",dfctest[2])
```

```
ADF= -23.779660161219788
p-value= 0.0
No. of lags= 48
```

Fig.13

Now, let's move to the various time series models.

4.3 Time Series Models

1. AR MODEL:

Regression: Used to predict continuous values of an item based on certain parameters.

Auto: Uses its own past values to predict future values.

Therefore, it can be summed up as follows: Autoregression is a time series model that uses observations from previous time steps as input to a regression equation to predict the value at the next time step. An autoregressive model of order p can be written as

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \dots + \phi_p y_{t-p} + \epsilon_t$$

where ϵ_t is white noise.

The simplest AR process is AR(0), which has no dependence between the terms. Only the error/innovation/noise term contributes to the output of the process, so AR(0) corresponds to white noise.

For an AR(1) process with a positive ϕ , only the previous term in the process and the noise term contribute to the output. If ϕ is close to 0, then the process still looks like white noise, but as ϕ approaches 1, the output gets a larger contribution from the previous term relative to the noise. This results in a "smoothing" or integration of the output, similar to a low pass filter.

An attempt is made to fit and predict traffic volume using AR model, assuming lag equals 1. And the RMSE score obtained is 1935.6236462636396, which is a very high value. And also the value of the predictions obtained are the same for all the rows. The plot obtained is a line parallel to the x-axis. Thus, we can conclude that AR model is not a good model for this dataset.

2. ARIMA MODEL:

An AutoRegressive Integrated Moving Average (ARIMA) model is a generalization of an autoregressive moving average (ARMA) model. Both of these models are fitted to time series data either to better understand the data or to predict future points in the series (forecasting). The AR part of ARIMA indicates that the evolving variable of interest is regressed on its own lagged (i.e., prior) values. The MA part indicates that the regression error is actually a linear combination of error terms whose values occurred contemporaneously and at various times in the past (i.e., Moving Average). The I (for "integrated") indicates that the data values have been replaced with the difference between their values and the previous values (and this differencing process may have been performed more than once).

ARIMA models are generally denoted as $ARIMA(p, d, q)$ where parameters p , d , and q are non-negative integers, p is the order (number of time lags) of the AutoRegressive model, d is the degree of differencing (the number of times the data have had past values subtracted), and q is the order of the Moving Average model.

The equation of the ARIMA model is given as:

$$y'_t = c + \phi_1 * y'_{t-1} + \dots + \phi_p * y'_{t-p} + \theta_1 * \epsilon_{t-1} + \dots + \theta_q * \epsilon_{t-q} + \epsilon_t$$

There are three terms in the equation:

AR(Auto Regression): The time series is regressed with its previous values i.e. y_{t-1} , y_{t-2} etc. The order of the lag is denoted as p .

I(Integration): The time series uses differencing to make it stationary. The order of the difference is denoted as d .

MA(Moving Average): The time series is regressed with residuals of the past observations i.e. error ϵ_{t-1} , error ϵ_{t-2} .etc. The order of the error lag is denoted as q .

In the above equation, y'_t is the differenced series, ϕ_1 is the coefficient of the first AR term, p is the order of the AR term, θ_1 is the coefficient of the first MA term, q is the order of the MA term and ϵ_t is the error.

An attempt is made to fit and predict traffic volume using ARIMA

model. And the RMSE score obtained is 2859.9363803965475, which is a very high value. Also, the mean of the traffic volumes in the test data equals 3173.0480987654323. And also the value of the predictions obtained are the same for all the rows. The plot obtained is a line parallel to the x-axis. Therefore, since the RMSE is similar in range to the mean of the test set, this is a bad model for this dataset.

3. Long Short-Term Memory (LSTM):

LSTMs is one particular type of recurrent neural networks (RNNs) which are family of neural networks for processing sequential data, capable of learning long-term dependencies. LSTMs are explicitly designed to avoid the long-term dependency problem. Remembering information for long periods of time is practically their main advantage. All recurrent neural networks have the form of a chain of repeating neural network modules. In standard RNNs, this repeating module will have a very simple structure, such as a single hyperbolic tangent layer. LSTM also have this chain structure, but the repeating module has a different structure. Instead of having a single layer of neural network, there are four, interacting in a special way.

The key idea of LSTM is a new structure called memory cell. It contains a neuron with a self-recurrent connection and three gates associated with it. The self-recurrent connection allows the state of memory cell to remain constant from one timestep to another without outside interference. Input and output gates can allow the signal to come in or go out of the neuron or prevent it. Each cells contains one or more memory cells and three nonlinear summation units. The nonlinear summation unit is also called the “gate”, which is divided into 3 kinds: “Input gate”, “Output gate” and “Forget gate”. They control the input and output of memory cells by matrix multiplication.

LSTM network has good memory properties and has advantages in

processing time series. In summary, without knowing the cyclical characteristics of a traffic, constructing the traffic prediction model with LSTM network is a good choice.

4.FBProphet:

Prophet is an open-source library for univariate (one variable) time series forecasting developed by Facebook.

Prophet implements what they refer to as an additive time series forecasting model, and the implementation supports trends, seasonality, and holidays. It is designed to be easy and completely automatic, e.g. point it at a time series and get a forecast. As such, it is intended for internal company use, such as forecasting sales, capacity, etc. We will focus on the Python interface.

The first step is to install the Prophet library using Pip as shown below in figure.

```
!pip install fbprophet
!pip install prophet
```

Fig.14

Next, we can import the Prophet library from fbprophet. Prophet requires data to be in Pandas DataFrames. To use Prophet for forecasting, first, a *Prophet()* object is defined and configured, then it is fit on the dataset by calling the *fit()* function and passing the data.

The *Prophet()* object takes arguments to configure the type of model we want, such as the type of growth, the type of seasonality, and more. By default, the model will work hard to figure out almost everything automatically.

The *fit()* function takes the *DataFrame* of our time series data which must have a specific format. The first column must have the name ‘*ds*’ and contain the date-times. The second column must have the name ‘*y*’ and contain the observations. This means we need to change the column names in the dataset.

This *DataFrame* can then be provided to the *predict()* function to calculate a forecast.

The result of the *predict()* function is a *DataFrame* that contains many columns. Perhaps the most important columns are the forecast date time (‘*ds*’), the forecasted value (‘*yhat*’), and the lower and upper bounds on the predicted value (‘*yhat_lower*’ and ‘*yhat_upper*’) that provide uncertainty of the forecast.

Prophet also provides a built-in tool for visualizing the prediction in the context of the training dataset. This can be achieved by calling the *plot()* function on the model and passing it a result *DataFrame*. It will create a plot of the training dataset and overlay the prediction with the upper and lower bounds for the forecast dates.

The resulting plot we obtain when we give the following command(Fig.15) is given below in Fig.16.

```
plot_components_plotly(model,forecast)
```

Fig.15



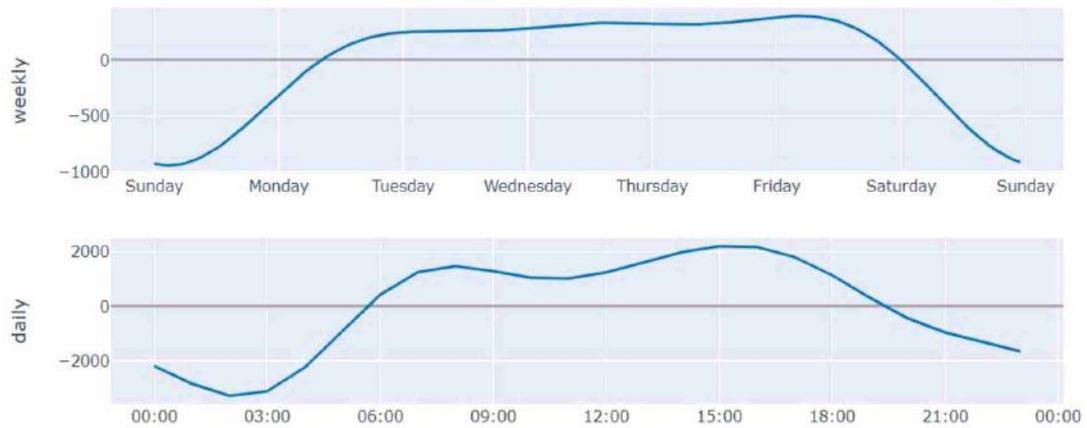


Fig.16

In Fig.18, we can also see that the forecasted value (*yhat*) lie between the lower (*yhat_lower*) and upper bounds (*yhat_upper*) by using the following command(Fig.17).

```
plt.figure(figsize=(10,7))
plt.plot(test['ds'],test['y'],color='blue')
plt.plot(forecast['ds'],forecast['yhat_lower'], color='green')
plt.plot(forecast['ds'],forecast['yhat_upper'], color='orange')
plt.plot(forecast['ds'],forecast['yhat'], color='red')
plt.show()
```

Fig.17

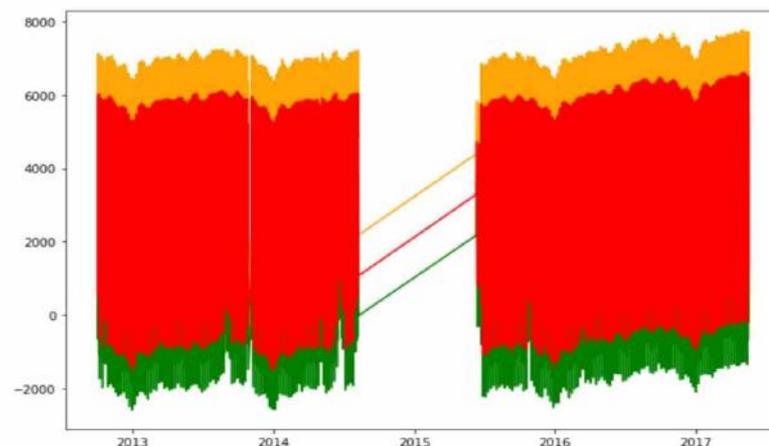


Fig.18

The plot containing the input data and forecast data is given below in Fig.19(a),19(b).

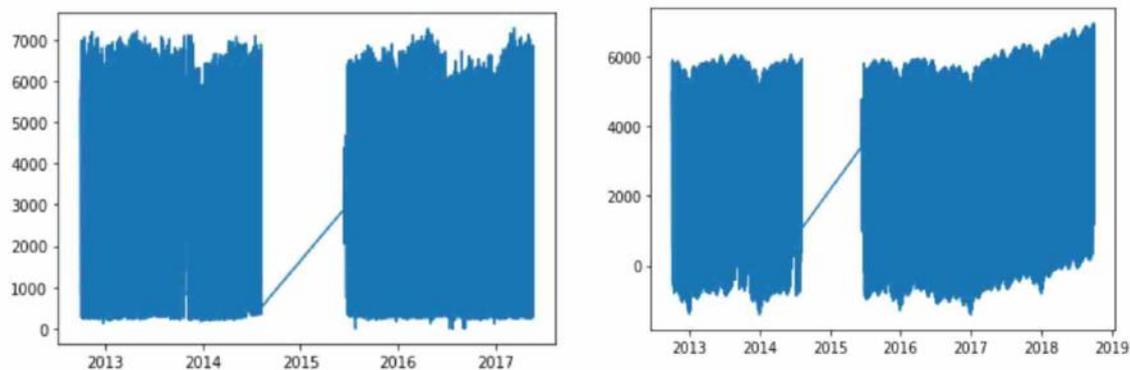


Fig.19(a),Fig.19(b)

Hence, an attempt is made to fit, predict and forecast traffic volume using fbprophet model. And the RMSE score obtained is 2691.4486516076877, which is a very high value. Also, the mean of the traffic volumes in the test data equals 3173.0480987654323.

Chapter 5

CONCLUSION

To conclude, all the objectives of this project are achieved. Prediction using the previously mentioned ML models are done after checking the cross-validation score. And Random Forest is found to be the best model among the 4 models. Predictions are made on the test data using the Random Forest Regressor and the resulting prediction is saved as an excel file. Also, a study is conducted on some of main concepts of time series analysis and also the popular time series models including LSTM and FBProphet are reviewed. An attempt is also made to forecast traffic volume using AR, ARIMA and FBProphet.

Chapter 6

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ST. TERESA'S COLLEGE
(AUTONOMOUS) AFFILIATED TO MAHATMA GANDHI UNIVERSITY



TRAKOM
PROJECT REPORT

In partial fulfilment of the requirements for the award of the degree of

BACHELOR OF SCIENCE IN
COMPUTER APPLICATIONS
[TRIPLE MAIN]

By

PHILOMINA LEFIYA P F
III B.Sc. Computer Applications [Triple Main]
Register No: SB19CA020

Under the guidance of
Mrs. Dhanya R

DEPARTMENT OF COMPUTER APPLICATIONS
2019-2022



CERTIFICATE

This is to certify that **Ms. PHILOMINA LEFIYA P F. (Reg. No: SB19CA020)** Bachelor of Science In Computer Applications (Triple main) VI semester student of **ST. TERESA'S COLLEGE ERNAKULAM** affiliated to Mahatma Gandhi university, has done project work entitled "**TRAKOM**" in PYTHON under the guidance of our senior faculties towards the fulfillment of the award of "Bachelor of Science In Computer Applications (Triple Main)" during the period of October 2021 to March 2022.

She successfully completed the project and during the period she was methodical and hardworking.

For RISS TECHNOLOGIES

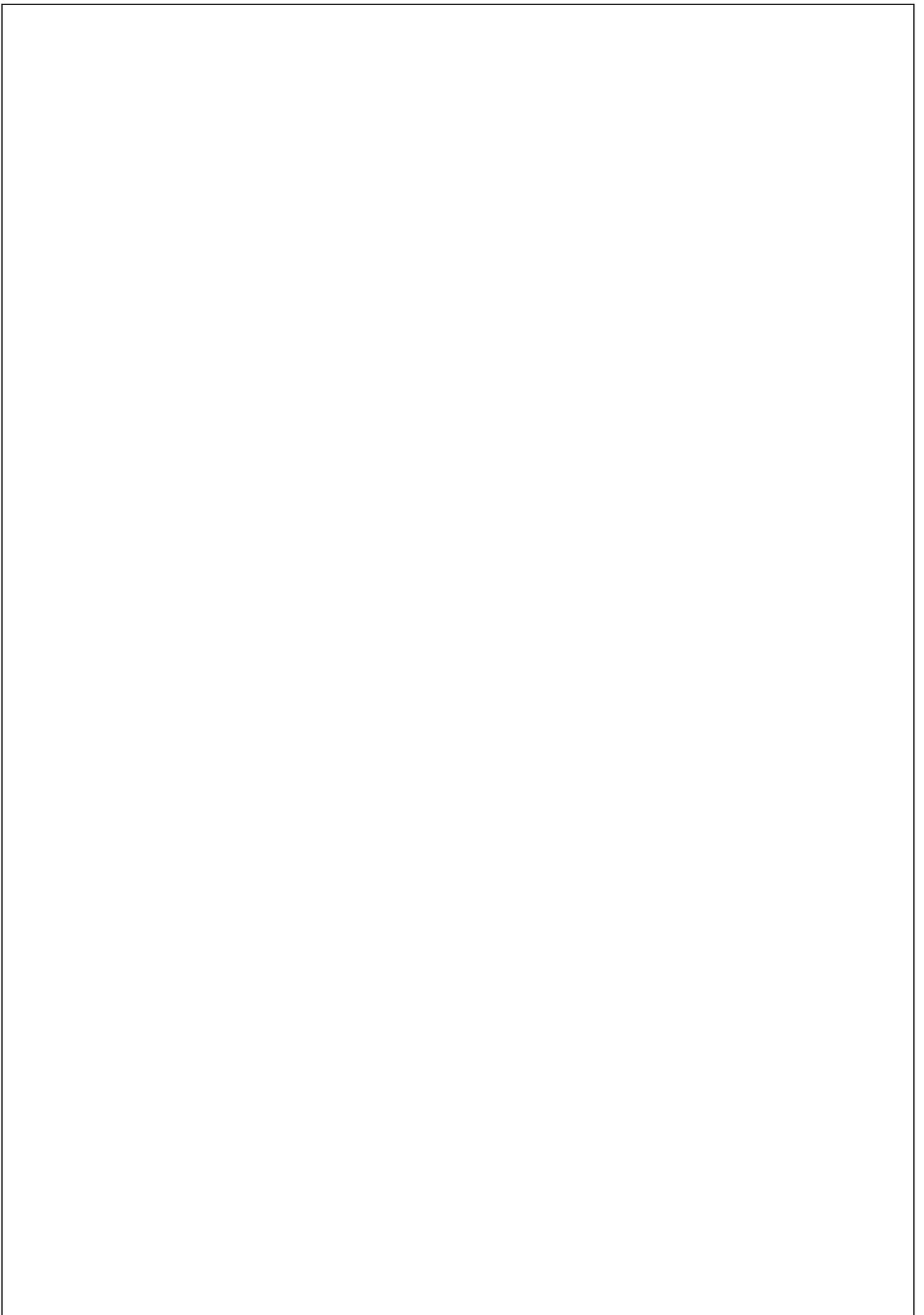
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CERTIFICATE

This is to certify that the project report entitled "TRAKOM", a bona fide record of the work done by **PHILOMINA LEFIYA P F**, Register No. SB19CA020 during the year 2021-22 and submitted in partial fulfilment of the requirements for the degree of Bachelor of Science in Computer Applications (Triple main) under Mahatma Gandhi University.

Head of the Department



Internal Examiner

External Examiner

Date: 06/04/2022

DECLARATION

I, **Philomina Lefiya P F**, BSc Computer Application (Triple Main) student of St. Teresa's College (Autonomous) Ernakulam. Register No. SB14CA020, hereby declare that the dissertation submitted for the Bachelor's Degree in Computer Applications is my original work. I further declare that the said work has not previously been submitted to any other university of academic body.

Date: 05/04/2022

Place: Emakulam



Philomina Lefiya P F

ACKNOWLEDGEMENT

First and foremost I thank God Almighty for his blessings. I take this opportunity to express my gratitude to all those who helped me in completing this project successfully. I wish to express my sincere gratitude to the Manager **Rev. Dr. Sr. Vinitha CSST**, the Director **Rev. Sr Emeline CSST** and the Principal **Dr. Lizzy Mathew** for providing all the facilities.

I express my sincere gratitude towards the Head of the Department **Mrs. Raji S Pillai** and the Course Coordinator Mrs. Sheeba Emmanuel for the support. I deeply express my sincere thanks to my guide **Mrs. Dhanya R** for her proper guidance and support throughout the project work.

I am highly indebted to my external guide at RISS Technologies, **Mr. Akash** for training me well to develop this project up to my level of expectation. I thank him for giving me such attention and time despite the hectic schedule.

My deepest appreciation goes to my beloved teachers whose cooperation and suggestion throughout the project helped me a lot. I thank all my friends and classmates for their support.

I convey my hearty thanks to my parents for their moral support, suggestion and encouragement.

PHILOMINA LEFIYA P F

SYNOPSIS

The main objective of this project is to offer system that simplify and automate the process of recording and tracking student attendance through face recognition technology. The management of the attendance can be a great burden on the teachers if it is done by hand. To resolve this problem, smart and auto attendance management system is being utilized. It is biometric technology to identify or verify a person from a surveillance video.

Taking and tracking students attendance manually, losing attendance sheets, dishonesty, wasted time and high error scales are problems facing the lecturers use the existing attendance system. It is a hard process, take time and cause a lot of paper-based work. As a result, in order to solve these problems and avoid errors we suggest to computerize this process by providing a system that record and manage student attendance automatically.

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1. INTRODUCTION

1.1 About Project

Maintaining the attendance is very important in all the institutes for checking the performance of students. Every institute has its own method in this regard. Some are taking attendance manually using the old paper or file based approach and some have adopted methods of automatic attendance using some biometric techniques. There are many automatic methods available for this purpose i.e. biometric attendance. All these methods also waste time because students have to make a queue to touch their thumb on the scanning device. This system uses the face recognition approach for the automatic attendance of students in the classroom environment without student's intervention. This attendance is recorded by using a camera attached in the classroom that is continuously capturing images of students, detect the faces in images and compare the detected faces with the database and mark the attendance. The main aim of the system is to mark the attendance but using image processing when the student enter into the class room then the attendance of student for particular lecture is mark. We are going to developed the system so when the particular student enter his own details then the details are match with the data based details as the match found the then the student can also able to see the present and absent

1.2 About Organization

RISS TECHNOLOGIES is a rapidly growing company that provides professional IT services. They are one of the largest and Best software development companies in Kerala with focus on .Net, PHP, Java, Software testing, SEO and Web Design.

1.3 Objectives of the Project and the Organization

The main objective of this project is to offer system that simplify and automate the process of recording and tracking student attendance through face recognition technology. The management of the attendance can be a great burden on the teachers if it is done by hand. To

resolve this problem, smart and auto attendance management system is being utilized. It is biometric technology to identify or verify a person from a surveillance video.

The main objective of the organisation is to continuously optimize their customers' business through our world-class solutions; services and products. They ensure the success of the company by constantly and consistently satisfying the customers, shareholders and employees.

2. SYSTEM ANALYSIS

2.1 Introduction

System Analysis is the complete study of the system and identifying its objectives mainly for problem solving purposes. Each and every modules of the system are evaluated. Inferences are made from these studies to ensure that all the components of the system is working efficiently.

System Analysis involves gathering information related to the system and developing the accurate tools for analysis. Studying and analysing the existing system is important for system analysis. Identifying the drawbacks in the existing system and how it is been rectified in the proposed system is one of the main aim.

2.2 Existing System

Traditional attendance marking techniques that is, pen and pa-per or signing attendance sheets are easy to bypass and trick as giving proxies or false signatures is a common practice among students nowadays, students take an unfair advantage of this at most times. But a facial recognition system is unassailable and cannot be fooled as each person has a set of unique and individual features common to that person and cannot be replicated or changed, it all comes down to one simple truth that is, unless you are physically present in the lecture your attendance will not get marked

2.3 Proposed System

Proposed project an automated attendance marking and management system is proposed by making use of face detection and recognition algorithms. Instead of using the conventional methods, this proposed system aims to develop an automated system that records the student's attendance by using facial recognition technology. The main objective of this work is to make the attendance marking and management system efficient, time saving, simple and easy. Here faces will be recognized using face recognition algorithms. The processed image will then be compared against the existing stored record and then attendance is marked in the database accordingly. Compared to existing system traditional attendance marking system, this system reduces the workload of people. This proposed system will be implemented with 4 phases such

as Image Capturing, Segmentation of group image and Face Detection, Face comparison and Recognition, Updating of Attendance in database.

2.4 System Specification

System specification specifies the hardware and software configuration of the new system. It helps to define the operational and performance guidelines of the system.

2.5 Operating System

An Operating System (OS) is an interface between computer user and computer hardware. It is a software which performs all the basic tasks like file management, memory management, process management, handling input and output and controlling peripheral devices such as disk drives and printers. The operating system required for proper execution of the system is Windows 10 or above. System specifications for the app to run:

- Android min SDK 23 – Marshmallow

2.6 Languages and Software Packages

✦ PYTHON

Python is a high-level, general-purpose programming language. Its design philosophy emphasizes code readability with the use of significant indentation. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small- and large-scale projects

✦ MySQL

MySQL is an open-source relational database management system (RDBMS); it is the world's second most widely used RDBMS, and the most widely used open-source client-server model RDBMS. The SQL acronym stands for Structured Query Language. The MySQL development project has made its source code available under

the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL is a popular choice of database for using web applications, and is a central component of the widely used LAMP open-source web application software stack (and other "AMP "stacks). LAMP is an acronym for "Linux, Apache, MySQL, Pearl, PHP, and Python ". Free-software open-source projects that require a fullfeatured database management system often use MySQL.

✦ HTML

Hypertext Markup Language, commonly referred to as HTML, is the standard markup language used to create web pages. Along with CSS, and JavaScript, HTML is a cornerstone technology used to create web pages, as well as to create user interfaces for mobile and web applications. Web browsers can read HTML files and render them into visible or audible web pages. HTML describes the structure of a website semantically along with cues for presentation, making it a markup language, rather than a programming language.

HTML can embed scripts written in languages such as JavaScript which affect the behaviour of HTML web pages. HTML markup can also refer the browser to Cascading Style Sheets (CSS) to define the look and layout of text and other material. Web browsers can also refer to Cascading Style Sheets (CSS) to define the appearance and layout of text and other material. The W3C, of CSS over explicit presentation HTML markup.

2.7 Hardware and Software Specifications

Software Requirements

A software requirement specification (SRS), a requirements specification for a software system, is a complete description of the behavior of a system to be developed and may include a set of use cases that describe interactions the users will have with the software. In addition it also contains non-functional requirements. Non-functional requirements impose constraints on the design or implementation (such as performance engineering requirements, quality standards, or design constraints) the software requirements specification document enlists all necessary requirements that are required for the project development. To derive the

requirements we need to have clear and thorough understanding of the products to be developed. This is prepared after detailed communications with the project team and customer.

Operating System: WINDOWS 8 or above for better performance

Front end: Python (For Web Application), HTML

Back end: MYSQL

Software: SubLime Text, WAMP, Android Studio

Web Browser: Internet Explorer/Google Chrome/Firefox

Web Server: Apache

Hardware Requirements

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware. A hardware requirements list is often accompanied by a hardware compatibility list (HCL), especially in case of operating systems. An HCL lists tested, compatible, and sometimes incompatible hardware devices for a particular operating system or application.

Processor: Intel Pentium or above.

Hard Disc: 320GB.

Display Type: PC Display.

3. SYSTEM DESIGN

3.1 Introduction

It is a process of planning a new business system or replacing an existing system by defining its components or modules to satisfy the specific requirements. Mainly focuses on how to accomplish the objectives of the system.

3.2 Haarcascade Algorithm

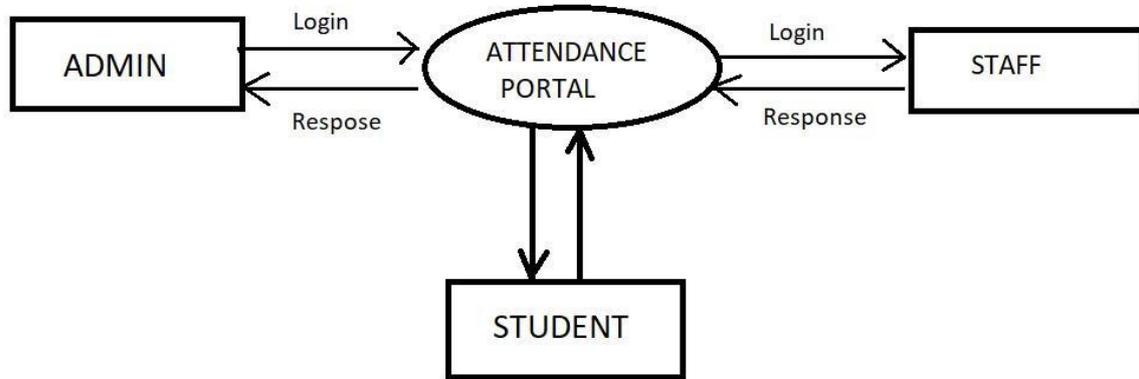
The haarcascade algorithm makes use of a kind of filter to perform feature extraction from the given image. These filters inspect only one portion of the image at a time. Then the intensity of the pixels in the white portion and in the black portion is added. The result of subtraction of these two summations is the feature extracted value.

3.3 Data Flow Diagram

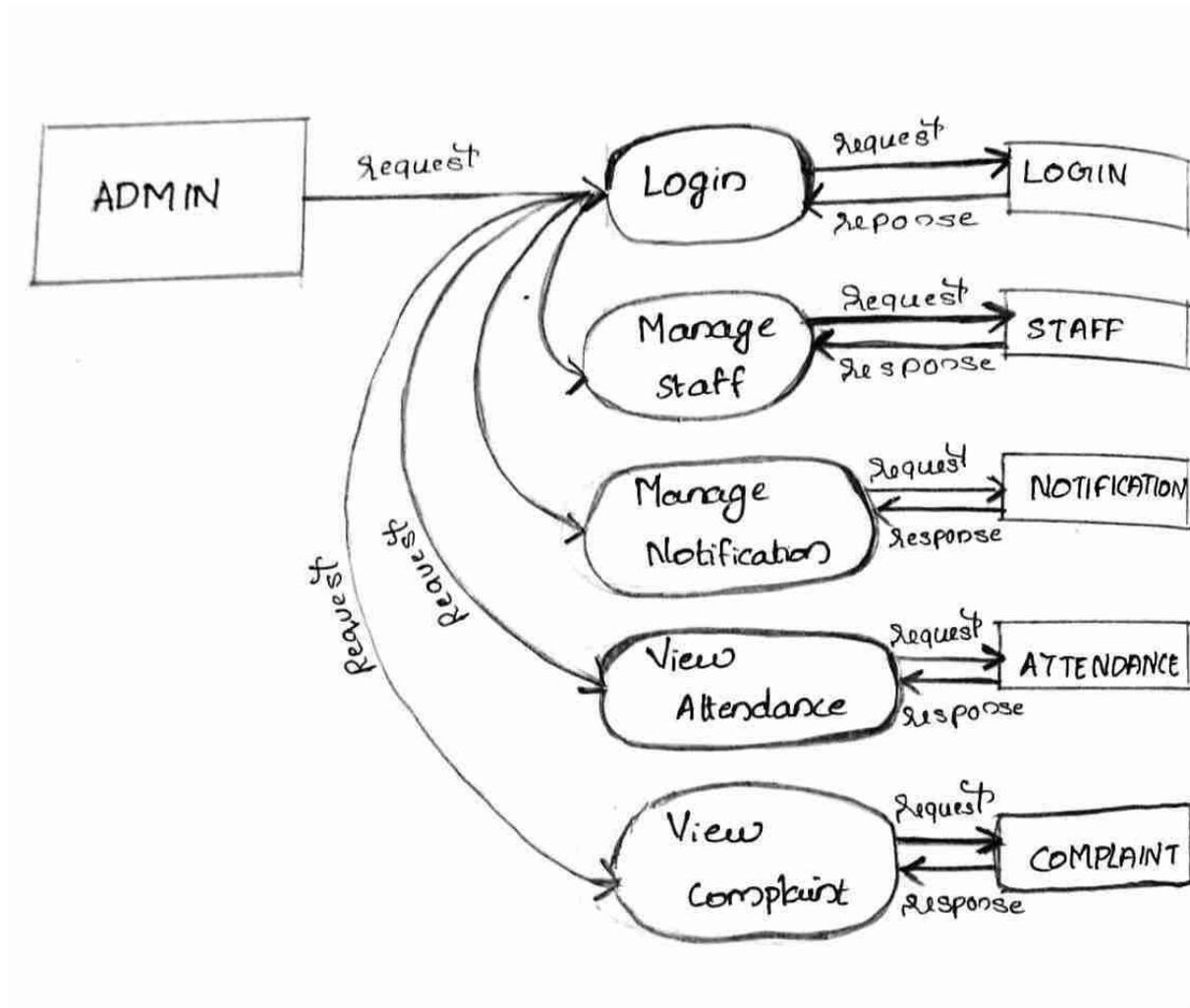
A data flow diagram (DFD) is a graphical representation of the flow of data through an information system. A DFD is often used as a primary step to create an overview of the system, which can later be elaborated.

A DFD shows what will be the input of the system as well as the output. It clearly represents where the data will come from and go to, and where the data will be stored.

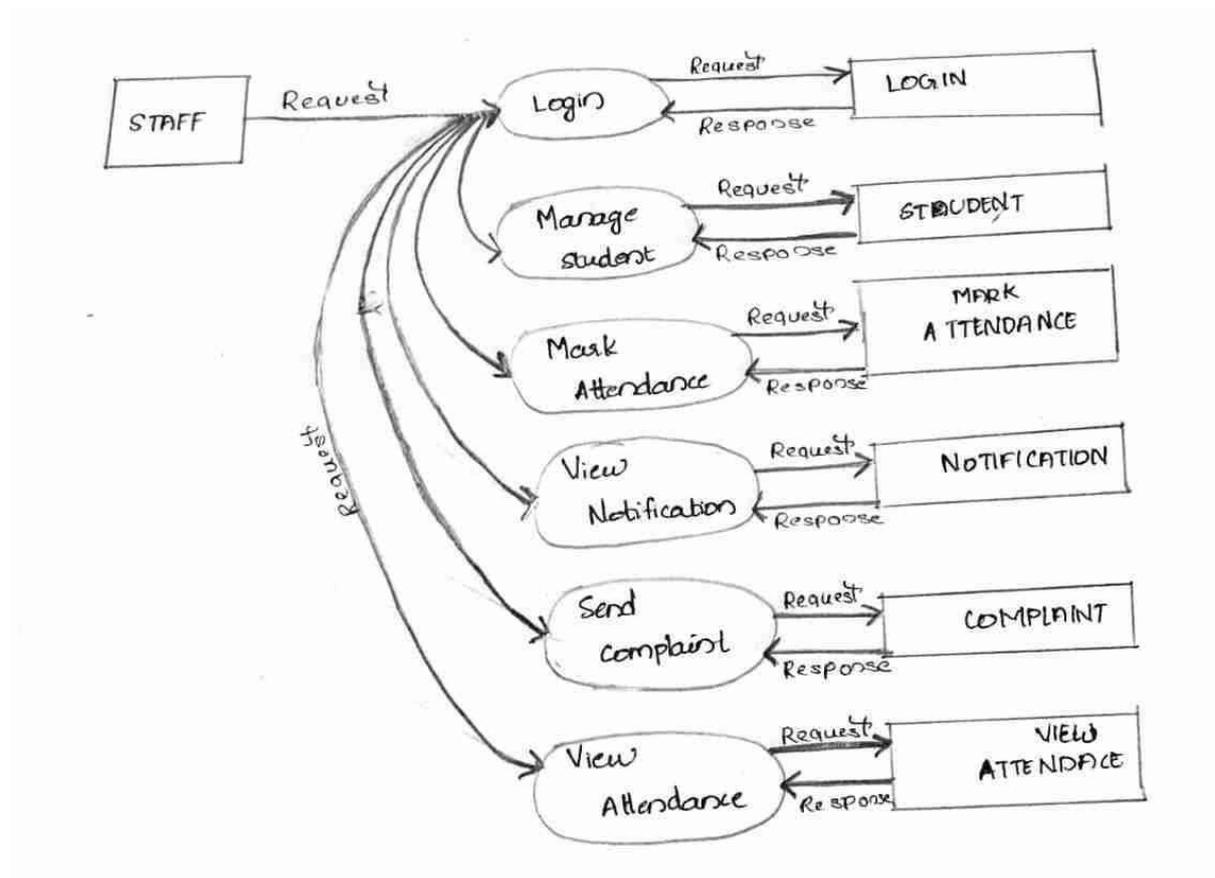
DFD Level Zero



DFD LEVEL ONE



DFD LEVEL TWO



3.4 Data Dictionary

A data dictionary contains metadata. The data dictionary is very important as it contains information such as what is in the database, who is allowed to access it, where is the database physically stored etc. The users of the database normally don't interact with the data dictionary, it is only handled by the database administrators.

3.5 Database Design

Database Design is a collection of processes. The main aim of database designing is to produce logical and physical design models for the suggested database system.

The logical model focuses on the data requirements and the data to be stored independent of physical components.

The physical data design model translates the logical design of the database onto physical media using hardware resources and software systems.

Login

Column	Type	Null	Default
login_id	Int(100)	No	
username	Varchar(200)	Yes	
password	Varchar(200)	Yes	
usertype	Varchar(200)	Yes	

Attendance

Column	Type	Null	Default
attendance_id	Int(100)	No	
staff_id	Int(100)	Yes	
student_id	int(200)	Yes	
date	varchar(100)	Yes	
time	varchar(200)	Yes	
type	varchar(200)	Yes	
periods	varchar(100)	Yes	
min	varchar(200)	Yes	

Staff

Column	Type	Null	Default
staff_id	int(100)	No	
login_id	int(100)	Yes	
fname	Varchar(200)	Yes	
lname	Varchar(200)	Yes	
place	Varchar(200)	Yes	
phone	Varchar(200)	Yes	
email	Varchar(200)	Yes	
designation	Varchar(200)	Yes	

Student

Column	Type	Null	Default
student_id	int(100)	No	
fname	Varchar(200)	Yes	
lname	Varchar(200)	Yes	
place	Varchar(200)	Yes	
phone	Varchar(200)	Yes	
email	Varchar(200)	Yes	
course	Varchar(200)	Yes	
photo	Varchar(200)	Yes	

complaint

Column	Type	Null	Default
complaint_id	int(200)	No	
staff_id	int(200)	Yes	
complaint	varchar(100)	Yes	
reply	varchar(100)	Yes	
date	varchar(100)	Yes	

Notification

Column	Type	Null	Default
notification_id	Int(100)	No	
notification	Varchar(200)	Yes	
date	Varchar(200)	Yes	

4. SYSTEM DEVELOPMENT

4.1 Introduction

Software Development is the process of analysing, designing, testing, implementation and maintenance. It is called Software Development Life Cycle (SDLC). Different SDLC include waterfall, prototyping, iterative, incremental, spiral development, rapid application development and agile methodology.

4.2 Process Description

Different processes of each module are as given below:

○ Admin

The admin has to login using username and password and can register or manage staff and notification. Admin can view attendance details of the students and can view complaints that are send by the staff. ○ **Staff Login**

The Staff has to login using username and password. In this activity, each staff or teacher can login to their page, can add or manage student details, can mark attendance by specifying each period and time and can view the attendance of students, can view notification that send by admin and send complaint to the admin.

○ Device(webcam)

In this activity, staff can detect face and mark attendance of the students.

4.3 Code Design

Main.py

```
from flask import Blueprint,request,render_template,flash,session
import uuid
```

```
import os from
core import *

app=Flask(__name__)
app.secret_key="aa"

@app.route('/')
def home():
    return render_template('home.html')

@app.route('/markattanadance',methods=['get','post'])
def markattanadance():

    if 'next' in request.form:
        pid=request.form['pid']
        mi=request.form['min']
        s=val(pid,mi)

    return render_template('markattandance.html')

@app.route('/login/',methods=['get','post'])
def login(): if "submits" in
request.form:
users=request.form['username']
passss=request.form['password'] q="select
```

```
* from login where username='%s' and
password='%s'
%(users,pass)
print(q)
res=select(q)
if res:
    session['lid']=res[0]['login_id']
    session['login_id']=res[0]['login_id']
    if res[0]['usertype']=="admin":
        return redirect(url_for('adminhome'))
    elif res[0]['usertype']=="staff":
        q="select * from staff where login_id='%s'"%(session['lid'])
        res=select(q)
        if res:
            session['sid']=res[0]['staff_id']
            print(session['sid'])
            return redirect(url_for('staffhome'))
        else:
            flash("Invalid Username and password")
    else:
        flash("Invalid Username and password")

return render_template('login.html')
```

```
@app.route('/adminhome')

def adminhome():

    return render_template('adminhome.html')

@app.route('/staffhome') def staffhome(): data={ }

sid=session['sid'] q="select * from staff where

staff_id='%s'"%(sid) res=select(q) data['na']=res

return render_template('staffhome.html',data=data)

@app.route('/adminmanagestaff',methods=['get','post'])

def adminmanagestaff():

    data={ } if "id" in request.args:

id=request.args['id'] q="delete from staff

where staff_id='%s'" %(id) delete(q) return

redirect(url_for('adminmanagestaff')) if

"submits" in request.form:

fname=request.form['fname']

lname=request.form['lname']

place=request.form['place']

phone=request.form['phone']

email=request.form['email']

desig=request.form['desig']

uname=request.form['uname']

passs=request.form['pass']
```

```
q="insert into login values(null,'%s','%s','staff')" %(uname,pass)
```

```
id=insert(q) q="insert into staff
```

```
values(null,'%s','%s','%s','%s','%s','%s','%s')
```

```
%(id,fname,lname,place,phone,email,desig)
```

```
id=insert(q)
```

```
flash('Added successfully...') return
```

```
redirect(url_for('adminmanagestaff'))
```

```
q="select * from
```

```
staff" res=select(q)
```

```
print(res)
```

```
data['staffs']=res
```

```
return render_template('adminmanagestaff.html',data=data)
```

```
@app.route('/staffmanagestudent',methods=['get','post'])
```

```
def staffmanagestudent():
```

```
data={} if "id" in
```

```
request.args:
```

```
id=request.args['id']
```

```
q="delete from staff
```

```
where staff_id='%s'"
```

```
%(id) delete(q)
```

```
return redirect(url_for('staffmanagestudent'))

if "submits" in request.form:
    fname=request.form['fname']
    lname=request.form['lname']
    place=request.form['place']
    email=request.form['email']
    phone=request.form['phone']
    course=request.form['course']

    i=request.files['image']
    path="static/uploads/"+str(uuid.uuid4()+i.filename)
    i.save(path)

    # q="insert into login values(null,'%s','%s','staff')" %(username,password)
    # id=insert(q) q="insert into student
        values(null,'%s','%s','%s','%s','%s','%s','%s')"
    %(fname,lname,place,phone,email,course,path)
    id=insert(q)

    # path = 'static/uploads/'
    path=""
    # Check whether the
    # specified path is # an existing file
    pid=str(id) isFile =
```

```
os.path.isdir("static/trainimages/"+pid)
print(isFile) if(isFile==False):
    os.mkdir('static\\trainimages\\'+pid) image1=request.files['image1']
path="static/trainimages/"+pid+"/"+str(uuid.uuid4()+image1.filename
image1.save(path)

image2=request.files['image2']
path="static/trainimages/"+pid+"/"+str(uuid.uuid4()+image2.filename
image2.save(path)

image3=request.files['image3']
path="static/trainimages/"+pid+"/"+str(uuid.uuid4()+image3.filename
image3.save(path) enf("static/trainimages/")

flash('Added successfully...') return
redirect(url_for('staffmanagstudent'))
q="select * from student" res=select(q)
print(res) data['student']=res

return render_template('staffmanagstudent.html',data=data)

@app.route('/admin_send_notification',methods=['get','post'])
def admin_send_notification():
```

```
if 'send' in request.form:
    complaint=request.form['com'] q="insert into notification
values(null,'%s',now())"%(complaint) insert(q)
flash("notification send")
# return redirect(url_for('app.admin_send_notification'))
return render_template("admin_send_notification.html")
```

```
@app.route('/staff_send_complaints',methods=['get','post'])
```

```
def staff_send_complaints():
```

```
    sid=session['sid']
```

```
    if 'send' in request.form:
```

```
        complaint=request.form['com']
```

```
        q="insert                into                complaint
```

```
values(null,'%s','%s','pending',now())"%(sid,complaint)
```

```
insert(q) flash("complaint send") return
```

```
redirect(url_for('staff_send_complaints')) return
```

```
render_template("staff_send_complaints.html")
```

```
@app.route('/staff_view_notification',methods=['get','post'])
```

```
def staff_view_notification():
```

```
    data={} sid=session['sid'] q="select * from notification"
```

```
res=select(q) data['not']=res return
```

```
render_template("staff_view_notification.html",data=data)
```

```

@app.route('/admin_view_send_complaint',methods=['get','post']) def
admin_view_send_complaint():
    data={} q="SELECT *,CONCAT(`fname`,` `lname`) AS `name` FROM
`complaint` INNER JOIN `staff` USING(`staff_id`)" res=select(q)

    data['complaints']=res

    j=0 for i in
range(1,len(res)+1):
    print('submit'+str(i)) if
'submit'+str(i) in request.form:
        reply=request.form['reply'+str(i)]
        print(reply) print(j)
        print(res[j]['complaint_id']) q="update complaint set reply='%s' where
complaint_id='%s'"
        %(reply,res[j]['complaint_id'])
        print(q) update(q) flash("success") return
redirect(url_for('admin.admin_view_send_complaint'))

    j=j+1 return
render_template('admin_view_send_complaint.html',data=data)

@app.route('/adminviewattendance',methods=['get','post'])
def adminviewattendance():
    data={} if 'submits' in
request.form:
    val=request.form['vals']

```

```
hn=request.form['hn']
q="SELECT
*,CONCAT(`student`.`fname`,`student`.`lname`) AS
sname,CONCAT(`staff`.`fname`,`staff`.`lname`) AS
sfname FROM attendance
INNER JOIN student
USING(student_id)
INNER JOIN `staff`
USING(staff_id) where
periods='%s' and date like
'%s'" %(hn,val)

print(q)
res=select(q)
print(res)
data['attendance']=res

else:
q="SELECT      *,CONCAT(`student`.`fname`,`student`.`lname`)  AS
sname,CONCAT(`staff`.`fname`,`staff`.`lname`) AS      sfname
      FROM attendance INNER JOIN student USING(student_id) INNER
JOIN `staff` USING(staff_id)" res=select(q) print(res)
data['attendance']=res

return render_template('adminviewattendance.html',data=data)
```

```
@app.route('/uploadimagesforstaff',methods=['get','post'])
) def uploadimagesforstaff(): data={ }
staff_id=request.args['ids'] if 'val' in request.args:
val=request.args['val'] else:
val=None

if val=="1":
# pritrn("Haii")
import cv2

# 1.creating a video object
video = cv2.VideoCapture(0)

# 2. Variable
a = 0

# 3. While
loop while
True: a = a +
1

# 4.Create a frame object
check, frame = video.read()

# Converting to grayscale
#gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)

# 5.show the frame!
cv2.imshow("Capturing",frame)
```

```
# 6.for playing
key = cv2.waitKey(1)
if key == ord('q'):
break

# 7. image saving
showPic =
cv2.imwrite("static/trainimages/"+staff_id+"/"+str(uuid.uuid4())+".jpg",frame)
print(showPic) q="update staff set noofinput='1' where staff_id='%s'"
%(staff_id) update(q)

# 8. shutdown the camera video.release()
cv2.destroyAllWindows return
redirect(url_for('adminmanagestaff')) if
val=="2": import cv2

# 1.creating a video object
video = cv2.VideoCapture(0)

# 2. Variable
a = 0

# 3. While
loop while
True: a = a +
1

# 4.Create a frame object
check, frame = video.read()

# Converting to grayscale
#gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)

# 5.show the frame!
```

```

cv2.imshow("Capturing",frame)
# 6.for playing

key = cv2.waitKey(1)

if key == ord('q'):

break

# 7. image saving

showPic =
cv2.imwrite("static/trainimages/"+staff_id+"/"+str(uuid.uuid4())+".jpg",frame)
e) print(showPic) q="update staff set noofinput='2' where staff_id='%s'"

%(staff_id) update(q)

# 8. shutdown the camera video.release()

cv2.destroyAllWindows return

redirect(url_for('adminmanagestaff')) if

val=="3": import cv2

# 1.creating a video object

video = cv2.VideoCapture(0)

# 2. Variable

a = 0

# 3. While

loop while

True: a = a +

1

# 4.Create a frame object

check, frame = video.read()

# Converting to grayscale

#gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)

```

```
# 5.show the frame!
cv2.imshow("Capturing",frame)

# 6.for playing
key = cv2.waitKey(1)
if key == ord('q'):
break

# 7. image saving
showPic =
cv2.imwrite("static/trainimages/"+staff_id+"/"+str(uuid.uuid4())+".jpg",frame)
e) print(showPic) q="update staff set noofinput='3' where staff_id='%s'"
%(staff_id) update(q)

# 8. shutdown the camera video.release()
cv2.destroyAllWindows return
redirect(url_for('adminmanagestaff')) q="select noofinput from
staff where staff_id='%s'" %(staff_id) print(q) res=select(q)
if res:
data['val']=res[0]['noofinput']
else:
data['val']=0 data['ids']=staff_id return
render_template('uploadimagesforstaff.html',data=data)
app.run(debug=True,port=5010)
```

5. SYSTEM TESTING AND IMPLEMENTATION

5.1 Introduction

Software testing is defined as a process to check whether the actual results match the expected results and to ensure that the software system is error free. Software testing also helps to identify defects, gaps or missing requirements in contrary to the actual requirements. It can be done manually or using automated tools.

5.2 Implementation

Implementation is the action that must follow any preliminary thinking in order for something to actually happen. Software/hardware implementations should always be designed with the end user in mind and the implementation process usually benefits from user involvement and support from managers and other top executives in the company. If users participate in the design and implementation of the system, ideally it will serve their business objectives more accurately and reflect their priorities and the ways in which they prefer to work.

5.3 Debugging

Debugging is the process of finding and resolving defects or problems within a system that prevent the proper functioning of the system.

Different types of debugging methods used in this system are:

- **Unit Testing**

The application was divided into smaller components and tested individually. Each code was executed separately to ensure accuracy.

- **Integration Testing**

Each small component was integrated or combined into a module to ensure that each module works properly when put together. This was done to check connectivity between modules.

- **System Testing**

The system as a whole was tested by combining every module. This was to ensure that each process have a particular order. This was to ensure that the system does not crash while using.

- **Validation Testing**

In the registration fragment, validation is carried out to ensure user enters values in all the fields and the fields like full name, contact number, email and monthly income are validated individually. In the login fragment, incorrect inputs like username incorrect and password incorrect if used for login, then it was ensured that the appropriate error message was displayed. In the health data fragment, validation is carried out in fields like height, weight, hip, waist measurements, blood pressure, total cholesterol, HDL cholesterol, blood sugar, serum triglyceride individually. In activity tracker fragment, validation is carried out to ensure user enters values in the water intake field, energy spent field, diet field.

5.4 System Security

Password encryption is used to protect each user's details.

5.5 Scope for Future Enhancement

The current system is flexible and can be modified in the future. This system can be deployed for verification and attendance tracking at various government offices and corporates. For access control verification and identification of authentic users it can also be installed in bank lockers and vaults. For identification of criminals the system can be used by police force also.

6. CONCLUSION

Conclusion

The software developed has fulfilled the necessary requirements as required by the user. It is ensured that all the programs are working properly in the “Trakom” application. The system is used to operate in a user-friendly manner. Proper documentation done from different areas provides smooth running of all the operations without difficulty. This project avoids errors. The main objective of this project is to offer system that simplify and automate the process of recording and tracking student attendance through face recognition technology. Haarcascade Algorithm is used to identify or verify a person from a digital image or surveillance video.

7. APPENDIX

HOME PAGE



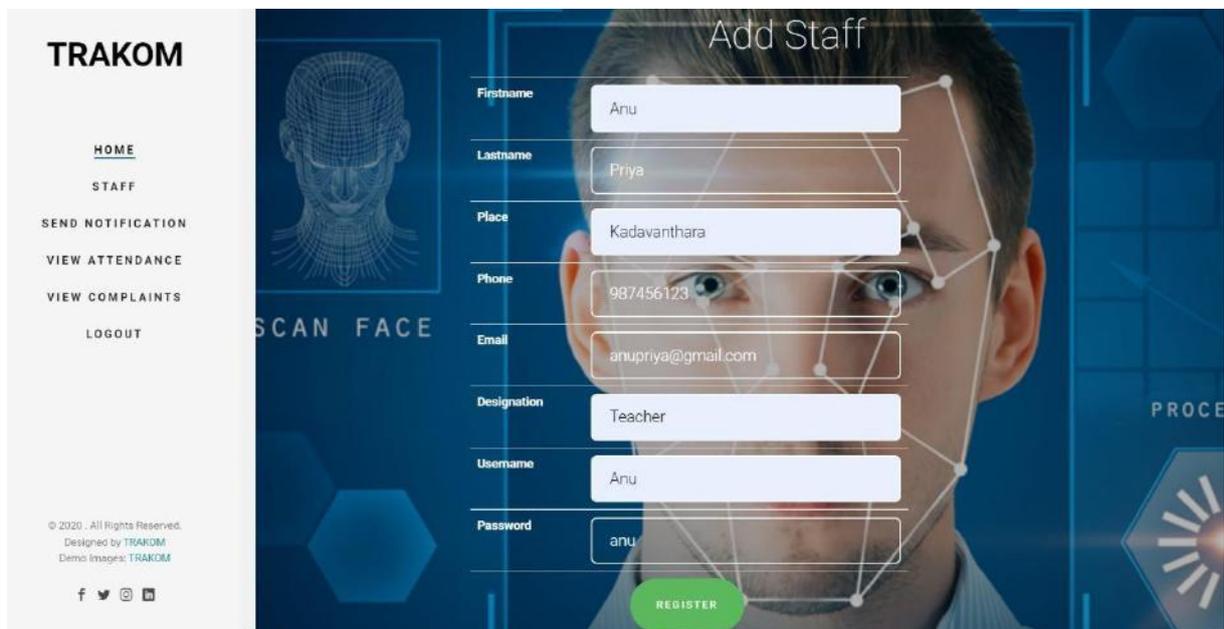
ADMIN LOGIN



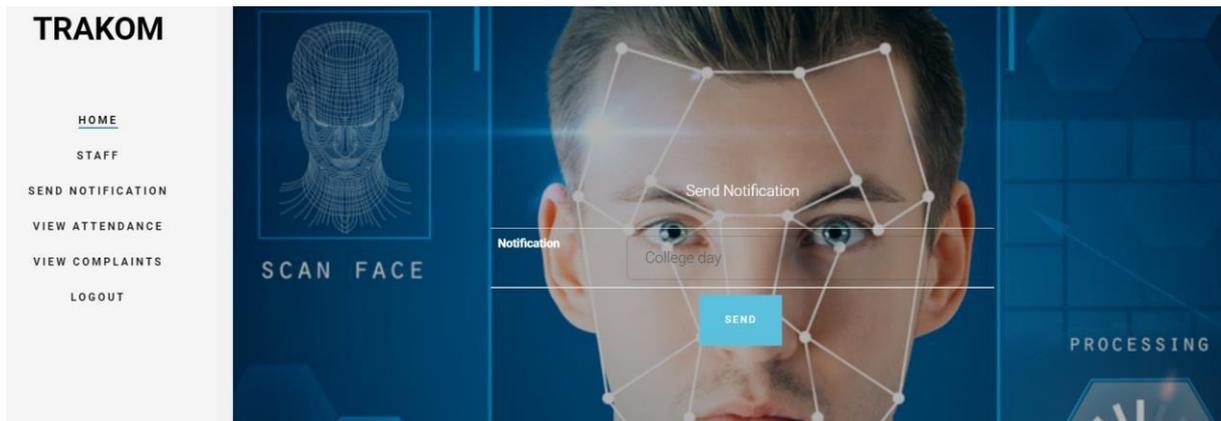
ADMIN PAGE



MANAGE STAFF



SEND NOTIFICATION



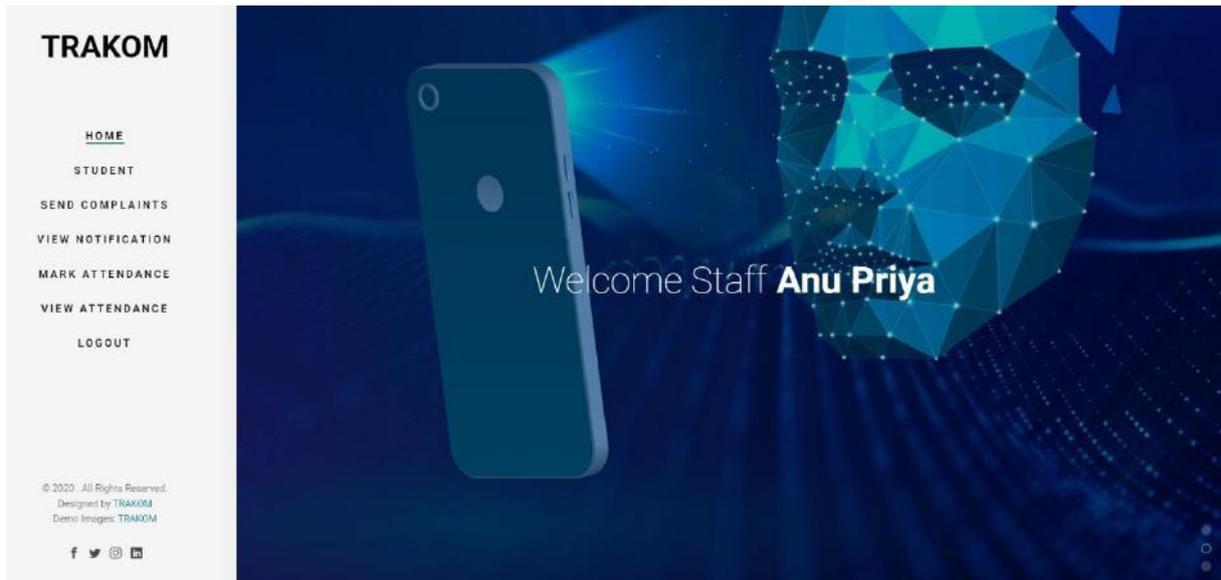
VIEW ATTENDANCE

Staff	Name	Date	Time	
AnuPriya	AshikaTinu	2022-04-01	11:27:25	Present
AnuPriya	AshikaTinu	2022-03-31	08:54:22	Late
AnuPriya	HannaK S	2022-04-01	11:54:02	Present
AnuPriya	AshikaTinu	2022-04-02	10:49:19	Present
AnjaliP R	EvaniaJoseph	2022-04-02	13:01:29	Present
AnuPriya	HannaK S	2022-04-02	17:05:38	Present
AnuPriya	AshikaTinu	2022-04-03	12:13:47	Present
AnuPriya	HannaK S	2022-04-03	12:14:04	Present
AnuPriya	JumanaMariyam	2022-04-03	12:14:27	Present

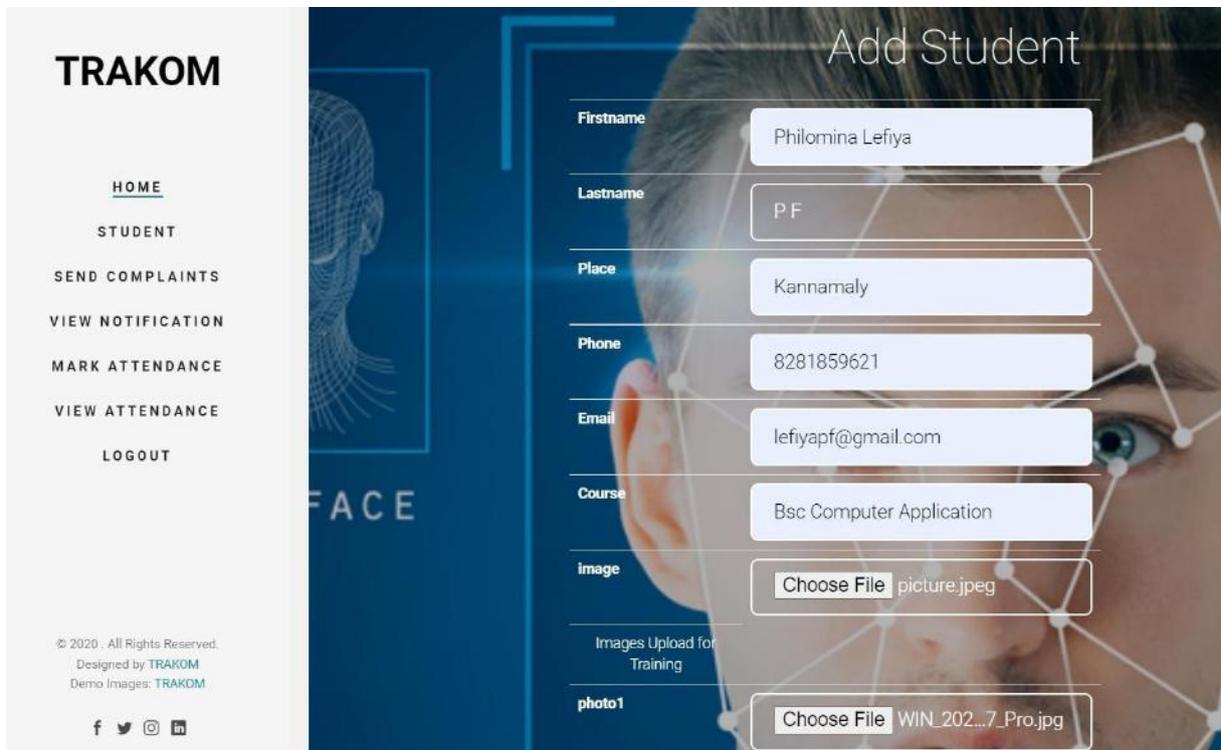
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Demo Images: TRAKOM

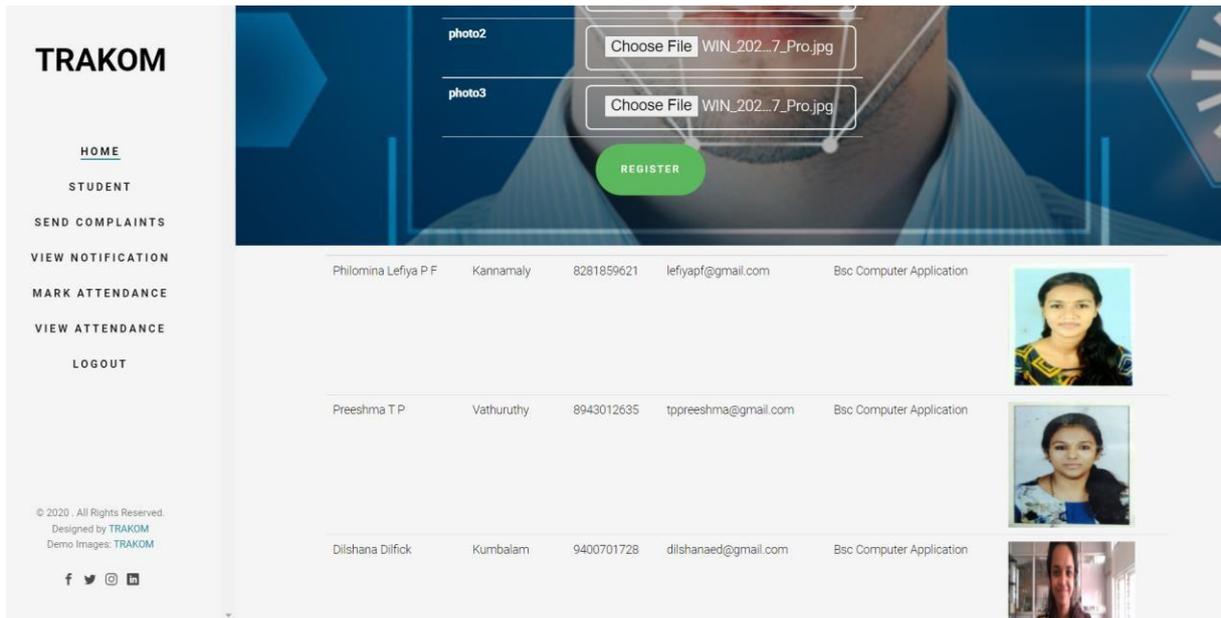
f t i l

STAFF HOME

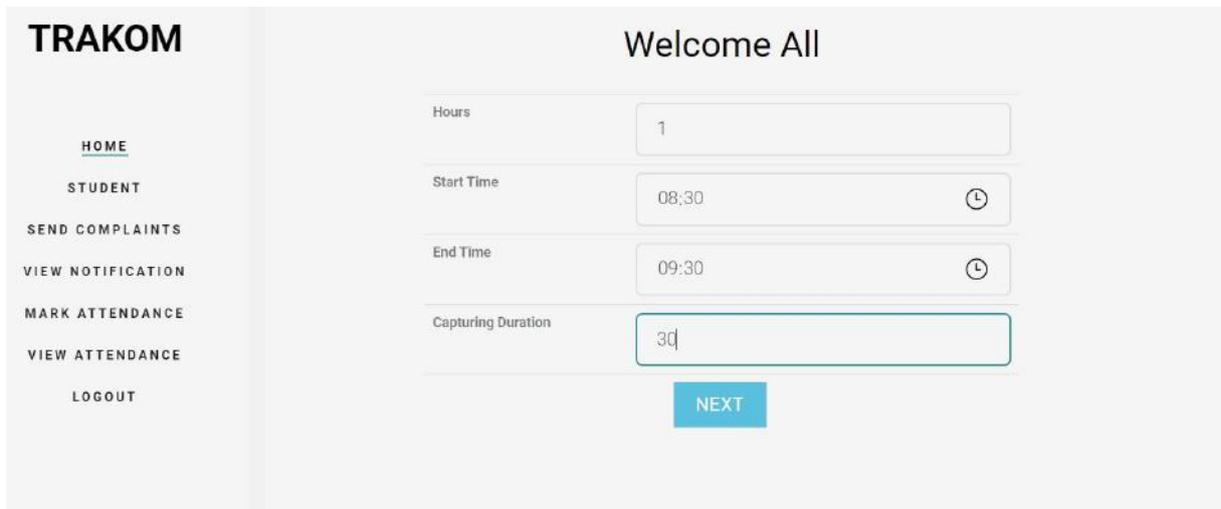


MANAGE STUDENT

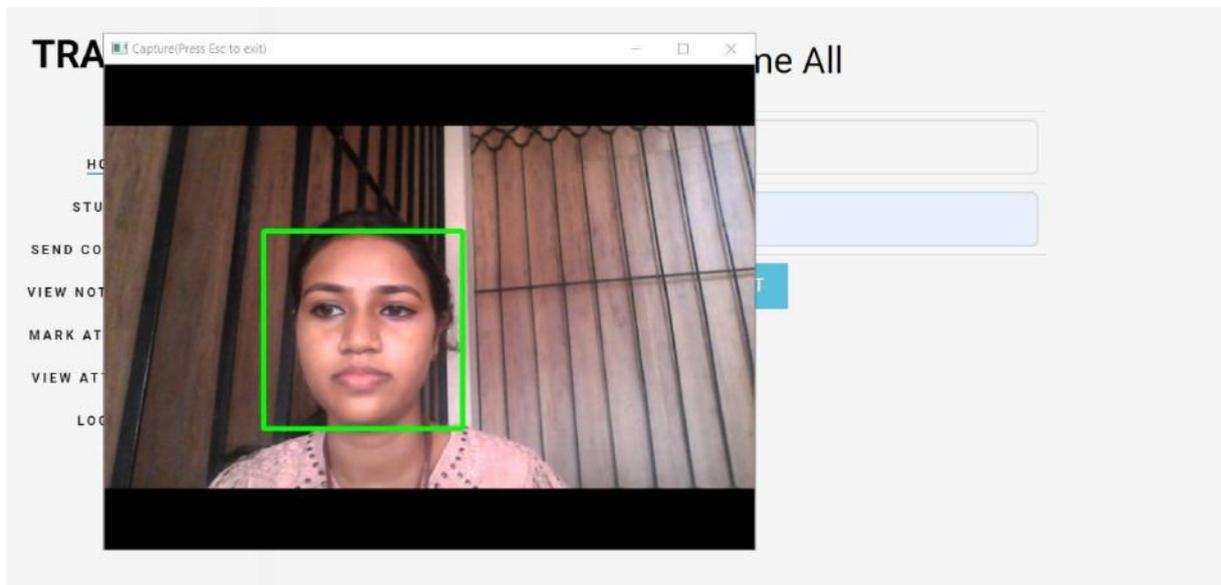




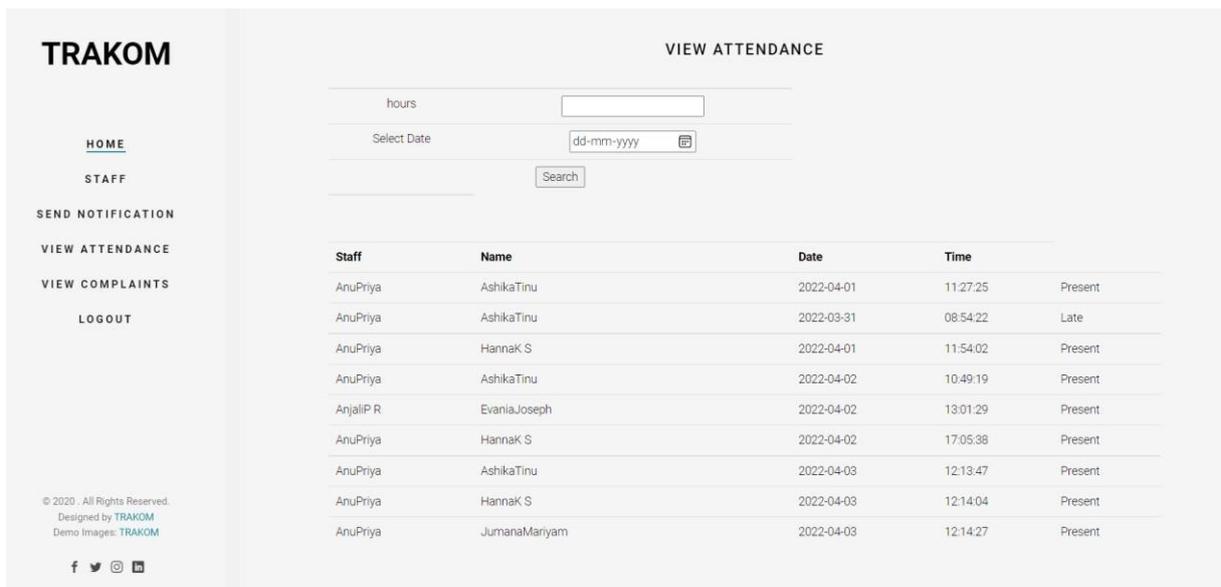
MARK ATTENDANCE



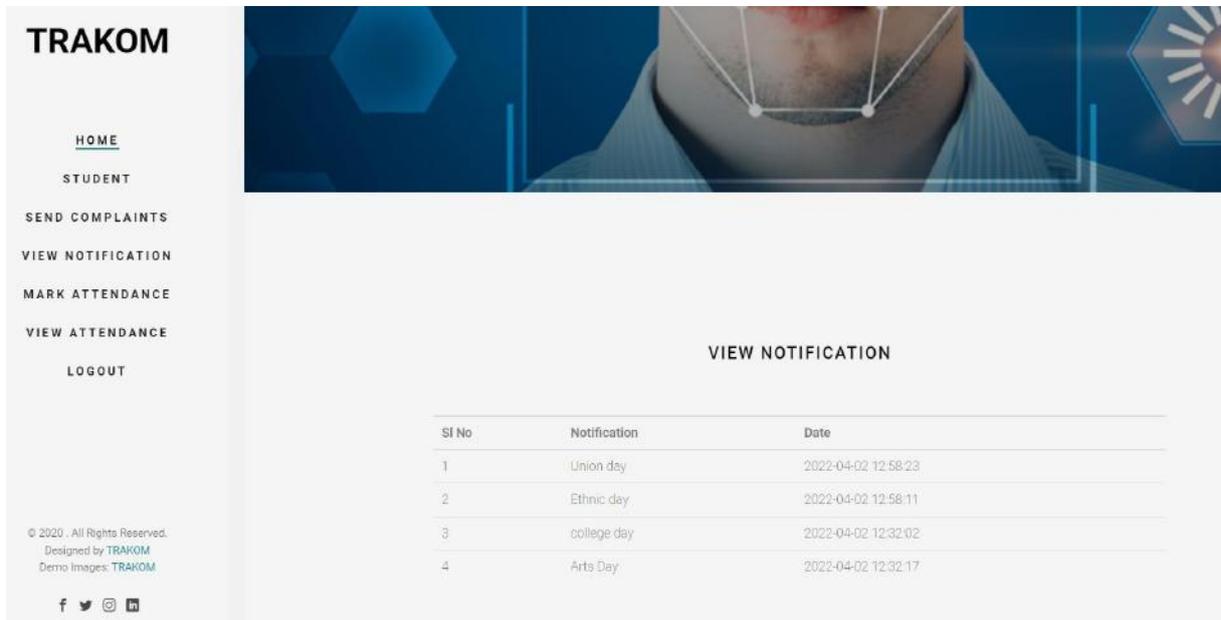
FACE DETECTING



VIEW ATTENDANCE



VIEW NOTIFICATION



TRAKOM

[HOME](#)

[STUDENT](#)

[SEND COMPLAINTS](#)

[VIEW NOTIFICATION](#)

[MARK ATTENDANCE](#)

[VIEW ATTENDANCE](#)

[LOGOUT](#)

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f t @ ln

VIEW NOTIFICATION

Sf No	Notification	Date
1	Union day	2022-04-02 12:58:23
2	Ethnic day	2022-04-02 12:58:11
3	college day	2022-04-02 12:32:02
4	Arts Day	2022-04-02 12:32:17

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- <https://www.tutorialspoint.com/>
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- <https://www.mysqltutorial.org/>

**ST. TERESA'S COLLEGE
(AUTONOMOUS) AFFILIATED TO MAHATMA GANDHI
UNIVERSITY**



PARK-ITT

PROJECT REPORT

In partial fulfilment of the requirements for the award of the degree of

**BACHELOR OF SCIENCE IN
COMPUTER APPLICATIONS
[TRIPLE MAIN]**

By

PHLOMINA SABU

III DC B.Sc. Computer Applications [Triple main]

Register No: SB19CA021

Under the guidance of

Mrs. Raji S Pillai

DEPARTMENT OF COMPUTER APPLICATIONS

2019-2022



CERTIFICATE

This is to certify that Ms. PHILOMINA SABU. (Reg. No: SB19CA021) Bachelor of Science In Computer Applications (Triple main) VI semester student of ST. TERESA'S COLLEGE ERNAKULAM affiliated to Mahatma Gandhi university, has done project work entitled "PARK-ITT" in PYTHON+ANDROID under the guidance of our senior faculties towards the fulfillment of the award of "Bachelor of Science In Computer Applications (Triple Main)" during the period of October 2021 to March 2022.

She successfully completed the project and during the period she was methodical and hardworking.

For RISS TECHNOLOGIES

Chief Executive Officer



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CERTIFICATE

This is to certify that the project report entitled "PARK-ITT", a bona fide record of the work done by **PHILOMINA SABU** during the year 2021-22 and submitted in partial fulfilment of the requirements for the degree of Bachelor of Science in Computer Applications (Triple main) under Mahatma Gandhi University.

Head of the Department

Internal Examiner

External Examiner



Date: 6/04/2022

DECLARATION

PHILOMINA SABU, BSc. Computer Applications[Triple Main] final year student of St. Teresa's College (AUTONOMOUS) Ernakulam Register NO: SB19CA021 ,hereby declare the dissertation submitted for the Bachelor's Degree in Computer Applications is my original work. I further declare that the said work has not previously has been submitted to any other university or academic body.

DATE: 5/04/2022

PLACE: Ernakulam



PHILOMINA SABU

ACKNOWLEDGEMENT

First and foremost we thank **GOD** Almighty for his blessings. We take this opportunity to express our gratitude to all those who helped me in completing this seminar successfully. We wish to express my sincere gratitude to the Manager **Rev. Dr. Sr. Vinitha** CSST, Director **Rev. Sr. Emelin** CSST and the principal **Dr.Lizzy Mathew** for providing all the facilities.

We express my sincere gratitude towards the Head of the Department **Mrs. Raji S Pillai** and the Course Coordinator **Mrs.Sheeba Emmanuel** for the support. We express my sincere thanks to my guide **Mrs. Raji S Pillai** for her proper support and guidance.

We have indebted to my beloved teachers whose cooperation and suggestion throughout the project. We thank all my friends and classmates for their Support.

We convey my hearty thanks to my Parents for the morsl support, suggestion and encouragement.

SYNOPSIS

Parking management system for managing the records of the incoming and outgoing vehicles in an parking house It's an easy for Admin to retrieve the data if the vehicle has been visited through number he can get that data . Now days in many public places such as malls, multiplex system, hospitals, offices, market areas there is a crucial problem of vehicle parking. The vehicle parking area has many lanes/slots for car parking. So to park a vehicle one has to look for all the lanes. Moreover this involves a lot of manual labour and investment. Instead of vehicle caught in towing the vehicle can park on safe and security with low cost.

The objective of this project is to build a Vehicle Parking management system that enables the time management and control of vehicles using number plate recognition. The system that will track the entry and exit of cars, maintain a listing of cars within the parking lot, and determine if the parking lot is full or not. It will determine the cost of per vehicle according to their time consumption.

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1. INTRODUCTION

1.1 About Project

In the modern age. Many people have vehicles. Vehicle is now a basic need. Every place is under the process of urbanization. There are many corporate offices and shopping centers etc. There are many recreational places where people used to go for refreshment. So, all these places need a parking space where people can park their vehicles safely and easily. Every parking area needs a system that records the detail of vehicles to give the facility. These systems might be computerized or non-computerized. With the help of computerized system we can deliver a good service to customer who wants to park their vehicle into the any organization's premises.

Vehicle parking management system is an automatic system which delivers data processing in very high speed in systematic manner. Parking is a growing need of the time. Development of this system is very useful in this area of field. We can sell this system to any organization. By using our system they can maintain records very easily. Our system covers the every area of parking management. In coming future there will be excessive need of Vehicle parking management system.

1.2 About Organization

RISS TECHNOLOGIES is a rapidly growing company that provides professional IT services. They are one of the largest and Best software development companies in Kerala with focus on .Net, PHP, Java, Software testing, SEO and Web Design.

1.3 Objectives of the Project and the Organization

Users friendly. Should be more efficient.They should provide more security. The idea behind our Android Application-''Park-itt'' is to help the user for online parking booking. In this application user can view various parking areas also he can select it to view whether parking slot is available or not. If the parking slot is available in parking then user can book it for some specific time slot also, this system provides an additional feature of cancelling the bookings. It also utilize the open ground for parking with security. So, it will solve the parking and traffic problem. In this there is no need to use additional costly camera and scanner device for verification purpose.

The main objective of the organisation is to continuously optimize their customers' business through our world-class solutions; services and products. They ensure the success of the company by constantly and consistently satisfying the customers, shareholders and employees.

2. SYSTEM ANALYSIS

2.1 Introduction

System Analysis is the complete study of the system and identifying its objectives mainly for problem solving purposes. Each and every modules of the system are evaluated. Inferences are made from these studies to ensure that all the components of the system is working efficiently.

System Analysis involves gathering information related to the system and developing the accurate tools for analysis. Studying and analysing the existing system is important for system analysis. Identifying the drawbacks in the existing system and how it is been rectified in the proposed system is one of the main aim.

2.2 Existing System

- ▶ Present day's car parking has become major issue in urban area with lack of parking facilities.
- ▶ it is very difficult and frustrating to find a parking space in most metropolitan areas, especially during the rush hours.to solve these problem .

2.3 Proposed System

- ▶ I. Users friendly
- ▶ ii. Should be more efficient
- ▶ iii. They should provide more security. The idea behind our Android Application- "Park-itt" is to help the user for online parking booking. In this application user can view various parking areas also he can select it to view whether parking slot is available or not.
- ▶ iv. If the parking slot is available in parking then user can book it for some specific time slot also, this system provides an additional feature of cancelling the bookings. It also utilize the open ground for parking with security. So, it will solve the parking and traffic problem. In this there is no need to use additional costly camera and scanner device for verification purpose.

2.4 System Specification

System specification specifies the hardware and software configuration of the new system. It helps to define the operational and performance guidelines of the system.

2.5 Operating System

An Operating System (OS) is an interface between computer user and computer hardware. It is a software which performs all the basic tasks like file management, memory management, process management, handling input and output and controlling peripheral devices such as disk drives and printers. The operating system required for proper execution of the system is Windows 10 or above. System specifications for the app to run:

- Android min SDK 23 – Marshmallow

2.6 Languages and Software Packages

▶ Java

Java is a class-based, object-oriented programming language that is designed to have as few implementation dependencies as possible. It produces software for multiple platforms.

▶ PYTHON

Python is a high-level, general-purpose programming language. Its design philosophy emphasizes code readability with the use of significant indentation.

▶ MySQL

MySQL is the most popular Open-Source Relational SQL Database Management System. MySQL is used for developing various web-based software applications.

▶ HTML

The HyperText Markup Language or HTML is the standard markup language for documents designed to be displayed in a web browser. It can be assisted by technologies such as Cascading Style Sheets and scripting languages such as JavaScript.

2.7 Hardware and Software Specifications

Software Requirements

Operating System: Windows 10 or above

Front End: HTML, Python(for web application),ANDROID(for mobile application)

Back End: MySQL

Software: Sublime text, WAMP, Android Studio

Web Browser: Internet Explorer/ Google Chrome/Firefox

Developing tool: Python

Hardware Requirements

Processor: Intel i5 8th gen or above

RAM: 8 GB or above

Hard Disk: 1GB or above free space

3. SYSTEM DESIGN

3.1 Introduction

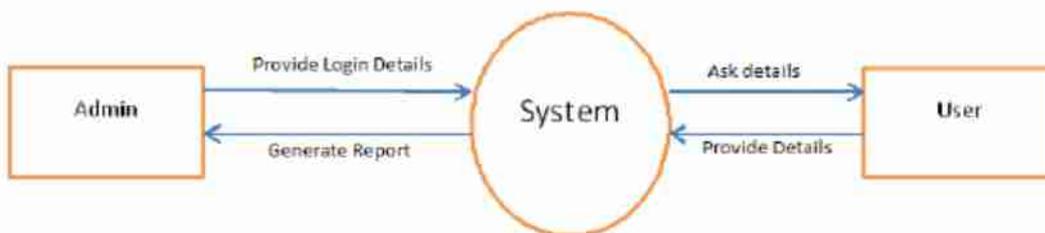
It is a process of planning a new business system or replacing an existing system by defining its components or modules to satisfy the specific requirements. Mainly focuses on how to accomplish the objectives of the system.

3.2 Data Flow Diagram

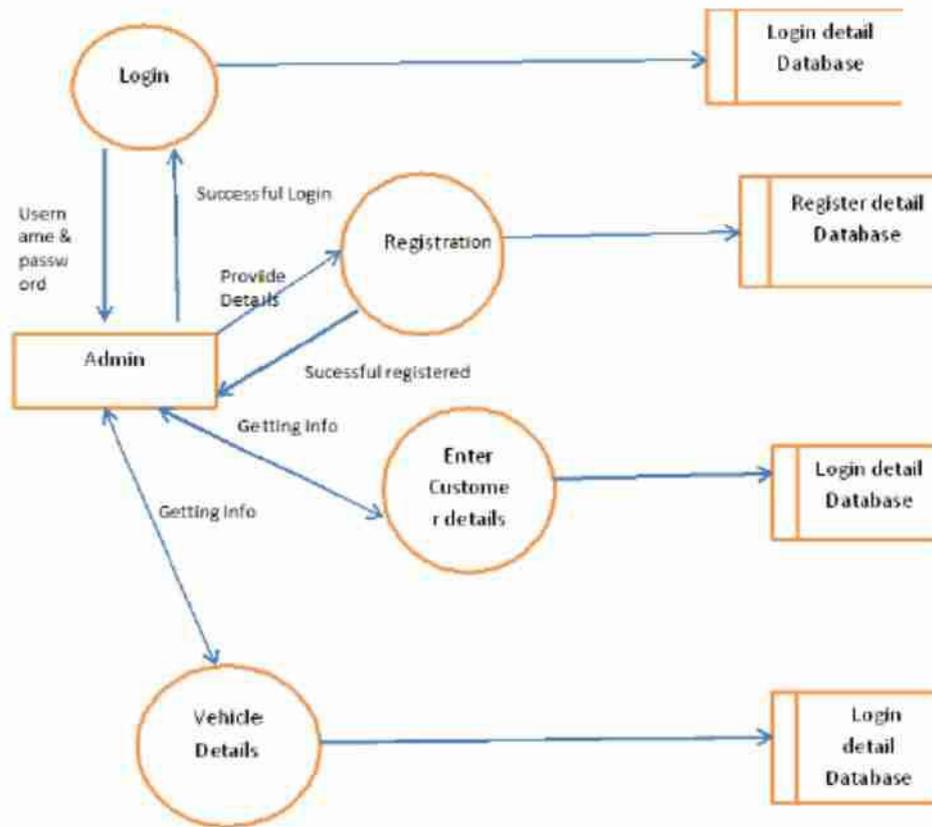
A data flow diagram (DFD) is a graphical representation of the flow of data through an information system. A DFD is often used as a primary step to create an overview of the system, which can later be elaborated.

A DFD shows what will be the input of the system as well as the output. It clearly represents where the data will come from and go to, and where the data will be stored.

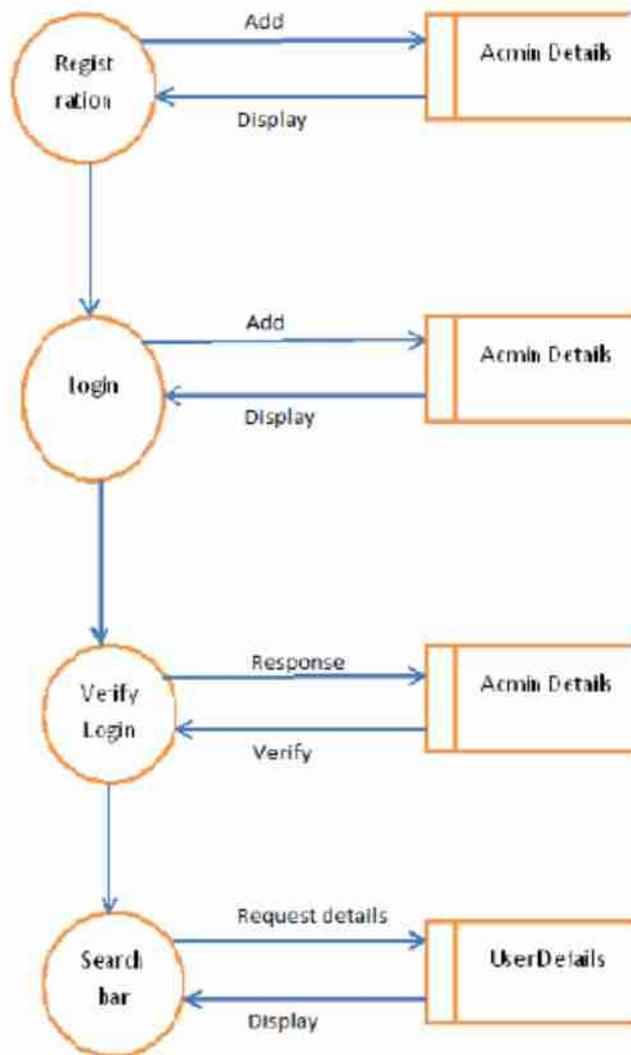
DFD Level 0



Level 1:



Level 2:



3.3 Data Dictionary

A data dictionary contains metadata. The data dictionary is very important as it contains information such as what is in the database, who is allowed to access it, where is the database physically stored etc. The users of the database normally don't interact with the data dictionary, it is only handled by the database administrators.

3.4 Database Design

Database Design is a collection of processes. The main aim of database designing is to produce logical and physical design models for the suggested database system.

The logical model focuses on the data requirements and the data to be stored independent of physical components.

The physical data design model translates the logical design of the database onto physical media using hardware resources and software systems.

tb_login

Column	Type	Null	Default
login_id	Int(100)	No	
username	Varchar(200)	Yes	
password	Varchar(200)	Yes	
usertype	varchar(10)	Yes	

tb_parking location

Column	Type	Null	Default
location_id	int(200)	No	
Location_name	int(200)	Yes	
place	varchar(100)	Yes	
latitude	varchar(100)	Yes	
longitude	varchar(100)	Yes	
description	varchar(100)	Yes	

tb_slots

Column	Type	Null	Default
Slo_-id	int(100)	No	
Slot_description	varchar(100)	Yes	
Slot_status	varchar(100)	Yes	
Location_id	varchar(100)	Yes	

Park-itt-parking slot booking application

amount	varchar(100)	Yes	
--------	--------------	-----	--

tb_users

Column	Type	Null	Default
User_id	int(200)	Yes	
Login_id	int(100)	Yes	
First_name	varchar(200)	Yes	
Last_name	varchar(200)	Yes	
House_name	varchar(200)	Yes	
Place	varchar(200)	Yes	
Encode	varchar(200)	Yes	
Latitude	varchar(200)	Yes	
Longitude	varchar(200)	Yes	
Phone	varchar(200)	Yes	
email	varchar(200)	yes	

tb_booking

Column	Type	Null	Default
book_id	int(200)	No	
User_id	varchar(200)	Yes	
Starting_date	varchar(200)	Yes	
Starting_time	varchar(200)	Yes	
Ending_date	varchar(200)	Yes	
Ending_time	varchar(200)	Yes	
Slot_id	varchar(200)	Yes	
Amount	varchar(200)	Yes	
status	varchar(200)	yes	

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tb_payment

Column	Type	Null	Default
payment_id	int(100)	No	
book_id	int(100)	Yes	
amount	varchar(200)	Yes	
Mode of payment	Varchar(100)	Yes	
Date	Varchar(100)	Yes	
status	varchar(100)	yes	

Tb_complaint

Column	Type	Null	Default
Complaint_id	int(100)	No	
User_id	int(100)	Yes	
Description	varchar(100)	Yes	
Date	varchar(100)	Yes	
Status	varchar(100)	Yes	
solution	varchar(100)	yes	

4. SYSTEM DEVELOPMENT

4.1 Introduction

Software Development is the process of analysing, designing, testing, implementation and maintenance. It is called Software Development Life Cycle (SDLC). Different SDLC include waterfall, prototyping, iterative, incremental, spiral development, rapid application development and agile methodology.

4.2 Process Description

Different processes of each module are as given below:

▶ Starting the android application :

First of all user need to install a 'validspot' application on him android device.

▶ Registration and login

User can use this app using login to the system. If user is new then first time registration is required.

▶ Search and view parking

User can find their parking based on destination address.so, based on its nearest parking lists will be displayed on screen. In which parking name, parking address and its type will be shown.

▶ View and Book your slot

Parking slot will be shown based on selection of parking. Here color code is used to differentiate the available slot and booked slot. After selection of slot, registration certificate (R.C) number is required for final booking purpose. Here, default time period for booked slot is 24 hour.

▶ Last step for parking of car

The client will have to reach the parking in 30 minutes. If it is not reach within 30 minutes then his booked slot will be cancel. Otherwise Final confirmation message will be given to user if he will park their car in proper slot.

4.3 Code Design

User.py

```
from flask import *
from database import *
user=Blueprint("user",__name__)
@user.route('/user_home', methods=['get','post'])
def user_home():
    return render_template("user_home.html")

@user.route('/booking',methods=['get','post'])
def booking():
    data={}
    logid=session['logid']
    if 'submit' in request.form:
        sdate=request.form['starting_date']
        stime=request.form['starting_time']
        edate=request.form['ending_date']
        etime=request.form['ending_time']
        slot=request.form['slot']
        q="select amount from slots where slot_id='%s'"%(slot)
        s=select(q)
        amnt=s[0]['amount']
        # print(amnt)
        data['amnt']=amnt
        q="INSERT INTO booking VALUES(NULL,(select user_id from users where
log_id='%s'),'%s','%s','%s','%s','%s','NA')"%(logid,sdate,stime,edate,etime,slot,amnt)
        bookid=insert(q)
        return render_template("user_payment.html",data=data)
    q="select * from slots"
    res=select(q)
    data['slots']=res
```

Park-itt-parking slot booking application

```
        return render_template("user_booking.html",data=data)

    @user.route('/payment',methods=['get','post'])
    def payment():
        data={ }
        logid=session['logid']
        q="select amount from booking where book_id=(select book_id from booking where
user_id=(select user_id from users where log_id='%s')" %(logid)
        if 'submit' in request.form:
            amt=request.form['amount']
            mod=request.form['mode_of_payment']
            date=request.form['date']
            q="INSERT INTO payment VALUES(NULL,(select book_id from booking
where user_id=(select user_id from users where
log_id='%s')),'%s','%s','%s','NA')"%(logid,amt,mod,date)
            insert(q)
        return render_template("user_payment.html",data=data)

    @user.route('/profile',methods=['get','post'])
    def profile():
        data={ }
        q="select * from users"
        res=select(q)
        data['profile']=res
        return render_template("user_profile.html",data=data)
```

Public.py

```
from flask import *

from database import *

public=Blueprint('public',__name__)

@public.route('/',methods=['get','post'])

def login():

    if 'submit' in request.form:
```

Park-itt-parking slot booking application

```
uname=request.form['username']
```

```
pwd=request.form['password']
```

```
q="select * from login where username='%s' and password='%s'"%(uname,pwd)
```

```
res=select(q)
```

```
if res:
```

```
    session['logid']=res[0]['log_id']
```

```
    if res[0]['type']=='admin':
```

```
        return redirect(url_for('admin.home'))
```

```
    # if res[0]['type']=='user':
```

```
        # return redirect(url_for('user.user_home'))
```

```
return render_template("login.html")
```

```
@public.route('/reg',methods=['get','post'])
```

```
def reg():
```

```
    if 'submit' in request.form:
```

```
        fname=request.form['first_name']
```

```
        lname=request.form['last_name']
```

```
        hname=request.form['house_name']
```

```
        place=request.form['place']
```

```
        pincode=request.form['pincode']
```

```
        lat=request.form['latitude']
```

Park-itt-parking slot booking application

```
lon=request.form['longitude']

phn=request.form['phone']

email=request.form['email']

uname=request.form['username']

pwd=request.form['password']

q="insert into login values(null,'%s','%s','user')"%(uname,pwd)

id=insert(q)

q="INSERT                                INTO                                users
VALUES(NULL,'%s','%s','%s','%s','%s','%s','%s','%s','%s')"%(id,fname,lname,hname,place,pincode,lat,lon,phn,email)

insert(q)

return render_template("registration.html")

@public.route('/loc',methods=['get','post'])

def loc():

    data={ }

    q="select * from parking_locations"

    res=select(q)

    data['view'] =res

    return render_template("parking.html",data=data)
```

admin.py

```
from flask import *

from database import *

import qrcode

import uuid
```

Park-itt-parking slot booking application

```
admin=Blueprint('admin',__name__)

@admin.route('/home',methods=['get','post'])

def home():

    return render_template("admin_home.html")

@admin.route('/loc_reg',methods=['get','post'])

def loc_reg():

    data={ }

    if 'action' in request.args:

        action=request.args['action']

        id=request.args['id']

    else:

        action=None

    if action=="delete":

        q="delete from parking_locations where loc_id='%s'"%(id)

        delete(q)

    if 'action' in request.args:

        action=request.args['action']

        id=request.args['id']

    else:

        action=None

    if action=="delete":

        q="delete from parking_locations where loc_id='%s'"%(id)

        delete(q)
```

Park-itt-parking slot booking application

```
if 'submit' in request.form:
```

```
    lname=request.form['loc_name']
```

```
    place=request.form['place']
```

```
    lat=request.form['latitude']
```

```
    lon=request.form['longitude']
```

```
    des=request.form['description']
```

```
    q="INSERT                                INTO                                parking_locations  
VALUES(NULL,'%s','%s','%s','%s','%s')%(lname,place,lat,lon,des)
```

```
    insert(q)
```

```
    q="select * from parking_locations"
```

```
    res=select(q)
```

```
    data['view'] =res
```

```
    return render_template("admin_locregistration.html",data=data)
```

```
@admin.route('/slot_reg',methods=['get','post'])
```

```
def slot_reg():
```

```
    data={ }
```

```
    if 'action' in request.args:
```

```
        action=request.args['action']
```

```
        id=request.args['id']
```

```
    else:
```

```
        action=None
```

```
    if action=="delete":
```

```
        q="delete from slots where slot_id='%s'"%(id)
```

```
        delete(q)
```

Park-itt-parking slot booking application

if 'submit' in request.form:

locname=request.form['locname']

sdes=request.form['slot_description']

amt=request.form['amount']

```
q="INSERT                                INTO                                slots
VALUES(NULL,'%s','free','%s','%s','filename')"%(sdes,locname,amt)
```

id=insert(q)

path = "static/qrcode/" + str(uuid.uuid4()) + ".png"

img = qrcode.make(id)

img.save(path)

```
q="UPDATE slots SET qr_code='%s' WHERE slot_id='%s'" %(path,id)
```

update(q)

return redirect(url_for('admin.slot_reg'))

```
q="select * from parking_locations"
```

res=select(q)

data['loc']=res

```
q="select * from slots inner join parking_locations using(loc_id)"
```

res=select(q)

data['sv'] =res

return render_template("admin_slotregistration.html",data=data)

```
@admin.route('/slot_status',methods=['get','post'])
```

```
def slot_status():
```

data={ }

```
q="select * from slots inner join parking_locations using(loc_id) "
```

Park-itt-parking slot booking application

```
res=select(q)

data['sts']=res

return render_template("admin_slotstatusview.html",data=data)

@admin.route('/reg_users',methods=['get','post'])

def reg_users():

    data={ }

    q="select * from users"

    res=select(q)

    data['regu']=res

    return render_template("admin_viewregusers.html",data=data)

@admin.route('/book_info',methods=['get','post'])

def book_info():

    data={ }

    q="select * from booking inner join slots using(slot_id) "

    res=select(q)

    data['bv']=res

return render_template("admin_viewbookinginfo.html",data=data)

@admin.route('/view_payment',methods=['get','post'])

def view_payment():

    data={ }

    q="SELECT          CONCAT(first_name,'          ',last_name)          AS
user_name,`booking`.`amount`,`mode_of_payment`,`date` FROM payment INNER JOIN
booking USING(book_id) INNER JOIN users USING (user_id)"

    res=select(q)
```

Park-itt-parking slot booking application

```
data['pay']=res

return render_template("admin_payrep.html",data=data)
```

```
@admin.route('view_complaint' ,methods=['get','post'])
```

```
def view_complaint():
```

```
    data={ }
```

```
    q="select          concat(first_name,'          ',last_name)          as
user_name,`description`,`date`,`solution,complaint_id from complaint inner join users USING
(user_id)"
```

```
    res=select(q)
```

```
    data['com']=res
```

```
    return render_template("admin_viewcomplaint.html",data=data)
```

```
@admin.route('/view_replay' ,methods=['get','post'])
```

```
def view_replay():
```

```
    data={ }
```

```
    id=request.args['id']
```

```
    q="select *,concat(first_name,' ',last_name) as user_name from complaint inner join
users using (user_id) WHERE complaint_id='%s'" %(id)
```

```
    res=select(q)
```

```
    print(res)
```

```
    data['vr']=res
```

```
    if 'submit' in request.form:
```

```
        solution=request.form['soln']
```

Park-itt-parking slot booking application

```
q="UPDATE complaint SET solution='%s' WHERE complaint_id='%s'"  
%(solution,id)
```

```
update(q)
```

```
return redirect(url_for("admin.view_complaint"))
```

```
return render_template("admin_replay.html",data=data)
```

5. SYSTEM TESTING AND IMPLEMENTATION

5.1 Introduction

Software testing is defined as a process to check whether the actual results match the expected results and to ensure that the software system is error free. Software testing also helps to identify defects, gaps or missing requirements in contrary to the actual requirements. It can be done manually or using automated tools.

5.2 Implementation

Implementation is the action that must follow any preliminary thinking in order for something to actually happen. Software/hardware implementations should always be designed with the end user in mind and the implementation process usually benefits from user involvement and support from managers and other top executives in the company. If users participate in the design and implementation of the system, ideally it will serve their business objectives more accurately and reflect their priorities and the ways in which they prefer to work.

5.3 Debugging

Debugging is the process of finding and resolving defects or problems within a system that prevent the proper functioning of the system.

Different types of debugging methods used in this system are:

- **Unit Testing**

The application was divided into smaller components and tested individually. Each code was executed separately to ensure accuracy.

- **Integration Testing**

Each small component was integrated or combined into a module to ensure that each module works properly when put together. This was done to check connectivity between modules.

- **System Testing**

The system as a whole was tested by combining every module. This was to ensure that each process have a particular order. This was to ensure that the system does not crash while using.

- **Validation Testing**

In the registration fragment, validation is carried out to ensure user enters values in all the fields and the fields like full name, contact number, email and monthly income are validated individually. In the login fragment, incorrect inputs like username incorrect and password incorrect if used for login, then it was ensured that the appropriate error message was displayed. In the health data fragment, validation is carried out in fields like height, weight, hip, waist measurements, blood pressure, total cholesterol, HDL cholesterol, blood sugar, serum triglyceride individually. In activity tracker fragment, validation is carried out to ensure user enters values in the water intake field, energy spent field, diet field.

5.4 System Security

Password encryption is used to protect each user's details.

5.5 Scope for Future Enhancement

The current system is flexible and can be modified in the future.

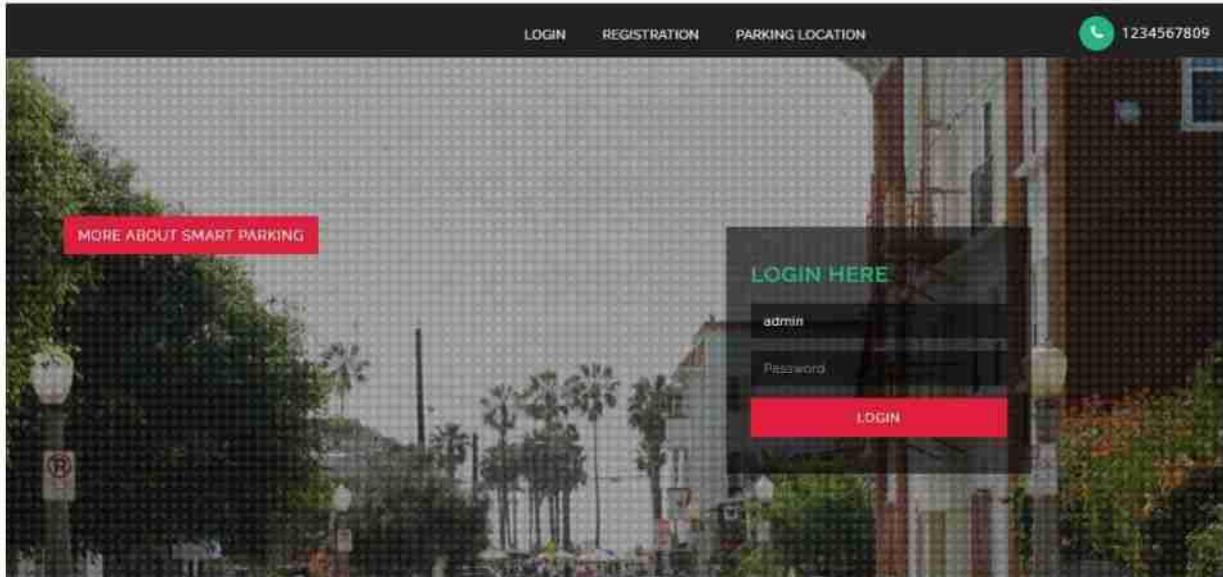
6. CONCLUSION

CONCLUSION

The software developed has fulfilled the necessary requirements as required by the user. It is ensured that all the programs are working properly in the “Park-itt” application. The system is used to operate in a user-friendly manner. Proper documentation done from different areas provides smooth running of all the operations without difficulty. The system that has been developed in android studio is to improve the user interactivity. This project avoids errors. The system has achieved the objective of proving the appropriate exercise and diet patterns to its users. The project has been implemented and tested.

7. APPENDIX

*LOGIN PAGE



*REGISTRATION

REGISTRATION

LOCATION NAME	<input type="text"/>
PLACE	<input type="text"/>
LATITUDE	<input type="text"/>
LONGITUDE	<input type="text"/>
DESCRIPTION	<input type="text"/>

View Map:

SUBMIT

* SLOT REGISTRATION

REGISTRATION

LOCATION NAME	<input type="text" value="Select"/>
SLOT DESCRIPTION	<input type="text"/>
AMOUNT	<input type="text"/>

* PARKING LOCATION



PARKING LOCATIONS

LOCATION NAME	PLACE	LATITUDE	LONGITUDE	DESCRIPTION	ACTION
ernakulam	mg road	9.8916	76.2999	heavy traffic place	DELETE
kattapana	vellayankudi bus stand	9.7557	77.1254	wide area	DELETE
padma junction	Ernakulam	9.7	9.76	near ksrtc busstand	DELETE

Park-itt-parking slot booking application

* ADMIN VIEW REGISTERD USERS

USER DETAILS

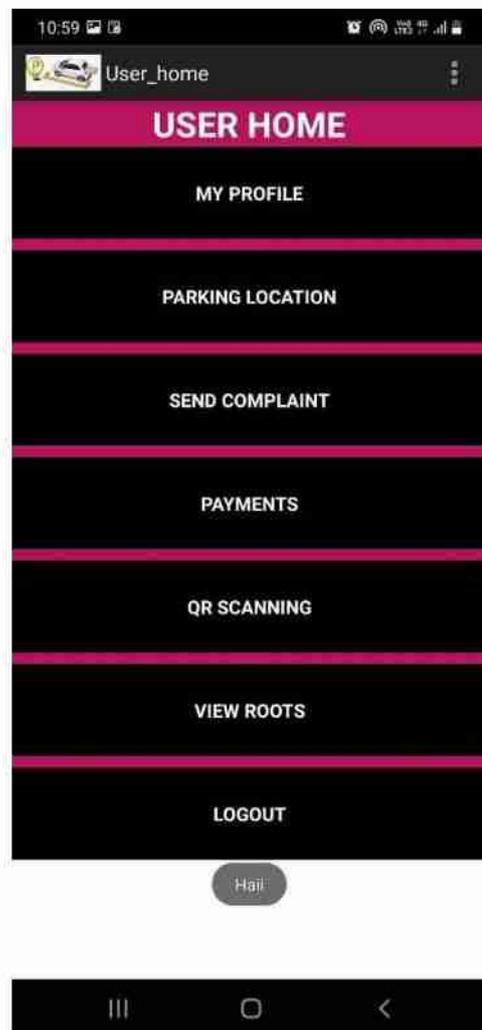
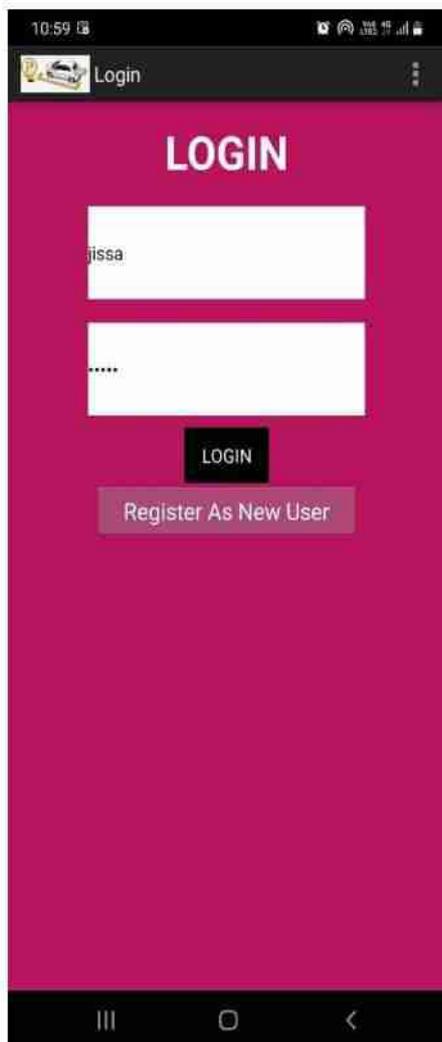
FIRST NAME	LAST NAME	HOUSE NAME	PLACE	PINCODE	LATITUDE	LONGITUDE	PHONE NUMBER	EMAIL
jissa	mathew	urumbithadathil	nedumkandam	685553	56	32	8238826141	jissa@gmail.com
aleka	mathew	urumbithadathil	chembalam	685553	45	88	9947305829	aleka@gmail.com
aleena	mathew	urumbithadathil	idukki	685551	98	39	9562954894	aleena@gmail.com
amitu	aaa	dfg	kkk	6609978			23658	jissa298@gmail.com
Jayalaxmi	jolly	jolly hut	nedumkandam	68765433			685553	Jaya@gmail.com

* ADMIN VIEW PAYMENT DETAILS

PAYMENT DETAILS

USER NAME	AMOUNT	MODE OF DELIVERY	DATE
aleka mathew	200	online	20-12-2019
aleena mathew	100	online	1-1-2020
preeshma t p	0	online	2022-04-04

USER INTERFACE



Park-itt-parking slot booking application

10:59

User_profile

MY PROFILE

FIRST NAME
jissa

LAST NAME
mathew

HOUSE NAME
urumbithadathil

PLACE
nedumkandam

PINCODE
685553

PHONE NUMBER
6238826141

EMAIL
jissaa@gmail.com

UPDATE

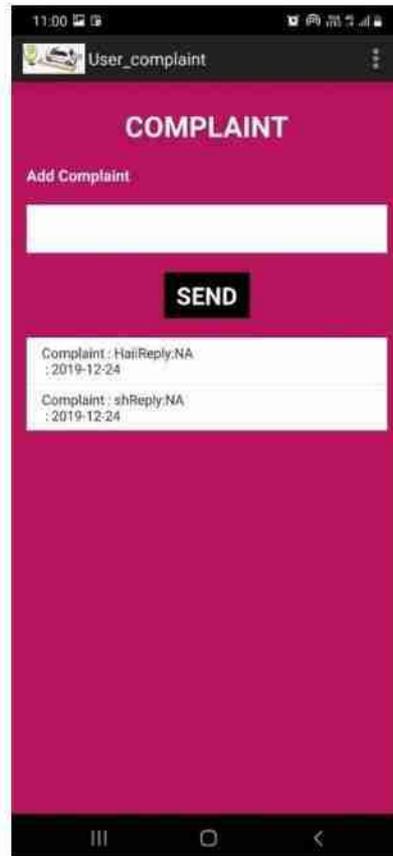
5:40

User_View_Nearest_Parking_Lo...

PARKING LOCATION

Location Name : ernakulam
Place : mg roadlatitude9.9816 longitude: 76.2999
description : heavy trafficamount90

Park-itt-parking slot booking application



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- <https://gist.github.com/mstfldmr/fc4fa436f2e553b10865>
- <https://www.javatpoint.com/>
- <https://www.mysqltutorial.org/>

ST. TERESA'S COLLEGE
(AUTONOMOUS)
AFFILIATED TO MAHATMA GANDHI UNIVERSITY



DAILY EXPENSE TRACKER
PROJECT REPORT

In partial fulfilment of the requirements for the award of the degree of

**BACHELOR OF VOCATIONAL
SOFTWARE DEVELOPMENT**

By

M PONNUMANI
III BVoc Software Development
Register No: VB19SWD011

Under the guidance of
Mrs Harsha K M

DEPARTMENT OF COMPUTER APPLICATIONS
2021-2022

CERTIFICATE



This is to certify that the project report entitled "DAILY EXPENSE TRACKER ", a bonafide record of the work done by M PONNUMANI during the year 2021-22 and submitted in partial fulfilment of the requirements for the degree of Bachelor of Vocational Software Development under Mahatma Gandhi University.

Head of the Department



Internal Examiner

External Examiner



An ISO 9001:2015 Certified Company



APRIL 5, 2022

TO WHOM SO EVER IT MAY CONCERN

This is to certify that PONNUMANI.M, 6th semester, BVOC – Software Development student of ST. TERESA'S COLLEGE, ERNAKULAM has successfully completed a project titled "DAILY EXPENCE TRACKER" from our organization.

The duration of the project was for 3 months. The Project was incorporated in JAVA, ANDROID and was implemented successfully.

Thanking you,

For LCC Computer Education

T.S. Ramaswamy
Director



DECLARATION

I, M PONNUMANI (Register no: VB19SWD011), BVoc. Software Development final year student of St. Teresa's College (Autonomous), Ernakulam, hereby declare that the project submitted named DAILY EXPENSE TRACKER for the Bachelor's Degree in Software Development is my original work. I further declare that the said work has not previously been submitted to any other university or academic body.



M PONNUMANI

Place : Ernakulam

Date : 6/4/2022

ACKNOWLEDGEMENT

In this humble endeavour I have received a great deal of support and guidance from different quarters. First and foremost I thank the God almighty, for bestowing upon me abundance of grace, wisdom and power throughout the study and making it a success.

I am extremely grateful to my Director Rev. Dr. Sr. Vinitha (CSST) and principle Dr. Lizzy Mathew for giving me this opportunity.

I take this opportunity to express my profound sense of gratitude and indebtedness to the Head of the Department of Computer Applications Mrs RAJI S PILLAI, my project guide

Mrs HARSHA K M and all the teaching faculty, for the encouragement and guidance in accomplishing the work.

I extend my gratitude to Mrs Janisha, faculty at LCC COMPUTER EDUCATION, Ernakulam under whose guidance and support this project work has been carried out.

Last but not the least, I would like to thank my parents and friends for motivating me and providing me the right environment for making this project work a great success.

SYNOPSIS

The DAILY EXPENSE TRACKER is a software application which is an attempt to manage our daily expenses in a more efficient and manageable way. Sometime we can't remember where our money goes. And we can't handle our cash flow.

Instead of keeping a diary or a log of the expenses, this application enables the user to not just keep the control on the expenses but also to generate and save reports.

With the help of this application, the user can manage their expenses on a daily, weekly and monthly basis. Users can insert and delete transactions as well as can generate and save their reports.

The graphical representation of the application is the main part of the system as it appeals to the user more and is easy to understand.

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1.INTRODUCTION

1.1 ABOUT PROJECT

This project is an attempt to manage our daily expenses in a more efficient and manageable way. Sometime we can't remember where our money goes. And we can't handle our cash flow.

For this problem, we need a solution that everyone can manage their expenses. So, we decided to find an easier way to get rid of this problem. So, our application attempts to free the user with as much as possible the burden of manual calculation and to keep the track of the expenditure.

Instead of keeping a diary or a log of the expenses, this application enables the user to not just keep the control on the expenses but also to generate and save reports.

With the help of this application, the user can manage their expenses on a daily, weekly and monthly basis. Users can insert and delete transactions as well as can generate and save their reports.

The graphical representation of the application is the main part of the system as it appeals to the user more and is easy to understand.

FEATURES OF DAILY EXPENSE TRACKER ANDROID APP PROJECT

- Create multiple accounts/budget
- Selecting income stream type (full time /part time)
- Delete account
- Modify Transactions
- Offline data store
- Passcode security
- Selecting budget mode (Weekly/Monthly)
- Generate reports as PDF files
- Fully customizable categories
- Cash flow (Pie/Bar/Graph)
- Expenses percentage
- Show transaction note
- Manage (making tally) group expense (of users)

1.2 ABOUT ORGANIZATION

Founded in Cochin back in the year 1992, LCC started its journey as a premier computer coaching center and later advanced into one of the most reputed brands for computer learning throughout India. LCC has surpassed victory in finding and refining those hidden talents in our pupils, to deliver thousands of IT presto the evergreen IT Industry every year. Whether you are a novice, a mediocre or a professional in computer technologies, we have the right course for you to advance and follow an ambitious career path.

we also mold students into professional characters for interviews through job fairs, placement workshops, seminars, presentations and various other personality development programs. To sum it up, in spite of being the right platform to build your sharp IT knowledge, LCC also supports your first step to career by introducing you to the complex technology job sector through placement opportunities to reputed companies.

1.3 OBJECTIVES OF BOTH PROJECT AND ORGANIZATION

With the help of this application, the user can manage their expenses on a daily, weekly and monthly basis. Users can insert and delete transactions as well as can generate and save their reports. The graphical representation of the application is the main part of the system as it appeals to the user more and is easy to understand.

Technology as you can imagine, advances every second. It feeds upon itself i.e., technology makes more technology possible. LCC's expert academicians and certified faculties interact with our leading computer technology company allies like (include LCCs alliances here for eg. Java, Red Hat, Microsoft and Oracle)to come up with relevant certification courses (short term, long term, professional, and career courses) after thorough market research and study. LCC is also the training partner to World famous MNC TOTAL SOLUTIONS INC, CHICAGO, USA, and its allied Company EZMRX Bangalore. Our curriculum features the largest offering of computer course varieties to keep you updated with cutting edge technology through expert and experienced training faculties. This will help the students pursue a job of their dreams with better career prospects and industry best salaries.

2.SYSTEM ANALYSIS

2.1 INTRODUCTION

System analysis involves studying the way an organization currently receives and process data to produce information with the goal of determining how to make it work better. System analysis includes both a preliminary and a detailed stage. Detailed analysis includes an in depth look at what is wanted and contains more refined cost and benefits studies.

The system study is the process of gathering and interpreting facts, using this information for further studies on the system. It does various feasibility studies. In these studies, a rough figure of the system activities can be obtained, from which the decisions about the strategies to be followed for effective system study and analysis can be taken. The system study also identifies the method collection to be followed.

Analysis involves the requirement determination and specifications. The purpose is to provide an understanding and to enable a communication about the system between the developers and the people establishing the requirements. Therefore, the analysis is typically terms of code or programs during this phase; it is the first step towards really understanding the requirements.

2.2 EXSISTING SYSTEM

In existing, we need to maintain the Excel sheets, CSV etc. files for the user daily and monthly expenses. In existing, there is no as such complete solution to keep a track of its daily expenditure easily. To do so a person as to keep a log in a diary or in a computer, also all the calculations need to be done by the user which may sometimes results in errors leading to losses.

2.3 PROPOSED SYSTEM

To reduce manual calculations, we propose an application which is developed by Android. This application allows users to maintain a digital automated diary. Each user will be required to register on the system at registration time, the user will be provided id, which will be used to maintain the record of each unique user. Expense Tracker application which will keep a track of Income-Expense of a user on a day-to-day basis. This application takes Income from user and divides in daily expense allowed. If u exceed that day's expense it will cut if from your income and give new daily expense allowed amount, and if that day's expense is less, it will add it in savings.

2.4 SYSTEM SPECIFICATION

A software requirement specification (SRS), a requirements specification for a software system, is a complete description of the behavior of a system to be developed and may include a set of use cases that describe interactions the users will have with the software. In addition, it also contains non-functional requirements. Non-functional requirements impose constraints on the design or implementation (such as performance engineering requirements, quality standards, or design constraints) The software requirements specification document enlists all necessary requirements that are required for the project development. To derive the requirements, we need to have clear and thorough understanding of the products to be developed. This is prepared after detailed communications with the project team and customer.

2.5 OPERATING SYSTEM

Windows10 an Overview

Windows 10 includes improved network, application and Web services. It provides increased reliability and scalability, lowers your cost of computing with powerful, flexible management services, and provides the best foundation for running business application.

Network Data Security

Network data can be protected on the wire or at the network interface. Securing data at the network requires a firewall to proxy services and mediate connections between the internal network, (LAN) and external network (Internet). This is the purpose of Proxy Server.

Internet Protocol Security

Internet Protocol Security (IPsec) is a framework of open standards for ensuring secure private communications over Internet Protocol networks, using cryptographic security services.

2.6 LANGUAGES AND SOFTWARE PACKAGE JAVA

Java is a general-purpose computer-programming language that is concurrent, class- based, object-oriented, and specifically designed to have as few implementation dependencies as possible. It is intended to let application developers "write once, run anywhere" (WORA), meaning that compiled Java code can run on all platforms that support Java without the need for recompilation. Java applications are typically compiled to bytecode that can run on any Java virtual machine (JVM) regardless of computer architecture. As of 2016, Java is one of the most popular programming languages in use, particularly for client-server web applications, with a reported 9 million developers. Java was originally developed by James Gosling, a Canadian, at Sun Microsystems (which has since been acquired by Oracle Corporation) and released in 1995 as a core component of Sun Microsystems' Java platform. The language derives much of its original features from Smalltalk, with a syntax similar to C and C++, but it has fewer low-level facilities than either of them.

MySQL

MySQL is a relational database management system (RDBMS) which is more than 11 million institutions. The program runs as a server providing multi-user access to a number of databases.

MySQL is owned and sponsored by a single for-profit firm, the Swedish company MySQL AB, now a subsidiary of Sun Microsystems, which holds the copyright to most of the code base. The project's source code is available under terms of the GNU General Public License, as well as under a variety of proprietary agreements.

ANDROID

Android is a Linux-based operating system designed primarily for touch screen mobile devices such as Smartphone and tablet computers. Initially developed by Android, Inc., which Google backed financially and later bought in 2005. Android is open source and Google releases the code under the Apache License. This open-source code and permissive licensing allows the software to be freely modified and distributed by device manufacturers,

FRONT END: ANDROID

Android is a Linux based operating system designed primarily for touch screen mobile devices such as smart phones and tablet computers. Android is open source and Google releases the code under the Apache License This open-source code and permissive licensing allows the software to be freely modified and distributed by device manufacturers, wire- less carriers and enthusiast developers. Additionally, Android has a large community of developers writing applications that extend the functionality of devices, written primarily in a customized version of the Java programming language. Android is an open-source mobile operating system that combines and builds up on parts of many different open-source projects.

Graphical user interfaces

Web frameworks

Multimedia

Database

Networking

ANDROID STUDIO

This includes project and code templates that make it easy to add well- established patterns such as a navigation drawer and view pager. You can start with a code template or even right-click an API in the editor and select Find Sample Code to search for examples. Moreover, you can import fully functional apps from GitHub, right from the Create Project screen.

Android Studio provides a robust static analysis framework and includes over 280 different lint checks across the entirety of your app. additionally, it provides several quick fixes that help you address issues in various categories, such as performance, security, and correctness, with a single click.

Android software development is the process by which new applications are created for the Android operating system. Applications are usually developed in the Java programming language using the Android Software Development Kit.

ADT (Android Development Tools) is the software used to develop android apps. It basically encases Eclipse IDE, which is a multi-language Integrated development environment (IDE)

comprising a base workspace and an extensible plug-in system for customizing the environment... The latest version comes with ADT plug-in preinstalled and bundled to the IDE.

SDK (Software Development Kit or "devkit") is typically a set of software development tools that allows for the creation of applications for a certain software package software framework, hardware platform, computer system, video game console, operating system, or similar development platform. It may be something as simple as an application programming interface

The major advantages of Android Studio are:

- o Faster Deployment of Fresh Builds.
- o More Accurate Programming.
- o the newly introduced emulator is 3 as faster in CPU, RAM, & I/O in comparison to its predecessor.
- o Promoting is an important component of the app marketing, and Android Studio 2.0 takes it to a new high.

INTERNET EXPLORER WEB BROWSER

INTERNET EXPLORER(IE) makes it easier to get the most from the world wide web, whether we are searching for new information or browsing your favorite website. and built-in intelligence technology can save us time completing web tasks, such as automatically completing web addresses an

ADVANTAGES OF IE

When we start typing a frequently used web address in the address bar, a list of similar appears that you can choose from. And if a web page address is wrong, IE can search for similar addresses to try to find a match.

Search for websites by clicking the search button on the toolbar.

In the search bar type a word or phrase that describes what you are looking for.

Go to other web pages similar to the one you are viewing without even doing a search. Just use the show related sites feature.

Browse through the list of web pages you recently visited by clicking the history button on the tool bar.d form for, and automatically detecting your network and connection status.

2.7 HARDWARE SPECIFICATION

The selection of hardware is very important in the existence and proper working of any software. When selecting hardware, the size and capacity requirements are also important. Below are some of the hardware that is required by the system.

Main Processor	Intel core i3 or above
RAM	8 GB or Above
Keyboard	Standard 108 keys
Mouse	3D Optical mouse
Monitor	15" Standard
Hard disk	10 GB of available disk space minimum or Above

2.8 SOFTWARE SPECIFICATION

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware. A hardware requirements list is often accompanied by a hardware compatibility list (HCL), especially in case of operating systems. An HCL lists tested, compatible, and sometimes incompatible hardware devices for a particular operating system or application.

We require much different software to make the application which is in making to work efficiently. It is very important to select the appropriate software so that the software works properly.

Operating System	64-bit Microsoft® Windows® 8/10/11
Programming Language	Java, Android
RDBMS	MYSQL
Web Server	Apache Tomcat & Glassfish Server
Scripting language	JSP

3.SYSTEM DESIGN

3.1 INTRODUCTION

System design is an interactive process through which requirements are transmitted to a “blue print” for constructing the software initial; the blue print depicts a holistic view of software that is design is represented at a high-level abstraction a level that can be directly traced to specific data, functional and behavioral requirements. System design is the solution to the creation of a new system. This is the important aspect made up of several steps. System design is the process of developing specifications for a candidate system that meet the criteria established in the system analysis. Major step in system design is the preparation of the input forms and output reports in a form applicable to the users.

The main objective of system design is to use the package easily by a computer operator. System design is the creative act of invention, developing new inputs, a database, off-line files, methods, procedures and output for processing business to meet an organization objective. System design-built information gathered during the system analysis. As design interaction occurs, subset-quant refinement leads to design representation at much lower level of abstraction. System design is a creative art of inventing and developing input, data bases, off line files, method and procedures, for processing data to get meaning full output that satisfy the organization objectives. Through the design phase consideration to the human factor, that is inputs to the users will have on the system.

Some of the main factors that have to be noted using the design of the system are:

- Practicability

System must be capable of being operated over a long period of time and must have ease of use.

- Efficiency

Make better use of available resources. Efficiency involves accuracy, timeliness and comparability of system output.

- Cost

Aim of minimum cost and better results.

- Security

Ensure physical security of data.

3.2 HIERARCHICAL CHART

A hierarchical chart is described as a visual representation of a system of hierarchy and can also be referred to as a structure chart. Roles, ranks or positions are clearly laid out in an illustrated format that depicts the relationship between the elements. The top of the chart is generally reserved for the most important or significant part of the system of hierarchy. Cascading down from the top are the other components of the system of hierarchy.

3.3 E-R DIAGRAM

An entity-relationship diagram (ERD) is a data modelling technique that graphically illustrates an information system's entities and the relationships between those entities. An ERD is a conceptual and representational model of data used to represent the entity framework infrastructure. The elements of an ERD are:

- Entities
- Relationships
- Attributes

3.4 DATA FLOW DIAGRAM

A Data Flow Diagram (DFD) or a bubble chart is a graphical tool for structured analysis. It was De Macro in 1978 and Gene and Carson in 1979 who introduced DFD. DFD models a system transforms the data and creates, output data-flows which go by using external entities from which data flows to a process which to other processes or external entities or files. Data in files many also flow to processes as inputs.

There are various symbols used in DFD. Bubbles represent the process. Named arrows indicate the dataflow. External entities are represented by rectangles and are outside the system such as vendors or customers with whom the system interacts. They either supply or consume data. Entities supplying data are known as sources and those that consume data are called sinks. Data are stored in a data store by a process in the system. Each component in a DFD is labelled in with a descriptive name. Process names are further identified with a number.

BASIC DFD SYMBOLS

Square:



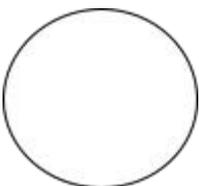
A square or sink is a person or part of an organization, which enters or receives information from the system, but is considered to be outside the context of data flow model

Arrow:



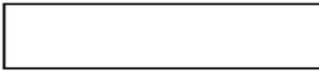
Arrow represents a data flow or a route, which enables packets of data to travel from one point to another. Data may flow from a source to a processor and from data store or process. An arrow lines depicts the flow, with arrowhead pointing in the direction of flow.

Circle:



A Process represents transformation where incoming data flows are changed into outgoing data flows.

Open rectangle:



A data is a repository of data that is to be stored for use by one or more process may be as simple as buffer or queue or sophisticated as relational database. They should have clear names. If a process merely uses the content of store and doesn't alter it, the arrowhead goes only from the store to the process. If process alters the details in the store, then a double-headed arrow is used.

Rules for drawing Data Flow Diagram

Establish the context of the data flow diagram by identifying all of the net input and output data flows.

- Select a starting point for drawing the data flow diagram
- Give meaningful labels to all data flow lines.
- Label all processes with action verbs that relate input and output data flows.
- Omit insignificant functions routinely handled in the programming process.
- Don't include control or flow of control information.
- Don't try to put too much information in one data flow diagram. Try to plan for the number of levels.
- Be prepared to start over.

NORMALIZATION

The process of normalization is concerned with the transformation of the conceptual schema to a computer represent able form. Normalization reduces the redundancies and anomalies.

THE FIRST NORMAL FORM

First Normal form does not allow multivalued and composite valued attributes. It states that the domain of an attribute must include only atomic values and that value of any attribute in a table must be single value from the domain of that attribute.

- THE SECOND NORMAL FORM

In Second Normal form, for relation where primary key contains multiple attributes, on key attribute should not be functionally dependent on a part of the primary key.

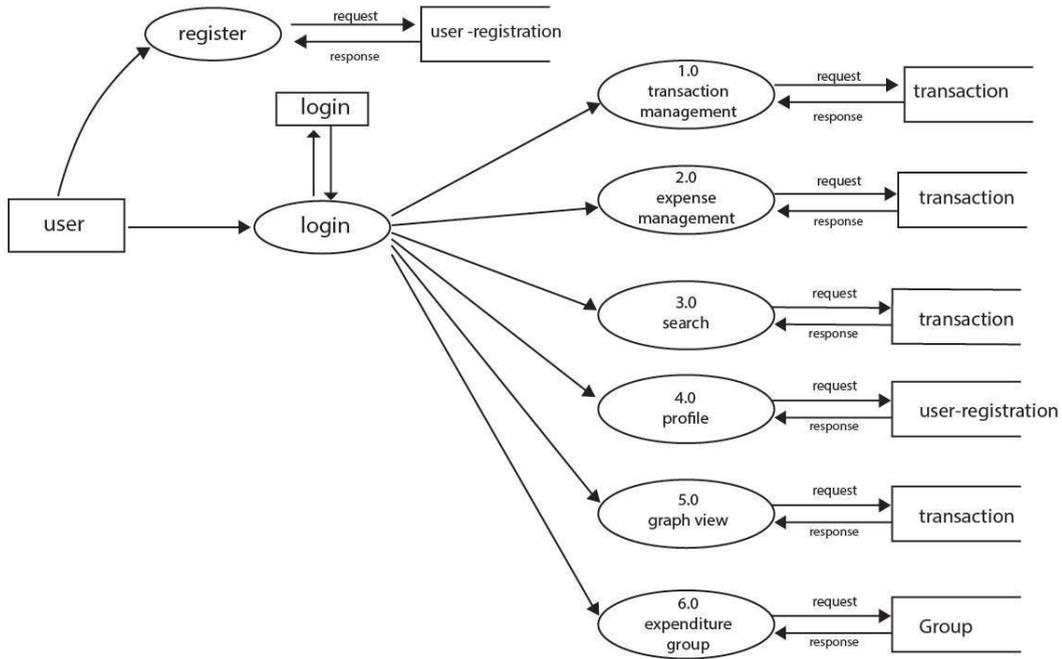
- THE THIRD NORMAL FORM

In Third Normal form, relation should not have a non-key attribute functionally determined by non-key attribute. That is there should be no transitive dependency of a non-key attribute on the primary key.

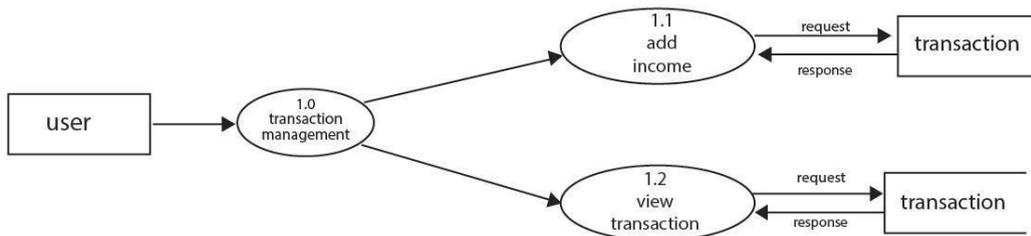
DATAFLOW DIAGRAMS



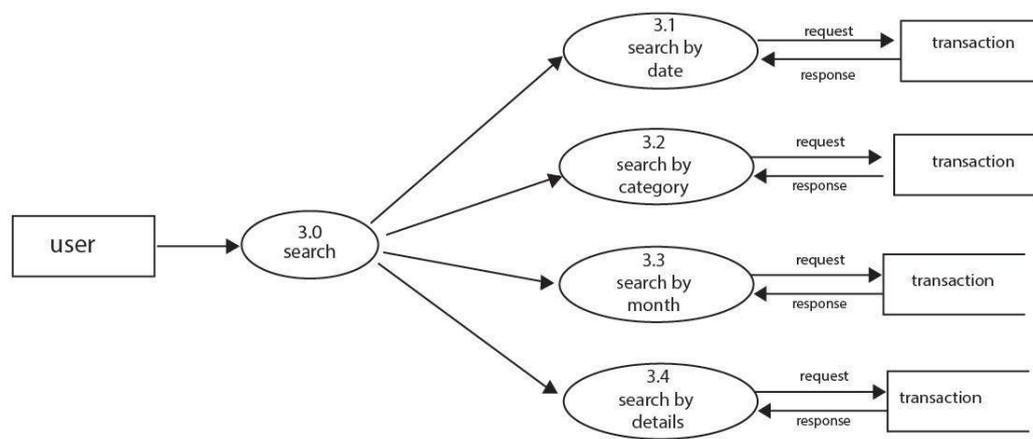
Level 1 expenditure

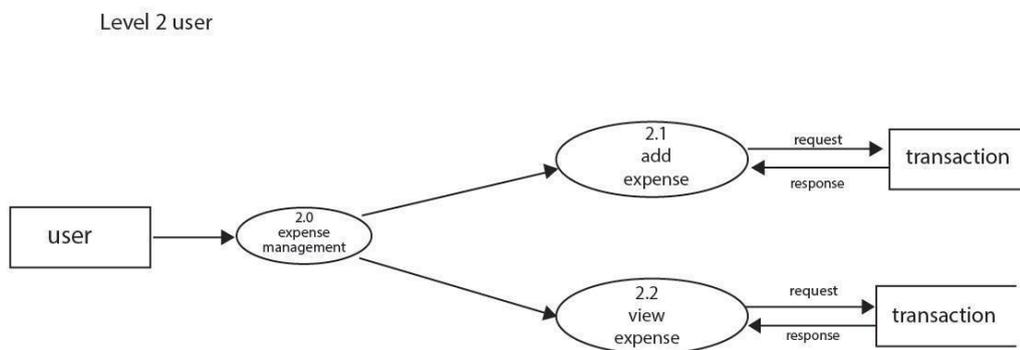
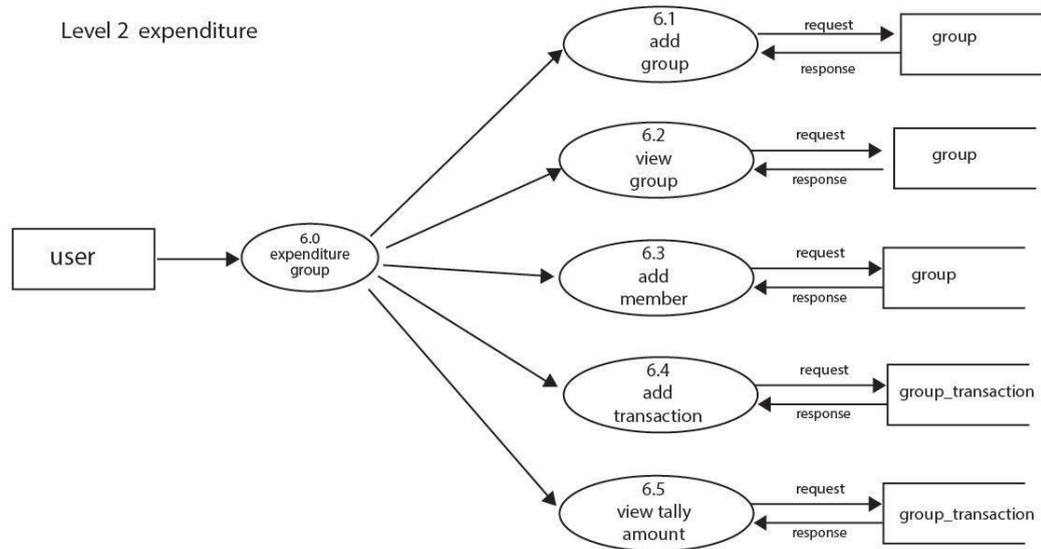


Level 2 expenditure



Level 2 expenditure





3.5 DATA DICTIONARY

The terms data dictionary and data repository indicate a more general software utility than a catalogue. A catalogue is closely coupled with the DBMS software. It provides the information stored in it to the user and the DBA, but it is mainly accessed by the various software modules of the DBMS itself, such as DDL and DML compilers, the query optimiser, the transaction processor, report generators, and the constraint enforcer. On the other hand, a data dictionary is a data structure

that stores metadata, i.e., (structured) data about information. The software package for a stand-alone data dictionary or data repository may interact with the software modules of the DBMS, but it is mainly used by the designers, users and administrators of a computer system for information resource management. These systems maintain information on system hardware and software configuration, documentation, application and users as well as other information relevant to system administration.

3.6 DATABASE DESIGN

The Database design is the process of producing a detailed data model of a database. The logical data model contains all the needed logical and physical design choices and physical storage parameters needed to generate a design in a Data Definition Language, which can then be used to create a database. A fully attributes for each entry.



Table: group_transaction

Columns (7)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading existing

	Field	Type
	tid	int(30) NOT NULL
	uid	int(30) NULL
	gid	int(30) NULL
	amount	varchar(30) NULL
	description	varchar(300) NULL
	date	varchar(30) NULL
	image	longblob NULL



Table: login

Columns (6)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading existing data.

	Field	Type
	logid	int(11) NOT NULL
	uid	int(20) NULL
	username	varchar(30) NULL
	password	varchar(30) NULL
	type	varchar(30) NULL
	status	varchar(30) NULL



Table: transaction

Columns (7)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading existing data.

	Field	Type
	tid	int(30) NOT NULL
	uid	int(30) NULL
	type	varchar(30) NULL
	amount	int(30) NULL
	details	varchar(300) NULL
	category	varchar(30) NULL
	date	date NULL



Table: user_registration

Columns (6)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading existing data.

	Field	Type
	uid	int(11) NOT NULL
	name	varchar(30) NULL
	address	varchar(200) NULL
	phone	varchar(30) NULL
	email	varchar(30) NULL
	password	varchar(30) NULL



Table: feedback

Columns (5)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading exist

	Field	Type
🔑	fid	int(11) NOT NULL
	uid	int(11) NULL
	subject	varchar(30) NULL
	details	varchar(200) NULL
	date	varchar(30) NULL



Table: group

Columns (5)

Calculate Optimal Datatypes

Find the optimal datatypes for this table by reading

	Field	Type
🔑	gid	int(30) NOT NULL
	uid	int(30) NULL
	name	varchar(100) NULL
	date	varchar(30) NULL
	idlist	varchar(300) NULL

4.SYSTEM DEVELOPMENT

4.1 INTRODUCTION

Systems development is the process of defining, designing, testing, and implementing a new software application or program. It could include the internal development of customized systems, the creation of database systems, or the acquisition of third party developed software. Participate in open forum, post feedbacks. In software engineering a software development methodology (also known as a system development methodology, software development life cycle, software development process, software process) is a splitting of software development work into distinct phases (or stages) containing activities with the intent of better planning and management. It is often considered a subset of the systems development life cycle. The methodology may include the pre-definition of specific deliverables and artefacts that are created and completed by a project team to develop or maintain an application.

Common methodologies include waterfall, prototyping, iterative and incremental development, spiral development, rapid application development, extreme programming and various types of agile methodology. Some people consider a life-cycle "model" a more general term for a category of methodologies and a software development "process" a more specific term to refer to a specific process chosen by a specific organization.

4.2 PROCESS DESCRIPTION

ADD INCOME/ADD EXPENSE

This module deals with adding income and expenses. The user has both options available for adding income and expense. But there is a condition if the user hasn't entered the amount yet then the user can't enter expenses. When the user enters any transaction then that transaction will be added in both Spending and Transaction tabs. If the user wants to delete that transaction, then the user has to long click the transaction available in the spending tab then that transaction will be deleted from both tabs.

MODIFY TRANSACTIONS

If the user wants to delete that transaction, then the user has to click the transaction available in the spending tab then that transaction will be deleted from both tabs.

FILTER TRANSACTION VIEW

In the transaction tab, the user can filter the transactions. In the Spinner, users can select the day, month and year and then click the filter button and according to the day, month and year transactions will appear. If the user wants to filter the transactions only on the basis of day, for example, user-selected Monday then all transactions will appear that were made on Monday.

MULTIPLE ACCOUNTS

Users can create multiple accounts. In the account tab. User has the option available for creating a new account. Users will click the “+” sign button then a dialog will appear on the screen and the user can enter the name of the account then that name will be saved in the account tab. If a user wants to delete the particular account, then the user has to 1 click the account name user want to delete. Then that account will be deleted.

TRANSACTIONS OVERVIEW AS PIE/BAR/GRAPH

The user has three options available for graphical representation. When the user rotates the device then the pie chart will appear on the screen and also switch is available on the screen when the user will click on the bar chart will appear on the screen and when the user clicks on graph then Graph will appear on the screen.

PASSCODE

The passcode is available in setting option at the top bar. When the user clicks on the passcode switch when the user switches on then the passcode screen will appear and the user can choose the password and that password will be saved in the database. After that when the user will open the application user have to enter the passcode and that passcode will be matched with passcode saved in the database. If the user entered the wrong passcode, then the error message will appear.

4.3 CODE DESIGN

Login:

```
package com.syntax.expenditure;

import android.Manifest;
import android.app.Dialog;
import android.content.Context;
import android.content.Intent;
import android.content.SharedPreferences;
import android.content.pm.PackageManager;
import android.os.Build;
import android.os.Bundle;
import android.util.Log;
import android.view.MotionEvent;
import android.view.View;
import android.view.Window;
import android.view.WindowManager;
import android.widget.Button;
import android.widget.EditText;
import android.widget.LinearLayout;
import android.widget.TextView;
import android.widget.Toast;
import android.widget.Toolbar;

import androidx.appcompat.app.ActionBar;
import androidx.appcompat.app.AppCompatActivity;
import androidx.core.app.ActivityCompat;

import com.android.volley.AuthFailureError;
import com.android.volley.Request;
import com.android.volley.Response;
import com.android.volley.VolleyError;
import com.android.volley.toolbox.StringRequest;
```

```

import com.android.volley.toolbox.Volley;
import com.syntax.expenditure.Common.Utility;

import java.util.HashMap;
import java.util.Map;

public class Login extends AppCompatActivity {

    EditText username, password;
    Button btnlog;
    TextView reg;
    String UNAME, PASS;
    Dialog dialog;
    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        requestWindowFeature(Window.FEATURE_NO_TITLE);
        getWindow().setFlags(WindowManager.LayoutParams.FLAG_FULLSCREEN,
            WindowManager.LayoutParams.FLAG_FULLSCREEN);

        setContentView(R.layout.activity_login);

        ActionBar actionBar = getSupportActionBar();
        actionBar.hide();
        Toolbar toolbar = new Toolbar(this);
        toolbar.setVisibility(View.INVISIBLE);

        int PERMISSION_ALL = 1;
        String[] PERMISSIONS = {
            Manifest.permission.WRITE_EXTERNAL_STORAGE,
            Manifest.permission.READ_EXTERNAL_STORAGE,
            Manifest.permission.ACCESS_FINE_LOCATION,
            Manifest.permission.CAMERA,

```

```

        Manifest.permission.ACCESS_COARSE_LOCATION,
        Manifest.permission.SEND_SMS,
    };

    if (!hasPermissions(this, PERMISSIONS)) {
        ActivityCompat.requestPermissions(this, PERMISSIONS, PERMISSION_ALL);
    }

    username = findViewById(R.id.login_username);
    password = findViewById(R.id.login_password);
    btnlog = findViewById(R.id.login_btnlog);
    reg = findViewById(R.id.login_signup);

    btnlog.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View view) {

            UNAME = username.getText().toString();
            PASS = password.getText().toString();
            if (UNAME.isEmpty()) {
                username.requestFocus();
                username.setError("enter username");
            } else if (PASS.isEmpty()) {
                password.requestFocus();
                password.setError("enter password");
            } else {
                login();
            }
        }
    });

    reg.setOnTouchListener(new View.OnTouchListener() {
        @Override

```

```

public boolean onTouch(View view, MotionEvent motionEvent) {
    startActivity(new Intent(getApplicationContext(), User_registration.class));
    return false;
}
});
}

```

```

public void login() {

    com.android.volley.RequestQueue queue = Volley.newRequestQueue(getApplicationContext());
    StringRequest request = new StringRequest(Request.Method.POST, Utility.url, new
Response.Listener<String>() {
    @Override
    public void onResponse(String response) {
        Log.d("*****", response);
        if (!response.trim().equals("failed")) {
            SharedPreferences.Editor editor = getSharedPreferences("SharedData",
MODE_PRIVATE).edit();
            editor.putString("logid", response.trim());
            editor.commit();
            startActivity(new Intent(getApplicationContext(), UserHome.class));

        } else {
            Toast.makeText(getApplicationContext(), "Login failed..!",
Toast.LENGTH_LONG).show();
        }
    }
}, new Response.ErrorListener() {
    @Override
    public void onErrorResponse(VolleyError error) {

```

```

        Toast.makeText(getApplicationContext(), "my error :" + error,
Toast.LENGTH_LONG).show();
        Log.i("My error", "" + error);
    }
}) {
    @Override
    protected Map<String, String> getParams() throws AuthFailureError {

        Map<String, String> map = new HashMap<String, String>();
        map.put("key", "login");
        map.put("username", UNAME);
        map.put("password", PASS);

        return map;
    }
};
queue.add(request);
}

public static boolean hasPermissions(Context context, String... permissions) {
    if (Build.VERSION.SDK_INT >= Build.VERSION.CODES.M && context != null &&
permissions != null) {
        for (String permission : permissions) {
            if (ActivityCompat.checkSelfPermission(context, permission) !=
PackageManager.PERMISSION_GRANTED) {
                return false;
            }
        }
    }
    return true;
}
}

```

Registration:

```
package com.syntax.expenditure;

import android.content.Intent;
import android.os.Bundle;
import android.util.Log;
import android.view.MotionEvent;
import android.view.View;
import android.view.Window;
import android.view.WindowManager;
import android.widget.Button;
import android.widget.EditText;
import android.widget.RadioButton;
import android.widget.RadioGroup;
import android.widget.TextView;
import android.widget.Toast;
import android.widget.Toolbar;

import androidx.appcompat.app.ActionBar;
import androidx.appcompat.app.AppCompatActivity;

import com.android.volley.AuthFailureError;
import com.android.volley.Request;
import com.android.volley.Response;
import com.android.volley.VolleyError;
import com.android.volley.toolbox.StringRequest;
import com.android.volley.toolbox.Volley;
import com.syntax.expenditure.Common.Utility;

import java.util.HashMap;
import java.util.Map;

public class User_registration extends AppCompatActivity {
```

```
EditText name,address,phone,email,password;  
TextView login;  
Button btnreg;  
String NAME,ADDRESS,PHONE,EMAIL,PASS;
```

```
@Override
```

```
protected void onCreate(Bundle savedInstanceState) {  
    super.onCreate(savedInstanceState);  
    requestWindowFeature(Window.FEATURE_NO_TITLE);  
    getWindow().setFlags(WindowManager.LayoutParams.FLAG_FULLSCREEN,  
        WindowManager.LayoutParams.FLAG_FULLSCREEN);  
    setContentView(R.layout.activity_user_registration);  
    ActionBar actionBar = getSupportActionBar();  
    actionBar.hide();  
    Toolbar toolbar = new Toolbar(this);  
    toolbar.setVisibility(View.INVISIBLE);  
    name=findViewById(R.id.user_reg_name);  
    address=findViewById(R.id.user_reg_address);  
    phone=findViewById(R.id.user_reg_phone);  
    email=findViewById(R.id.user_reg_email);  
    password=findViewById(R.id.user_reg_password);  
    btnreg=findViewById(R.id.user_reg_btnreg);  
    login=findViewById(R.id.user_reg_login);
```

```
btnreg.setOnClickListener(new View.OnClickListener() {
```

```
    @Override
```

```
    public void onClick(View view) {
```

```
        NAME=name.getText().toString();  
        ADDRESS=address.getText().toString();  
        PHONE=phone.getText().toString();  
        EMAIL=email.getText().toString();
```

```
PASS=password.getText().toString();
```

```
if(NAME.isEmpty()){
    name.requestFocus();
    name.setError("Enter Name");
}else if(ADDRESS.isEmpty()){
    address.requestFocus();
    address.setError("Enter Address");
}else if(PHONE.isEmpty() || PHONE.length()!=10){
    phone.requestFocus();
    phone.setError("Enter Phone");
}else if(EMAIL.isEmpty() || !EMAIL.matches("[a-zA-Z0-9._-]+@[a-z]+\.[a-z]+")){
    email.requestFocus();
    email.setError("Enter Email");
}else if(PASS.isEmpty()){
    password.requestFocus();
    password.setError("Enter Password");
}else{
    user_Registration();
}
});
```

```
login.setOnTouchListener(new View.OnTouchListener() {
    @Override
    public boolean onTouch(View view, MotionEvent motionEvent) {
        startActivity(new Intent(getApplicationContext(), Login.class));
        return false;
    }
});
```

```
}
```

```

public void user_Registration()
{

    com.android.volley.RequestQueue queue = Volley.newRequestQueue(getApplicationContext());
    StringRequest request = new StringRequest(Request.Method.POST, Utility.url, new
Response.Listener<String>() {
    @Override
    public void onResponse(String response) {
        Log.d("*****",response);
        if(!response.trim().equals("failed"))
        {
            String id=response;
            Toast.makeText(getApplicationContext(), "Registration Successfull",
Toast.LENGTH_LONG).show();
            Intent i =new Intent(User_registration.this, Login.class);
            startActivity(i);
        }
        else
        {
            Toast.makeText(getApplicationContext(), "ERROR REGISTRATION !",
Toast.LENGTH_LONG).show();
        }
    }
}, new Response.ErrorListener() {
    @Override
    public void onErrorResponse(VolleyError error) {

        Toast.makeText(getApplicationContext(), "my error :" + error,
Toast.LENGTH_LONG).show();
        Log.i("My error", "" + error);
    }
}

```

```

    }
  }) {
    @Override
    protected Map<String, String> getParams() throws AuthFailureError {
        Map<String, String> map = new HashMap<String, String>();
        map.put("key", "reg_user");
        map.put("name", NAME);
        map.put("address", ADDRESS);
        map.put("phone", PHONE);
        map.put("email", EMAIL);
        map.put("password", PASS);

        return map;
    }
  };
  queue.add(request);
}

}

```

Profile:

```

package com.syntax.expenditure.ui;

import android.content.SharedPreferences;
import android.os.Bundle;

import androidx.fragment.app.Fragment;

import android.util.Log;
import android.view.LayoutInflater;
import android.view.View;
import android.view.ViewGroup;
import android.widget.Button;
import android.widget.CompoundButton;

```

```

import android.widget.EditText;
import android.widget.ImageView;
import android.widget.Switch;
import android.widget.Toast;

import com.android.volley.AuthFailureError;
import com.android.volley.Request;
import com.android.volley.Response;
import com.android.volley.VolleyError;
import com.android.volley.toolbox.StringRequest;
import com.android.volley.toolbox.Volley;
import com.syntax.expenditure.Common.Utility;
import com.syntax.expenditure.R;

import java.util.HashMap;
import java.util.Map;

import static android.content.Context.MODE_PRIVATE;

public class Profile extends Fragment {
    String NAME,PHONE,EMAIL,ADDRESS;
    EditText name,phone,email,address;
    Switch edit;
    Button btnupdate;
    ImageView logout;
    @Override
    public View onCreateView(LayoutInflater inflater, ViewGroup container,
        Bundle savedInstanceState) {
        // Inflate the layout for this fragment
        View view= inflater.inflate(R.layout.fragment_profile, container, false);

        name=view.findViewById(R.id.profile_name);
        phone=view.findViewById(R.id.profile_phone);

```

```

email=view.findViewById(R.id.profile_email);
address=view.findViewById(R.id.profile_address);
edit=view.findViewById(R.id.profile_edit);
btnupdate=view.findViewById(R.id.profile_btnupdate);
logout=view.findViewById(R.id.logout);
logout.setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View v) {

        android.os.Process.killProcess(android.os.Process.myPid());
        System.exit(1);
    }
});
edit.setOnCheckedChangeListener(new CompoundButton.OnCheckedChangeListener() {
    @Override
    public void onCheckedChanged(CompoundButton buttonView, boolean isChecked) {
        if(isChecked){
            btnupdate.setVisibility(View.VISIBLE);
            name.setFocusableInTouchMode(true);
            phone.setFocusableInTouchMode(true);
            email.setFocusableInTouchMode(true);
            address.setFocusableInTouchMode(true);
        }else{
            btnupdate.setVisibility(View.INVISIBLE);
            name.setFocusableInTouchMode(false);
            phone.setFocusableInTouchMode(false);
            email.setFocusableInTouchMode(false);
            address.setFocusableInTouchMode(false);
        }
    }
});
btnupdate.setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View v) {

```

```

NAME=name.getText().toString();
ADDRESS=address.getText().toString();
PHONE=phone.getText().toString();
EMAIL=email.getText().toString();
if(NAME.isEmpty()){
    name.requestFocus();
    name.setError("UserName");
}else if(ADDRESS.isEmpty()){
    address.requestFocus();
    address.setError("Address");
}else if(PHONE.isEmpty()){
    phone.requestFocus();
    phone.setError("Password");

}else if(EMAIL.isEmpty()){
    email.requestFocus();
    email.setError("Password");

}else{

    updateProfiledetails();
}
});
getProfiledetails();
return view;
}
public void getProfiledetails() {

    com.android.volley.RequestQueue queue = Volley.newRequestQueue(getApplicationContext());
    StringRequest request = new StringRequest(Request.Method.POST, Utility.url, new
Response.Listener<String>() {
    @Override
    public void onResponse(String response) {

```

```

Log.d("*****", response);
if (!response.trim().equals("failed")) {

    String fulldata[] = response.trim().split("#");
    name.setText(fulldata[0]);
    address.setText(fulldata[1]);
    phone.setText(fulldata[2]);
    email.setText(fulldata[3]);

} else {
    // Toast.makeText(getApplicationContext(), "failed..!", Toast.LENGTH_LONG).show();
}
}
}, new Response.ErrorListener() {
    @Override
    public void onErrorResponse(VolleyError error) {

        Toast.makeText(getContext(), "my error :" + error, Toast.LENGTH_LONG).show();
        Log.i("My error", "" + error);
    }
}) {
    @Override
    protected Map<String, String> getParams() throws AuthFailureError {
        Map<String, String> map = new HashMap<String, String>();
        SharedPreferences prefs = getContext().getSharedPreferences("SharedData",
MODE_PRIVATE);
        final String uid = prefs.getString("logid", "No logid");//"No name defined" is the default
value.
        map.put("key", "getProfiledetails");
        map.put("uid", uid);
        return map;
    }
};

```

```

    queue.add(request);
}

// .....
public void updateProfiledetails() {

    com.android.volley.RequestQueue queue = Volley.newRequestQueue(getContext());
    StringRequest request = new StringRequest(Request.Method.POST, Utility.url, new
Response.Listener<String>() {
    @Override
    public void onResponse(String response) {
        Log.d("*****", response);
        if (!response.trim().equals("failed")) {
            Toast.makeText(getContext(), "Updated..!", Toast.LENGTH_LONG).show();
            btnupdate.setVisibility(View.INVISIBLE);
            name.setFocusableInTouchMode(false);
            phone.setFocusableInTouchMode(false);
            email.setFocusableInTouchMode(false);
            address.setFocusableInTouchMode(false);

        } else {
            // Toast.makeText(getApplicationContext(), "failed..!", Toast.LENGTH_LONG).show();
        }
    }
}, new Response.ErrorListener() {
    @Override
    public void onErrorResponse(VolleyError error) {

        Toast.makeText(getContext(), "my error :" + error, Toast.LENGTH_LONG).show();
        Log.i("My error", "" + error);
    }
}) {
    @Override
    protected Map<String, String> getParams() throws AuthFailureError {

```

```

    Map<String, String> map = new HashMap<String, String>();
    SharedPreferences prefs = getContext().getSharedPreferences("SharedData",
MODE_PRIVATE);
    final String uid = prefs.getString("logid", "No logid");//"No name defined" is the default
value.
    map.put("key", "updateProfiledetails");
    map.put("uid",uid);
    map.put("name",NAME);
    map.put("phone",PHONE);
    map.put("email",EMAIL);
    map.put("address",ADDRESS);
    return map;
}
};
queue.add(request);
}
}

```

Other:

```

package com.syntax.expenditure.Common;
import android.annotation.SuppressLint;
import android.app.Activity;
import android.graphics.BitmapFactory;
import android.graphics.Color;
import android.util.Log;
import android.view.LayoutInflater;
import android.view.View;
import android.view.ViewGroup;
import android.widget.AdapterView;
import android.widget.Filter;
import android.widget.Filterable;
import android.widget.ImageView;

```

```

import android.widget.LinearLayout;
import android.widget.TextView;

import com.syntax.expenditure.R;

import org.jetbrains.annotations.NotNull;

import java.io.IOException;
import java.util.ArrayList;
import java.util.List;

public class TransactionAdapter extends ArrayAdapter<Transaction> implements Filterable {

    Activity context;
    List<Transaction> rest_List;

    public ArrayList<Transaction> orig;
    public ArrayList<Transaction> list_myrest;

    public TransactionAdapter(Activity context, List<Transaction> rest_List) {
        super(context, R.layout.cust_transaction_rowitem, rest_List);
        this.context = context;
        this.rest_List = rest_List;
    }

    @Override
    public View getView(int position, View convertView, ViewGroup parent) {
        // TODO Auto-generated method stub
        LayoutInflater inflater = context.getLayoutInflater();
        View view = inflater.inflate(R.layout.cust_transaction_rowitem, null, true);

        TextView type = (TextView) view.findViewById(R.id.cust_trans_type);
        TextView date = (TextView) view.findViewById(R.id.cust_trans_date);

```

```

TextView amount = (TextView) view.findViewById(R.id.cust_trans_amount);
TextView category = (TextView) view.findViewById(R.id.cust_trans_category);
TextView description = (TextView) view.findViewById(R.id.cust_trans_description);
LinearLayout layout = view.findViewById(R.id.cust_trans_layout);

if(rest_List.get(position).getType().trim().equals("Expense")){
    layout.setBackgroundColor(Color.parseColor("#F3D1D1"));
    type.setText("▲ "+rest_List.get(position).getType());
}else{
    layout.setBackgroundColor(Color.parseColor("#D5FBD6"));
    type.setText("▼ "+rest_List.get(position).getType());
}

date.setText(rest_List.get(position).getDate());
amount.setText("₹ "+rest_List.get(position).getAmount());
category.setText("☐ "+rest_List.get(position).getCategory());
description.setText("◆ "+rest_List.get(position).getDescription());

return view;
}

```

```

@NotNull
public Filter getFilter(final String filterType) {

    list_myrest = new ArrayList<>(rest_List);

    return new Filter() {
        @Override
        protected FilterResults performFiltering(CharSequence constraint) {
            final FilterResults oReturn = new FilterResults();
            final ArrayList<Transaction> results = new ArrayList<Transaction>();
            if (orig == null)

```

```

//      orig = (ArrayList<InquiryPojo>) rest_List;
orig = list_myrest;

if (constraint != null) {
    if (orig != null && orig.size() > 0) {

        switch (filterType) {
            case "category":

                for (final Transaction g : orig) {
                    if (g.getCategory().toLowerCase().contains(constraint.toString()))
                        results.add(g);
                }
                break;
            case "details":

                for (final Transaction g : orig) {
                    if (g.getDescription().toLowerCase().contains(constraint.toString()))
                        results.add(g);
                }
                break;
            case "date":

                for (final Transaction g : orig) {
                    if (g.getDate().toLowerCase().contains(constraint.toString()))
                        results.add(g);
                }
                break;
            case "month":

                for (final Transaction g : orig) {
                    if(!constraint.toString().trim().isEmpty()){
                        String data[]=g.getDate().toLowerCase().trim().split("-");

```

```

        int listmonth = Integer.parseInt(data[1]);
        int frommonth = Integer.parseInt(constraint.toString().trim());
        if (listmonth==frommonth)
            results.add(g);
        }

    }
    break;

    case "all":
        for (final Transaction g : orig) {

            results.add(g);
        }
    }

    }
    oReturn.values = results;
}
return oReturn;
}

@SuppressWarnings("unchecked")
@Override
protected void publishResults(CharSequence constraint,
                               FilterResults results) {
    rest_List = (ArrayList<Transaction>) results.values;
    notifyDataSetChanged();
}
};
}
public void notifyDataSetChanged() {
    super.notifyDataSetChanged();
}

```

```
}
```

```
@Override
```

```
public int getCount() {  
    return rest_List.size();  
}
```

```
@Override
```

```
public Transaction getItem(int position) {  
    return rest_List.get(position);  
}
```

```
@Override
```

```
public long getItemId(int position) {  
    return position;  
}
```

5. SYSTEM TESTING AND IMPLEMENTATION

5.1 INTRODUCTION

System testing is actually a series of different testes whose primary purpose is to fully exercise the computer-based system. All though each test has a different purpose, all work to verify that all system elements have been properly integrated and perform all allocated functions. The following are the main objectives of testing:

1. Testing is process of executing a program with the intent of finding errors.
2. A new test case is one that has a high probability of finding an undiscovered error.
3. It is a set of activities that can be planned in advance and conducted automatically.

Testing is an important stage in the software development life cycle. System testing is a critical element of a software quality assurance and represents the ultimate review of specification, design and coding.

Testing is an important stage in the software development life cycle. System testing is a critical element of a software quality assurance and represents the ultimate review of specification, design and coding.

Testing is a very tedious and time-consuming job. For a test to be successful the tester should try and make the program file. Each test is designed with the intention of finding errors in the way system will process it. Though testing of a program doesn't guarantee the reliability of the system, it is done to assure that the system runs errors free. The Testing process begins by developing a comprehensive plan to test the general function-laity and special features on a variety of platform combinations. Strict quality control procedures are used. The Process verifies that the application meets the requirements specified in the system requirements document and is bug free. At the End of each testing day, the summary of completed and failed tests is prepared. Applications are not allowed to launch until all identified problem are fixed. Finally, a report is prepared at the end of testing to show exactly what was tested and to list the final outcomes. The software testing methodology is applied in four distinct phases:

- Unit Testing
- Integration Testing
- User Acceptance Testing
- Output Testing

5.2 SYSTEM IMPLEMENTATION

The implementation phase of the software development is concerned with translating design specification into source code. The user tests the developed system and changes are made according to their needs. Our system has been successfully implemented. Before implementation several tests have been conducted to ensure that no errors are encountered during the operation. The implementation phase ends with an evaluation of the system after placing into the operation for a period of time.

The process of putting the developed system in actual use is called system implementation. This includes all those activities that take place to convert from old system to new system. The system can be implemented only after testing is done and is found to be working to specifications. The implementation stage is a systems project in its own right. The implementation stage involves following tasks:

- Careful planning.
- Investigation of system and constraints.
- Design of method to achieve change over.
- Evaluation of the changeover method.

5.3 DEBUGGING

Debugging is the process of finding and resolving of defects that prevent correct operation of computer software or a system. In software development, debugging involves locating and correcting code errors in a computer program. Debugging is part of the software testing process and is an integral part of the entire software development lifecycle. The debugging process starts as soon as code is written and continues in successive stages as code is combined with other units of programming to form a software product.

5.4 BLACK-BOX TESTING

Black-box testing is a method of software testing that examines the functionality of an application without peering into its internal structures or workings. This system was tested using black-box method. All inputs and their corresponding outputs were checked.

5.5 WHITE-BOX TESTING

White-box testing (also known as clear box testing, glass box testing, transparent box testing, and structural testing) is a method of testing software that tests internal structures or workings of an application, as opposed to its functionality (i.e., black-box testing). In white-box testing an internal perspective of the system, as well as programming skills, are used to design test cases. The tester chooses inputs to exercise paths through the code and determine the appropriate outputs. The code of this system was checked and examined, and the errors were rectified.

5.6 SYSTEM SECURITY

System security is the control of access to a computer system's resources, especially its data and operating system files. It includes controlling physical access to the hardware, as well as protecting against harm that may come via network access, data and code injection, and due to malpractice by operators, whether intentional, accidental, or due to them being tricked into deviating from secure procedures.

In this system, access to the website is controlled by providing a login. The account login function shall allow account members to enter their username and password once verified, users will be able to attend the exam and view their results.

5.7 SYSTEM MAINTENANCE

System maintenance is a going activity, which covers a wide variety of activities including, removing program and design errors, updating documentation and test data and updating user support system maintenance is a catchall term used to describe various forms of computer or server maintenance required to keep a computer system running properly, it can describe network maintenance which could mean that servers are being physical repaired, replaced or mode. For the purpose of convenience, maintenance may be categorized into three classes they are:

CORRECTIVE MAINTENANCE

This type of maintenance implies removing errors in a program, which might have kept in the system due to faulty design or wrong assumption.

ADAPTIVE MAINTENANCE

In adaptive maintenance program functions are changed to enable the information system to satisfy the information needs of the user.

PERFECTIVE MAINTENANCE

In perfective maintenance means adding new programs or modifying the existing programs to enhance the performance of the information system. This type of maintenance under taken to respond to user addition needs which may be due to the changes within or outside of the organization.

5.8 FUTURE ENHANCEMENTS

This application can take a good market as it is usable by anyone who are willing to manage their expenses and aiming to save for the future investments and many more. There is not range criteria or any kind of profession or gender are focused.it will wood used hugely as well as having people group to maintains tally Account.

6.CONCLUSION

6.1 CONCLUSION

After making this application we assure that this application will help its users to manage the cost of their daily expenditure. It will guide them and aware them about their daily expenses. It will prove to be helpful for the people who are frustrated with their daily budget management, irritated because of amount of expenses and wishes to manage money and to preserve the record of their daily cost which may be useful to change their way of spending money. In short, this application will help its users to overcome the wastage of money.

7.APPENDIX

7.1 SAMPLE INPUT DESIGN OUTPUT DESIGN



Username

Password

SIGNIN

[sign up now](#)

PROFILE 



[Edit](#)

Name

Address

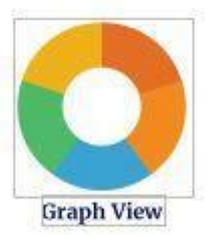
Phone

Email

Munnar trip
 # Hussatn
 Created on 21/03/2021

 Tally Money  Add Member  Add Money

- Item 1
Sub item 1
- Item 2
Sub item 2
- Item 3
Sub item 3
- Item 4
Sub item 4
- Item 5
Sub item 5
- Item 6
Sub item 6
- Item 7
Sub item 7
- Item 8
Sub item 8



Edit Expense

Amount

Edit Income

Amount

Expense Entry

Amount



SIGNUP

[already registered? login me.](#)

Expense

2/2/2021

520

Category

3rd Floor, Darmodhayam Building,, Shanmugham Road,
Marine Drive, Kochi, Kerala 682031

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8.1 BIBLIOGRAPHY

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- Introduction to Database Management- Naveen Prakash
- Analysis and Design of Information System - V. Rajkumar
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FEMINIST IDENTITY AND PSYCHOLOGICAL WELL-BEING

PROJECT REPORT

**A STUDY ON THE RELATIONSHIP BETWEEN FEMINIST IDENTITY
DEVELOPMENT AND PSYCHOLOGICAL WELL-BEING**

Submitted by:

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In partial fulfilment of the requirement for award of the degree of

B.Sc. PSYCHOLOGY



ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

Nationally Re-accredited at 'A++' level (4th cycle)

Affiliated to: Mahatma Gandhi University

MARCH 2022

CERTIFICATE

This is to certify that the project report entitled, “THE RELATIONSHIP BETWEEN FEMINIST IDENTITY DEVELOPMENT AND PSYCHOLOGICAL WELL-BEING”, is a bonafide record submitted by MS. POOJA MOOSAD, Reg. No. SB19PSY046, in partial fulfilment of the requirements for the award of the Degree of Bachelor of Psychology during the academic year 2019-2022.



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DECLARATION

I, Pooja Moosad, hereby declare that the study presented in the dissertation entitled, “The Relationship Between Feminist Identity Development and Psychological Well-being”, which is submitted to the Department of Psychology, St. Teresa’s College, Ernakulam is a bonafide record of the research work carried out by me, under the supervision and guidance of Ms. Anjitha Venugopal, Assistant Professor, Department of Psychology, St. Teresa’s College, Ernakulam, in partial fulfillment of the requirements for the degree of Bachelor of Science in Psychology and has not previously formed the basis for the award of any degree, diploma, fellowship, title or recognition before.

Place: Ernakulam

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Date: 5.5.2022

ACKNOWLEDGEMENT

Undertaking a research project for the first time requires constant assistance and guidance. Hence, I would like to express my gratitude to the Department of Psychology, St. Teresa's College, Ernakulam for providing me with this opportunity.

I acknowledge my gratitude to my research guide, Ms. Anjitha Venugopal, Assistant Professor, Psychology, for encouraging and guiding us throughout all the phases of our research.

I extend my sincere thanks to my parents, teachers and my research partners who supported me throughout this time. I am grateful to everyone who gave me guidance, encouragement, suggestions and constructive criticisms which immensely improved this project.

Above all, I thank God Almighty for blessing me in all the stages of the project and for helping me complete the project successfully.

Thanking you

Pooja Moosad

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CHAPTER I
INTRODUCTION

INTRODUCTION

1.1 BACKGROUND OF STUDY

One of the most famous social and political movements in the world, The Women's Rights Movement arose from the displeasure of a handful of women and went on to better women's lives for centuries, starting from a single spark of rebellion against the institution of patriarchy. Though the major goals of the feminist movement involve reform on issues like equal pay, reproductive rights, and sexual harassment, the priorities vary among communities and individuals. Whether the opposition is against domestic violence or genital mutilation, the idea of feminism is still looked at with contempt and derision.

Despite holding feminist ideas some women still seem to fear wearing the label of a feminist. The word has been twisted and misinterpreted throughout history. When feminists like Laura Cereta published *Epistolae familiares* (Collected Letters of a Renaissance Feminist) in the 15th century containing a panoply of letters from women about the denial of education and marital oppression to the absurdity of women's garments, they would not have had the faintest idea that six centuries down the lane, the world is still dealing with the same kind of problems. From a pro-sati society, India has also grown along with the world. The same cannot be said about the rural and interior parts of the country for they still deal with female infanticides and child marriages because daughters are a "burden".

The progress, if any, is that today women are more opinionated and assertive in their views on feminism. However, living in a society that continues to propagate traditionalist views, the effect of such feminist ideals on their well-being and as a result, their ability to fully function as a member of the society is yet to be fully uncovered.

1.2 PROBLEM STATEMENT

The following research seeks to study the relationship between feminist identity and psychological well-being in Indian Women. The study also aims to ascertain the reliability of the Feminist Identity Composite Scale (FIC) in Indian women.

1.3 NEED AND SIGNIFICANCE OF THE STUDY

When a photo of the Twitter CEO holding a placard ‘Smash Brahmanical Patriarchy’ hit social media platforms in 2018, multiple groups took offence and deemed it “hate speech” and an attempt to “malign the community”. More recently Indian men trended #MarriageStrike on Twitter to express their disapproval of criminalising marital rape, which currently is legal in India. Some deemed it a win-win for the feminist movement in the country as the men who trended the hashtag refused to marry if their future wives are given the power to “consent” to sexual relations with the husband. In India, forced sexual relations are not considered a criminal offence if it happens under the institution of legalised marriage. Kerala boasts of having a literacy rate of 96.2% but the cases of dowry deaths in the second half of 2021 shocked the entire state. A large part of the educated population still holds traditionalist views that are anything but progressive. When the court decided to open Sabarimala Temple’s gates to women of menstruating ages, the majority of the Hindu population, men and women alike, protested against the change. While the entrance of women is allowed legally, it is far from reality. Most often they are stopped at the footsteps of the temple by temple staff who deem it disruptive to the peace on the temple grounds.

Regardless of its source, the experience of oppression has an effect on the development and well-being of an individual. With increased patriarchal practices, women and other minorities have come to face adversities in various aspects of their lives. Even today identities of women are often linked with the men involved in their lives in collectivistic patrilineal societies like India. Women are also more likely to have depression, anxiety and somatic complaints. In the 21st century, women still are at a social disadvantage in India. There is a need to understand

how much of this disadvantage is tolerated by women today and how its acceptance or resistance is affecting their well-being and in the long term, their ability to function competently as a member of society.

1.4 SCOPE OF THE STUDY

This study adds to the growing research literature on gender studies and sheds light on how institutionalised injustice can be detrimental to mental health. At its core, feminism remains a movement for full economical, social and political equality for women. Feminism today is an umbrella term that advocates for equality among people regardless of their gender. It seeks to interrogate and eradicate the inequalities along the lines of sexuality, gender, sex, race, ability and class. Feminists all over the world seek to explore the inequities along these intersectional lines and eliminate them. Since feminist ideologies have not garnered enough positive attention in the mainstream Indian culture, this study aims to explore the development of feminist identity and the impact it can have on well-being. The study attempts to ensure the reliability of the Feminist Identity Composite scale in an Indian population for future reference.

1.5 OBJECTIVES OF THE STUDY

- To find a relationship between feminist identity and psychological well-being in Indian women.
- To ascertain the reliability of the Feminist Identity Composite Scale in Indian women.

1.6 LIMITATIONS OF THE STUDY

This study was carried out diligently to the best of our ability. However, there are a few limitations that may have a possible influence on the results. Due to the COVID-19 pandemic, the data was primarily collected via Google Forms. The majority of the women under the sample were South Indians/Keralites. Hence, a large scale study coupled with personal interviews of each woman in the sample is required to completely understand the relationship between feminist identity and psychological well-being

CHAPTER II
REVIEW OF LITERATURE

LITERATURE REVIEW

Feminism is best understood as that which “emphasizes the validity of women’s own interpretations of their lived experiences and needs, protests against the institutionalized injustice perpetrated by men as a group against women as a group, and advocates the elimination of that injustice by challenging the various structures of authority or power that legitimate male prerogatives in a given society” (Yakushko, 2007; Offen, 1988). In this male-dominated society, gender and gender discrimination are observed to have a significant impact on mental health, as women have a less social advantage, and it has been noted that the scarcity of protective factors like feeling respected or valued increases this risk (Basu, 2012).

Empowerment and solidarity among women, promotion of gender equality (Harlan, 1998), and awareness of the social and personal impacts of living in a patriarchal culture can lead to the advancement of the women’s movement and better living conditions for women. According to feminist theorists, such awareness can facilitate distinguishing healthy and socially ingrained behaviour, thereby promoting personal freedom in making healthy life decisions (Saunders & Kaushbeck-West, 2006; Prochaska & Norcross, 1999). In this manner, from what was earlier limited to equal rights, feminism of today has a broader area of coverage. As a result of intersectionality, various types of feminism emerge, such as socialist feminism, liberal feminism, and lesbian feminism to name a few (Henley, Meng, O’Brien, McCarthy, & Sockloskie, 1998; Szymanski, 2004; DeBlaere et al., 2019), each pioneering a diverse definition of the feminist ideology.

The multiracial feminist theory hypothesises that feminist identification, the salience of feminism in women’s lives and what women understand feminism to be, may differ across racial and ethnic groups (Harnois, 2005; Robnett and Anderson, 2017; Liu & Zheng, 2019). In the US, Caucasian females look for equal academic, employment, and political opportunities whereas African-American females seek ways to seamlessly blend family life along with their careers while trying to reduce the effect of racism in their lives. Moving over to collectivistic Asian

culture, feminist reforms have diverse goals and only lately involved diverse individuals from the grassroots level at the forefront, instead of the state and intellectuals. Additionally, the fourth wave of feminism in China has ideals aligning with international feminist goals such as security from sexual misconduct and addressing LGBTQ issues along with an equal division of family and work roles (Liu & Zheng, 2019). Marginalized women with their unique social locations due to their multiple identities develop feminist identities differently from their nonmarginalized counterparts. DeBlaere and Bertsch in 2013, explored the relationship between perceived sexist events and distress in sexual minority women of colour and found that as women better understand their multiple identities, they learn to better identify their experiences with discrimination.

In psychological research, approaches that have dominated the feminist literature involve a developmental model that arose from counselling psychology and a social psychology model. Measures of feminist identity and its correlates have mostly been based on Downing and Roush's theoretical model developed in 1985 based on Cross' (1971; Cross & Vandiver, 2001) developmental model of politicized Black identity. This approach identified five feminist identity stages through which an individual progresses and clearly defines how one moves from unquestioned acceptance of a dominant group's beliefs about oneself to consciousness and activism regarding one's disadvantaged position in society. The stages include Passive Acceptance, Revelation, Embeddedness-Emanation, Synthesis, and Active Commitment, which are further elaborated in the theoretical framework. Feminist identity as politicized group identity is an extensively studied area in social psychology. To describe the constituents of group consciousness, three broad categories are utilised Identity, Injustice, and, Efficacy.

Based on the developmental model, Feminist Identity Scale (FIS) (Rickard, 1989) and Feminist Identity Development Scale (FIDS) (Bargad and Hyde, 1991) were constructed first. The Feminist Identity Composite (FIC; Fischer et al., 2000) includes the best items from its two predecessors. Rooted in the social identity approach, Feminist Perspectives Scale (FPS; Henley et al., 1998) and Attitudes Toward Feminism and the Women's Movement Scale (FWM;

Fassinger, 1994) are widely used. Interestingly, there are significant overlaps between the developmental and social models of feminist identity development, for instance, the Revelation and Injustice are based on the awareness of social inequalities and Active Commitment and Efficacy are rooted in the behavioural manifestation of the feminist identity. Thus, self-labelling or identifying as a feminist or non-feminist has been linked to the extent of a woman's feminist actions.

However, feminist identities may differ depending on how questions are asked. Around 81% of women who did not consider themselves feminists agreed with some or all of the goals of feminism. Adopting the label of "feminist" can cause unease due to stereotyping in many women, who instead choose to identify with their specific beliefs (Liss et al., 2001). Indicating the broader implications of the development of feminist identity, Szymanski et al. (2009) suggest that there is a need to focus on internalized misogyny, the subconscious devaluation or mistrust of other women and belief in male superiority, particularly in therapy. Internalized misogyny can aggravate the relationship between sexist events and psychological distress in heterosexual women. Since women have much less economic and political power than men in the patriarchal structure of the world, sociopolitical roots play a major role in the aetiology and maintenance of many mental health struggles faced by women (McNamara & Rickard, 1989). Thus, feminist identity and its development is a powerful tool in therapy for women.

In a study to explore the well-being among university students with relatively homogenous backgrounds alongside their gender roles, September et al. (2001) administered a test that clearly emphasized the distinction between biological sex and gender roles without explicitly mentioning the terms *feminine* and *masculine*. The results indicated that the majority of women were classified as androgynous, suggesting that they are more comfortable with defying stigmatized gender roles perhaps due to the rising heat of feminism. Women who are in the later stages of feminist identity are more likely to identify as bisexual or lesbian (Yakushko, 2007; Simoni et al. 1999). The study also sheds light on the fact that women with feminist identities were more likely to have graduate degrees, work outdoors and have more income. Ryff (1995)

defines psychological well-being as feeling good about one's self and one's life, the sense that one is continuing to grow and develop as a person, the belief that life has meaning and purpose, having good relationships with others, the ability to manage life effectively, and a sense of self-determination. A theoretical model devised based on this suggested six components namely, Self-Acceptance, Positive Relations, Autonomy, Environmental Mastery, Purpose in Life, and Personal Growth each plays a role in determining the well-being of a person (Ryff, 1995; September et al., 2001). Researchers also found demographic differences in various aspects of well-being. Holding strong feminist beliefs has been linked with high self-esteem (Fischer and Good 1994), self-efficacy (Eisele and Stake 2008), academic achievement (Valenzuela 1993), rejection of feminine norms for thinness and appearance (Hurt et al. 2007), sexual well-being (Schick et al. 2008), and sexual openness (Bay-Cheng and Zucker 2007).

Exposure to feminist ideology is said to have a negative correlation with depressive episodes in females (Mauthner, 1998; Weitz, 1982). Also, Yakushko in 2007 found that women who held Moderate and Feminist Values as opposed to Traditional Values had a significantly higher measure of overall well-being. Since FIC has been proved to be the most appropriate scale so far to measure feminist identity development, over 20 studies have used it. The FIC subscales have been related to optimism (Peterson et al., 2008), autonomy (Yoder, Snell, & Tobias, 2012), racial acceptance and awareness of White privilege (Wolff & Munley, 2012), multiple psychological distress variables (e.g., negative affect, depression, phobic anxiety, body image concerns; Blue & Berkel, 2010; Clarke, Murnen, & Smolak, 2010; Fischer & Good, 2004; Murnen & Smolak, 2008; Sabik & Tylka, 2006), and indicators of well-being (e.g., self-esteem, self-efficacy, personal growth, self-acceptance, personal agency, self-empowerment; Peterson et al., 2008; Yakushko, 2007; Yoder et al., 2012). However, the majority of the FIC studies have been done with undergraduate students and focus on the experiences of heterosexual women (DeBlaere et al., 2019). When Szymanski (2004, 2005) used the scale with sexual minority women in two studies, one yielded results that align with the heterosexual sample whereas the other one produced contradictory results. Moreover, Caucasian American females have been the focal samples of such studies. The internal consistency reliability estimates for each stage of FIC

are 0.74 (passive acceptance), 0.75 (revelation), 0.86 (embeddedness-emanation), 0.71 (synthesis) and 0.81 (active commitment) in these studies. However, when administered to African-American students, Cronbach's alpha was lower for all five subscales (Blue & Berkel, 2010) and in the case of women from mainland China, four items of the FIC had to be dropped and two others had poor factor loadings (Liu & Zheng, 2019). Similarly, the convergent, discriminant and construct validity only reached the recommended cut-offs in the Caucasian females but had variations in the marginalised samples. These studies suggest that feminist identity development is closely tied to the socio-cultural experiences of a woman and this model may not apply universally, especially to the individuals belonging to marginalized groups.

In a country like India, where people are much more insular and community-oriented, feminism is often misunderstood and therefore frowned upon. Through the handful of Indian studies regarding gender or feminist identity development, the consensus reached was that problems women face do not stem from internal personal deficiencies but rather from the society itself (eg. sexism, racism) (Srivastava, K, 2007). With globalisation, waves of Western ideals of individualism swept through the country, especially influencing the millennial and Gen-Z women. The two generations of women are perhaps much more open to declaring themselves as feminists. There, however, remains great uncertainty in the well-being of such women in a largely collectivistic country like India. Further research among women is required to ascertain how strong their ideals are and how much is it affecting their well-being in the country. There is also an urgency to assess psychometric properties like reliability and validity of the FIC in diverse samples (eg. Indian women) for future revisions.

CHAPTER III
THEORETICAL FRAMEWORK

THEORETICAL FRAMEWORK

In light of the existing literature, there is a lack of authentic research on the psychological well-being of Indian women with respect to their feminist identity development. To bridge this gap, this research aims to gather and analyse data from Indian women to find possible correlations between their feminist identity and psychological well-being.

Feminism can be explained as “a concept that can encompass both an ideology and a movement for sociopolitical change based on a critical analysis of male privilege and women's subordination within any given society” (Offen, 1988). The American Psychological Association defines it as “any of a number of perspectives that take as their subject matter the problems and perspectives of women or the nature of biological and social phenomena related to gender”. The concept of identity is also outlined by the APA, as involving “a sense of continuity, or the feeling that one is the same person today that one was yesterday or last year.” Erikson defines it as a “fundamental organising principle which develops constantly throughout the lifespan.” This process of identity formation uses all levels of mental functioning, with self-reflection and observation (Kaur, 2021; Erikson, 1974).

Feminist identity may be described as what a young woman forms in late adolescence as the foundation for her adult identity (Kaur, 2021; Josselson, 1987). Eisele and Stake (2008) define it as “a woman’s collective or social identity that involves adopting feminist attitudes and identifying as a feminist”. It may also be defined as “a woman’s recognition of gender-based boundaries and inequality and a drive toward their demise” (Colaner & Rittenour, 2015; Allen, 2000).

A theory of feminist identity development that supports the current study is the model proposed by Downing and Roush (1985). This theory has been based on Cross’ (1971) theory of positive Black identity development, comprising five stages: pre-encounter, encounter, immersion-emersion, internalisation and internalisation-commitment.

Downing and Roush's model also describes five stages—passive acceptance, revelation, embeddedness-emanation, synthesis and active commitment. Women may go through these stages at different speeds, cycle through them over and over, stagnate at certain points or revert to earlier stages.

The first stage, Passive Acceptance (PA), involves a state in which women are not aware of, or in denial of the individual and institutional prejudice against them. Women in this stage are accepting of the male dominating system and its perspectives like traditional gender roles and the idea that men are superior. They may not engage with people who disturb the balance they have created for themselves. During the transition period to the next stage, women may become 'ready' to change or take a risk (Downing & Roush, 1985; Erickson, 1950).

The second stage, Revelation (R), is activated when women experience one or more crises that they are no longer able to ignore, such as an unhappy marriage, inability to pursue an education or career, witnessing discrimination against their daughters, encounters with activists for the women's rights movement or gender-based violence or abuse. This change may be sudden, or more often, gradual, and may be made difficult by the perceptual distortions that are typical of women in the passive acceptance stage. During the revelation stage, women feel both anger, as feeling betrayed or duped by the universe (Downing & Roush, 1985; Avery, 1977), as well as guilt for their participation in their own oppression and lack of wanting to change things. Dualistic thinking of all men as negative and all women as positive is also seen.

The third stage, Embeddedness-Emanation (EE), is in particular, more difficult for women, as the dominant culture is so deeply ingrained in them in all aspects of their lives. Women may feel the need to withdraw from their other circles and engross themselves in creative activities such as art, music or drama that show how oppressed women are. A close emotional connection is created with other women, giving them chances to strengthen their identities and release their anger into a support system. In the second half of this stage, women become open to different viewpoints and a more relativistic perspective, while still exerting

caution around men. They gradually realise that simply raging about oppression is not dismantling the dominant culture and come to an awareness that their beliefs in the embeddedness phase are as rigid as in the passive acceptance phase.

The fourth stage, Synthesis (S), involves an integration of positive female qualities with one's own personality to create a realistic self-concept that surpasses gender roles and is capable of evaluating men individually rather than with collective stereotypes. Women in this stage have "struck a flexible truce" (Downing & Roush, 1985; Avery, 1977) with the world. They are able to direct their energy in a productive manner and respond to discrimination appropriately.

The fifth stage, Active Commitment (AC), is concerned with women learning to put this newfound identity into meaningful action to make a change in society. This may be done by using their unique talents to choose issues that are relevant to them, and to which they can contribute. Only a few women progress to this stage; many women who externally appear to be working for their rights may be doing so out of some unfulfilled need leftover from previous stages like revelation or embeddedness.

For further studies to be carried out on feminist identity development, there must be measures to assess these levels in women. To evaluate feminist identity development, three scales have been created on the basis of this model.

The Feminist Identity Scale (FIS) was developed by Rickard in 1987. This scale, though based on the Downing and Roush model, dropped the dimension of Active Commitment as it was thought to be a "behavioural manifestation of S-level integration" (Rickard, 1989), and less a separate identity. A study later conducted (Rickard, 1989) to assess the relationship between dating behaviours and feminist identity level attempted to validate the FIS. Liss et al. (2001) assessed the factors that predicted and hindered feminist social identity in college women, using the FIS to assess feminist identity development.

The Feminist Identity Development Scale (FIDS) was developed by Bargad and Hyde in 1991 to assess the effect of educational courses in women's studies on the feminist identity development of women who attended them. While other studies measured attitude changes, self-esteem changes, career aspirations, and generalized beliefs of social roles due to women's studies, there were none assessing personal conceptions of feminism at the time. The accompanying study using the developed scale showed that women's studies courses did in fact contribute to the development of a feminist identity (Bargad & Hyde, 1991). Moradi and Subich (2002) investigated feminist identity development and perceived sexist events along with their relation to psychological distress, using the FIDS to assess feminist identity.

The Feminist Identity Composite Scale (FIC) was developed by Fischer et al. (2000) in response to the need for more sophisticated assessments of feminist identity development. It intended to operationalize the Downing and Roush model, retaining the five dimensions. The above scales of FIS and FIDS were examined and a composite measure was derived "using their best items" (Fischer et al., 2000) with better psychometric properties, consistency and validity. As the feminist identity development of a population of Indian women is being evaluated for the first time, it is fair to believe that the FIC would be a more appropriate scale in the current study.

Moradi and Subich (2002) compared the reliability and validity of the three scales assessing feminist identity development described above and found that only the Feminist Identity Composite scale had acceptable internal consistency reliability for all subscales. Content validity was found to be best for the Feminist Identity Development Scale; overall trends indicated that the FIC was superior. Hyde (2002) commented on this evaluation, stating that there were inconsistencies and that both the FIDS and FIC are comparable measures

Nevertheless, several studies have used the FIC to examine feminist identity. Fischer and Good (2004) found that the dimension of Revelation was linked with greater psychological distress. A study by DeBlaere in 2013 on the moderating role of womanism between perceived sexism and psychological distress, showed comparable results that womanism correlated

positively with psychological distress. Saunders and West (2006) investigated the relationships between feminist identity development, gender role orientation and psychological well-being; a more developed feminist identity as measured by the FIC, related positively to psychological well-being. Parallel to these findings, Yakushko (2007) reported that women who had more feminist values scored higher in overall well-being than those with traditional values.

As Ryff (1995) defined, psychological well-being includes “feeling good about one’s self and one’s life, the sense that one is continuing to grow and develop as a person, the belief that life has meaning and purpose, having good relationships with others, the ability to manage life effectively and a sense of self-discrimination.” The concept of well-being can also be described as, “optimal psychological functioning and experience” (Ryan & Deci, 2001). Two traditions can typically be observed in the study of well-being, that is, the hedonic view and the eudaimonic view.

The hedonic view equates pleasure or happiness with well-being. This approach has historically been seen in many forms and its focus may range from bodily pleasures to broader self-interests (Ryan & Deci, 2001). More modern concepts of hedonism have included pleasures of both the mind and body (Ryan & Deci, 2001; Kubovy, 1999) and the belief that well-being comprises subjective happiness and experiences of pleasure and displeasure. Hedonic contents of well-being include satisfaction and comfort and are associated with self-focus and the ‘here and now’ (Huta, 2016).

The eudaimonic view suggests that not all desires a person has will create a sense of well-being when they are achieved. Not all pleasure producing outcomes promote wellness. Eudaimonia is thought to occur when the life activities of people are most congruent with their deeply held values (Ryan & Deci, 2001; Waterman, 1993), and in this case, people would feel most authentic and engage in activities that led to personal growth and development. Eudaimonic contents of well-being would include personal maturity, ethics, authenticity, autonomy and broader meaning to life, as well as associations with balancing the self and others, balancing the

present and future and creating one's own vision (Huta, 2016). This approach has been adopted by Ryff, as evaluated in 1989, in which it was found that many theories of well-being overlap with some similar features. These make up the core dimensions of Ryff's six-factor theory of psychological well-being, detailed as follows.

The first dimension is *self-acceptance*, regarded as the most recurrent criterion of psychological well-being. Being able to accept oneself is a defining feature of good mental health, maturity, ideal functioning and reaching one's full potential. The second dimension involves *positive relations with others*, or the ability to love and be loved, and to have trusting interpersonal relationships. People who have reached self-actualization are described as having more empathy for humans and being capable of deeper relationships. The third dimension is *autonomy*, which emphasises independence and self-control. A fully functioning person is said to have an internal locus of evaluation, using personal standards to assess themselves rather than seek approval from others to feel self-worth. A person should ideally have a sense of freedom of choice without needing to rely on collective fears or beliefs of society.

The fourth dimension is *environmental mastery*, that is, the ability of a person to create environments that are suited for their mental state. Many theories of well-being stress the necessity of active participation, advancing in the world and changing it with various physical or mental activities, also see it as a sign of maturity. The fifth dimension, *purpose in life*, is included in definitions of mental health and maturity. A person should have a sense of direction or meaning in life, as well as certain goals to achieve. The last dimension, *personal growth*, suggests that a person should continue to grow and expand themselves, to increase their potential throughout their life. Instead of stopping at a state wherein, they have no problems, they may try to remain open to new experiences. This dimension comes closest in meaning to the notion of eudaimonia.

In an attempt to operationalize these dimensions for future examination, a scale for psychological well-being was created (Ryff, 1989), by defining each of the six aspects of positive functioning.

For example, a high scorer in self-acceptance has a positive attitude towards themselves and acknowledges their good as well as bad qualities, while a low scorer is not satisfied with themselves and wishes to be someone different. A high scorer in autonomy is self-determining and independent, while a low scorer conforms to peer pressure and needs others to make decisions for them.

Ryff's Psychological Well-being scales were used in a study assessing the impact of self-labelling as a feminist and feminist beliefs on women's well-being, egalitarianism and activism (Yoder et al., 2011). The scales were adjusted for a single measure of overall well-being, and it was found that self-labelling was not related to personal well-being, but feminist beliefs were. Another study by Yoder et al. (2012) used three of the six independent scales of Ryff's well-being measure, namely, autonomy, self-acceptance and personal growth. It was discovered that feminist beliefs and well-being with liberation are complexly and significantly related.

September et al. (2001) examined this model of well-being in young adults using Ryff's scales in a study of the relation between well-being, impostor feelings and gender role orientation. From the study, it was found that well-being derived from positive interpersonal relationships is higher in people with more expressive traits, and well-being derived from autonomy is higher in those with more instrumental traits. Saunders and West (2006) also used Ryff's measure to determine the relationships between feminist identity, gender roles and psychological well-being. Here, instrumentality, expressiveness and feminist identity were positively associated with well-being. Yakushko in 2007 had comparable findings, also using Ryff's scales to measure six domains of subjective well-being.

Ryff's Psychological Well-being scales have become a very widely used measure of positive psychological functioning, made evident by the abundant publications utilising this scale. As stated above, this measure has been used in studies of feminist identity and well-being in other countries. Based on the existing literature, it is convincing that this scale would be the best fit for the current study.

CHAPTER IV
RESEARCH AND METHODOLOGY

RESEARCH AND METHODOLOGY

4.1 OBJECTIVES

- To find a relationship between feminist identity and well-being in Indian women.
- To ascertain the reliability of the Feminist Identity Composite Scale in Indian women.

4.2 HYPOTHESES

The primary hypotheses are,

1. H₀: There is no significant relationship between subscales of the Feminist Identity Composite Scale and subscales of Ryff's Scales of Psychological Well-being.

H₁: There is a significant relationship between subscales of the Feminist Identity Composite Scale and subscales of Ryff's Scales of Psychological Well-being.

2. H₀: The Feminist Identity Composite Scale is not reliable for the chosen sample population.

H₁: The Feminist Identity Composite Scale is reliable for the chosen sample population.

The secondary hypotheses are,

3. H₀: There is no significant relationship between age, Feminist Identity and Psychological Well-being.

H₁: There is a significant relationship between age, Feminist Identity and Psychological Well-being.

4. H₀: There is no significant association between identifying as a Feminist and Psychological Well-being.

H₁: There is a significant association between identifying as a Feminist and Psychological Well-being.

4.3 RESEARCH DESIGN

The study done is based on a quantitative research design aimed at understanding the relationship between feminist identity and well-being in Indian women. Non-probability snowball sampling was used to collect responses from the participants. Consent to participate in the study and the demographic details like name, age, employment status and place of residence were collected as well. The questionnaires circulated via Google Forms yielded initial responses from 345 women of which 5 fell under the exclusion criteria. Therefore, the final sample size was 340. The Feminist Identity Composite Scale and The Ryff Scales of Psychological Well-being (18-item version) were the tools utilized for the same. The data was organised using Microsoft Excel and the statistical analysis was done using IBM SPSS software version 28.0.1.1 (14). Pearson's Correlation test, Regression Analysis and Chi-square test were run and probable associations between variables were found. Cronbach's Alpha was found using the same software to check the reliability of the questionnaires among the Indian population.

4.4 SOURCES OF DATA

The data was collected by circulating Google Forms online. Non-probability snowball sampling was used to collect the same. The participants were Indian women who are of the age 18 or above.

4.5 SAMPLE DESIGN

The sample design used was non-probability snowball sampling. Sampling is a technique of selecting a representative part of the population such that it has all the characteristics of the population. From this sample, statistical inferences are made and generalised to the population. In non-probability sampling, the selection of the sample is done randomly. As opposed to probability sampling, every element in the population does not have an equal chance of being selected. Snowball sampling is used when direct access to the sample is limited (eg. due to COVID-19). Here the researchers pass on the questionnaire to a few participants who in turn pass it on to others who fit the criteria.

4.6 SAMPLE SIZE

The total sample size was 345, of which 5 responses were excluded due to evident response bias or not fitting the inclusion criteria. The sample was predominated by women from Kerala although it included women from other states of India as well, such as Delhi, Karnataka, Tamil Nadu, Maharashtra, Telangana, Meghalaya, Andhra Pradesh, Uttar Pradesh, West Bengal and Goa.

4.7 SAMPLING METHOD

For this study, the sample was chosen based on two criteria: (i) the participant has to be of Indian nationality and (ii) the participant has to be of the age 18 or above at the time of responding. Making use of snowball or network sampling, the responses were collected to meet a controlled quota. The researchers contacted a few individuals who met the selection criteria and the sample grew like a snowball rolling downhill to include a sizable population with these characteristics. The response collection carried on until the specified quota criteria were met and 345 responses were obtained. From this, 5 were excluded due to evident response bias and failure to meet the sampling criteria, leaving 340 valid responses.

4.8 METHOD OF DATA COLLECTION

The data collection was primarily via Google Forms. The questionnaire was drafted consisting of asking the demographic details like name, age, state of residence, socioeconomic status and whether they identify as a feminist. This was followed by the Feminist Identity Composite scale and Ryff's Psychological Well-being scale. The data was organised using Microsoft Excel. IBM SPSS software version 28.0.1.1 (14) was used to perform the statistical analyses.

4.9 DRAFTING A QUESTIONNAIRE

Demographic Details

The demographic information of the participants was collected using a brief questionnaire asking for the participant's age, work status, the state in which they currently reside and self-perceived socioeconomic status. An additional question asked if they considered themselves to be feminists.

Feminist Identity Composite Scale

The participant's level of feminist identity development was measured using the Feminist Identity Composite Scale (FIC; Fisher et al., 2000). Formed from the Feminist Identity Scale (FIS; Rickard, 1987) and the Feminist Identity Development Scale (FIDS; Bargad & Hyde, 1991), this scale consists of 33 positively phrased statements that are intended to assess an individual's positive feminist identity. Each question is scored with a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). This scale follows the Downing and Roush model (1965) of feminist identity development, spanning five dimensions or subscales, Passive Acceptance, Revelation, Embeddedness-Emanation, Synthesis and Active Commitment. The subscale scores were calculated by finding means across the items in each subscale and higher means indicated a higher level of agreement with that stage.

The FIC is found to have acceptable Cronbach's alpha scores, primarily when the sample population consisted of white women. Fisher et al. (2000) found alpha coefficients from 0.68-0.84 for the subscales. The internal consistency reliability estimates for each stage of FIC are 0.74 (passive acceptance), 0.75 (revelation), 0.86 (embeddedness-emanation), 0.71 (synthesis) and 0.81 (active commitment) in the mentioned studies. Blue and Berkel (2010), however, conducted a study with African women, resulting in relatively lower reliability. An assessment of the reliability of the FIC in an Indian population is yet to be done.

Ryff's Psychological Well-being Scale

In this study, the short version of Ryff's measure of psychological well-being (1989) was used. This scale contains 18 statements, assessing six dimensions of psychological well-being, which are autonomy (independence and self-control), environmental mastery (capacity to manage environments), personal growth (continuing to grow and develop oneself), positive relations with others (having warm and trusting relationships), purpose in life (a sense of direction and meaning) and self-acceptance (being positive towards oneself). Agreement with each statement was indicated using a 7-point Likert-type scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Reliability measures were found to range from 0.8 to 0.9 on each subscale.

4.10 DATA ANALYSIS TECHNIQUES

Correlation

Correlation is measuring the degree of the relationship between two variables. Karl Pearson's coefficient of correlation otherwise known as simple correlation is the most widely used method. The value r is known as the correlation coefficient, whose values lie between -1 and +1. All positive values indicate positive correlations, that is, when one variable increases in value, the other also increases, and negative values indicate negative correlations, that is, when the value of one variable increases, the other decreases. If the value of r is 0, that means there is no correlation. An r value of -1 is indicative of a perfect negative correlation and a value of +1 is a perfect positive correlation. This means that variations in the independent variable account for

100% of the variations in the dependent variable, and there is a constant change in the dependent variable for each unit change in the independent variable. The closer the r value is to 1, the higher the correlations.

Regression

A set of statistical procedures to find out trends in data or to estimate relationships between a dependent and a series of other independent variables is called regression analysis. Regression enables researchers to estimate how dependent variables are affected as the independent variable changes. Such descriptions of variables are obtained by fitting a line to the observed data. The method attempts to quantify the strength and character of this relationship. Regression can be mainly of three types linear, multiple linear and nonlinear. The former two are the most commonly used ones and the latter is used when there is a requirement to interpret complicated data sets that have a nonlinear relationship.

Multiple Linear Regression

This technique is used in estimating the relationship between one dependent variable and two or more independent variables. Here, the dependent variable shows either a linear relationship with the independent variable(s) or a non-linear relationship. The technique allows researchers to understand the relative contribution of each independent variable in the total variance. Researchers make use of this technique when,

- the strength of the relationship between the independent variable(s) and the dependent variable is to be determined
- the values of the dependent variable at specific values of the independent variable are to be found out

Reliability

The consistency of a research study or a psychological tool is called its reliability in psychological research. When a measure produces similar results under consistent conditions it is said to have high reliability. The primary idea, therefore, is to be able to replicate significant

results when the study is performed under similar conditions. The reliability of a psychological tool can be measured or assessed by checking the consistency of results obtained across time, observers and parts of the test itself.

Reliability may be any of the following types,

- Test-retest Reliability – The consistency is checked in the results of the same population across time.
- Inter-rater (Inter-observer or Inter-coder) Reliability – The consistency is checked when raters or observers administering the test are different.
- Internal Consistency – The consistency is checked within different parts of the test.

Cronbach's alpha

Developed by Lee Cronbach in 1951, Cronbach's alpha or coefficient alpha measures the internal consistency or the reliability of a scale. It can be thought of as the mean of all possible split-half coefficients, corrected by the Spearman-Brown formula. In this method, assessment of reliability is done by comparing the covariance among the items of an instrument with the overall variance. Relative to this overall variance, a reliable instrument or test would have a great deal of covariance. High covariance often indicates a strong relationship between the variables.

Chi-Square Test

A Chi-square (χ^2) test is used to assess if there is a significant relationship between the two nominal variables. A set of observed values are compared against the expected values to ascertain the existing relationship between them. The two commonly used χ^2 tests are the χ^2 goodness of fit test and the χ^2 test of independence. For a χ^2 test of independence, a p-value that is less than or equal to the significance level indicates there is sufficient evidence to conclude that the observed distribution is not the same as the expected distribution.

CHAPTER V
DATA ANALYSIS

DATA ANALYSIS

Correlation

The relationship between the main variables feminist identity measured using the FIC and psychological well-being was found by using Pearson's Correlation in IBM SPSS software. Pearson's correlation is the most commonly used measure of correlation in statistics. Also called Pearson's Product Moment Correlation, this allows researchers to find out whether there exists a linear relationship between two numerical data sets. Here, the subscale and total scores of FIC were correlated with the subscale and total scores of Ryff's Psychological Well-being to understand whether there exists a relationship between the variables. Correlation was also used to evaluate the relationship between age with Feminist Identity scores and age and well-being scores.

Reliability

The reliability of the FIC scale was also tested in Indian women using Cronbach's alpha on SPSS. This measure assesses internal consistency or the consistency within different parts of the test. This measure is most commonly employed to check the reliability of the questionnaire when there are multiple Likert items in it. The FIC is scored on a 5-point Likert scale with responses ranging from Strongly Disagree to Strongly Agree.

Regression

Multiple linear regression, an extension of simple linear regression, is used to estimate the relationship between one dependent variable and two or more independent variables. Using the SPSS software this tool was used to identify the relationship between the subscales of Feminist Identity (independent variable) with overall well-being and with each subscale of Ryff's Psychological Well-being test.

Chi-square Test

This test evaluates the association between two categorical variables. The relationships between the subscales and total scores of the FIC and whether the participants considered themselves a feminist were examined. The subscale and total values were classified into Low, Average and High categories based on the quartile values—values up to the first quartile fell in ‘Low’, values up to the third quartile fell in ‘Average’ and values above this fell in ‘High’. The relationships between these were found using chi-square tests on IBM SPSS.

CHAPTER VI
FINDINGS

FINDINGS

Prior to the data analysis, exclusion criteria were applied and five responses were dropped due to evident response bias and failure to meet the sampling criteria, as mentioned in the previous chapter. Out of 345 responses, 340 were valid and used in the data analysis. Of the 340 participants, based on work status 47.1% were students, 10% were not employed, and 42.9% were employed. 53.53% fall between the ages of 18 and 25, 23% fall between the ages of 25 and 40, and 23.3% are 40 and above. 85.59% of the participants are residents of Kerala, 2.64% Tamil Nadu, 2.35% Karnataka, 1.76% Maharashtra, 1.17% Abroad and the remaining from other states in India. The participants were asked to describe their socioeconomic status and 73.2% are upper-middle class, 26.2% lower-middle class, and 0.6% high.

The participants were considerably varied in whether they considered themselves feminists, with 45% replying with 'Yes' to the question 'Are you a feminist?', 28.8% replying with 'Maybe' and 26.2% replying with 'No.' 95.5% of the participants who responded with 'No' to this question had higher scores in the Embeddedness, Synthesis and Active Commitment subscales, which may imply a misconception or prejudice associated with the term 'feminist', leading to some reluctance to identify with it.

It was found that the majority of the participants fell in the Synthesis stage, coming up to 42.65%. 1.18% of participants belonged to the Passive Acceptance stage, 4.71% fell in Revelation, 25.29% in Embeddedness and 26.18% in Active Commitment. If participants had similar scores in more than one subscale, as a general rule, the higher one was chosen. 77.2% of participants in the Synthesis stage belong to the upper-middle class or high socioeconomic class, but there is no significant relationship between the stages and the socioeconomic status.

The average feminist identity development score was obtained from the mean total scores of the same, as 3.53 (SD=0.36) of a maximum possible 5. On a 5-point response scale, this

indicates a neutral level of feminist identity. The average psychological well-being score was obtained from the mean total scores in a similar procedure, as approximately 5 (SD=0.75) of a maximum possible 7. On a 7-point response scale, this indicates a moderately high level of well-being.

The mean subscale scores and mean total scores of the Feminist Identity Composite Scale (FIC) and Ryff's Psychological Well-being Scale, as well as their respective standard deviations, are listed in Table 1.1 and 1.2.

Table 1.1

Means and standard deviations of FIC scores

Scores	Mean	Standard Deviation
Overall FIC	3.53	0.37
Passive Acceptance	2.36	0.73
Revelation	3.37	0.74
Embeddedness	3.78	0.86
Synthesis	4.19	0.49
Active Commitment	4.08	0.55

Table 1.2

Means and standard deviations of Well-being scores

Scores	Mean	Standard Deviation
Overall Well-being	4.99	0.75
Autonomy	4.89	0.94
Environmental Mastery	4.85	1.04
Personal Growth	5.65	1.00
Positive Relations	4.89	1.32
Purpose in Life	4.71	1.14
Self-Acceptance	5.24	1.21

As observed from the table, participants scored relatively similarly on the six subscales of Ryff's Psychological Well-being scale.

Relationship between subscales of the Feminist Identity Composite Scale and subscales of Ryff's Scales of Psychological Well-being

The relationships between the main variables of interest—feminist identity development and psychological well-being were examined. Using Pearson's correlation, it was found that the subscales and total scores of the FIC are significantly correlated with the subscales and total scores of Ryff's psychological well-being scale. The following table displays these values.

Table 2
Correlations between FIC scores and Well-being scores

	PA	R	EE	S	AC	FIC	AU TO	EN V	PG	PR	PL	SA	WB
PA	1	-0.108*	-0.108*	-0.170*	-0.235*	0.214**	-0.176*	0.086	-0.267*	-0.090	-0.199*	-0.038	-0.141*
		0.047	0.046	*0.002	*<0.001	<0.001	*0.001	0.119	*<0.001	0.101	*<0.001	0.485	*0.009
R		1	0.376**	0.221**	0.343**	0.724**	-0.062	-0.269*	-0.007	-0.240*	-0.132*	-0.234*	-0.252*
			<0.001	<0.001	<0.001	<0.001	0.254	*<0.001	0.895	*<0.001	0.015	*<0.001	*<0.001
EE			1	0.220**	0.325**	0.589**	-0.110	-0.163*	0.053	-0.058	-0.005	-0.024	-0.067
				<0.001	<0.001	<0.001	0.860	*0.003	0.333	0.290	0.921	0.659	0.218
S				1	0.697**	0.605**	0.162**	-0.106	0.255**	0.103	0.222**	0.195**	0.260**
					<0.001	<0.001	0.003	0.053	<0.001	0.060	<0.001	<0.001	<0.001
AC					1	0.678**	0.142**	0.063	0.220**	0.051	0.212**	0.193**	0.201**
						<0.001	0.009	0.242	<0.001	0.350	<0.001	<0.001	<0.001

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FIC	1	-0.0 16	-0.0 91	0.04 1	-0.1 27*	-0.0 20	-0.0 20	-0.0 65
		0.77 1	0.09 9	0.44 9	0.02 0	0.71 9	0.71 5	0.23 5
AU TO	1	0.25 6**	0.22 2**	0.14 9**	0.00 5	0.22 8**	0.45 6**	
		<0.0 01	<0.0 01	0.00 7	0.93 0	<0.0 01	<0.0 01	
EN V			1	0.30 1**	0.34 2**	0.11 4*	0.47 6**	0.64 7**
				<0.0 01	<0.0 01	0.03 8	<0.0 01	<0.0 01
PG				1	0.34 7**	0.36 9**	0.33 3**	0.62 5**
					<0.0 01	<0.0 01	<0.0 01	<0.0 01
PR					1	0.43 6**	0.41 5**	0.72 0**
						<0.0 01	<0.0 01	<0.0 01
PL						1	0.25 0**	0.53 8**
							<0.0 01	<0.0 01
SA							1	0.74 6**
								<0.0 01
WB								1

** Correlation significant at 0.01 level (2-tailed).

* Correlation significant at 0.05 level (2-tailed).

From Table 2, it is evident that Passive Acceptance of the FIC is significantly negatively associated with other FIC subscales, as well as with Autonomy, Personal Growth, Purpose in

Life and overall Well-being. It is significantly positively correlated to total FIC scores. Other relationships are not significant.

Revelation subscale of FIC is significantly positively associated with Embeddedness, Synthesis, Active Commitment and total FIC scores; and negatively associated with Environmental Mastery, Positive Relations, Purpose in Life, Self-Acceptance and overall Well-being. Other relationships are negative but not significant.

Embeddedness-Emanation subscale of FIC is significantly positively associated with Synthesis, Active Commitment and total FIC scores, and negatively associated with Environmental Mastery. Other relationships are mainly negative but not significant. It has no significant association with overall Well-being.

Synthesis subscale of FIC is significantly positively associated with Active Commitment and total FIC scores, as well as with Autonomy, Personal Growth, Purpose in Life, Self-Acceptance and overall Well-being. Other relationships are positive but not significant.

Active Commitment subscale of FIC is significantly positively associated with total FIC scores, as well as with Autonomy, Personal Growth, Purpose in Life, Self-Acceptance and overall Well-being. Other relationships are positive but not significant.

The subscales of Ryff's psychological well-being are all significantly positively associated with each other and with overall well-being, apart from Autonomy with Purpose in Life.

In short, Passive Acceptance and Revelation subscales are negatively associated with well-being, Synthesis and Active Commitment are positively associated with well-being and Embeddedness has no significant relationship with well-being. Before conducting the regression analysis to understand the effect of the subscales of FIC on the subscales and overall well-being, the skewness of the dependent variables was found, as depicted in the following table.

Table 3*Skewness statistics of the dependent variables for regression analysis*

Dependent Variables	Skewness Statistic
Autonomy	-0.501
Environmental Mastery	-0.498
Personal Growth	-0.697
Positive Relations	-0.172
Purpose in Life	-0.094
Self-Acceptance	-0.624
Overall Well-being	-0.209

The variables are slightly negatively skewed. The regression model in the study uses the overall well-being score as well as the six subscale scores as the dependent variables, and the five subscales of the FIC as the independent variables.

The following table shows a regression analysis with overall well-being as the dependent variable and the five subscales of the FIC as the independent variables.

Table 4.1*Regression analysis with overall well-being scores as the dependent variable*

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	4.322	0.395		10.955	<0.001
PA	-0.113	0.052	-0.109	-2.163	0.031
R	-0.353	0.056	-0.348	-6.358	<0.001
EE	-0.041	0.048	-0.047	-0.867	0.387
S	0.336	0.105	0.218	3.186	0.002
AC	0.216	0.100	0.158	2.163	0.031

$R^2=0.195$, $F=16.15$, $p \text{ value}<0.001$

In this regression, R^2 is found to be 0.195, indicating that 19.5% of the variation in total well-being can be explained by the subscales of the FIC. The regression is significant at 1% level of significance ($F=16.15$, $p\text{-value}<0.001$). The B coefficients show that Passive Acceptance,

Revelation and Embeddedness are negatively related to well-being, and Synthesis and Active Commitment are positively related. The beta values show that the highest negatively related variable is Revelation (-0.348), and the highest positive one is Synthesis (0.218). The significance or p-values show that Passive Acceptance, Revelation, Synthesis and Active Commitment significantly affect overall well-being.

When adding age as an independent variable, the R^2 value increases to 0.226, that is, 22.6% of the variation in total well-being can be explained by the subscales of the FIC and age. The regression shows that age positively influences well-being.

Similar regression analyses are conducted for each subscale of Ryff's psychological well-being. The following table shows a regression analysis with Autonomy as the dependent variable and the FIC subscales as the independent variables.

Table 4.2

Regression analysis with Autonomy scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	4.349	0.580		7.498	<0.001
PA	-0.182	0.077	-0.129	-2.365	0.019
R	-0.174	0.082	-0.127	-2.134	0.034
EE	-0.020	0.070	-0.017	-0.283	0.777
S	0.278	0.155	-0.133	1.797	0.073
AC	0.104	0.147	0.056	0.708	0.480

$R^2=0.057$, $F=4.055$, $p\text{ value}=0.001$

Here, the R^2 value is 0.057, which means that 5.7% of the variation in Autonomy is explained by the subscales of the FIC. The independent variables of Passive Acceptance and Revelation are significantly negatively related to Autonomy, while the Synthesis and Active Commitment subscales are positively related but not significant.

For the Environmental Mastery subscale, a regression analysis was done with independent variables as the FIC subscales, as shown in the following table.

Table 4.3

Regression analysis with Environmental Mastery scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	4.131	0.641		6.445	<0.001
PA	0.176	0.085	0.110	2.074	0.039
R	-0.394	0.090	-0.252	-4.365	<0.001
EE	-0.160	0.077	-0.119	-2.071	0.039
S	0.268	0.171	0.113	1.566	0.118
AC	0.252	0.162	0.119	1.554	0.121

$R^2=0.108$, $F=8.090$, $p \text{ value}<0.001$

The R^2 value is 0.108, which means that 10.8% of the variation in Environmental Mastery is explained by the subscales of the FIC. Here, the Passive Acceptance, Revelation and Embeddedness subscales are significantly related to Environmental Mastery; Passive Acceptance positively and the others negatively. Synthesis and Active Commitment are positively related, but not significant.

For the Personal Growth subscale, a regression analysis was done with independent variables as the FIC subscales, as shown in the following table.

Table 4.4

Regression analysis with Personal Growth scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	4.617	0.565		8.177	<0.001
PA	-0.324	0.075	-0.228	-4.320	<0.001
R	-0.119	0.079	-0.086	-1.502	0.134
EE	0.015	0.068	0.013	0.227	0.821
S	0.401	0.151	0.190	2.658	0.008
AC	0.109	0.143	0.058	0.764	0.446

$R^2=0.122$, $F=9.283$, $p \text{ value}<0.001$

The R^2 value is 0.122, which means that 12.2% of the variation in Personal Growth is explained by the subscales of the FIC. Here, the Passive Acceptance and Synthesis are significantly related. Synthesis is positively related, while Passive Acceptance is negatively related.

For the Positive Relations subscale, a regression analysis was done with independent variables as the FIC subscales, as shown in the following table.

Table 4.5

Regression analysis with Positive Relations scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	5.527	0.760		7.271	<0.001
PA	-0.163	0.101	-0.086	-1.614	0.107
R	-0.551	0.107	-0.299	-5.151	<0.001
EE	-0.026	0.092	-0.016	-0.280	0.780
S	0.320	0.203	0.114	1.575	0.116
AC	0.080	0.192	0.032	0.418	0.676

$R^2=0.096$, $F=7.090$, $p \text{ value}<0.001$

Here, the R^2 value is 0.096, which means that 9.6% of the variations in Positive Relations are explained by the subscales of the FIC. While Passive Acceptance, Revelation and Embeddedness are negatively related and Synthesis and Active Commitment are positively related, only Revelation is significant.

For the Purpose in Life subscale, a regression analysis was done with independent variables as the FIC subscales, as shown in the following table.

Table 4.6

Regression analysis with Purpose in Life scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	3.777	0.630		5.991	<0.001
PA	-0.242	0.084	-0.153	-2.895	0.004
R	-0.344	0.089	-0.222	-3.877	<0.001
EE	-0.018	0.076	-0.014	-0.239	0.811
S	0.324	0.168	0.138	1.925	0.055
AC	0.334	0.160	0.160	2.094	0.037

$R^2=0.121$, $F=9.200$, $p \text{ value}<0.001$

Here, the R^2 value is 0.121, which means that 12.1% of the variations in Purpose in Life are explained by the subscales of the FIC. Both Passive Acceptance and Revelation are significantly negatively related to this subscale, while Active Commitment is significantly positively related.

For the Self-Acceptance subscale, a regression analysis was done with independent variables as the FIC subscales, as shown in the following table.

Table 4.7

Regression analysis with Self-Acceptance scores as the dependent variable

Variable	B coefficient	Std. Error	Beta coefficient	t	p value
(Constant)	3.535	0.700		5.050	<0.001
PA	0.055	0.093	0.031	0.590	0.556
R	-0.536	0.099	-0.309	-5.442	<0.001
EE	-0.039	0.084	-0.026	-0.464	0.643
S	0.423	0.187	0.161	2.263	0.024
AC	0.416	0.177	0.178	2.349	0.019

$R^2=0.134$, $F=10.341$, $p \text{ value}<0.001$

Here, the R^2 value is 0.134, which means that 13.4% of the variations in Self-Acceptance are explained by the subscales of the FIC. Here, Revelation is significantly negatively related to Self-Acceptance, while both Synthesis and Active Commitment are positively and significantly related.

In general, the regression analysis shows that Synthesis, Active Commitment and age are significantly positively related to well-being and its subscales, while Passive Acceptance, Revelation and Embeddedness are rather negatively associated with well-being and its subscales.

From the correlation and regression analyses, it is evident that the first hypothesis H_0 has been rejected, so there is a significant relationship between the subscales of the Feminist Composite Identity scale and Ryff's Psychological Well-being scale.

Reliability of Feminist Identity Composite Scale

Reliability analyses have been done using Cronbach's alpha, a reliability measure for which if values are above 0.6, the reliability is considered good and 0.4-0.6 are average. As the focus of the current study and the second hypothesis is regarding the reliability of the Feminist Identity Composite, the Cronbach's alpha values for the FIC and subscales are shown in the table below. The reliability of Ryff's Psychological Well-being measure has also been found.

Table 5

Cronbach's alpha values for the FIC and subscales

Scale/Subscale	Cronbach's Alpha
Feminist Identity Composite scale	0.82
Passive Acceptance subscale	0.77
Revelation subscale	0.84
Embeddedness-Emanation subscale	0.91
Synthesis subscale	0.80
Active Commitment subscale	0.83

The reliability of all subscales of the FIC as well as the total scores of FIC are very good. The reliability of Ryff's Psychological Well-being scale is slightly less, but also above average, at 0.76. From this result, the second hypothesis that the Feminist Identity Composite Scale is not reliable for the chosen sample population of Indian women can be rejected.

Relationship between age, Feminist Identity and Psychological Well-being

In the next section of data analysis, correlations between any demographic variables (age, socioeconomic status and self-identified feminism) and main variables of interest were investigated.

Of these, age was slightly negatively correlated with the mean total FIC score at a 0.01 significance level, as well as with Revelation and Embeddedness-Emanation subscales; and slightly positively correlated with Passive Acceptance subscale. There were no significant correlations between age and Synthesis and Active Commitment subscales. Age was slightly positively correlated with the mean total psychological well-being score at 0.01 significance level, as well as with Environmental Mastery, Positive Relations and Self-Acceptance subscales. There were no significant correlations with Autonomy, Personal Growth and Purpose in Life subscales. Pearson's correlation was used. These correlations are given in Tables 6.1 and 6.2

Table 6.1

Correlations between age and FIC scores

	Age	PA	R	EE	S	AC	Overall FIC
Age	1	0.213** <0.001	-0.318** <0.001	-0.328** <0.001	-0.038 0.480	-0.070 0.199	-0.193** <0.001
PA		1	-0.108* 0.047	-0.108* 0.046	-0.170** 0.002	-0.235** <0.001	0.214** <0.001
R			1	0.376** <0.001	0.221** <0.001	0.343** <0.001	0.724** <0.001

EE	1	0.220** <0.001	0.325** <0.001	0.589** <0.001
S		1	0.697** <0.001	0.605** <0.001
AC			1	0.678** <0.001

** Correlation significant at 0.01 level (2-tailed).

* Correlation significant at 0.05 level (2-tailed).

Table 6.2

Correlations between age and Well-being scores

	Age	AUTO	ENV	PG	PR	PL	SA	Overall Well-being
Age	1	0.106 0.051	-0.289* * <0.001	-0.005 0.932	0.226** <0.001	0.103 0.059	0.178** 0.001	0.243** <0.001
AUTO		1	0.343** <0.001	0.262** <0.001	0.109* 0.045	-0.035 0.523	0.310** <0.001	0.487** <0.001
ENV			1	0.282** <0.001	0.343** <0.001	0.086 0.111	0.533** <0.001	0.677** <0.001
PG				1	0.286** <0.001	0.340* * <0.001	0.331** <0.001	0.628** <0.001
PR					1	0.418* * <0.001	0.438** <0.001	0.713** <0.001
PL						1	0.245** <0.001	0.544** <0.001
SA							1	0.763** <0.001

** Correlation significant at 0.01 level (2-tailed).

* Correlation significant at 0.05 level (2-tailed).

Association between identifying as a Feminist and Psychological Well-being.

All five subscales and the total FIC scores were significantly associated at 0.01 level, indicating that self-identified feminists had higher scores in the FIC.

The relationships between the subscales and total scores of psychological well-being, and whether participants considered themselves to be feminists were also found, as per the secondary hypothesis. The subscales of Autonomy, Environmental Mastery and Purpose in Life were significantly associated with whether they identified as feminists, but Personal Growth, Positive

Relations and Self-Acceptance were not significant. Overall well-being was also not significantly associated, indicating that self-identified feminists did not necessarily have higher well-being. The following tables show these associations.

Table 7.1*Associations between Autonomy subscale scores and identifying as a feminist*

		Autonomy Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	36 23.4%	81 52.6%	37 24.0%	154 100%
	Maybe	42 43.3%	42 43.3%	13 13.4%	97 100%
	No	27 30.3%	43 48.3%	19 21.3%	89 100%
Total		105 30.9%	166 48.8%	69 20.3%	340 100%

Chi-square value=12.1, df=4, p-value=0.017

Table 7.2*Associations between Environmental Mastery subscale scores and identifying as a feminist*

		Environmental Mastery Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	54 35.1%	72 46.8%	28 18.2%	154 100%
	Maybe	23 23.7%	53 54.6%	21 21.6%	97 100%
	No	10 11.2%	47 52.8%	32 36%	89 100%
Total		87 25.6%	172 50.6%	81 23.8%	340 100%

Chi-square value=21.3, df=4, p-value<0.001

Table 7.3*Associations between Personal Growth subscale scores and identifying as a feminist*

		Personal Growth Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	37 24.0%	86 55.8%	31 20.1%	154 100%
	Maybe	35 36.1%	50 51.5%	12 12.4%	97 100%
	No	33 37.1%	46 51.7%	10 11.2%	89 100%
Total		105 30.9%	182 53.5%	53 15.6%	340 100%

Chi-square value=8.34, df=4, p-value=0.080

Table 7.4*Associations between Positive Relations subscale scores and identifying as a feminist*

		Positive Relations Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	40 26%	87 56.5%	27 17.5%	154 100%
	Maybe	30 30.9%	47 48.5%	20 20.6%	97 100%
	No	20 22.5%	44 49.4%	25 28.1%	89 100%
Total		90 26.5%	178 52.4%	72 21.2%	340 100%

Chi-square value=5.20, df=4, p-value=0.267

Table 7.5*Associations between Purpose in Life subscale scores and identifying as a feminist*

		Purpose in Life Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	43 27.9%	88 57.1%	23 14.9%	154 100%
	Maybe	45 46.4%	35 36.1%	17 17.5%	97 100%
	No	32 36%	42 47.2%	15 16.9%	89 100%
Total		120 35.3%	165 48.5%	55 16.2%	340 100%

Chi-square value=11.53, df=4, p-value=0.021

Table 7.6

Associations between Self-Acceptance subscale scores and identifying as a feminist

		Self-Acceptance Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	44 28.6%	85 55.2%	25 16.2%	154 100%
	Maybe	32 33%	52 53.6%	13 13.4%	97 100%
	No	16 18%	49 55.1%	24 27%	89 100%
Total		92 27.1%	186 54.7%	62 18.2%	340 100%

Chi-square value=9.44, df=4, p-value=0.051

Table 7.7

Associations between overall well-being scores and identifying as a feminist

		Overall Well-being Scores			
		Low	Average	High	Total
Are you a feminist?	Yes	38 24.7%	76 49.4%	40 26%	154 100%
	Maybe	30 30.9%	47 48.5%	20 20.6%	97 100%
	No	21 23.6%	43 48.3%	25 28.1%	89 100%
Total		89 26.2%	166 48.8%	85 25%	340 100%

Chi-square value=2.355, df=4, p-value=0.671

Socioeconomic status responses were divided into lower-middle class and upper-middle class/high class and compared against the mean subscales of the FIC as well as with the mean total, in a similar process. The subscales of Passive Acceptance, Revelation, Synthesis and Active Commitment, as well as total FIC scores, were not found to have a significant association with socioeconomic status; however, the Embeddedness subscale was found to be significant at a 0.05 significance level. Overall, there is no significant relationship.

The mean subscales and total scores of psychological well-being were classified similarly into Low, Average and High. The subscales of Autonomy, Environmental Mastery, Personal Growth, Purpose in Life and Self-Acceptance were not found to be significantly associated with socioeconomic status. Positive Relations and overall well-being were related to socioeconomic status at a 0.05 significance level.

Discussion

Feminism is a range of socio-political ideologies and movements aiming to define and establish the equality of sexes on all grounds. The origin of the idea dates back to 3rd century BCE Rome, where women blocked entrances to the Capitoline Hill to express their disapproval of the laws limiting them to use expensive goods. From what might have started as a disagreement that was discussed at tea among the womenfolk, feminism has since grown into a wave of movements that have questioned and continues to question ethos across the globe. However, in this male-dominated world, the struggle for equality still continues.

The feminist label has long been viewed by the traditional communities as misleading. Collectivistic communities, especially ones like India, consider feminism to be something 'against their culture'. Among the dissenters, some people expect women to stick to traditional gender roles, while others claim to be advocates for women's rights but are hesitant to label themselves as feminists. Perhaps owing to these conditions, as much as a quarter of the sample identified as non-feminists. Ironically, nearly all the sceptics had scores that were suggestive of feminist identity. This indicates that more than being unsupportive of the cause of feminism, it is the discredited label that seems to be the issue. On the other end, self-identified feminists also

had higher scores in the FIC, indicating that while some women are influenced by society's take on the feminist label, there exist other women who understand the true reason for what the movement stands for.

Most women fell in the Synthesis stage of Feminist Identity. This stage is the fourth stage that involves the integration of positive feminine qualities with one's own personality to create a realistic self-concept that surpasses gender roles and the capability of evaluating men individually rather than with collective stereotypes. This suggests that most women in the sample are aware of the defects in the system and they are able to direct their energy to respond appropriately to discrimination. This is the highest level to which most women progress. They fight their own battles but seldom do they commit to bringing change for the larger good.

Reliability analyses done for the FIC scale using Cronbach's alpha indicated that the scale is reliable for the sample of women chosen. Suggesting that FIC is a reliable scale to measure the feminist identity of Indian women, these findings can aid future research. However, an analysis of reliability and validity on a larger and more diverse sample can support this finding.

Analyses showed that psychological well-being and feminist identity development are significantly correlated. More importantly, the Passive Acceptance and Revelation subscales are negatively related to well-being. This suggests that the internalisation of and conformity to misogynistic ideas influence a woman's mental health significantly. The inequality and injustice that women face in a male-dominated world give rise to discomfort and stress, which may even escape the notice of the oppressed individual, and reduce women's psychological well-being. However, once these individuals are able to identify the root of their distress, they move a step ahead in their feminist identity but this does not improve their mental well-being yet. Perhaps, recognizing all the ways in which they are disadvantaged and discriminated against adds to the existing factors negatively impacting the women's psychological health. Unsurprisingly, the subscales Synthesis and Active Commitment are positively associated with well-being. As the final stages in the development of feminist identity, the positive association of these subscales

with overall well-being indicate that once women reach these levels in their lives, they are bound to experience a better mental health status. The inclusion of stereotypically feminine values or qualities into one's personality, not as an internalisation of social norms, but as a conscious choice of self-acceptance leads women to have a better self-concept. This integration allows the individuals to look beyond gender roles and enable them to evaluate their counterparts as individuals and not in the light of stereotypes. Being able to set aside stereotypic appraisals of people, women with fully developed feminist identities also feel the urge to make the world a better place for everyone. These women have the resources and ideas to act in congruence with their beliefs. Being an instrument of change has many positive effects on the mental well-being of a person; making even the slightest of impacts on the world can be greatly satisfying for a woman who is operating to change the world for the better. Regression analysis yields that Passive Acceptance, Revelation, Synthesis and Active Commitment significantly affect overall well-being, where Revelation is the highest negatively related and Synthesis is the highest positively related.

For this chosen sample, findings revealed that age and Passive Acceptance are slightly positively correlated and the same is slightly negatively correlated with Revelation and Embeddedness-Emanation subscales. This might indicate the effect of social conditioning throughout women's lives. As a woman grows older, perhaps the initial motivation to not conform to the system decreases due to the numerous forms of discrimination and harassment she faces. This might make women regress to a state of Passive Acceptance, where they are in denial of the injustices that are happening to them. They assume traditional gender roles, internalise these values, and believe that "this is how the system is supposed to be". Such beliefs might help them cope with the feelings of being unfairly treated. Age was also seen to be slightly positively correlated with overall psychological well-being. Assumption of traditional gender roles might bring forth much applause and acceptance from people around them which might act as a reinforcing factor for such beliefs. The association is seen only in subscales Environmental Mastery, Positive Relations and Self-Acceptance. Correlations with Autonomy, Personal Growth and Purpose in Life subscales showed no significant relations. In the same breath, higher scores

of feminist identity, Synthesis and Active Commitment, were obtained by women of all ages in the sample indicating the influence of age on being a feminist is only as strong as any other factor.

While the socioeconomic status of the women did not have a significant relationship with the overall development of feminist identity, it was considerably associated with the Embeddedness subscale. This connection can be attributed to the fact that the lack of financial resources and social mobility in lower socioeconomic classes limits the creative exploration that is characteristic of this dimension. Women in this stratum of society may adhere to the patriarchal values because, in their family, a male has a better chance at education and thus the advantage of being an earning member. Women with higher socioeconomic status have the resources to support themselves without relying on others and this autonomy allows these women to accept themselves for who they are and have healthier relationships with those around them. This relation is proved by the association of the Positive Relations and Self-Acceptance subscales and overall well-being scores with socioeconomic class.

Considering the relation between social factors and well-being, claiming to hold feminist ideals and expressing them is bound to have an influence on the psychological well-being of an individual. There were correlations between the subscales of Autonomy, Environmental Mastery and Purpose in Life with self-identification as a feminist. Women who readily exert their independence and function to meet their own principles rather than seek approval from others experience a freedom of choice that improves the state of their mental health. This freedom of choice also enables women to create an environment for themselves that suits their own needs without conforming to the collective misogynistic ideals. Perhaps, as a result of this, women who identify as feminists have a direction in life that is not dictated by others and display a brand of maturity that seems to advance themselves and the people around them.

CHAPTER VII
RECOMMENDATIONS

RECOMMENDATIONS

Since there is a scope of error when people fill in data on Google Forms, it is recommended to conduct the study offline through surveys in the presence of an administrator. Suggestions also include making use of the 42-item version of Ryff's Psychological Well-being Test as opposed to the 18-item version used in the present study. The sample size can also be increased to include diverse individuals with respect to age, socioeconomic class, education and region. The reliability of FIC may be confirmed among Indian women by increasing the sample size and the regional and socioeconomic variety in the sample.

CHAPTER VIII
CONCLUSION

CONCLUSION

The present study aimed to find a relationship between Feminist Identity and Psychological Well-being in a sample of Indian women. Women who believe in abiding by traditional gender roles have less psychological well-being than women who are on the higher levels of feminist identity. The Feminist Identity Composite Scale was also found to be reliable in the chosen sample of Indian women. The data also revealed that older women in the chosen sample are more likely to be in the Passive Acceptance stage. It was also found that self-identified feminists had higher scores in the FIC. Data indicates that self-identified feminists did not necessarily have higher well-being

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APPENDIX A

Relation Between Feminist Identity And Psychological Well-being

Hello, ladies!

We are final year students of B.Sc. Psychology at St. Teresa's College (Autonomous), Ernakulam. Through this survey, we aim to collect the data to measure the relation between feminist identity development and psychological well-being in Indian women who are 18 and above.

We appreciate you taking the time to fill out this form. We request you to be honest while answering the questions and to complete it to the best of your knowledge.

Thank you!

Informed Consent

I volunteer to participate in this research project, "Relation Between Feminist Identity And Psychological Well-being". I understand that this project is designed to gather information for a non-funded academic research work. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty. I understand that the researchers will not identify me by my name in any reports using information obtained from the study, and that my confidentiality as a participant in the study will remain secure. I also understand that the information obtained from this research will be used for academic purposes only.

By clicking on the 'I Agree' option, I confirm that I have read the above information and give my full consent to participate in this study.

I agree

APPENDIX B

A. Demographic Details

1. Email ID
2. Name (Initials Only)
3. Age
4. Work Status
 - Employed
 - Not Employed
 - Student
5. State of Current Residence
6. How would you describe your socio-economic status?
 - High
 - Upper Middle Class
 - Lower Middle Class
 - Poor
7. Are you a Feminist?
 - Yes
 - No
 - Maybe

B. Feminist Identity Composite Scale

Each item was required to be rated according to the following scale,

- a. Strongly disagree
- b. Disagree
- c. Neither agree nor disagree
- d. Agree
- e. Strongly agree

1. I am very committed to a cause that I believe contributes to a more fair and just world for all people.
2. I want to work to improve women's status.
3. I am willing to make certain sacrifices to effect change in this society in order to create a nonsexist, peaceful place where all people have equal opportunities.
4. It is very satisfying to me to be able to use my talents and skills in my work in the women's movement.
5. I care very deeply about men and women having equal opportunities in all respects.
6. I choose my "causes" carefully to work for greater equality of all people.
7. I feel that I am a very powerful and effective spokesperson for the women's issues I am concerned with right now.
8. On some level, my motivation for almost every activity I engage in is my desire for an egalitarian world.
9. I owe it not only to women but to all people to work for greater opportunity and equality for all.
10. I feel like I have blended my female attributes with my unique personal qualities.
11. I am proud to be a competent woman.
12. I have incorporated what is female and feminine into my own unique personality.
13. I enjoy the pride and self-assurance that comes from being a strong female.

14. As I have grown in my beliefs I have realised that it is more important to value women as individuals than as members of a larger group of women.
15. Gradually, I am beginning to see just how sexist society really is.
16. I feel angry when I think about the way I am treated by men and boys.
17. Men receive many advantages in society and because of this are against equality for women.
18. I never realized until recently that I have experienced oppression and discrimination as a woman in society.
19. I feel like I've been duped into believing society's perceptions of me as a woman.
20. My female friends are like me in that we are all angry at men and the ways we have been treated as women.
21. In my interactions with men, I am always looking for ways I may be discriminated against because I am female.
22. Regretfully, I can see ways in which I have perpetuated sexist attitudes in the past.
23. I am very interested in women writers.
24. I am very interested in women musicians.
25. I am very interested in women artists.
26. I am very interested in women's studies.
27. I don't see much point in questioning the general expectation that men should be masculine and women should be feminine.
28. One thing I especially like about being a woman is that men will offer me their seat on a crowded bus or open doors for me because I am a woman.
29. I like being a traditional female.
30. I think that men and women had it better in the 1950s when married women were housewives and their husbands supported them.
31. If I were married to a man and my husband was offered a job in another state, it would be my obligation to move in support of his career.
32. I think that most women will feel most fulfilled by being a wife and a mother.
33. I think it's lucky that women aren't expected to do some of the more dangerous jobs that men are expected to do, like construction work or race car driving.

C. Ryff's Psychological Well-being Scale

Each item was required to be rated according to the following scale,

- a. Strongly agree
- b. Somewhat agree
- c. A little agree
- d. Neither agree nor disagree
- e. A little disagree
- f. Somewhat disagree
- g. Strongly disagree

1. "I like most parts of my personality."
2. "When I look at the story of my life, I am pleased with how things have turned out so far."
3. "Some people wander aimlessly through life, but I am not one of them."
4. "The demands of everyday life often get me down."
5. "In many ways I feel disappointed about my achievements in life."
6. "Maintaining close relationships has been difficult and frustrating for me."
7. "I live life one day at a time and don't really think about the future."
8. "In general, I feel I am in charge of the situation in which I live."
9. "I am good at managing the responsibilities of daily life."
10. "I sometimes feel as if I've done all there is to do in life."
11. "For me, life has been a continuous process of learning, changing, and growth."
12. "I think it is important to have new experiences that challenge how I think about myself and the world."
13. "People would describe me as a giving person, willing to share my time with others."
14. "I gave up trying to make big improvements or changes in my life a long time ago"
15. "I tend to be influenced by people with strong opinions"
16. "I have not experienced many warm and trusting relationships with others."

17. "I have confidence in my own opinions, even if they are different from the way most other people think."

18. "I judge myself by what I think is important, not by the values of what others think is important."

**A STUDY ON THE EFFECTS OF SOCIAL INFLUENCE,
HYGIENE CONCERN, PRODUCT AWARENESS AND
PSYCHOLOGICAL FACTORS ON THE ADOPTION OF
MENSTRUAL CUPS**

PROJECT REPORT

**Submitted By:
POOJA RADHAKRISHNAN (REG NO: SB19BMS019)**

**Under the Guidance of:
SMT. MEGHA MARY MICHAEL**

**In partial fulfilment of the requirements for award of the degree of
BACHELOR OF MANAGEMENT STUDIES (INTERNATIONAL
BUSINESS)**



ST.TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

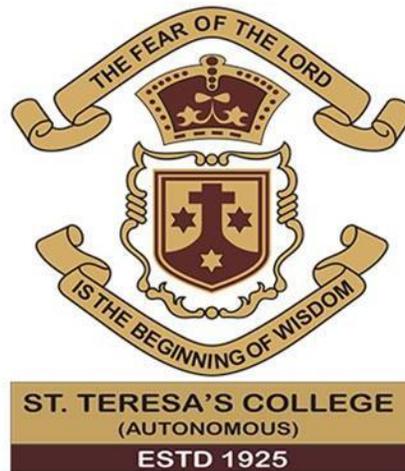
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Nationally Re-Accredited At 'A++' Level (Fourth Cycle)

MARCH 2022

Valued by : *[Signature]*
09/05/22
Dr. Sr. Usha. A.

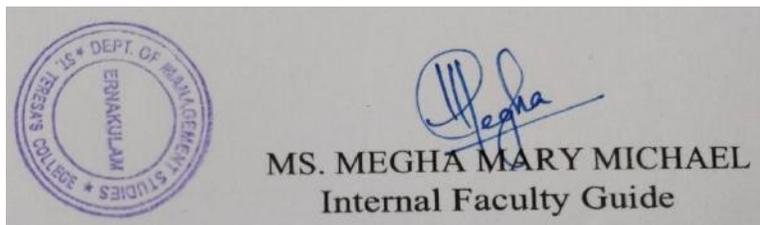
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KOCHI – 682011



CERTIFICATE

This is to certify that the project entitled “The Study on the effects of Social influence, Hygiene concern, Product awareness and Psychological factors on the adoption of Menstrual cups”, has been successfully completed by Ms Pooja Radhakrishnan, Reg. No.SB19BMS019, in partial fulfilment of the requirements for the award of degree of Bachelor of Management Studies in International Business, under my guidance during the academic years 2019-2022.

Date: 09-05-2022

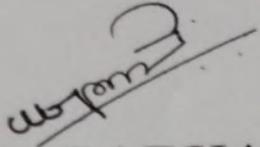


DECLARATION

I, Pooja Radhakrishnan, Reg. No.SB19BMS019, hereby declare that this project work entitled “The Study on the effects of Social influence, Hygiene concern, Product awareness and Psychological factors on the adoption of Menstrual cups” is my original work.

I further declare that this report is based on the information collected by me and has not previously been submitted to any other university or academic body.

Date: 09-05-2022



POOJA RADHAKRISHNAN
Reg. No.SB19BMS019

ACKNOWLEDGEMENT

I would like to place on Project Report my debt of gratitude to those who helped me in the preparation of this project.

I thank Dr Lizzy Mathew, Principal and Dr. Sr. Vineetha, Director, St. Teresa's College Ernakulam for permitting me to take up this opportunity of doing an in-depth study on on the effects of Social influence, Hygiene concern, Product awareness and Psychological factors on the purchase and use of Menstrual cups.

I take this opportunity to express my deep sense of gratitude and whole hearted thanks to Dr. Megha Mary Michael who is also the HOD of the department of Management Studies for guiding me in all stages of this project, without whom this project would have been a distant reality.

Last but not the least; I extend my heartfelt thanks to my family and friends for their valuable and proficient guidance and enormous support bestowed during the tenure of this exertion.

Pooja Radhakrishnan

EXECUTIVE SUMMARY

The researcher is presenting this report on “The Study on the effects of Social influence, Hygiene concern, Product awareness and Psychological factors on the adoption of Menstrual cups” conducted among the women in Kerala between the age group of 15-55 years old.

Factors like social influence, product awareness, hygiene concern and psychological factors plays a really important role in consumer buying behavior and decision making.

Social circle is one place where a lot of people get introduced to new products which they later end up trying out due to good reviews from their close circle. Product awareness is really required when it comes to buying a product. People buy new product only after having a comprehensive idea or even a broad idea about the product.

Psychological factors like fear, excitement, curiosity etc influences buying decision of customers. It can be seen clearly in cases of products like Kinder joy, Leggo, etc which is sold solely based on children’s excitement and curiosity. Hygiene concern is another factor that makes or breaks it for customers. Only after ensuring that the said product is safe and hygienic to use do consumers buy it.

Even though it’s been in the market for over decades, only recently did menstrual cup piqued the interest of women reasons being convenience, sustainability and durability. A lot of women have switched to menstrual cup recently but still more than half of the women population seem hesitant in using the cup. In this study we focus on finding the effect of social influence, hygiene concern, product awareness and psychological factors mainly fear and hesitance.

It starts with the rationale behind preparing the report, objectives, significance of the study and the background of the industry to get a better idea regarding the survey and the feminine hygiene industry.

This research is then followed by a survey which reveals some facts about the women's awareness about menstrual cup, their hygiene concerns, how social influence plays a role in their perception and other psychological factors regarding menstrual cup.

The report has been concluded with the interpretation of the whole study and the information collected is presented with the help of tables and diagrams.

It was found that psychological factors and hygiene concerns play an important role in women's perception towards menstrual cup. The study is then concluded with some suggestions that can be used to overcome these concerns among women.

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CHAPTER - 1

INTRODUCTION TO THE STUDY

1.1. BACKGROUND OF THE STUDY

Menstruation, or period, is normal vaginal bleeding that occurs as part of a woman's monthly cycle. Every month, your body prepares for pregnancy. If no pregnancy occurs, the uterus, or womb, sheds its lining. The menstrual blood is partly blood and partly tissue from inside the uterus. Menstruation has been considered a taboo for a long time in India. There was no discussion regarding the difficulties faced by the women during “that time of month” It's in recent times that Indian women started addressing the adversities that they face during their monthly cycle including the traditional practices and the health issues. Managing menstrual hygiene is a problem for many women around the world, especially in developing countries like India. The lack of access to sanitary products, clean water, knowledge and other necessary resources leads to taboos and health implications. For a long time Indian women used clothes as a protection. Later there was a gradual shift from that of clothes to sanitary napkins. Even though disposable napkins appear to be more convenient there are a lot of hygiene problems that come with it. One of the major issues with it is the high probability of having a vaginal infection and disposal of the pads. There are a lot of other “period protectors” that are much safer than pads. The factor that plays as an obstacle in adopting those measures are the lack of awareness and hesitation among Indian women.

One such safer measure is the menstrual cup. A menstrual cup is a menstrual hygiene device which is inserted into the vagina during menstruation. Its purpose is to collect menstrual fluid (blood from the uterine lining mixed with other fluids). Menstrual cups are usually made of flexible medical grade silicone, latex, or a thermoplastic isomer that's designed for use inside the vagina during periods to collect blood. The cup doesn't absorb the menstrual flow like tampons or pads do, it catches and collects it. While it might seem like menstrual cups popped up overnight, they've actually been around in some form since the 1800s. The first patent for a menstrual cup design was awarded in 1867 and the prototype was pretty much a rubber sack that was attached to a ring. This early version was meant to be inserted into the vagina to collect blood. The menstrual cup could then be pulled out by a cord that was attached to it. Even though menstrual cups were around in the 50s and 60s, they still weren't widely embraced. As a result, the menstrual cup category as a whole faded into the background until the late 80s.

Consumers' motives determine or activate behavior resulting in purchases. Also consumer behavior cannot be predicted simply from motivations. Other intervening individual factors come into play. These factors tend to influence the consumer's perception of various products and brands of products that may be utilized to satisfy his/her needs. Customer perception refers to the consumer's feelings about a

brand/product. It encompasses all their beliefs, expectations, and experiences with the business and its products, whether positive or negative.

Some of the important individual intervening variables are consumer's attitudes, self-image, and habits. The purchase decision process starts with the identification of a need that is unmet. Once the desire for a need satisfaction arises, the next step that the consumer passes in the purchase decision-making process is evaluating different products or services as ways of satisfying the unmet need. Evaluation helps the consumer decide the brand to be purchased or the seller to satisfy his need.

Their attitudes play an important role in the process of evaluating alternatives and selecting a particular brand of a product or so that the consumer can satisfy his/her need. Attitudes thus play a direct and influential role in consumer behavior.

Consumers' attitudes toward a company's products significantly influence the success or failure of its marketing strategy. Attitude is considered to be the most important determinant of buying behavior. Customer attitudes are a composite of a person's beliefs about, feelings about, and behavioral intentions toward your business. Based on past experience with the business and those of the competitors, understanding customer attitudes can help companies monitor and change customer's intentions about the product/brand/company. Attitude study is important because it affects consumers' selective processes, learning, and ultimately the buying decision making.

The main purpose of the project is to understand the women's perception, attitude and factors that influence their purchase and use of menstrual cup.

1.2. STATEMENT OF PROBLEM

There have been more and more women coming out, sharing their experiences and difficulties during their period days. Also period hygiene is gaining a lot of momentum making not only women but other genders too aware about such important matters. In such a time understanding why women still go for sanitary napkins rather than safer methods like menstrual cups is necessary. This research is conducted to study the attitude and perception of women towards menstrual cups and what holds them back from switching to it.

1.3. LITERATURE REVIEW

Menstruation and menstrual practices are still clouded by taboos and socio-cultural restrictions resulting in adolescent girls remaining ignorant of the scientific facts and hygienic health practices, which sometimes result into adverse health outcomes.

Menstruation is a phenomenon unique to the females. The onset of menstruation is one of the most important changes occurring among the girls during the adolescent

years. The first menstruation (menarche) occurs between 11 and 15 years with a mean of 13 years.

Adolescent girls constitute a vulnerable group, particularly in India where female child is neglected one. Menstruation is still regarded as something unclean or dirty in Indian society. The reaction to menstruation depends upon awareness and knowledge about the subject. The manner in which a girl learns about menstruation and its associated changes may have an impact on her response to the event of menarche. Although menstruation is a natural process, it is linked with several misconceptions and practices, which sometimes result into adverse health outcomes.

Hygiene-related practices of women during menstruation are of considerable importance, as it has a health impact in terms of increased vulnerability to reproductive tract infections (RTI). The interplay of socio-economic status, menstrual hygiene practices and RTI are noticeable. Today millions of women are sufferers of RTI and its complications and often the infection is transmitted to the offspring of the pregnant mother.

Menstrual hygiene management (MHM) is an essential aspect of hygiene for women and adolescent girls between menarche and menopause. Despite being an important issue concerning women and girls in the menstruating age group MHM is often overlooked in our society.

It is through family and friends, adolescent girls usually come across the various factors about menstruation. One thing that is one of the biggest problem in India is the lack of knowledge among girls pre-menstrual stage. It's only after the girls get their first period that such information are shared with them. Even so, a lot of women, even the educated ones, don't have full knowledge about menstruation and hygiene management. It's only when we have adequate knowledge that we pay more attention to hygiene management. One of the best product for this is menstrual cup but unfortunately a lot of women are not well informed about menstrual cups thus leading to hesitation in adopting it. The factors that can influence women into adopting or trying out the product will be: **Social influence, Hygiene concern, Product awareness and Psychological Factors.**

1.3.1. Social Influence

The typical outcome of social influence is that our beliefs and behaviors become more similar to those of others around us. At times, this change occurs in a spontaneous and automatic sense, without any obvious intent of one person to change the other.

Influence also sometimes occurs because we believe that other people have valid knowledge about an opinion or issue, and we use that information to help us make

good decisions. Social influence plays a major role in consumer buying behavior. Even when we buy the simplest of things we always look for extra information or opinions of other people to arrive at a better decision. It's most prominent in online shopping. It's only after ensuring that the product has good reviews that we think to try it out.

Social influence can play a major role in familiarizing a product like menstrual cup among the common folk. Most of the people look up to celebrities or influencers and even to their friends and families in a lot of aspects like fashion, lifestyle etc. When such public figures or close linked people recommend a product there is a higher chance of people at least considering to try it out.

In case of a product like menstrual cup friends and families can play a major role as people have more trust in them. If one of the friends in your friend circle tries out the product and is satisfied with it, there is a higher chance of them sharing more information about it and how much easy and convenient it is to use. This can give a positive outlook to menstrual cup in others mind. And as a matter of fact word of mouth has its own magic and can convince people into literally everything.

1.3.2. Hygiene Concerns

Menstruation and menstrual practices still face many social, cultural, and religious restrictions which are a big barrier in the path of menstrual hygiene management. In many parts of the country especially in rural areas girls are not prepared and aware about menstruation so they face many difficulties and challenges at home, schools, and work places. Despite the irrational taboos associated with it, menstruation is a natural physiological process that every healthy woman undergoes. But although every woman experiences it on a regular basis, not everyone is well-informed about the need to ensure hygiene. Hygiene is the practice of keeping yourself and your surroundings clean, especially in order to prevent illness or the spread of diseases. Menstruating women need to pay particular attention to personal hygiene. During this time, a woman's vulnerability towards potentially life-threatening ailments increases. Poor menstrual hygiene can lead to many issues, such as fungal or bacterial infections of the reproductive tract and the urinary tract.

While reviewing literature, I found that little, inaccurate, or incomplete knowledge about menstruation is a great hindrance in the path of personal and menstrual hygiene management. Girls and women have very less or no knowledge about reproductive tract infections caused due to ignorance of personal hygiene during menstruation time. In rural areas, women do not have access to sanitary products or they know very little about the types and method of using them or are unable to afford such products due to

high cost. Unfortunately, due to lack of knowledge on menstruation preparedness and management or due to shyness and embarrassment the situation becomes worse for girls. Menstruation is a natural process but it is still a taboo in Indian society as it is considered unclean and dirty.

1.3.3. Product Awareness

Product Awareness is the degree of knowledge that the customers have about a product. The first step in purchasing a product is developing the knowledge that the product exists. Information about function, benefits, quality, price, compatibility, usability all are important for the purchase to happen. A consumer's purchase intention depends upon very much on the level of satisfaction, he expects and receives. If the brand/product satisfies the consumer he will become a regular buyer of that particular brand/product but if not the consumer might engage in the negative marketing of the brand.

The lack of product awareness and the existing taboos are restricting women to buy menstrual cups. As mentioned proper awareness of the product is required to form purchase intention. A lot of Indian women lack such awareness regarding menstrual cup thus leading to lack of demand for the product. Even though a lot of women have now known about the product factors like fear, hygiene concern, leakage concern etc are holding them back from trying out this product. These all have impending impact on the adoption rate of menstrual cups.

1.3.4. Psychological Factors

Consumers' psychological factors like their emotions, desires, and motivations are important and plays a huge role in their buying behavior. It is important for any company to understand their customers' perception, their desires and motivation to devise the most suitable advertising and marketing campaigns. Sometimes campaigns that focuses on people's feelings can be very useful, like Paper Boat is a company that uses childhood nostalgia to market their product and that attracts a lot of people since it is associated with their childhood. This makes people interested in a product or brand and motivates them to try it out.

The main psychological factor that we focuses on this study is customers' emotions especially their fears, concerns and misconceptions regarding menstrual cup. So there is a lot of misinformation and stigma floating around regarding menstrual cup. Most of the women are only half informed about menstrual cup at the best and as we all know half knowledge is more dangerous than zero knowledge. These bits and pieces of information caused a lot of mayhem in women's mind regarding the cup. It has arose a lot of concerns and fears among women. The common one being that

menstrual cup are difficult to insert and remove and a lot of women are afraid that it will get stuck in their vagina. Some women may find it difficult to adjust to it initially but it's just the starting trouble after that it's all a cakewalk. One final and noteworthy perk is that menstrual cups may help take your period cramps. While this may not be the case for every user, many women report fewer and less intense menstrual cramps when using a cup instead of tampons and majority of women are unaware of this magical ability of menstrual cup.

Because of these misconceptions and prejudices regarding menstrual cup a lot of women are still hesitant in adopting it.

1.4. SCOPE OF THE STUDY

The study is conducted in Kerala. The researcher aims to collect data from 100+ women ranging from 15-55 age range to understand their perception, attitudes and concerns regarding menstrual cups.

1.5. SIGNIFICANCE OF THE STUDY

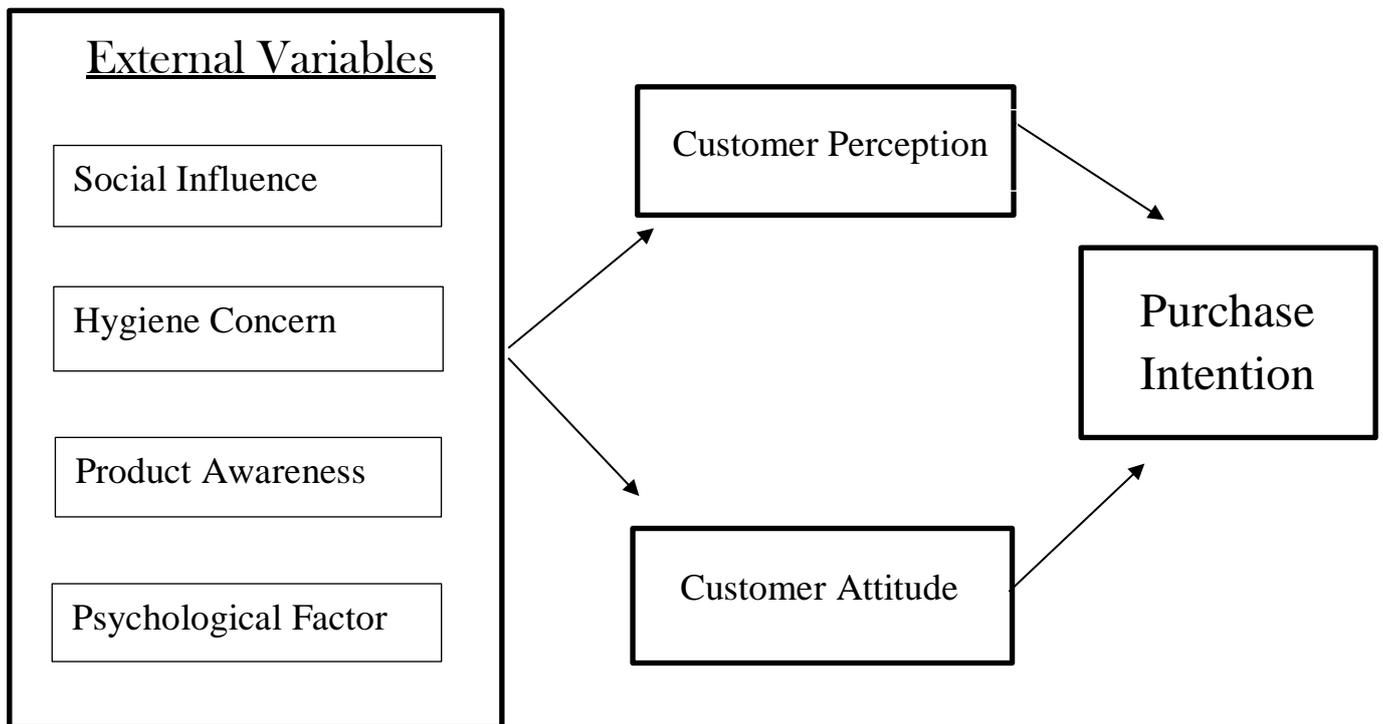
“The market size is 1-2% of the population in India. Hence multinationals haven't dipped their legs into the pool of menstrual cup products since they will require a bigger market size to launch such a product”. These were the words by Akarsh Tekriwal, the founder of SafeCup, an Indian manufacturer of menstrual cups. The reason for such a small market for such a better product is because of the hesitation and concerns among women around menstrual cups. Conducting this study can help the companies in understanding the attitude of Indian women and thus devise strategies and plans that can help them penetrate into the market and be a go to product.

1.6. RESEARCH OBJECTIVE

The main objectives of this study are:

1. To understand the customer attitude towards menstrual cups.
2. To understand the customer perception regarding period hygiene.
3. To understand the customer perception regarding menstrual cups.
4. To understand the factors that affect their decision making process.

1.7. DEVELOPMENT OF CONCEPTUAL MODEL



1.8. RESEARCH HYPOTHESIS

Hypothesis(1): There is a positive relation between social influence and purchase and use of menstrual cup.

Hypothesis(2): There is a positive relation between hygiene concern and purchase and use of menstrual cup.

Hypothesis(3): There is a positive relation between product awareness and purchase and use of the menstrual cup

Hypothesis(4): There is a positive relation between psychological factors and purchase and use of the menstrual cup.

1.9. RESEARCH METHODOLOGY

1.9.1. DATA COLLECTION

When it comes to data collection, there are two methods that are generally used by researchers to collect data. These methods are Primary data collection methods and Secondary data collection methods. Primary data collection methods include

collection of data through observation, questionnaire, case studies, projective techniques and schedules. Secondary data is one that already exists and it may be collected through published or unpublished sources. Published sources include publications by the government, public records, records held by banks etc. Unpublished sources include data from letters, diaries unpublished biographies and work etc.

The tool used by the researcher for the data collection to understand the factors influencing perception of customers, was through questionnaires.

Secondary data in research was used to find out about the industry's profile and the company's profile. It was also used in the introduction of study and literature review. All secondary data related information has been collected from previously done research papers and credible internet websites.

1.9.2. SAMPLING

1.9.2.1. Population

Population is the collection of the elements which has some or the other characteristics in common. The number of elements in the population is the size of the population. In this survey, the population comprises all the women in the age group of 15-55 years who are in their menstruation stage in Kerala.

1.9.2.2. Sample size

The sample for the research is confined to women between 15-55 years old in Kerala. The female population percentage between the age group of 15-59 is about 62.85 in India. In Kerala the female population percentage between the age group of 15-59 is about 30.92%. Keeping in view the limitation of time and resources, the sample size taken is 120 respondents. Questionnaires were distributed through social media platforms like WhatsApp, Instagram and Twitter to the respondents and enough time was given to the respondents to fill the questionnaire to reduce sampling error within Kerala.

1.9.2.3. Sampling Techniques

There are two mainly two types of sampling techniques – Probability and Non-probability sampling techniques. Probability sampling techniques uses randomisation to make sure that every element of the population gets equal chance to be part of the selected sample. The various kinds of probability sampling techniques are simple random, systematic, stratified random sampling, cluster and multi stage sampling. Non-probability sampling technique is more reliant on the researcher's ability to select

elements for the sample. The outcome of this kind of sampling may be biased and may not be possible to extrapolate the outcome to the population. The various kinds of non-probability sampling techniques include convenience, purposive, quota and snowball sampling.

The female population percentage between the age group of 15-59 is about 62.85 in India. In Kerala the female population percentage between the age group of 15-59 is about 30.92%. This study focuses on women in India but since it is difficult to reach out to such a vast number of people scattered around the country, I took Kerala as my Cluster for sample.

The method I used here is Cluster sampling, i.e. Non probability sampling, where I reached out to about 120 women between the age group of 15-55 spread around in different parts of Kerala.

1.9.3. TOOLS USED FOR DATA COLLECTION

The questionnaire is carefully designed to meet the requirements of the research. The questionnaire focuses on 3 parts that are the respondents' satisfaction regarding their current product, their perception and attitude towards menstrual cup and also about their concerns regarding menstrual cup. For understanding respondents' opinion regarding their current period product a scale ranging from extremely satisfied to extremely dissatisfied was provided with various attributes pertaining to period products.

To understand the respondents' perception, attitude and also their concerns regarding menstrual product a series of statements were provided to be ranked between a scale of strongly agree to strongly disagree. The questionnaire also had questions to better understand the respondents' awareness regarding the cup and also to know whether they will use or continue to use menstrual cup.

1.9.4. DATA ANALYSIS TECHNIQUES

The entire data has been analyzed using SPSS software package. The tools used for analysis in SPSS for this research are as following

- i. One-way Anova
- ii. Correlation and Linear Regression

1.10. LIMITATIONS OF THE STUDY

- It was difficult to reach out to such a large sample size.
- Getting the respondents to trust the researcher and get them to answer the questionnaire was quite challenging.
- Some people might have been uncomfortable talking about such sensitive matters provided that menstruation is still considered a taboo in many parts of the country.
- There are higher chances of inaccuracy as respondents may not have answered honestly due to the taboo around menstruation.
- It was difficult to get women around 45-55 years answer the questionnaire honestly.

CHAPTER - 2

INDUSTRY, COMPANY AND PRODUCT PROFILE

2.1. INDUSTRY PROFILE

Hygiene is a series of practices performed to preserve health. According to the World Health Organization (WHO), hygiene refers to conditions and practices that help to maintain health and prevent spread of diseases. Personal hygiene refers to maintaining body's cleanliness. Some practices are gender-specific, such as among woman during menstruation. The global personal hygiene market is segmented into product, gender, distribution channel, and region. On the basis of product, the market is categorized into soaps, hand sanitizers, bath & shower products, face care products, and others. By gender, it is classified into unisex, male, and female. On the basis of distribution channel, it is segmented into retail pharmacies, hospital-based pharmacies, supermarkets, and e-commerce. Region wise, the market is analyzed across North America, Europe, Asia-Pacific, and LAMEA. Growth of the personal hygiene market is driven by increasing awareness regarding benefits of maintaining cleanliness and personal hygiene, surge in likelihood of epidemic or pandemic outbreaks, and rise in disposable income, coupled with growing willingness to pay for these products. In this our market is categorized on the basis of gender, i.e. Female or Feminine hygiene market.

2.1.1. FEMININE HYGIENE MARKET

Feminine hygiene products are personal care products used during menstruation, vaginal discharge, and other bodily functions related to the vulva and vagina. The global feminine hygiene market is segmented by product type into sanitary pads/napkins, tampons, menstrual cups, panty liners, and other product types. By distribution channel, the market is segmented into supermarket/hypermarket, convenience stores, drug stores/pharmacies, online retail stores, and other distribution channels. By geography, the market is segmented into North America, Europe, Asia-Pacific, South America, and Middle East & Africa. The report also offers market size and forecasts for feminine hygiene products across four major regions.

2.1.2. MARKET OVERVIEW

The global feminine hygiene market is projected to witness a CAGR of 6.7% during the forecast period (2021 - 2026). Over the medium term, increasing awareness about female health and hygiene and the emergence of low-cost feminine hygiene products are expected to boost the demand for the feminine hygiene products market during the forecast period. As a result, the demand for products such as tampons, menstrual cups, and internal cleansers and sprays is expected to grow rapidly in more developed regions, such as North America and Western Europe.

Asia-Pacific is emerging as one of the emerging markets, owing to the higher penetration of sanitary pads in this region, though other menstrual hygiene products are still at a nascent stage in Asia. Personal hygiene awareness campaigns taken up by government agencies have contributed to an increase in demand for sanitary products in this region.

Some manufacturers use low-quality raw materials to produce hygiene products, causing concerns about an increase in allergies and vaginal infections. This has led to more awareness recalls, particularly in developing countries

2.1.3. KEY MARKET TRENDS

2.1.3.1. The Dominant Position Held by the Sanitary Pad Segment

Globally, more women are getting educated about female hygiene products. However, the Asia-Pacific market still prefers sanitary pads, whereas the Americans are gradually shifting toward tampons and menstrual cups. Various kinds of sanitary napkins/pads, like with wings, great absorbents, thin pads, cotton-filled pads, scented pads, etc., can be seen in various supermarkets and even convenience stores, thereby furthering its market share in the global market.

Moreover, countries around the world are witnessing an increasing number of promotions and educational sessions, due to the increasing prominence of social media and the various initiatives taken by the government and NGOs to increase awareness about the benefits of using menstrual hygiene products, such as sanitary napkins.

For instance, to make sanitary napkins more affordable and accessible, the Government of India, in 2019, announced the price reduction of Jan Aushadhi Suvidha Oxo-Biodegradable Sanitary Napkins, which were launched in 2018, to INR 1 per pad, from INR 2.5. Such factors are expected to propel the demand for feminine hygiene products.

2.1.3.2. Increasing Measures of Women Hygiene in Asia-Pacific Driving the Market

The population of Asia-Pacific is huge and is growing further. Various companies have introduced different brands of feminine hygiene products for various economic sections of society. China's local sanitary pads market emerges as the largest market, followed by the United States.

Though the awareness about hygiene products is less in the Asian markets, there is potential to be tapped into or explored by various companies. Owing to the increased demand for feminine hygiene products, the manufacturers in Asia-Pacific are launching various other products.

For instance, tampons were considered to be luxury products in India, and they were only used by few consumers in tier-1 cities. Moreover, with the surge of online retailing across the country, tier-2 and tier-3 consumers have also started driving the sales of tampons. For example, Visionaari, a Delhi-based (India) tampon manufacturer, claimed that about 50% of its orders now come from tier-2 and tier-3 regions, owing to easy access through the online retail channels.

2.1.4. COMPETITIVE LANDSCAPE

The global feminine hygiene market is highly competitive, with the presence of various global and regional companies. Some major global companies in the market include Procter and Gamble, Kimberly-Clark Corporation, Unicharm Corporation, and Johnson & Johnson.

Kimberly-Clark Corporation is one of the most active companies in the feminine hygiene market. The company has been involved in frequent launches of newly developed products in developing and potential countries to improve its market share. For instance, in 2019, Johnson & Johnson's brand Carefree® launched the acti-fresh® panty liners with new and improved twist resist technology that helps minimize bunching and twisting.

2.1.5. MARKET SCENARIO IN INDIA

The feminine hygiene products market was valued at INR 32.66 Billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of ~16.87% during the 2021 - 2025 period, to reach a value of INR 70.20 Billion by 2025.

In 2020, of approximately 355 Million menstruating women, less than 41% used hygienic menstruation protection methods. Hygienic menstruation products such as sanitary napkins, menstrual cups, tampons, panty liners, and intimate cleansers are common in India. Sanitary napkins are used the most with approximately 17.63% of the menstruating women using them.

Improved awareness regarding feminine hygiene and the benefits of using hygienic personal care products propel market growth. Government initiatives to promote menstrual awareness among women and adolescent girls also drive the market.

Some of the programs and initiatives introduced by the government include the Rashtriya Kishor Swasthya Karyakram scheme, exemption of tampon tax, and subsidization of sanitary napkins. However, social stigma regarding menstruation, high prices of hygiene products, and their negative impact on the environment are some of the factors that hinder its growth.

2.1.5.1. MAJOR PLAYERS IN INDIA

- * Procter & Gamble Hygiene and Health Care Limited.
- *Johnson and Johnson.
- *Kemberly-Clark Lever Ltd.
- *Elize Lifestyle Private Limited
- *Heyday
- *Redcliffe Hygiene Private Limited
- *Saathi Eco Innovations India Private Limited
- *Unicharm India Private Limited.

2.2. COMPANY PROFILE

There are several companies in India that play a major role in the Feminine Hygiene Market. The most prominent ones are as follows:

2.2.1. PROCTER & GAMBLE HYGIENE AND HEALTH CARE LIMITED

The Procter & Gamble Company (P&G) is an American multinational consumer goods corporation headquartered in Cincinnati, Ohio, founded in 1837 by William Procter and James Gamble. It specializes in a wide range of personal health/consumer health, and personal care and hygiene products; these products are organized into several segments including beauty; grooming; health care; fabric & home care; and baby, feminine, & family care.

Procter and Gamble Hygiene and Health Care Ltd is a company that is involved in the manufacturing and selling of feminine hygiene care and health care products. The portfolio includes brands like Ambi Pur, Head & Shoulders, Olay, Pampers, Vicks, Tide Ariel etc. The business is divided into feminine hygiene business and healthcare business. The feminine hygiene business offers sanitary napkins and feminine sanitary hygiene products; its best known brand is Whisper. It is usually known as Always in western countries. Whisper is a widely used sanitary napkin in India. More than half of Indian women prefer the brand Whisper over others. Whisper is a market giant with about 54.8% of market share in India.

2.2.2. JOHNSON AND JOHNSON

Johnson & Johnson (J&J) is an American multinational corporation founded in 1886 that develops medical devices, pharmaceuticals, and consumer packaged goods. Its common stock is a component of the Dow Jones Industrial Average and the company is ranked No. 36 on the 2021 Fortune 500 list of the largest United States corporations by total revenue. Johnson & Johnson is one of the world's most valuable companies, and is one of only two U.S.-based companies that has a prime credit rating of AAA,^{[7][8]} higher than that of the United States government. Johnson & Johnson's brands include numerous household names of medications and first aid supplies. Among its well-known consumer products are the Band-Aid Brand line of bandages, Tylenol medications, Johnson's Baby products, Neutrogena skin and beauty products, Clean & Clear facial wash and Acuvue contact lenses. Johnson & Johnson's pharmaceutical arm is Janssen Pharmaceuticals. It is also involved in the feminine hygiene market. They have a range of personal health and feminine hygiene products - including sanitary napkins, tampons and pantyliners, to meet the evolving needs of the Indian woman. Their best known brand in India is Stayfree. The brand that comes after Whisper in brand preference in India is Stayfree sanitary napkins. Its market share is 30.8 % in India.

2.2.3. KEMBERLY-CLARK LEVER LTD

Kimberly-Clark Corporation is an American multinational personal care corporation that produces mostly paper-based consumer products. The company manufactures

sanitary paper products and surgical & medical instruments. Kimberly-Clark brand name products include Kleenex facial tissue, Kotex feminine hygiene products, Cottonelle, Scott and Andrex toilet paper, Wypall utility wipes, KimWipes scientific cleaning wipes & Huggies disposable diapers and baby wipes. Founded in Neenah, Wisconsin, in 1872 and based in the Las Colinas section of Irving, Texas since 1985, the company operated its own paper mills around the world for decades, but closed the last of those in 2012. With recent annual revenues topping \$18 billion per year, Kimberly-Clark is regularly listed among the Fortune 500. Their best known brand is Kotex. Kotex has a market share of about 3.4 % in India.

2.2.4. ELIZE LIFESTYLE PRIVATE LIMITED

Elize Lifestyle Private Limited is an unlisted private company incorporated on 11 August, 2016. It is classified as a private limited company and is located in North West, Delhi. Elize Lifestyle Private Limited, doing business as Carmesi, manufactures and supplies personal care products. The Company distributes sanitary pads, storage boxes, and disposal bags. Carmesi serves customers in India. It offers rash Free Sanitary Pads, Menstrual Cups. Their products are Carmesi sensitive sanitary pads and Carmesi menstrual cup. They are biodegradable sanitary napkins.

2.2.5. HEYDAY

Heyday is India's first mover in the biodegradable, organic and natural personal hygiene segment. They offer a range of natural sanitary napkins, baby diapers and panty liners for a safer, healthier and softer way of experiencing hygiene. Made from pure organic corn and bamboo fibres, Heyday pads and diapers provide a rash-free, allergy-free, and super soft journey of care. While most commercial sanitary pads and diapers monopolized by big giants use harmful synthetic raw materials in the production, Heyday products are plant based, completely safe, biodegradable and decompose within 2 years from disposal saving the Earth from acres of polluted landfills. Their main products are Heyday Natural sanitary napkins and Heyday reusable menstrual cup.

2.2.6. REDCLIFFE HYGIENE PRIVATE LIMITED

Redcliffe Hygiene Private Limited is a manufacturer of sanitary and menstrual pads, dust masks & industrial hygiene kits in Gurgaon, Haryana. Founded in 2017, Redcliffe Hygiene Private Limited is a pioneer in Personal Hygiene space in India and Globally with 4 products. Redcliffe Hygiene is a manufacturer of a range of hygiene consumables in the Indian market as well as the largest seller of toilet hygiene product in India. In addition, the company sells products into Middle East, Africa, and South East Asia and Pacific region. They offer sanitary napkins and menstrual cups in India.

2.2.7. SAATHI ECO INNOVATIONS INDIA PRIVATE LIMITED

Saathi is a purpose driven manufacturing company that makes eco-friendly hygiene products. Founded by graduates from MIT (US) and Nirma, we are innovators in the use of alternative materials and zero-waste production. Our mission is to create hygiene products that are good for the body, environment, and community. Saathi began in 2015 on a mission to create fully eco-friendly, compostable sanitary napkins using locally sourced banana fiber from the state of Gujarat, where Saathi is based. It was inspired by the idea of improving women's access to sanitary pads in India. They have products like bio-degradable sanitary napkins, bio-degradable panty liners, tampons and menstrual cup.

2.2.8. UNICHARM INDIA PRIVATE LIMITED

Unicharm Corporation also known as *Yuni Chāmu kabushiki kaisha* is a Japanese company that manufactures disposable hygiene products, household cleaning products, specializing in the manufacture of diapers for both babies and adult incontinence, feminine hygiene products and pet care products. The company has operations in 80 countries and is a market leader in Asia in baby and feminine care products. It holds the top share of diaper sales in China, India, Indonesia, Vietnam and Thailand. Also its market share is rapidly expanding in India, nearly doubling its sales every two years.

Unicharm traces its roots to the Taisei Kako Co., Ltd., founded by Keiichiro Takahara. Takahara's family operated a paper manufacturing business in Shikoku. After resigning in 1961 from his father's paper manufacturing company, he founded his own, Taisei Kako (Taisei Chemical Works). He then turned his attention to the manufacture and sale of selling wood wool cement board. Then the company in 1963 ventured to manufacture and sell sanitary napkins. The company then started selling tampons in 1974, when Unicharm Corporation was founded to separate the feminine care production from the main company. The company has a number of prominent brands in its portfolio, including MamyPoko, Charm, Moony, BabyJoy, Babylove, Sofy and Lifree, Teemo. Their most prominent feminine hygiene product is Sofy sanitary napkins. Sofy is the next most preferred pads in India from the big multinational companies.

2.3. PRODUCT PROFILE

There are plenty of period related products that are available in our market. Familiarizing these products are really important because only then women can choose the best product for themselves. Selecting the most suitable product among these is really important for a better menstrual hygiene management. Following are the period products available in our market.

2.3.1. SANITARY NAPKINS

A menstrual pad, or simply pad, (also known as a sanitary napkin, sanitary towel, feminine napkin or sanitary pad) is an absorbent item worn by women in their underwear when menstruating, bleeding after giving birth, recovering from gynecologic surgery, experiencing a miscarriage or abortion, or in any other situation where it is necessary to absorb a flow of blood from the vagina. A menstrual pad is a type of menstrual hygiene product that is worn externally, unlike tampons and menstrual cups, which are worn inside the vagina. Pads are generally changed by being stripped off the pants and panties, taking out the old pad, sticking the new one on the inside of the panties and pulling them back on. Pads are recommended to be changed every 3–4 hours to avoid certain bacteria that can fester in blood, this time also may differ depending on the kind worn, flow, and the time it is worn.

Menstrual pads are made from a range of materials, differing depending on style, country of origin, and brand. The pads are not the same as incontinence pads, which generally have higher absorbency and are worn by those who have urinary incontinence problems. Although menstrual pads are not made for this use, some use them for this purpose.

This is the most commonly used period product in developing countries like India. Most of the Indian women rely on sanitary napkins during their menstrual cycle. While it is easy to use and readily available, there are so many disadvantages pertaining to that product. It is difficult to dispose, since it has plastic coating and it is not bio-degradable. Thus it is too harmful for our environment. Also pads are suggested to be changed within 3-4 hours. When one fails to do that it can lead to so many health issues like rashes, inflammation in pelvic area, urinary tract infection, vaginal infection etc.

2.3.2. TAMPON

A tampon is a menstrual product designed to absorb blood and vaginal secretions by insertion into the vagina during menstruation. Unlike a pad, it is placed internally, inside of the vaginal canal. Once inserted correctly, a tampon is held in place by the vagina and expands as it soaks up menstrual blood. The majority of tampons sold are made of rayon, or a blend of rayon and cotton, along with synthetic fibers. Some tampons are made out of organic cotton. Tampons are available in several absorbency ratings. Several countries regulate tampons as medical devices. In the United States,

they are considered to be a Class II medical device by the Food and Drug Administration (FDA). They are sometimes used for hemostasis in surgery.

In certain aspects tampons are much better than sanitary napkins. It is small, and easy to use. If inserted correctly, we won't feel we are wearing a tampon, making them very comfortable and convenient. We can even go swimming when you are wearing a tampon which may not be practical with other period products. While this is an amazing fact of tampons it has some disadvantages too. The most dangerous one is health issues like Toxic shock syndrome (TSS). There is risk of TSS while using tampons. TSS is a rare bacterial infection that can cause damage to vital organs. To minimize your risk, always wash your hands before handling and inserting a tampon, use the lowest absorbency to suit your flow, change your tampon at least every 8 hours and always take the tampon out before you go to sleep. Also a lot of developing countries are yet to establish proper disposal methods or facilities for tampons.

2.3.3. CLOTH PADS

Cloth menstrual pads are cloth pads worn in the underwear to collect menstrual fluid (blood from uterine lining). They are a type of reusable menstrual hygiene product, and are an alternative to disposable sanitary napkins or to menstrual cups. Because they can be reused, they are generally less expensive than disposable pads over time, and reduce the amount of waste produced.

Generally they are made from layers of absorbent fabrics (such as cotton or hemp) which are worn during menstruation, post-birth bleeding or any other situation where it is necessary to absorb the flow of blood from the vagina, or to protect underwear from regular discharge of vaginal fluids. After use, they are washed, dried and then reused.

In case of environmental impact cloth napkins are much better than sanitary napkins and tampons. They are reusable and easier to dispose. It is environment friendly. It is washable and also a lot of women that have used cloth pad have claimed to have lesser cramps during their period.

Even though has such advantages there are some cons to it too. Cloth menstrual pads need to be washed with soap, properly dried, and cared for. Special care may need to be taken if the user has a candidiasis (yeast) infection. Pads can cause reinfection if not sterilized. Blood-borne pathogens such as hepatitis C are present in the menstrual pads of infected patients, and pose risk of infection if not sealed in leak-proof containers

2.3.4. CLOTH

In earlier times, in India women usually relied on a piece of cloth to prevent leakage during menstrual cycle. Still there are women who belongs to a much older age range using cloths during their periods. India have come a long way from that time period to the current days. Still there are a lot of rural part in India that still don't have access to period products like sanitary pads, tampons and all. Women usually use a long and

wide cloth that they secure either with a string or panties. After that these are washed and used again and again throughout their periods.

In a way it is good measure since it is easy to dispose, reusable and eco-friendly. But the biggest problem is that if not washed and sterilized properly it can cause serious health issues. It also causes odor and leakages which can be a hassle during menstrual cycle.

2.3.5. PERIOD UNDERWEAR

Period underwear (also known as menstrual underwear or period panties) are absorbent clothing designed to be worn during menstruation. The market for these products responds to consumers preferences to move away from the pads and tampons which are traditional period care (menstrual hygiene management) products. Different brands use different, often patented, technology for anti-microbial action, moisture-wicking and optimal absorption.

Period underwear is considered to be an eco-friendly way to cut down on waste and reduce spending. A customer described the product's features as "some menstrual-underwear styles are gorgeous but leaky, and others have Hoover Dam-level security but diaper-like silhouettes. The style that will be best for you depends on your period flow and preferences". Some manufacturers of period underwear are extending their ranges into other leak-proof clothes such as swimsuits, sportswear and sleepwear.

It is a very convenient product, as period underwear feel just like normal underwear. They are also another environmentally-friendly option as you just need to wash them and they can be reused. Its disadvantage is that you need to build a collection to ensure you have enough to see you through your period day and night, so the upfront cost can seem like a lot. If you have particularly heavy periods, you may need to use a pad or tampon with your period underwear on your heaviest days to ensure no leaks.

2.3.6. MENSTRUAL CUP

A Menstrual cup is a menstrual hygiene device which is inserted into the vagina during menstruation. Its purpose is to collect menstrual fluid (blood from the uterine lining mixed with other fluids). Menstrual cups are usually made of flexible medical grade silicone, latex, or a thermoplastic isomer. They are shaped like a bell with a stem or a ring. The stem is used for insertion and removal. The bell-shaped cup seals against the vaginal wall just below the cervix. Every 4–12 hours (depending on the amount of flow), the cup is removed, emptied, rinsed, and reinserted. After each period, the cup requires cleaning.

Unlike tampons and menstrual pads, cups collect menstrual fluid rather than absorbing it. Menstrual cups typically do not leak if used properly, though incorrect placement or inadequate cup size can cause some women to experience leakage. One cup may be reusable for up to 10 years. This makes their long-term cost lower than that of disposable tampons or pads, though the initial cost is higher. As menstrual cups are reusable, they generate less solid waste than tampons and pads, both from the products themselves and from their packaging. Most menstrual cup brands sell a smaller and a

larger size. Some menstrual cups are sold colorless and translucent, but several brands also offer colored cups.

Menstrual cups are a safe alternative to other menstrual products; risk of toxic shock syndrome infection is similar or less with menstrual cups compared to pads or tampons. The only disadvantage is that it can be quite tricky to insert and to get used to it at first. Also menstrual cup might not be suitable for everyone.

2.3.7. TYPES OF MENSTRUAL CUP

2.3.7.1. SHAPE

There are generally two shapes when it comes to menstrual cups: the tulip-shaped cup (think DivaCup) or the shallower, disc-shaped cup (SoftCup, Flex). It may take some experimentation with both kinds before finding a kind you like for your body, as both have different advantages. Now while most disc-shaped cups are made of plastic (whereas almost all tulip-shaped cups are made of silicone), the new Nixit cup is also made of silicone, so it's a good hybrid.

2.3.7.2. SIZE

Most menstrual cup brands sell a smaller and a larger size. The smaller size is typically recommended for women under 30 or women who have not given birth vaginally. The larger size is typically recommended for women over 30 or have given birth vaginally, or have a heavy flow. However, there have been no studies that show any need for a different sized cup based on age or parity. Cups with even smaller sizes are recommended for teenagers, as well as women and girls who are more physically fit, as those with stronger pelvic floor muscles may find a larger cup uncomfortable. If the cervix sits particularly low or is tilted, a shorter cup may be more suitable. Capacity is important for women who have a heavier flow. The average menstrual cup holds around 20 ml. Some cups are designed to be larger and hold 37–51 ml. Most sizes have a larger capacity than a regular tampon, which is 10–12 ml.

2.3.7.3. FLEXIBILITY

Menstrual cups also vary by firmness or flexibility. Some companies offer a range of firmness levels in their cups. A firmer cup pops open more easily after insertion and may hold a more consistent seal against the vaginal wall (preventing leaks), but some women find softer cups more comfortable to insert

2.3.7.4. COLOUR

The silicone of which most brands of cups are produced is naturally colorless and translucent. Several brands offer colored cups as well as, or instead of the colorless ones. Translucent cups lose their initial appearance faster than colored – they tend to get yellowish stains with use. The shade of a colored cup may change over time, though stains are often not as obvious on colored cups. Stains on any color of the cup can often be removed or at least lightened by soaking the cup in diluted hydrogen peroxide and/or leaving it out in the sun for a few hours.

Most cups produced do not have any other additives to them, except for the colored cups. The coloring used is reported to be safe and approved by the FDA for medical use and food coloring.

2.3.8. PROS AND CONS OF MENSTRUAL CUP

There are various pros and cons to every product. It is these factors that decides whether a product will be accepted or rejected by the masses. The pros and cons of menstrual cup are

PROS

*Reduce, reuse, recycle

Probably the most persuasive pro when it comes to pros and cons for menstrual cup is the positive effect that cups have on the environment. A menstrual cup does not produce any waste in the form of single-use, disposable packaging. So, switching to reusable menstrual hygiene products is a step in the right direction for the environment. Every little helps, and by using a menstrual cup, you could save 528 tampons/sanitary pads in 2 years.

*Don't splash your cash

A box of tampons or pads can be expensive, especially when you need to buy a new box every month. In the US, the average individual will spend over \$1,000 on menstruation products during their lifetime. However, by using a menstrual cup, you can save money and not have to think about purchasing tampons or pads every month.

*Change isn't always good

The manufacturers recommend that you change your tampon every 4 to 8 hours, and pads normally every 8 hours or so. One of the many pros of a menstrual cup is that you can wear it for up to 12 hours. This is due to the larger capacity of a menstrual cup, which is a strong advantage. A night pad can hold between 10 to 15 millilitres of blood, whereas a super-absorbent tampon will hold 12 millilitres of fluid. Depending on the size of your cup, the capacity can range from 25 to 30 millilitres. This means that you can go longer without having to empty your cup.

*Keep everything in balance

We all know how important vaginal health is. Any slight disruption in the body such as stress, diet or medication can cause an imbalance. Pads can create a warm, moist environment that encourages the growth of bacteria and can increase infections. These undesirable bacteria can end up causing a lot of discomfort and irritation. On the other hand, tampons can also upset your body's natural pH-balance. The high absorption in tampons can absorb all the natural (good) bacteria from your vagina, as well as menstrual blood. The removal of this good bacteria, as well as blood, could create an imbalance in your pH level.

A menstrual cup does not absorb anything but instead collects it. So, any natural fluids that are produced by your body are collected and then emptied later — there's no over-absorption, dryness, or discomfort. This leaves you with a well-balanced, happy vagina. A pretty good pro when it comes to the pros and cons of menstrual cups.

* No odor

Unfortunately, when blood is exposed to air, it has an unpleasant odour. And if you use pads, there is no way to prevent this from occurring. Even though it is completely natural, it's something that many feel embarrassed about or ashamed of. But there is a way to reduce odour and feel more confident during your period.

One of the great benefits of using a menstrual cup is the reduction in odour. Since a menstrual cup collects the blood inside your body, the blood is not exposed to air. And, since there is no prolonged exposure to air, your blood cannot produce an odor.

CONS

*Insertion takes time

Just like when you first used a tampon, although you think it will be easy, it actually turns out to be a lot harder than it looks. But after using them during your next few periods, it becomes so much easier. You start to get the hang of it. Your body begins to relax, and before you know it, you can change your tampon with your eyes closed. It's the same with a menstrual cup. It takes a few times to get the hang of it. But once you've gotten the hang of it, you will be able to empty and re-insert your cup with no problem.

Some people might see this as a con, as it does take some practice, and it might take some time.

*Cleaning your cup

Unlike disposable menstrual products, you need to take care of your menstrual cup. This means sanitising your cup between each menstrual cycle and checking for signs of wear and tear. However, there is no need to sanitise your cup every time you empty it during your period. Dr Nathan Riley explains that the menstrual cup can be removed and replaced without cleaning and this will not increase the risk of infection. But once your period is finished, you can easily sanitise your cup in boiling water for 3 to 5 minutes – just be careful not to burn the silicone.

*It can be messy

Inserting and emptying your cup means that you have to use your fingers. You really have to get in there and feel around. For some, this can be quite intimidating, especially if it is your first time. But after a while, you get used to it. When you empty your cup, you may find it interesting to see how much blood your body produces, as part of its natural rhythm. This could be seen as both a pro and a con for menstrual cups. Once you get used to using your hands, you will begin to realise just how amazing the human body really is.

CHAPTER - 3

DATA ANALYSIS AND INTERPRETATION

3.1 DEMOGRAPHIC CHARACTERISTICS

The demographic details of the respondents are given in table 3.1. The study was done on 120 women in Kerala from the age group of 15 to 55. In it about 78% of women fell under the 15-25 age group. The 26-35 age group had 12.5% of women falling under it. The 36-45 age group and 46-55 age group had 5.8% and 3.3% of respondents respectively.

About 61.7% of women were students. 10.8% of job seeker women, 22.5% of working women and 5% of homemakers also actively took part in this survey.

From the above survey it was found that 107 women (89.2%) are using sanitary napkins as their period product. There were 14 (11.7%) users of menstrual cup and 7(5.8%) and 4 (3.3%) women who uses cloth and cloth napkins respectively. 1(0.8%) women uses pantyliner.

Demographic characteristics	Number of respondents		Percentage
Age	15-25	94	78%
	26-35	15	12.5%
	36-45	7	5.8%
	46-55	4	3.3%
Occupation	Student	74	61.7%
	Jobseeker	13	10.8%
	Working women	27	22.5%
	Homemaker	6	5%
Product	Sanitary napkin	107	89.2%
	Cloth	7	5.8%
	Cloth napkin	4	3.3%
	Menstrual cup	14	11.7%
	Panty liner	1	0.8%

Table 3.1

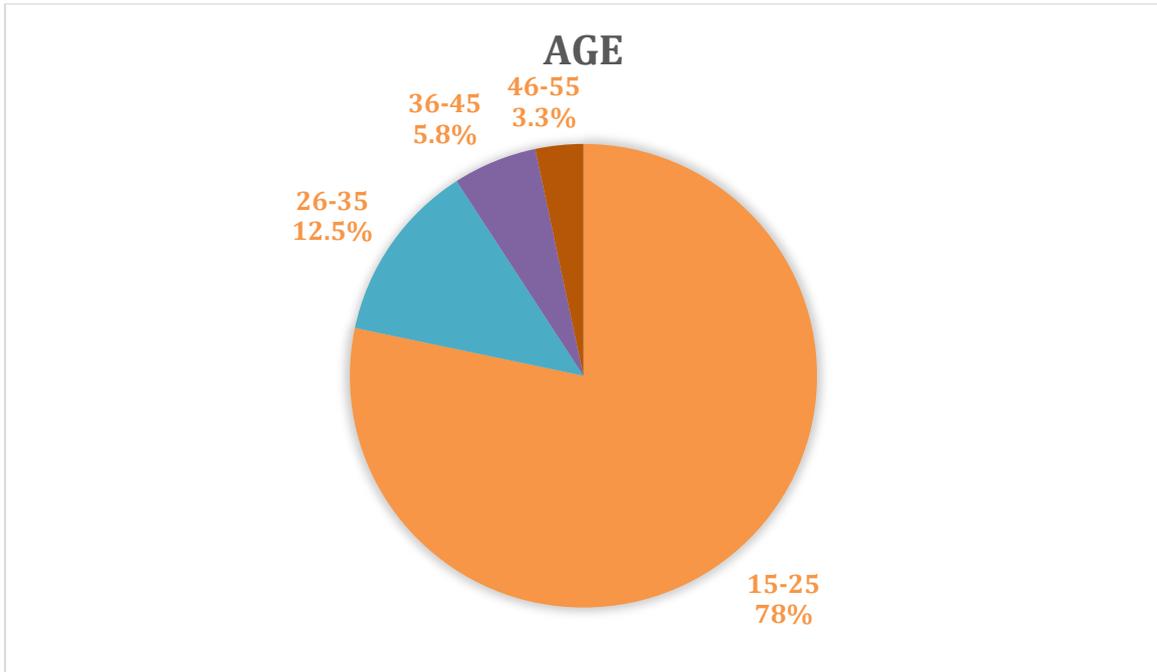


Figure 3.1 A

Interpretation: About 78% of women fell under the 15-25 age group. The 26-35 age group had 12.5% of women falling under it. The 36-45 age group had 5.8% and 46-55 age group 3.3% of respondents.

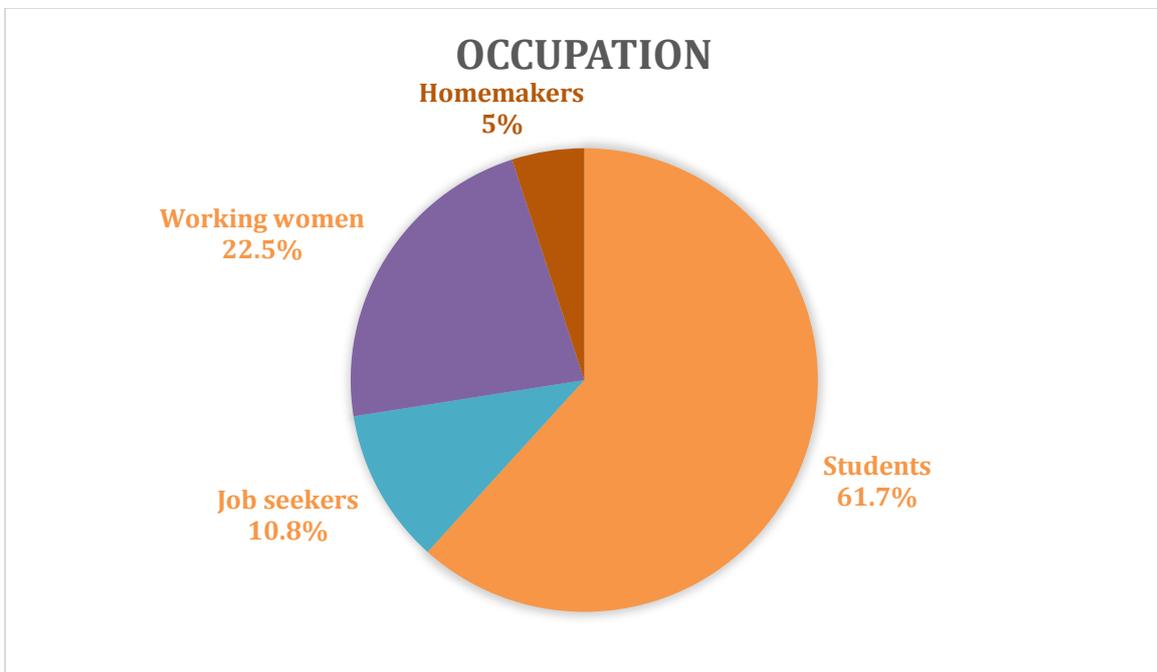


Figure 3.1 B

Interpretation: About 61.7% of women were students. 10.8% of job seeker women, 22.5% of working women and 5% of homemakers also actively took part in this survey.

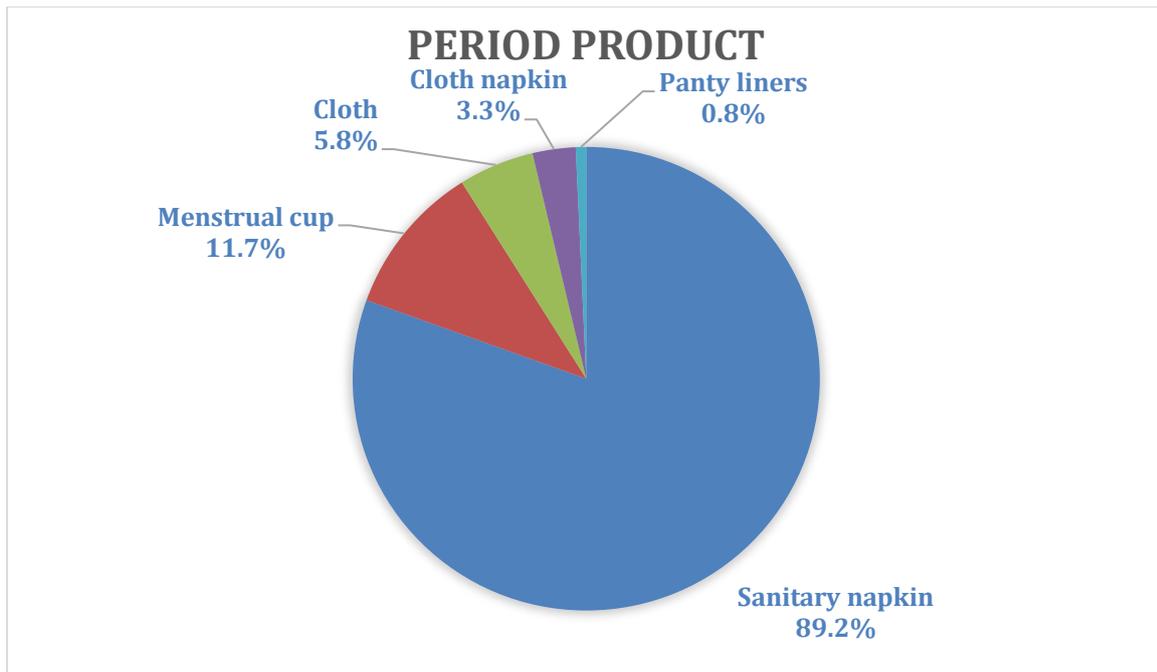


Figure 3.1 C

Interpretation: About 89.2% are using sanitary napkins as their period product. There were 11.7% users of menstrual cup and 5.8% uses cloth and 3.3% women uses cloth napkins. 0.8% uses panty liners.

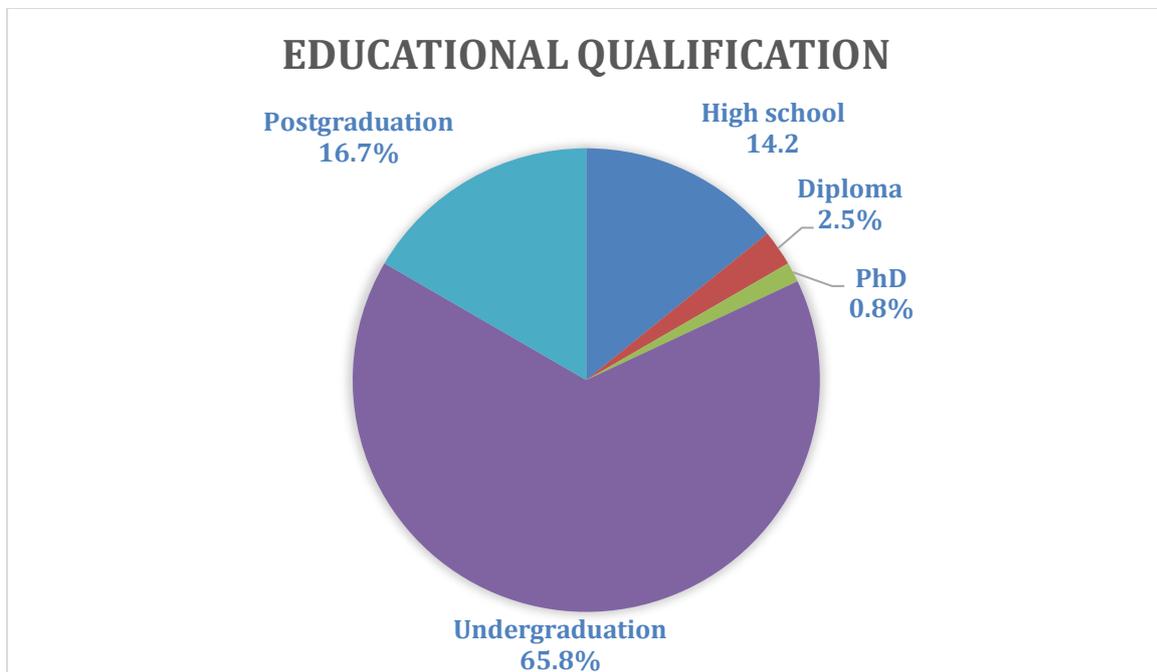


Figure 3.1 D

Interpretation: About 65.8% of women are undergraduates. 16.7% women are postgraduates. About 14.2% are high schoolers. 2.5% women have completed their diploma. Only 0.8% women holds a PhD.

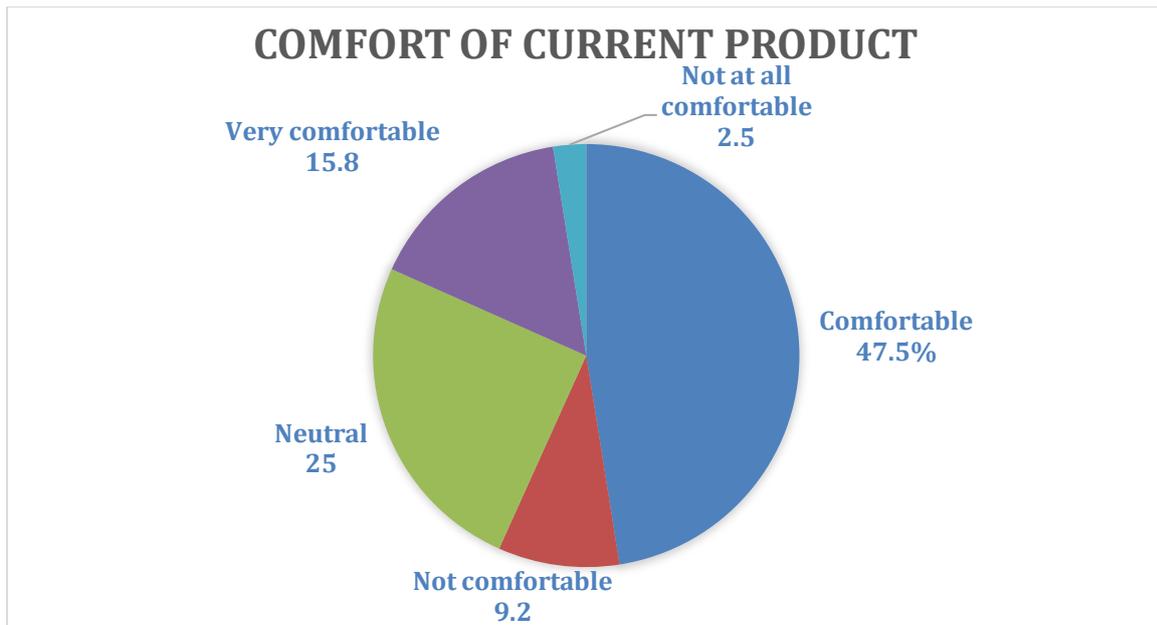


Figure 3.1 E

Interpretation: 15.8% women feel very comfortable with their current product, 47.5% feels comfortable and 25% of women feel neutral about their existing product. While 9.2% of respondents feel not comfortable with their product, about 2.5% felt not at all comfortable with their product.

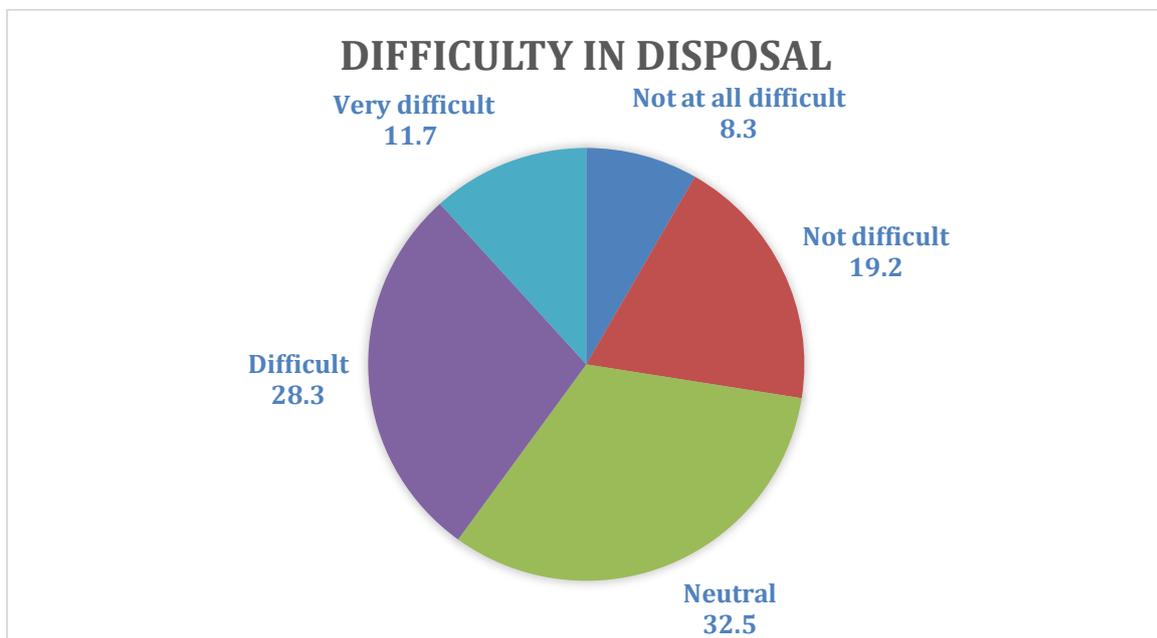


Figure 3.1 F

Interpretation: 11.7% women find it very difficult to dispose their current product, 28.3% finds it difficult and 32.5% of women feel neutral regarding difficulty in disposing their product. While 19.2% of respondents find it not difficult, about 8.3% find it not at all difficult to dispose their current product.

3.2. RELATIONSHIP BETWEEN SOCIAL INFLUENCE AND ADOPTION OF MENSTRUAL CUP.

Correlation analysis is a method of statistical evaluation used to study the strength of a relationship between two, numerically measured, continuous variables (e.g. height and weight). This particular type of analysis is useful when a researcher wants to establish if there are **possible connections** between variables.

The following table shows the correlation between social influence and adoption of menstrual cup.

Correlations			
		How likely are you to use/continue using menstrual cup	I have friend or family in close circle who uses menstrual cup
How likely are you to use/continue using menstrual cup	Pearson Correlation	1	.081
	Sig. (2-tailed)		.380
	N	120	120
I have friend or family in close circle who uses menstrual cup	Pearson Correlation	.081	1
	Sig. (2-tailed)	.380	
	N	120	120

Table 3.2 A

This table is made to find the influence of knowing a close friend or family who uses menstrual cup on other women regarding adoption of the said product. Here the significance is 0.081. Since the significance is above the accepted rate of 0.05, knowing a friend or family who uses menstrual cup does not influence women in their purchase behavior or attitude towards menstrual cup.

Correlations

		How likely are you to use/continue using menstrual cup(Select the suitable option)	I will use menstrual cup if more of my friends or family use it
How likely are you to use/continue using menstrual cup(Select the suitable option)	Pearson Correlation Sig. (2-tailed) N	1 120	.407** .000 120
I will use menstrual cup if more of my friends or family use it	Pearson Correlation Sig. (2-tailed) N	.407** .000 120	1 120

Table 3.2.B

This table is made to find the influence of having a close friend or family who uses menstrual cup on other women regarding adoption of the said product. Through this question we tried to find whether women are ready to try menstrual cup if more of their friends and family start using it. Here the significance is 0.407. Since the significance is above the accepted rate of 0.05, having more friends or family adopting menstrual cup does not influence women in their purchase behavior or attitude towards menstrual cup.

Summary of Hypothesis Statement.

#	Hypothesis Statement	Decision
H1	There is a positive relation between social influence and purchase and use of menstrual cup	Rejected

3.3. RELATIONSHIP BETWEEN HYGIENE CONCERN AND ADOPTION OF MENSTRUAL CUP.

One-Way ANOVA ("analysis of variance") compares the means of two or more independent groups in order to determine whether there is statistical evidence that the associated population means are significantly different. One-Way ANOVA is a parametric test.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	29.310	4	7.327	7.373	.000
Within Groups	114.282	115	.994		
Total	143.592	119			

Table 3.3.A

Through this question we were trying to find what women thought about menstrual cup in terms of hygiene. Most of the women, because of misconception believes that menstrual cups can be unhygienic so they refuse to use menstrual cup as their period product. Since significance of the study is 0.000 it evident that women are reluctant in using menstrual cups.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	36.725	4	9.181	9.880	.000
Within Groups	106.866	115	.929		
Total	143.592	119			

Table 3.3.B

Through this question we were trying to find what women thought about menstrual cup in terms of safety. Most of the women, because of misconception believes that menstrual cups can be unsafe. so they refuse to switch from their current product. Since significance of the study is 0.000 it evident that women are reluctant in using menstrual cups.

These questions were intended to find out the concerns of women regarding hygiene factor of menstrual cup. Two questions were taken in relation with that,so if we add up both it will be:

$$0.000 + 0.000 = 0.000$$

Which is below significance.

Summary of Hypothesis Statement.

#	Hypothesis Statement	Decision
H2	There is a positive relation between hygiene concern and purchase and use of menstrual cup	Accepted

3.4 RELATIONSHIP BETWEEN PRODUCT AWARENESS AND ADOPTION OF MENSTRUAL CUP.

Correlations

		How likely are you to use/continue using menstrual cup	How aware are you about menstrual cup?
How likely are you to use/continue using menstrual cup	Pearson Correlation Sig. (2-tailed) N	1 120	.480** .000 120
How aware are you about menstrual cup?	Pearson Correlation Sig. (2-tailed) N	.480** .000 120	1 120

Table 3.4.A

This test was done to find the influence of product awareness on purchase and use of menstrual cup. It was shown that many women are not fully aware about menstrual cup and even when they are aware they hesitate in using menstrual cup. Here the significance rate is 0.480. since it is above the accepted rate there is no correlation between product awareness and adoption of menstrual cup.

Correlations

		How likely are you to use/continue using menstrual cup	I have attended programs on familiarizing menstrual cup
How likely are you to use/continue using menstrual cup	Pearson Correlation Sig. (2-tailed) N	1 120	.207* .023 120
I have attended programs on familiarizing menstrual cup	Pearson Correlation Sig. (2-tailed) N	.207* .023 120	1 120

Table 3.4.B

This test was done to find whether women attend educational classes for menstrual cup and to find whether they have any influence on their attitude towards menstrual cup. It was shown that many women don't attend such classes. Here the significance rate is 0.207. since it is above the accepted rate there is no correlation between attending educational classes on menstrual cup and its adoption.

Summary of Hypothesis Statement.

#	Hypothesis Statement	Decision
H3	There is a positive relation between product awareness and purchase and use of menstrual cup	Rejected

3.5 RELATIONSHIP BETWEEN PSYCHOLOGICAL FACTORS AND ADOPTION OF MENSTRUAL CUP.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23.234	4	5.809	5.550	.000
Within Groups	120.357	115	1.047		
Total	143.592	119			

Table 3.5.A

This test was done to see whether there was any relation between women's fear of inserting the cup in vagina and its adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women's mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	49.034	4	12.259	14.909	.000
Within Groups	94.557	115	.822		
Total	143.592	119			

Table 3.5.B

This test was done to see whether there was any relation between women's fear of feeling uncomfortable with the cup in their vagina and its adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women's mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.316	4	8.329	8.686	.000
Within Groups	110.276	115	.959		
Total	143.592	119			

Table 3.5.C

This test was done to see whether there was any relation between women's prejudice of inserting the cup a painful experience and its adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women's mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.734	4	11.184	13.010	.000
Within Groups	98.858	115	.860		
Total	143.592	119			

Table 3.5.D

This test was done to see whether there was any relation between women’s fear of getting rashes from menstrual cup and its adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women’s mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28.205	4	7.051	7.028	.000
Within Groups	115.387	115	1.003		
Total	143.592	119			

Table 3.5.E

This test was done to see whether there was any relation between women’s fear of leakage issues and menstrual cups adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women’s mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.616	4	9.404	10.205	.000
Within Groups	105.975	115	.922		
Total	143.592	119			

Table 3.5.F

This test was done to see whether there was any relation between women’s fear of getting the cup stuck in their vagina and its adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women’s mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.053	4	10.263	11.510	.000
Within Groups	102.539	115	.892		
Total	143.592	119			

Table 3.5.G

This test was done to see whether there was any relation between women’s fear of having odor from menstruation and the cups adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women’s mind.

ANOVA

How likely are you to use/continue using menstrual cup

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.368	4	8.592	9.046	.000
Within Groups	109.224	115	.950		
Total	143.592	119			

Table 3.5.H

This test was done to see whether there was any relation between women’s fear of getting vaginal infection or other health issues and the cups adoption rate. It was found that a lot of women have such fear hence they hesitate in using menstrual cup. Since the significance rate is 0.000 it is proven that such fear is prevalent women’s mind.

These questions were intended to find out the concerns of women regarding hygiene factor of menstrual cup. Eight questions were taken in relation with that, so if we add all of it will be:

$$0.000 + 0.000 + 0.000 + 0.000 + 0.000 + 0.000 + 0.000 + 0.000 = 0.000$$

Which is below significance so:

Summary of Hypothesis Statement.

#	Hypothesis Statement	Decision
H4	There is a positive relation between psychological factors and purchase and use of menstrual cup	Accepted

CHAPTER - 4

SUMMARY OF FINDINGS, SUGGESTIONS AND CONCLUSIONS

4.1. LIST OF FINDINGS

From the above analysis we have found that

i. A population of 120 respondents was surveyed which constitutes female population around the age 15-55 years. 78% respondents were of age between 15-25 which is the age group with maximum respondents, 12.8% of population surveyed were of age group 26-35 years. 5.8% people belonged to age group 36-45 years, and only 3.3% of respondents surveyed were aged between 46-55 years.

ii. Maximum respondents i.e., 61.7% of respondents were students, 10.8% were jobseekers, 22.5% were working women and 5% were homemaker.

iii. About $\frac{3}{4}$ th of the total respondents have minimum qualification as undergraduation or even above that, i.e., 65.8% of respondents are undergraduates. 16.7% women are postgraduates. About 14.2% are highschoolers. 2.5% women have completed their diploma. Only 0.8% women holds a PhD. This shows that all of the respondents are well educated.

iv. Of the 120 respondents 89.2% of women uses sanitary napkin as their period product. Surprisingly 11.7% uses menstrual cup. While 5.8% women uses cloth during their periods only 3.3% women use cloth napkin and 0.8 uses panty liners as their period product.

v. While it shows that most of the respondents use sanitary napkins only 59.2% women picked napkins as their preferred choice. About 33.3% of women prefers menstrual cup over others. While 3.3% women prefers cloth napkins and 4.2% chose cloth as their preferred product.

vi. 15.8% women feel very comfortable with their current product, 47.5% feels comfortable with their product. 25% of women feel neutral with regards to their existing product. While 9.2% of respondents feel not comfortable with their product, about 2.5% felt not at all comfortable with their product.

vii. In terms of difficulty in disposing their period product 11.7% find it very difficult to dispose their product. 28.3% of women find it difficult to dispose their products and 32.5% feels neutral in this regards. While 19.2% of women find it not difficult when it comes to disposal part, about 8.3% of women find it not at all difficult to dispose their current period product.

viii. From the survey it was found out that 29.2% of the respondents are completely aware about menstrual cups and 53.3% of women says that they are aware about the cup. While 15% says they are neither aware nor unaware about the product, only 2.5% of the respondents are unaware about the product.

ix. It was found that only 15% of respondents have ever used menstrual cup the rest 85% of women have ever used the cup ever in their life.

x. Lastly 19.2% of women are certain that they will use or continue to use menstrual cup. 21.7% are likely to use or continue to use and 40% feels neutral in this area. 14.2% said that it is unlikely for them to use or continue to use the cup but 5% are sure that it is very unlikely of them to use or continue using menstrual cup.

xi. From the correlation test it was found that social influence don't have much impact on the purchase and adoption of menstrual cup even though it is through this medium that most women come to know about the cup. While some agreed to try out the product if more of their close friends and family use it, most of them felt neutral about it, i.e. , they neither agree nor disagree to use menstrual cup.

xii. Hygiene concern plays a significant role in the adoption of product. But due to misconceptions and lack of awareness a lot of women believe that menstrual cup have too much impending health issues.

xiii. From survey it was found that product awareness don't have much impact on the adoption rate of menstrual cup. Even though a lot of people are becoming more and more aware about menstrual cup and its benefits women still hesitate to try it out, which brings us to the next point.

xiv. The most prominent reason people refuse to try out menstrual cup is due to Psychological factors. The factors that we focused on in our study was emotions like fear and concerns associated with the product. A lot of women are afraid that the product will be uncomfortable, difficult to use, painful and that it might get stuck in their vagina. In this study it was proved that psychological factors play a major role when it comes to adoption of menstrual cups.

xv. At the end of survey it was clear that more and more women are becoming aware and ready to adopt menstrual cup. It is the lack of proper information that is stopping them.

4.2. SUGGESTIONS

- i. Since a lot of women have so much concerns and fear associated with the product trusted brands and market giants should step up their game as women have trust in these brands. In that case it will be easier to convince them.
- ii. Advertisement is one of the major platform through people get information regarding new or existing products. But there is hardly any advertisements for menstrual cups. If the manufacturers can create interactive and informative ads it will benefit them a lot and can boost their sale.
- iii. Organizing seminars and educational classes would be another helpful method in familiarizing women with the benefits and cons of menstrual cup.
- iv. Creating a page or site for interaction between women would be a great idea. Through this interested women can interact with women who have already used the product and can have a better idea about menstrual cups. It can also help them to share their concerns and find solutions for newbie users.
- v. Another method would be promotion through doctors like gynecologist. If doctors take some time to explain the side effects of pads and tampons and also inform the patients about the benefits of menstrual cup, there is a higher chance that women will follow it.
- vi. Sponsoring YouTube or Instagram beauty gurus or collaborating with influencers can help companies to reach out to a larger section of their target customers. A lot of youngsters and women look up to influencers for better lifestyles.
- vii. Product placements can also help companies to familiarize the product to a wider range of customers. Most often people try out products displayed in movies and hit TV shows. This can help boost the sales brand awareness and goodwill for companies.
- viii. Selecting top female actresses in different age categories for endorsement can help to attract more women towards the product. As a lot of women aspires to be like these celebrities they might try to adopt products endorsed by them. Also if actresses from different age categories are endorsing menstrual cup it gives of the message that women of all age group can use it and thus women in same age group as these actresses will feel more comfortable in opening upto menstrual cup.
- ix. Government initiatives can make a big change in the perspective of women. “Thinkal” a government project adopted in the Alapuzha municipality of Kerala in partnership with Hindustan Latex Ltd that distributed about 5000 menstrual cups free of cost was met with positive response from women.

- x. Creating trends can be another innovative idea to promote menstrual cups to youngsters. Social media is inseparable in the lives of youngsters so creating hashtags or viral videos can help in attracting attention towards the cup. Platforms like Twitter can be used to create trending hashtags which can cause a large traction to the topic or product.
- xi. Companies can conduct extensive surveys to better understand the attitude of women towards menstrual cup also they can delve into more categories regarding this. It can help them to identify unrealized factors that are holding women back from using menstrual cup.
- xii. Companies can put out more tutorial videos, this can help people understand that it is not too difficult to use menstrual cups. They can also share more information about how to clean, how to remove and also what to do just in case the cup gets stuck in vagina.

4.3. CONCLUSION

As we all know menstruation is considered as something dirty in our society. Due to this, there were not much discussion regarding menstrual hygiene management and the issues of not having proper hygiene during menstruation. Thankfully our society have progressed a lot from that era. Even though it is still treated as a taboo in many parts of India, and people have accepted it as a normal phenomenon in female body.

This study offered insights into deeper understanding of the women's perception attitude and concerns regarding menstrual cup.

This study mainly explored how women view the product and despite knowing the benefits of menstrual cup why they refuse to switch to menstrual cup. These are mainly because of the deep rooted stigma, concerns and fear that is around menstrual cup.

Through this study we came to know that more and more women are getting exposure to menstrual cup and some are already switched to it. Most of these women are satisfied with the benefits of menstrual cup and are suggesting it to their friends and family.

In this study we focused on the impact of social influence, hygiene concern, product awareness and psychological factors on the adoption of the menstrual cup. Even though social influence and product awareness proved to be not much significant in convincing women, hygiene concerns and psychological factors have greater impact on the minds of women. Due to so many misinformation and misconception women feel that menstrual cups are unsafe and unhygienic. Also the impending fear regarding the insertion and removal and also the fear of getting it stuck in vagina makes a lot of women not even wanting it to try out.

The intention of this study was to find the factors that influence the opinion of women regarding menstrual cup and to find solution for it. We came to the conclusion that it is mainly the fear and concern that stemmed from misinformation that led to fewer adoption of menstrual cup in India. Through stronger initiatives we can overcome this easily. Some of the suggestions being better promotion, awareness classes, interaction between users and non-users of menstrual cup etc. These initiatives can bring a lot of change in the current market scenario of menstrual cup.

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ANNEXURE

QUESTIONNAIRE

1. Age(Put a tick mark on suitable box)*

- 15-25
- 26-35
- 36-45
- 46-55

2. You are a _____(Put a tick mark on suitable box)*

- Student
- Job seeker
- Working women
- Homemaker/Housewife

3. Your educational qualification(Put a tick mark on suitable box)*

- High school
- Diploma
- Undergraduate
- Post graduate
- PhD

4. You are currently using _____(Put a tick mark on suitable box)*

- Sanitary napkin
- Tampon
- Cloth
- Cloth napkin
- Menstrual cup
- Others

5. Your preferred choice(Put a tick mark on suitable box)*

- Sanitary napkin
- Tampon
- Cloth
- Cloth napkin
- Menstrual cup
- Any other_____

6. How much do you spend on period related products on an average on a monthly basis(Put a tick mark on suitable box)*

- Less than 100
- 100-200
- 200-300
- More than 300

7. How long have you been using your current product(Put a tick mark on suitable box)* Less than 5 years

- 5-10
- 10-20
- 20-30
- More than 30 years

8. If you are using sanitary pad how many pads do you use in a day(Put a tick mark on suitable box)

- 1
- 2
- 3
- 4
- More than 5

9. How do you feel about your current product(Put a tick mark on suitable box)*

- Very comfortable
- Comfortable
- Neutral
- Not comfortable
- Not at all comfortable

10. Have you ever had any health issues pertaining from your current product?

If yes, what was it? (Put a tick mark on suitable box. You may select more than one option)*

- No
- Hormonal dysfunction
- Rashes
- Inflammation in pelvic region
- Vaginal allergies
- Urinary tract infection
- Others

11. How difficult do you think it is to dispose your current product(Put a tick mark on suitable box)*

- Very difficult
- Difficult
- Neutral
- Not difficult
- Not at all difficult

12. How satisfied are you about the following features of your current product.

Features	Extremely satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Extremely dissatisfied
Ease of use					
Ease of dispose					
Comfort					
Convenience					
Odorless					
Safety					
Leakage					
More time between changes					
Average money spend(monthly)					

13. How aware are you about menstrual cup(Put a tick mark on suitable box)*

- Completely aware
- Aware
- Neither aware or unaware
- Unaware
- Completely unaware

14. Have you ever used a menstrual cup?(Put a tick mark on suitable box)

- Yes
- No

15. How far do you agree with the following statement regarding menstrual cup

Statements	Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly Disagree
It is difficult to insert the menstrual cup to my vagina					
It will be uncomfortable					
It will be painful					
It will cause rashes					
There will be leakage issues					
It is unhygienic					
It is difficult to remove					
It will cause odor					
It will cause vaginal infection or other health issues					
It is an unsafe product					

I have friends or family in close circle who uses menstrual cup					
I will use menstrual cup if more of my friends or family use it					
I have attended programs on familiarizing menstrual cup					

16. How likely are you to suggest menstrual cup to others(Put a tick mark on suitable box)*

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

17. How likely are you to use/continue using menstrual cup

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

Project Report

On

**A STUDY OF THE MODELLING OF
CARBON DIOXIDE REMOVAL FROM THE
ATMOSPHERE**

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

MATHEMATICS

by

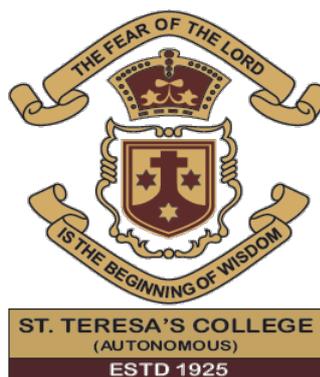
POORNASREE RAMACHANDRAN

(Register No. SM20MAT011)

(2020-2022)

Under the Supervision of

Smt.VEENA V S



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APRIL 2022

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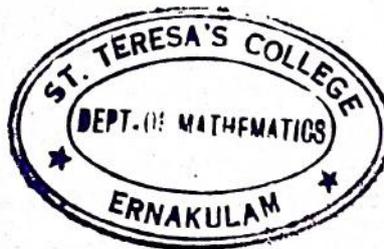
CERTIFICATE

This is to certify that the dissertation entitled, **A STUDY OF THE MODELLING OF CARBON DIOXIDE REMOVAL FROM THE ATMOSPHERE** is a bonafide record of the work done by Ms. **POORNASREE RAMACHANDRAN** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

Date: 27/5/2022

Place: Ernakulam

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of **Smt.VEENA V S** , Assistant Professor, Department of Mathematics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Place:

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Date: *27/5/2022*

SM20MAT011

ACKNOWLEDGEMENTS

First and foremost, I would like to thank God almighty, for the successful completion of my project.

I express my sincere thanks to the Director, Rev. Dr. Sr. Vinitha and Principal Dr. Lizzy Mathew of St. Teresa's College for giving me an opportunity to undertake this project.

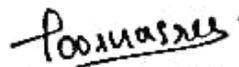
I acknowledge my sincere gratitude to Dr. Ursala Paul, Head of the Department of Mathematics for her constant support, which helped in the successful completion of my project.

I am grateful to Smt. Nisha Oommen, Smt. Dhanalakshmi O M, Smt. Veena V S, Smt. Alka Benny and all other faculties of the Department, for their valuable help and guidance during each stage of my work.

Last but not least, I would like to thank my parents and friends for motivating me and for the right environment for making this project work a great success.

Place:

Date: 27/05/2022


POORNASREE RAMACHANDRAN

SM20MAT011

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Chapter 1

INTRODUCTION

For the last few years, we people have been facing different kinds of natural phenomena globally.

The climatic conditions of our home earth are drastically changed, causing serious consequences to the humankind. The balance of our ecosystem is disrupted. Before anything worse happens, we have to make it stable.

The major situation we have to take care is, the rise in temperature of our atmosphere. The emission of global warming gases such as methane, carbon dioxide, etc. are the main reason for it. This can lead to adverse effects on humankind and our environment. Global warming may lead to severe problems like poor air quality, rise in sea levels, melting of glaciers, decrease in rainfall, draught, heat waves, effect on human health, etc.

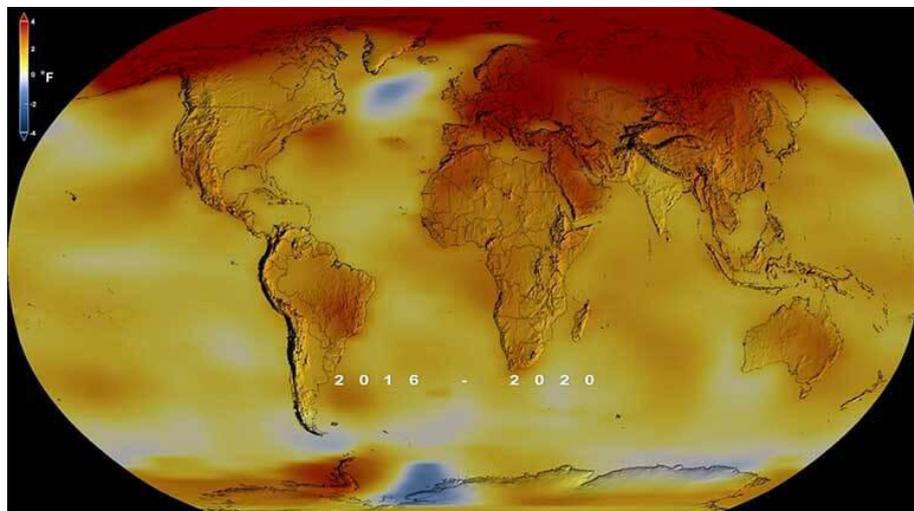
Carbon dioxide is the main contributor to global warming. In this project, we discuss the removal of carbon dioxide with the help of a mathematical model. And we discuss the different situations that may arise considering all of its related factors.

Chapter 2

BACKGROUND

According to the latest reports we got from NASA, 2020 was the hottest year on record. Also the average temperature of earth has risen significantly and it is due to the various human activities which include the emission of greenhouse gases like methane and carbon dioxide into the atmosphere.

We also know that our environment has its own capability of maintaining the equilibrium for the existence of life on earth. But unfortunately, the capacity of our ecosystems is becoming less efficient. They are not able to absorb the unwanted amount of such gases by themselves as earlier. So now it's our turn to find a solution to this. We should take necessary actions on time to avoid harsh consequences.



Chapter 3

TYPES OF MODELS

A Mathematical Model is a description of a system using mathematical concepts and language. Moreover, Mathematical Models are sets of equations that take into account many factors to represent a phenomenon. And the process of developing such a Model is termed Mathematical Modelling. Mathematical models are usually composed of relationships and variables. Relationships can be described by operators and Variables are abstractions of system parameters of interest that can be quantified. Several classification criteria can be used for mathematical models according to their structure:

- Linear vs. Non-linear
- Static vs. Dynamic
- Discrete vs. Continuous
- Deterministic vs. Stochastic

Chapter 4

FIELDS OF APPLICATIONS

- Virtual reality
- Artificial intelligence
- Robotics
- Computer animation
- Astronomy:
 - (i) Detection of planetary systems
 - (ii) Origin of the universe
 - (iii) Evolution of stars
- Weather prediction
- Biology :
 - (i) Protein folding
 - (ii) Human genome project
 - (iii) Population dynamics
 - (iv) Evolutionary pedigrees
 - (v) Spreading of infectious diseases (AIDS)
- Flight simulation
- Air traffic scheduling
- Trajectory planning

Chapter 5

CHEMICAL PROCESS

Carbon separation can be done in different ways. There are various methods like adsorption, absorption, membrane separation, oxygen combustion, sublimation and cryogenic separation.

In adsorption we use charcoal to capture carbon dioxide. In absorption we use a suitable absorbent of carbon dioxide and in membrane separation, we use different kinds of membranes to separate the carbon dioxide.

Here what we use is the absorption process and infusing liquid. In our case, we use a suitable absorbent and liquid species to reduce the rate of carbon dioxide in the atmosphere. What happens here is that, the liquid species and the absorbent gets reacted with the carbon dioxide in the atmosphere and forms another substance known as the secondary substance. And this secondary substance formed due to the reaction between carbon dioxide and other species is then removed by the gravity itself. And hence we can reduce the content of carbon dioxide present in our atmosphere.

5.0.1 SELECTED CHEMICAL PROCESS

The removal of Carbon Dioxide is done here by infusing liquid drops and suitable particulate matters (such as calcium oxide) in to the atmo-

sphere. When this global warming gas interacts with these externally introduced species, secondary phases are formed which are then removed from the atmosphere by gravity, reducing the concentration of global warming gas in the atmosphere.

Chapter 6

PROPOSED MODEL

We chose a place where the emission of the carbon dioxide takes place. There we introduce the liquid species and absorbent. To model the situation, we made some assumptions as follows;

- (i) The amount of carbon dioxide emitted is constant.

- (ii) The amount of liquid substance and absorbent used will be proportional to the amount of the carbon dioxide emitted.

- (iii) The resultant substance formed due to the reaction between carbon dioxide and the substances we introduced will be removed from the atmosphere by the gravity itself.

- (iv) There will always exist a threshold concentration of carbon dioxide in the atmosphere which causes no harm.

With the above assumptions, now let's define the variables needed for our model. Given below are the variables and what they denote :

C – the amount of carbon dioxide.

Q – the amount of carbon dioxide emitted from different sources.

d_0C – natural depletion of carbon dioxide.

L – the amount of liquid species.

CP – the amount of particulate matter formed.

Ca – the amount of a suitable absorbent.

l_1CL – depletion of CO_2 due to interaction with liquid species.

l_0 – natural depletion rate of liquid species.

p – the rate by which particulate matter is formed.

p_0 – natural depletion rate.

a – the rate of inflow of absorbent.

a_0Ca – natural depletion rate.

a_1 – interaction rate of carbon dioxide with absorbent.

All the above constants are assumed to be positive.

The following is our system of equations which represents our model;

$$\frac{dC}{dt} = Q - d_0C - l_1CL - a_1CCa \quad (6.1)$$

$$\frac{dL}{dt} = l(C - C_0) - l_0L - l_1CL \quad (6.2)$$

$$\frac{dCP}{dt} = pl_1CL - p_0CP \quad (6.3)$$

$$\frac{dCa}{dt} = aC - a_0Ca - a_1CCa \quad (6.4)$$

Now using these, we are going to analyze three different cases. In first we will be using the liquid only, in the second we will be using the absorbent only and then in the third we use both the liquid species and absorbent together. After analyzing the corresponding equations and also analyzing with giving values to them, (i.e. Numerical valuation) we will find the case which gives the best result.

Chapter 7

ANALYSIS OF DIFFERENT SITUATIONS

7.1 CASE I

WHEN ONLY LIQUID SPECIES IS USED

Here the amount of carbon dioxide is greater than what should be maintained. That is, the amount of carbon dioxide in the atmosphere is more than its threshold concentration.

In this case we not the absorbent but only the liquid species to reduce the amount of carbon dioxide present. Now we form some algebraic equations by equating the first three equations from our system and form a final equation to analyze this case.

These are the equations taken from our system;

$$\frac{dC}{dt} = Q - d_0C - l_1CL - a_1CCa \quad (7.1)$$

$$\frac{dL}{dt} = l(C - C_0) - l_0L - l_1CL \quad (7.2)$$

$$\frac{dCP}{dt} = pl_1CL - p_0CP \quad (7.3)$$

The following are obtained from the above;

$$Q - d_0C - l_1CL = 0 \quad (7.4)$$

$$L = \frac{l(C - C_0)}{(l_0 + l_1C)} = f(c) \quad (7.5)$$

$$CP = \frac{pl_1CL}{p_0} \quad (7.6)$$

$$F(C) = Q - d_0C - l_1Cf(c) \quad (7.7)$$

From these equations it's clear that the amount of carbon dioxide is inversely proportional to the amount of liquid species too. Which means, as the amount of liquid species we use increases the concentration of carbon dioxide decreases.

7.2 CASE II

WHEN ONLY ABSORBENT IS USED

Here we check whether we can reduce the amount of carbon dioxide in the atmosphere by using an absorbent alone. We use an absorbent equal in proportion with the amount of carbon dioxide emitted.

To analyze this case we take the required equations from our system and equate it to zero to find the values of some variables and to obtain the required final equation.

Later we put values in the resultant equation to analyze it numerically.

Given are the equations from our system;

$$\frac{dC}{dt} = Q - d_0C - l_1CL - a_1CCa \quad (7.8)$$

$$\frac{dCa}{dt} = aC - a_0Ca - a_1CCa \quad (7.9)$$

From the above we obtained the following equations;

$$Q - d_0C - a_1CCa = 0 \quad (7.10)$$

$$Ca = \frac{aC}{a_0 + a_1C} \quad (7.11)$$

From these we can understand that as the interaction and rate of absorbent increases, the concentration of carbon dioxide decreases. It is inversely proportional.

We can also verify this by differentiating the concentration of carbon 'C' with the rate of inflow of absorbent and its interaction rate. In both cases we will be getting a negative value.

7.3 CASE III

WHEN BOTH THE ABSORBENT AND THE LIQUID SPECIES ARE USED

In this case too we assume that the amount of carbon dioxide present in the atmosphere is greater than what we need.

Here we use both the absorbent and liquid species together to reduce the concentration of carbon dioxide in the atmosphere. We form the required equations from our system which is already defined. Then we analyze the case. We will be checking whether this case removes or reduces carbon dioxide more efficiently than the rest. We will later check it numerically also.

The following are the equations from the system;

$$\frac{dC}{dt} = Q - d_0C - l_1CL - a_1CCa \quad (7.12)$$

$$\frac{dL}{dt} = l(C - C_0) - l_0L - l_1CL \quad (7.13)$$

$$\frac{dCP}{dt} = pl_1CL - p_0CP \quad (7.14)$$

$$\frac{dCa}{dt} = aC - a_0Ca - a_1CCa \quad (7.15)$$

The equations below are obtained from the above.

$$Q - d_0C - l_1CL - a_1CCa = 0 \quad (7.16)$$

$$L = \frac{l(C - C_0)}{(l_0 + l_1C)} = f(c) \quad (7.17)$$

$$CP = \frac{pl_1CL}{p_0} \quad (7.18)$$

$$Ca = \frac{aC}{a_0 + a_1C} = g(c) \quad (7.19)$$

$$F(c) = Q - d_0C - l_1Cf(c) - a_1Cg(c) \quad (7.20)$$

In this case, since we use both the absorbent and liquid species the result will be much effective. There may arise a situation where the natural conditions become unfavourable so the chances of getting an unexpected result is there when we use either absorbent or liquid species.

Here we have two factors to reduce the amount of carbon dioxide, so more the effect will.

The equation itself shows that the concentration becomes negative when we use more amount of absorbent and liquid species together. And a negative value of carbon means that the excess amount is removed.

Chapter 8

VARIATIONS OF PARAMETERS

Variation of L with Q

Differentiating ' L ' with respect to ' C ', we get;

$$\frac{dL}{dC} = \frac{l_0}{(l_0 + l_1 C)^2} > 0 \quad (8.1)$$

And we already know that ;

$$\frac{dC}{dQ} > 0; \quad (8.2)$$

Therefore ;

$$\frac{dL}{dQ} = \frac{dL}{dC} \cdot \frac{dC}{dQ} \Rightarrow \frac{dL}{dQ} > 0 \quad (8.3)$$

From this we can understand that as the amount of carbon dioxide emitted increases, the amount of liquid species we should use will also increase.

Variation of C_a with Q

Differentiating ' C_a ' with respect to ' C ', we get;

$$\frac{dC_a}{dC} = \frac{aa_0}{(a_0 + a_1C)^2} \quad (8.4)$$

And we have ;

$$\frac{dC}{dQ} > 0 \quad (8.5)$$

Since

$$\frac{dC_a}{dQ} = \frac{dC_a}{dC} \cdot \frac{dC}{dQ} \quad (8.6)$$

We get ;

$$\frac{dC_a}{dQ} > 0 \quad (8.7)$$

From this we can understand that, as same as the above, here also, as the amount of carbon dioxide emitted increases, the amount of absorbent we should use will also increases.

Variation of C with l

Differentiating ' C ' with respect to ' l ', we get;

$$\frac{dC}{dL} = -\frac{l_1C^3}{Ql_0 + (l_1d_0 + ld)^2} < 0 \quad (8.8)$$

From this we can understand that the amount of carbon dioxide in the atmosphere decreases as the interaction between carbon dioxide and liquid species increases.

Chapter 9

NUMERICAL ANALYSIS

Now we are going to evaluate each of the equations in our cases by giving values to them numerically.

Let's first check what happens when only liquid species is used. And we can also verify whether the concentration of carbon dioxide is inversely proportional to the amount of liquid species as we got from the equations earlier.

For that;

Take the equation:

$$F(c) = Q - d_0C - l_1CL \quad (9.1)$$

Now let's fix the values of the variables other than 'L'.

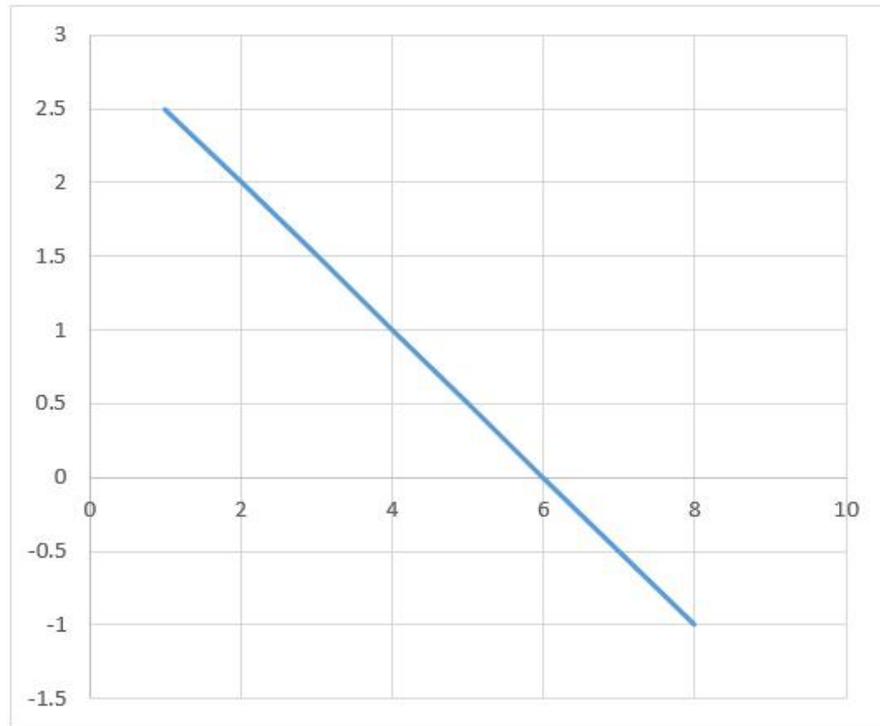
Let

$$Q = 4, d_0 = 1, C = 1, l_1 = 0.5 \quad (9.2)$$

From the graph below, clearly we can see that what we got from the equations is right. They are inversely proportional.

Table 9.1: Variations in the amount of carbon dioxide

x = L	y = F(C)
1	2.5
2	2
3	1.5
4	1
5	0.5
6	0
7	-0.5
8	-1



Now let's check the case when only absorbent is used.

Take the equation:

$$F(c) = Q - d_0C - a_1CCa \quad (9.3)$$

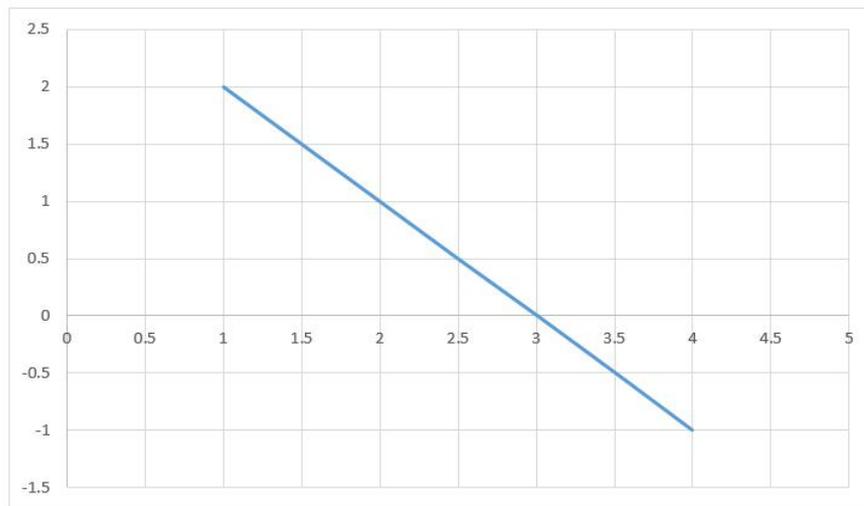
Now fix the values of the variables other than 'Ca '.

Let

$$Q = 4, d_0 = 1, C = 1, a_1 = 1. \quad (9.4)$$

Table 9.2: Variations in the amount of carbon dioxide

$x = Ca$	$y = F(C)$
1	2
1.5	1.5
2	1
2.5	0.5
3	0
3.5	-0.5
4	-1
4.5	-1.5



In this case also the concentration of carbon dioxide is inversely proportional. As the amount of absorbent increases the amount of carbon dioxide decreases.

Now let's check the case when both absorbent and liquid species is used.

Here we fix the values of variables except for ' L ' and ' Ca '.

Let

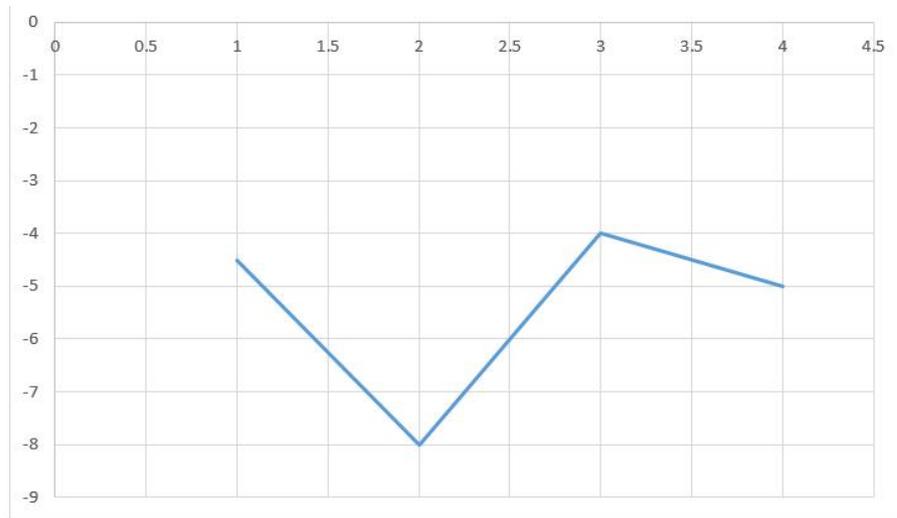
$$F(c) = Q - d_0C - l_1CL - a_1CCa \quad (9.5)$$

and the values be;

$$Q = 4, d_0 = 1, C = 2, l_1 = 1.5, a_1 = 1. \quad (9.6)$$

Table 9.3: Variations in the amount of carbon dioxide

x=L	y=Ca	F(C)
0.5	2	-3.5
1.5	1	-4.5
2	2	-8
1	1.5	-4
2	0.5	-5



Here we can see that the graph is completely in the negative region.

Chapter 10

CONCLUSION

After checking all the situations, we understood that the concentration of carbon dioxide decreases as the amount of the species we used for the reduction of carbon dioxide increases. The amount of carbon dioxide can be reduced and maintained in all cases. But we have to find the better one. That is, the case which is more efficient.

Since there is a chance for the absorbents to not react as we expect, it is better to use both liquid species and absorbents together. That is, the case III will yield better results than the other two. And we should always introduce the absorbents near the place where the emission exactly takes place so that the reactions will be effective. Timely action must be taken for the removal of carbon dioxide, or otherwise, it will cause a dangerous impact on the life on earth.

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**ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM**



**FINAL YEAR B.Sc PHYSICS
PROJECT REPORT
2021-22**

STUDY OF NPN TRANSISTOR CHARACTERISTICS

Project Report
on

STUDY OF NPN TRANSISTOR CHARACTERISTICS

Presented by

PRANAVY P

Register Number: AB19PHY022

Under the guidance of

Dr.SREEJA V G

Assistant Professor

Department of Physics,

St.Teresa's College(Autonomous), Ernakulam

Presented to

Mahatma Gandhi University, Kottayam

In partial fulfilment of the requirements for the award of
BACHELOR DEGREE OF SCIENCE IN PHYSICS



ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM
2022

**ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM**



CERTIFICATE

This is to certify that the project entitled '**STUDY OF NPN TRANSISTOR CHARACTERISTICS**' is an authentic work done by PRANAVY P, St. Teresa's College, Ernakulam, under my supervision at Department of Physics, St. Teresa's college partial requirements for the award of Degree of Bachelor Of science in Physics during the academic year 2021-22. The work presented in this dissertation has not been submitted for any other degree in this or any other university.

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Department

Dr. Sreeja V G

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Dr. Priya Parvathy Ameen Jose

Assistant Professor

PLACE: Ernakulam

DATE: 06/05/2022

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ERNAKULAM**



CERTIFICATE

This is to certify that the project entitled 'STUDY OF NPN TRANSISTOR CHARACTERISTICS' is an authentic work done by PRANAVY P, St. Teresa's College, Ernakulam, under my supervision at Department of Physics, St. Teresa's college partial requirements for the award of Degree of Bachelor Of science in Physics during the academic year 2021-22. The work presented in this dissertation has not been submitted for any other degree in this or any other university.

Supervising Guide
Department

Dr. Sreeja V G

Assistant Professor



Head of the Department

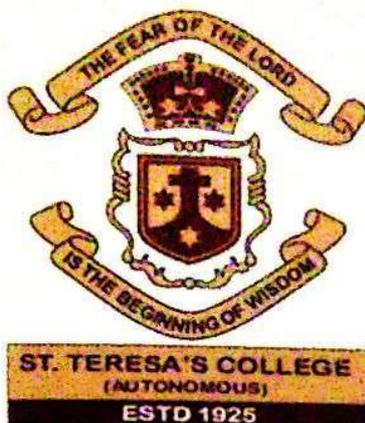
Dr. Priya Parvathy Ameena Jose

Assistant Professor

PLACE: Ernakulam

DATE: 06/05/2022

**ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM**



**B.Sc PHYSICS
PROJECT REPORT**

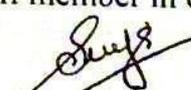
Name : PRANAVY P

Register Number : AB19PHY022

Year Of Work : 2021-2022

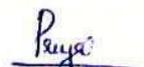
This is to certify that this Project work entitled '**STUDY OF NPN TRANSISTOR CHARACTERISTICS**' is an authentic work done by PRANAVY P.

Staff member in charge


Dr. Sreeja V G



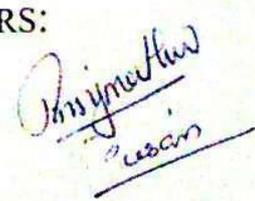
Head of the Department


Dr. Priya Parvathy Ameena Jose

Submitted for the university examination held at St. Teresa's College, Ernakulam .

Date: 08/05/2021

EXAMINERS:

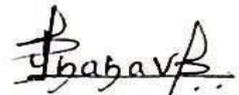

Susan

DECLARATION

I, **PRANAVY P**, final year B.sc Physics student, Department of Physics, St. Teresa's College, Ernakulam do hereby declare that the project work entitled '**STUDY OF NPN TRANSISITOR CHARACTERISTICS**' has been originally carried out under the guidance and supervision of Dr.Sreeja V G, Assistant Professor, Department of Physics, St.Teresa's College (Autonomous), Ernakulam in partial fulfilment for the award of the degree of Bachelor of Physics.I further declare that this project is not partially or wholly submitted for any other purpose and the data is included in the project is collected from various sources and true to the best of my knowledge.

PLACE: Ernakulam

DATE: 06/05/2022


PRANAVY . P

ABSTRACT

The transistor is without a doubt one of the most important contributions to the world of electrical components. Many firms have begun large-scale programmes to create transistor circuits, and practical applications will undoubtedly become more common in the near future.

This project “**Study of NPN Transistor Characteristics**” discusses the input and output characteristics of a NPN transistor in all the three configuration- CE, CB and CC.

ACKNOWLEDGEMENT

I thank Almighty for His abundant blessing throughout this journey and to make this project a successful one. I owe a deep sense of gratitude to our project guide Dr.Sreeja V G for her immense support and valuable ideas that helped us to make this project. I would like to express my sincere gratitude to the head of the department Dr. Priya Parvathy Ameena Jose for her esteemed guidance and encouragement. I would also like to thank and express my heartfelt acknowledgement to our teachers, lab assistants and all the non-teaching staff who have always been there to help us throughout. A heartfelt thanks to my group members for being the pillar of support. Last, thanking everyone who has helped and encouraged us to make this project a reality.

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CHAPTER - 1

AN INTRODUCTION TO TRANSISTORS

INTRODUCTION

A transistor is a type of semiconductor device that can be used to conduct as well as insulate electric current or voltage. It can act as both a switch and amplifier by providing a small signal voltage. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. They are the key components in most modern devices.

Transistors can be classified into :

- ❖ Bipolar junction transistors (BJTs)
- ❖ Field-Effect Transistors (FETs)
- ❖ Insulated Gate Bipolar Transistors (IGBTs)

Bipolar junction transistors are of two types :

- ❖ npn Transistor
- ❖ pnp Transistor

Field effect transistors are of two types :

- ❖ JFET
- ❖ MOSFET

1.1 BIPOLAR JUNCTION TRANSISTORS

A bipolar junction transistor or BJT is a three terminal semiconductor device consisting of two p-n junction diodes that can amplify signals. It uses both electrons and holes as charge carriers.

A typical transistor has three terminals that help to make connections to external circuits and carry the current. The three terminals are:

1. Emitter
2. Base
3. Collector

Emitter :

The emitter section supplies the charge. Hence it is heavily doped so that it can inject a large number of charge carriers into the base. The size of the emitter is always greater than the base but less than the collector. It is the negative lead of the transistor.

Base :

The base is the middle layer. The size of the base is very small. It is less than the emitter and collector. The size is kept small so that the charge that is coming from the emitter and entering the base do not recombine in the base region and is transferred to the collector region.

The base is lightly doped and it is used to activate the transistor.

Collector :

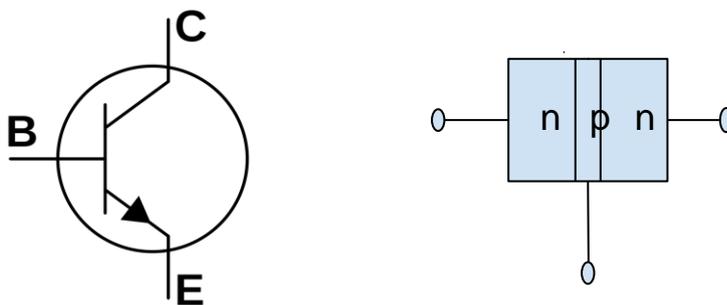
The function of the collector is to collect the charge carriers. It is moderately doped and the size is slightly large when compared to the emitter and base. It is because all the charges coming from the emitter recombine at base and heat is released in this process. Hence the collector terminal must be large so that it can dissipate the heat and the device is not burnt.

Bipolar junction transistors can be classified into two types:

- NPN Transistor
- PNP Transistor

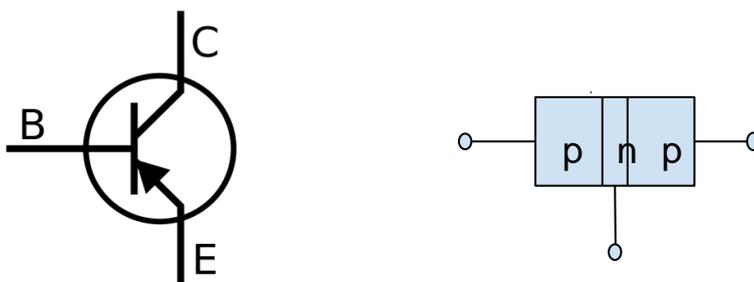
1.1.1 NPN Transistor

When a P type semiconductor layer is sandwiched between two N-type semiconductor layers the transistor is said to be a NPN transistor.



1.1.2 PNP Transistor

When an N-type semiconductor layer is sandwiched between two P-type semiconductor layers the transistor is said to be a PNP transistor



1.2 WORKING OF A TRANSISTOR

The transistor mainly works in three regions:

1. Active Region :-

When the emitter junction is forward biased and the collector junction is reverse bias the transistor is said to be in active mode. This region is used for amplification purpose. In the active region collector current is β times the base current i.e,

$$I_c = \beta I_B$$

Where,

I_c = Collector current

β = current amplification factor

I_B = base current

2. Saturation region :-

When both the emitter and collector junctions are forward biased the transistor will work in the saturation region. In this region the transistor is used for switching operation. The transistor act as an ON switch. In the saturation region

$$I_c = I_E$$

Where,

I_c = Collector current

I_E = Emitter current

3. Cut-off region :-

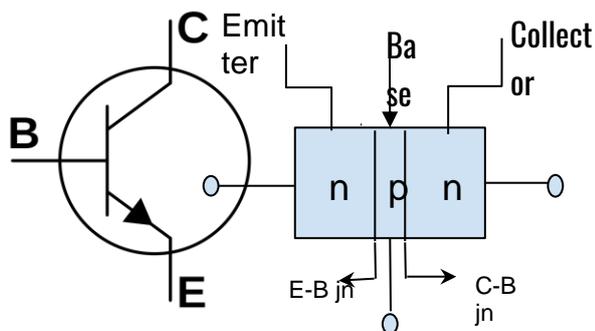
The transistor works in the Cut-off region when both the emitter and collector are reverse biased. Therefore,

$$I_E = I_c = I_B$$

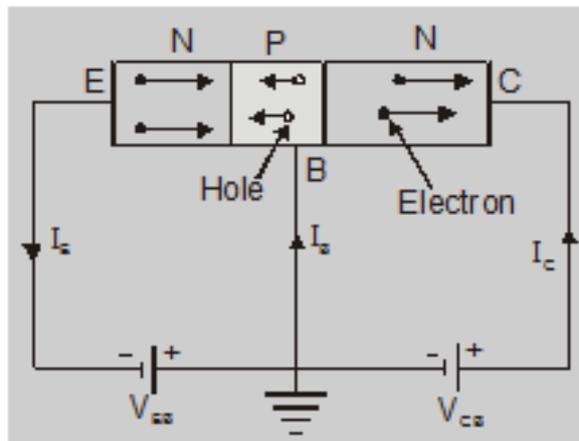
4. Reverse Active :-

In this the emitter base junction is reverse biased and collector base junction is forward biased.

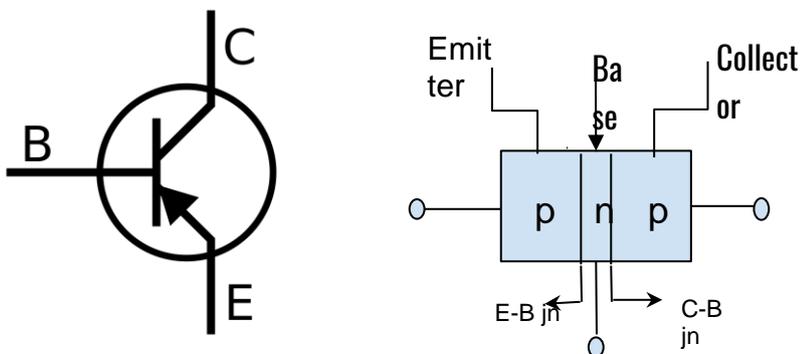
NPN Transistor



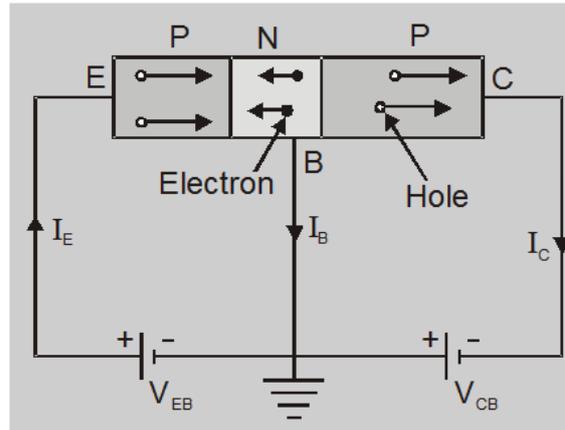
Since the Emitter-Base junction in a npn transistor is forward biased, a lot of electrons from the emitter enters the base region. Base is lightly doped with p-type impurities (Holes). Due to this there is very less electron-hole recombination i.e., very less electrons combine to constitute the base current (I_B). The remaining electrons cross over the collector region to constitute the collector current (I_C).



PNP Transistor



In a pnp transistor the emitter base junction is forward biased and collector base junction is reverse biased. Due to this a large number of holes flow from the emitter to the base and the electrons from base to the emitter region. The base is lightly doped with n-type impurities and hence number of electrons in base is very small. Due to this electron-hole recombination is less and a very few holes combine with the electrons to create the base current (I_B). The remaining holes cross over the collector region to create the collector current (I_C).



1.3 ADVANTAGES OF USING TRANSISTORS

Transistors have been proven as a very important invention in science. It has many uses and advantages:

- It is small in size and is very cost-efficient.
- It needs very low voltage to function.
- It has a long life and requires no power to operate.
- A single integrated circuit can be developed using the transistor.
- Current switches fast in the terminals.

1.4 LIMITATIONS OF TRANSISTORS

Even though transistors are extremely efficient, there are some limitations to its uses:

- Transistors get damaged very easily due to changes in electrical and temperature conditions.
- They lack higher electron mobility.
- They can get affected by radiation

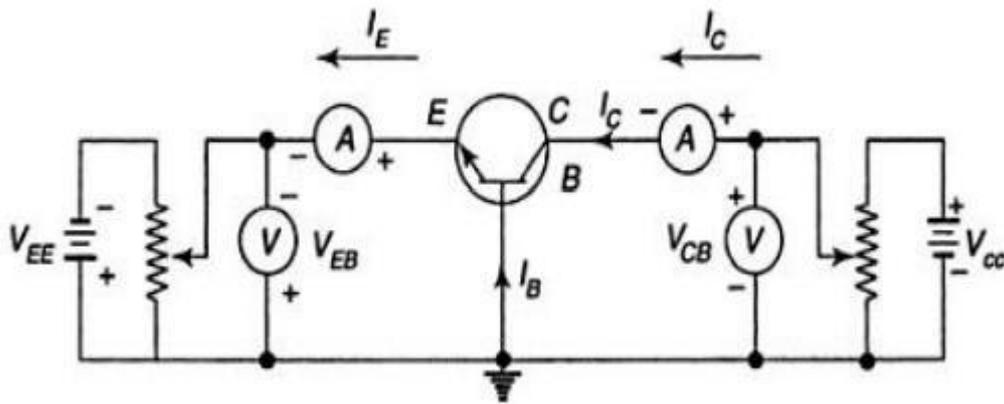
1.5 TRANSISTOR CONFIGURATIONS

Three types of configurations in a transistor are :

- Common Base configuration (CB)
- Common Emitter configuration (CE)
- Common Collector configuration (CC)

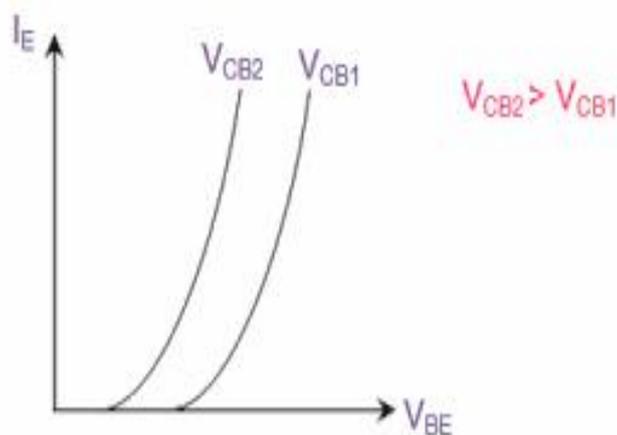
1.5.1 COMMON BASE CONFIGURATION

In the Common base configuration (CB) the Base is grounded and used as a common terminal for both input and output. It is also known as grounded base configuration. Here, the emitter is the input terminal and the collector is the output terminal.



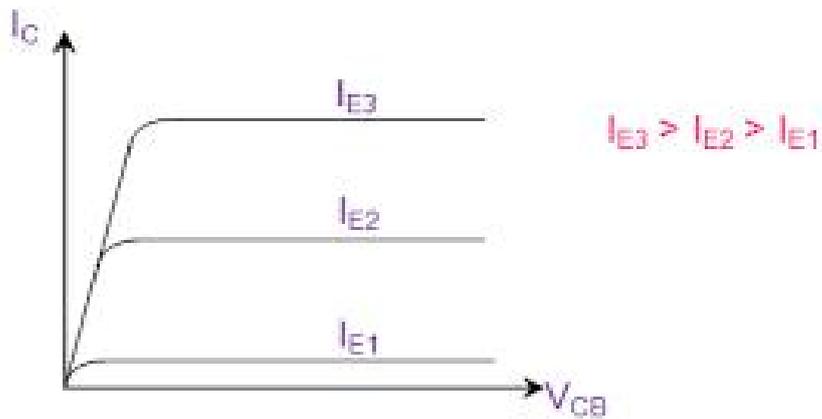
Input Characteristics

It is defined as the characteristic curve drawn between the input voltage to input current keeping output voltage constant. To determine the input voltage the collector base voltage (V_{CB}) is kept constant at zero and the emitter current I_E is increased from zero by increasing V_{EB} . This is repeated for higher fixed values of V_{CB}



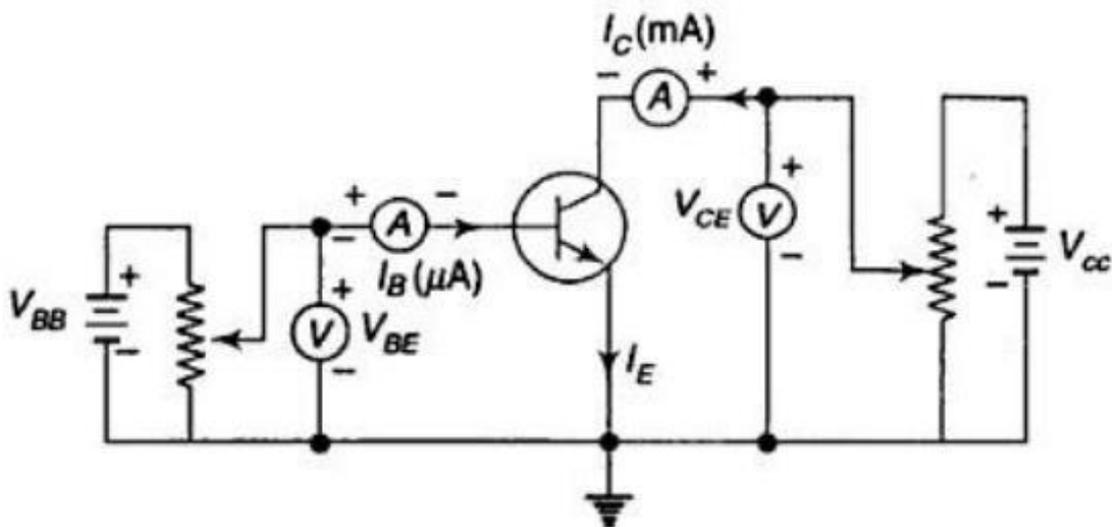
Output characteristics

It is defined as the characteristic curve drawn between output current and output voltage keeping input current constant. To determine the output characteristics the emitter current is kept constant at a particular value and the collector current (I_C) is increased from zero to higher values by increasing V_{CB} . This is repeated for higher fixed values of I_E . It is seen that for a constant value of I_E , I_C is independent of V_{CB} and the curves are parallel to X-axis of V_{CB}



1.5.2 COMMON EMITTER CONFIGURATION

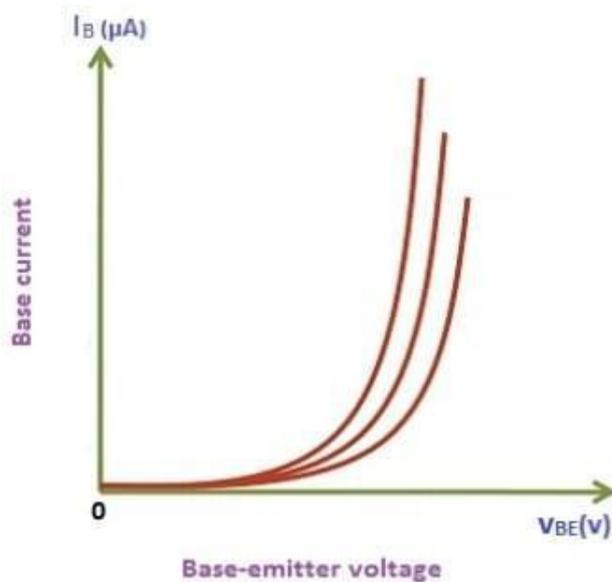
In common Emitter configuration (CE) the emitter is grounded and is a common terminal for both the input and output. It is also known as grounded emitter configuration. Here base is used as the input terminal and collector as the output terminal.



Input Characteristics

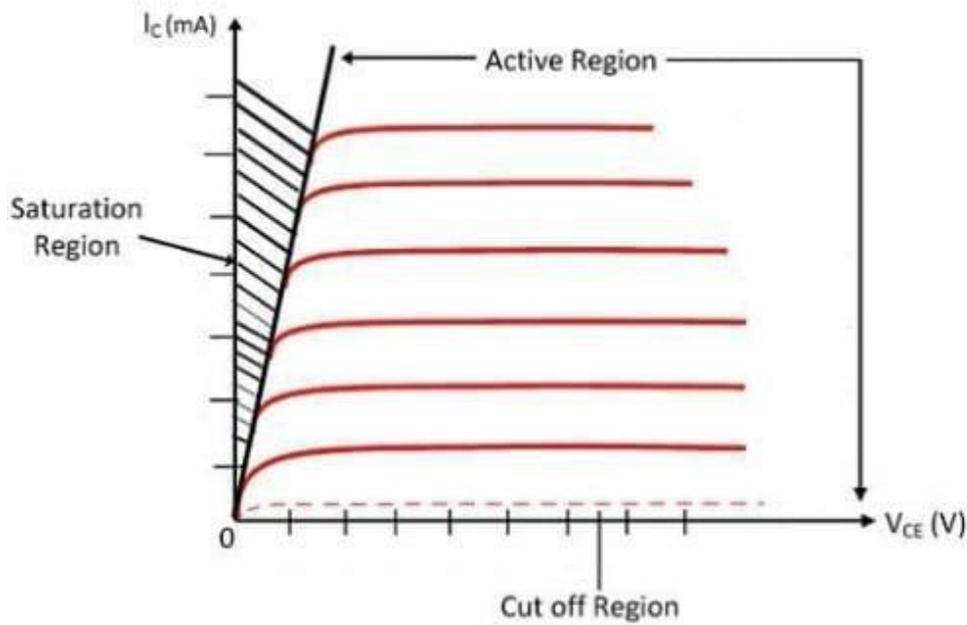
It is defined as the curve drawn between the input voltage and the input current at constant output voltage.

To determine the input characteristics the collector base voltage is kept constant V_{CB} at zero and base current I_B is increased from zero by increasing V_{BE} . This is repeated for higher values of V_{CE} .



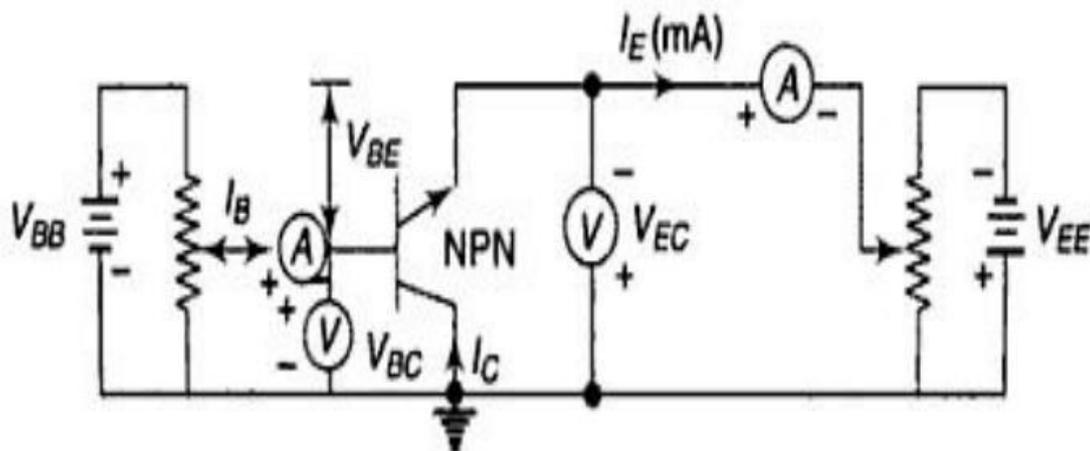
Output Characteristics

It is defined as the characteristic curve drawn between the output voltage to the output current at constant input current. To determine output characteristics, the base current I_B is kept constant at zero and collector current I_C is increased from zero by increasing V_{CE} . This is repeated for higher fixed values of I_B .



1.5.3 COMMON COLLECTOR CONFIGURATION

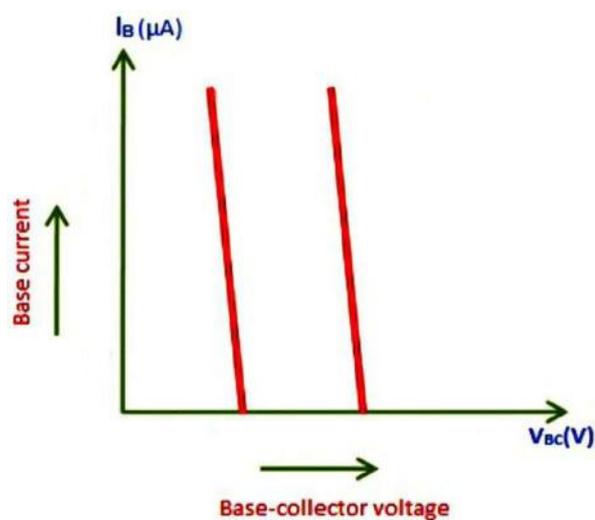
In a common collector configuration the collector is grounded and is used as the common terminal for both the input and the output terminal. It is also known as grounded collector configuration. Here the base is the input terminal and the emitter is the output terminal.



Input Characteristics

It is defined as the characteristic curve drawn between input voltage to input current whereas output voltage is constant.

To determine input characteristics, the emitter base voltage V_{EB} is kept constant at zero and base current I_B is increased from zero by increasing V_{BC} . This is repeated for higher fixed values of V_{CE} .

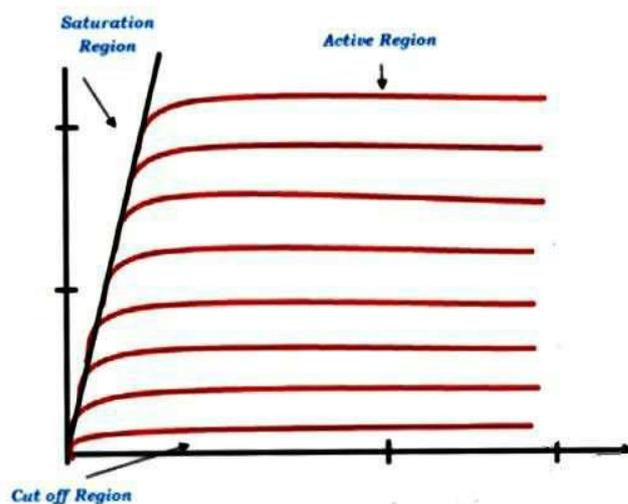


Output characteristics

It is defined as the characteristic curve drawn between output voltage to output current whereas input current is constant.

To determine output characteristics, the base current I_B is kept constant at zero and emitter current I_E is increased from zero by increasing V_{EC} . This is repeated for higher fixed values of I_B .

From the characteristic it is seen that for a constant value of I_B , I_E is independent of V_{EB} and the curves are parallel to the axis of V_{EC} .



CONCLUSION

Thus, a transistor is an electronic device made of three layers of semiconductor material that can act as an insulator and a conductor. It is an essential part of many technological advances and devices. This chapter helps to give an idea about the basic theory of transistors. It contains a quick view on the construction, working, types of transistors (nnp and pnp transistors) and advantages and limitations. It also covers the three configurations of transistors - Common Emitter Configuration (CE), Common Base Configuration (CB) and Common Collector Configuration (CC) and their respective input and output characteristics.

CHAPTER 2

BASIC REQUIREMENTS

(Details of Components and Devices)

INTRODUCTION

The experiment works with a npn transistor in all the three configuration i.e. CE, CB and CC configuration, to find the input and output characteristics. The basic devices used are transistor, voltmeter, ammeter, rheostat, battery eliminator, bread board and connection wires. This chapter contains the details regarding the components and devices used for the experiments.

2.1. COMPONENTS AND DEVICES

(i) Transistor BC 107

The BC107 is a small single NPN Transistor available in TO-18 metal can package. These transistors are age old and have been used in low noise and low signal designs. Today a lot of new transistors have come as replacement for BC107, but still the transistor can be found in the market for its legacy.



The **BC107** is a low signal NPN which is known for its low noise operations making it famously used in signal processing circuits and television receivers.

The transistor is still available in the market due to its legacy but you will find better modern transistors as replacement for BC107.

Applications:

- Driver Modules like Relay Driver, LED driver etc..
- Amplifier modules like Audio amplifiers, signal Amplifier etc..
- Darlington pair

(ii) Voltmeter:

It is an instrument that measures voltages of either direct or alternating electric current on a scale usually graduated in volts, millivolts (0.001 volt), or kilovolts (1,000 volts). Many voltmeters are digital, giving readings as numerical displays.



Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Meters using amplifiers can measure tiny voltages of microvolts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to-digital converter.

(iii) Ammeter

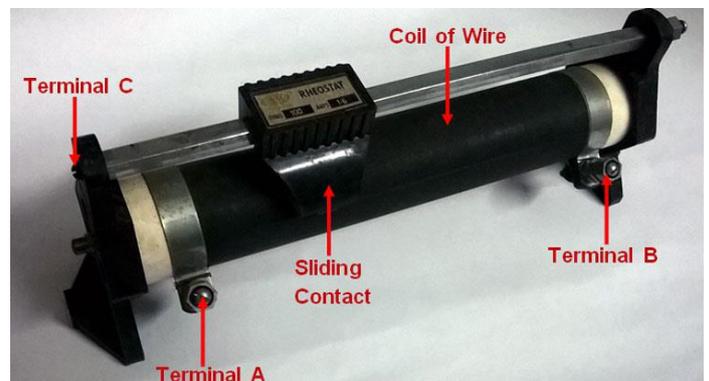
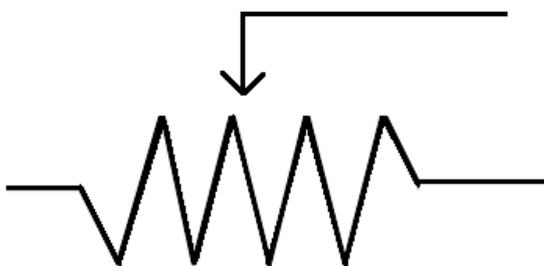
It is an instrument for measuring either direct or alternating electric current, in amperes. An ammeter can measure a wide range of current values because at

high values only a small portion of the current is directed through the meter mechanism; a shunt in parallel with the metre carries the major portion.



(iii) Rheostat

A rheostat is defined as a variable resistor which is used for controlling the flow of electric current either by increasing or decreasing the resistance. The term rheostat was coined by the English scientist Sir Charles Wheatstone and is derived from the Greek word “rheos” and “statis” which means current controlling device.



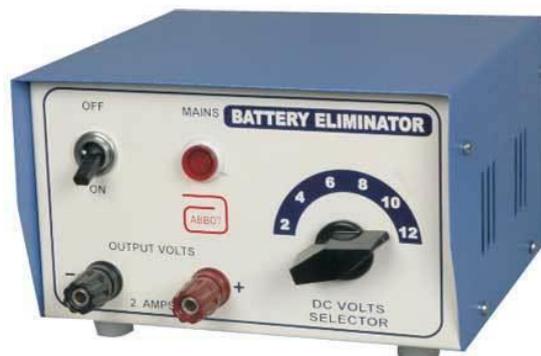
For any given rheostat, we can change its resistance. We know that resistance is dependent on three factors:

- Length
- Areas of cross-section
- Type

In order to change the resistance of the rheostat, the effective length needs to be changed with the help of sliding contact. The effective length is defined as the length between the fixed terminal and the position of the sliding terminal. As the effective length changes, the resistance of the rheostat changes.

(iv) **Battery Eliminator:**

A battery eliminator is a device powered by an electrical source other than a battery, which then converts the source to a suitable DC voltage that may be used by a second device designed to be powered by batteries. A battery eliminator eliminates the need to replace batteries but may remove the advantage of portability. A battery eliminator is also effective in replacing obsolete battery designs.



2.2 PROCEDURE

Connections are made as shown in the circuit diagrams. The rheostat Rh1 is used to vary base voltage (input voltage) V_{BE} and it is read from voltmeter V1. The base current (input current) I_B is measured using a microammeter (μA). The collector voltage (output voltage) V_{CE} is varied using the rheostat Rh2 and readings are noted from voltmeter V2. The collector current (output current) I_c is measured by the milliammeter (mA).

CONCLUSION

The chapter briefs the details, uses and types of various components and devices used in the experiment to find out the input and output characteristics of the transistor. The experiment is, thus, done with the npn transistor - Transistor BC 107, ammeter - to measure the current, voltmeter - to measure the voltage drop, rheostat - used as a variable resistance, battery eliminator - for supply of voltage, bread board and connecting wires.

CHAPTER-3

CHARACTERISTICS OF COMMON EMITTER CONFIGURATION

INTRODUCTION

In this chapter we try to find the input and output characteristics of common emitter configuration experimentally and compare it with the theoretical values.

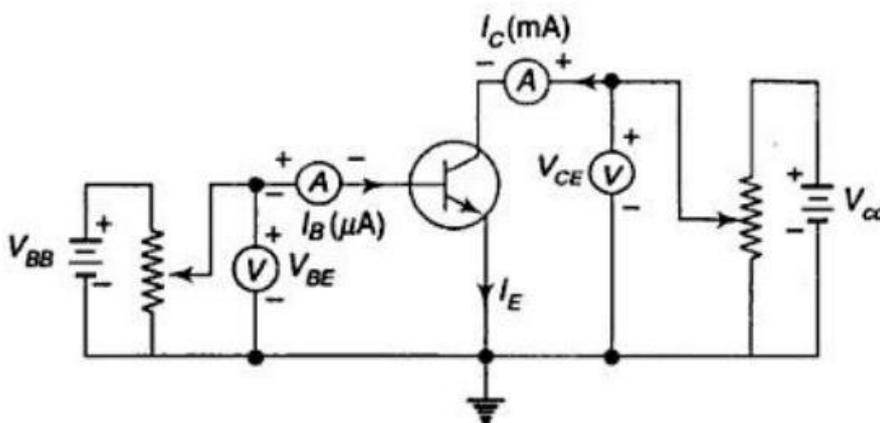
Aim

To study the input and output characteristics of a transistor in common emitter (CE) configuration.

Apparatus

Transistor BC107, Breadboard, Rheostat, Analogue Ammeter, Analogue voltmeter

Circuit diagram



3.1 Procedure

a) To find input characteristics:

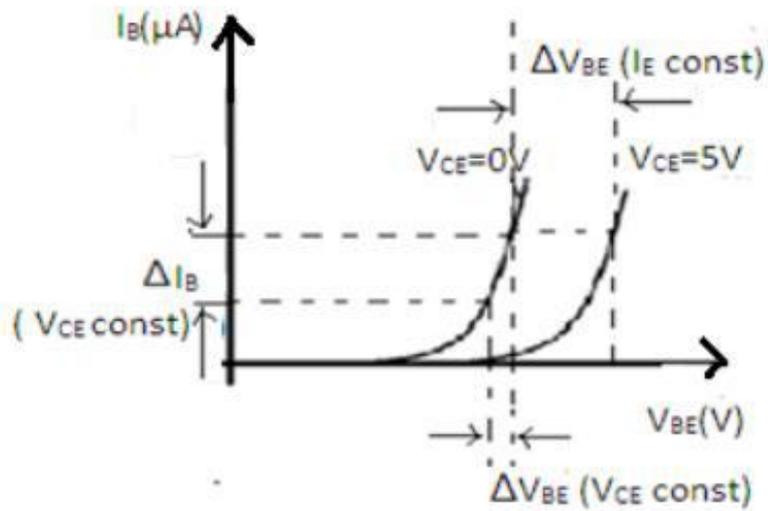
Connect the circuit diagram as shown in the circuit diagram. Keep output voltage $V_{CE}=0V$ by varying V_{CC} . Varying V_{BB} gradually, note down the base current I_B and base emitter voltage V_{BE} . Step size is not fixed because of linear curve. Initially vary V_{BB} in steps of 0.1 V. Once the current starts increasing vary V_{BB} in steps of 1V up to 12 V. Repeat the above procedure.

b) To find output characteristics:

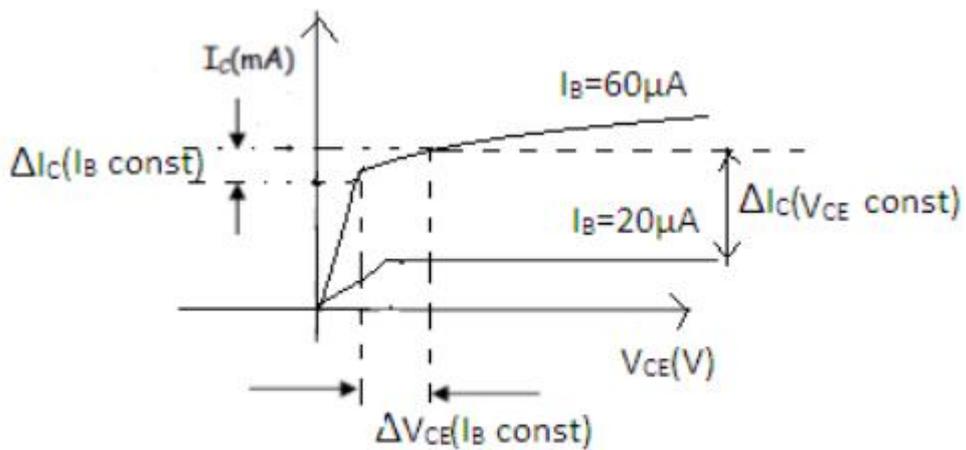
Connect the circuit diagram as shown in the figure. Keep base current (I_B) constant by varying the rheostat. Varying the rheostat gradually note down collector current (I_C) and collector emitter voltage (V_{CE}) Repeat the above experiment.

Plot the graph of input characteristics by taking V_{BE} on X axis and I_B on Y axis at a constant V_{CE} as a constant parameter. Plot the graph of output characteristics by taking V_{CE} on X axis and taking I_C on Y axis taking I_B as a constant parameter.

Graph



Input Characteristics



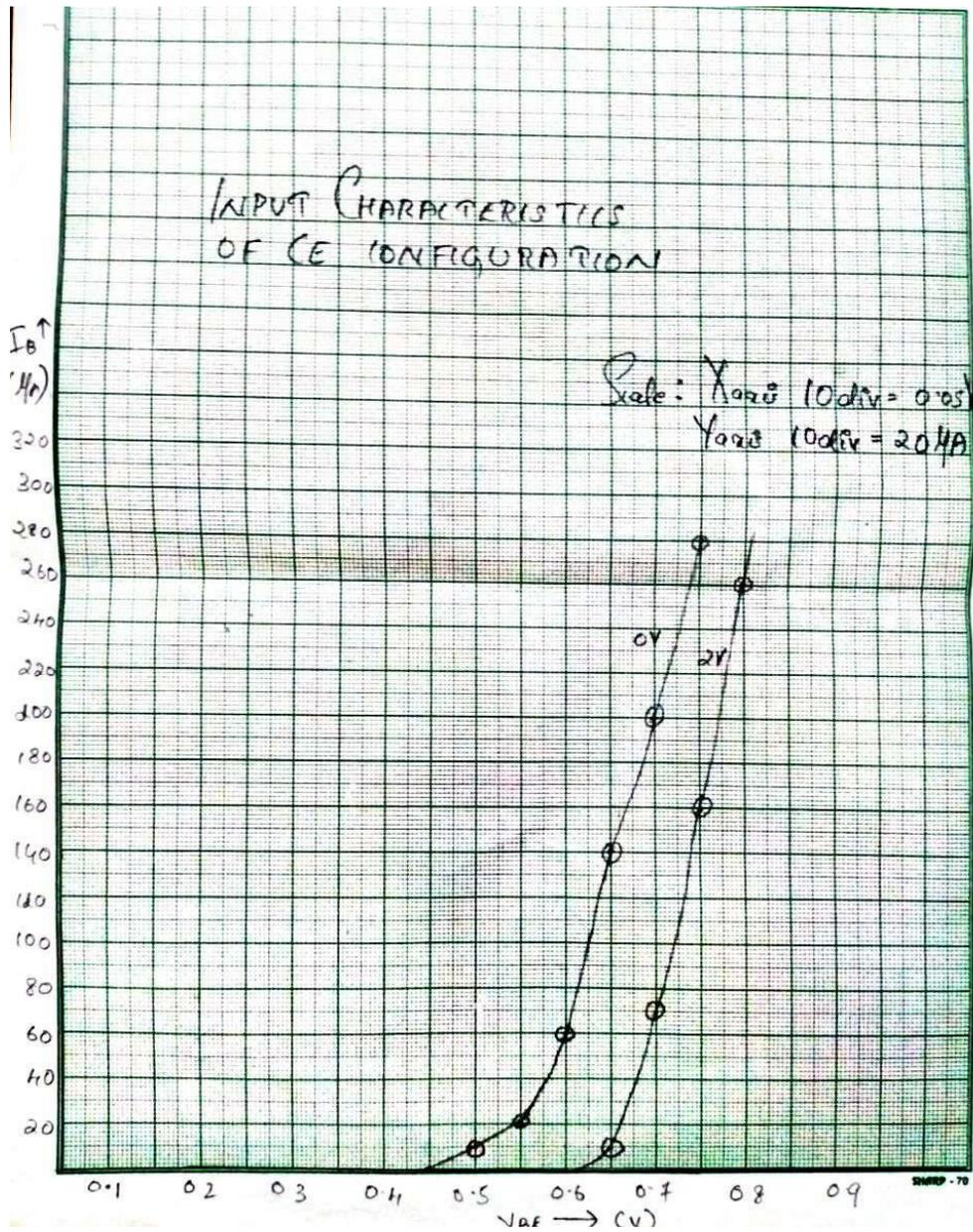
Output Characteristics

3.2 Observations

INPUT CHARACTERISTICS

$V_{CE} = 0V$		$V_{CE} = 2V$	
$V_{BE}(V)$	$I_B(\mu A)$	$V_{BE}(V)$	$I_B(\mu A)$
0.5	10	0.65	10

0.55	20	0.7	70
0.6	60	0.75	160
0.65	140	0.8	260
0.7	200	0.85	370
0.75	280	0.9	460



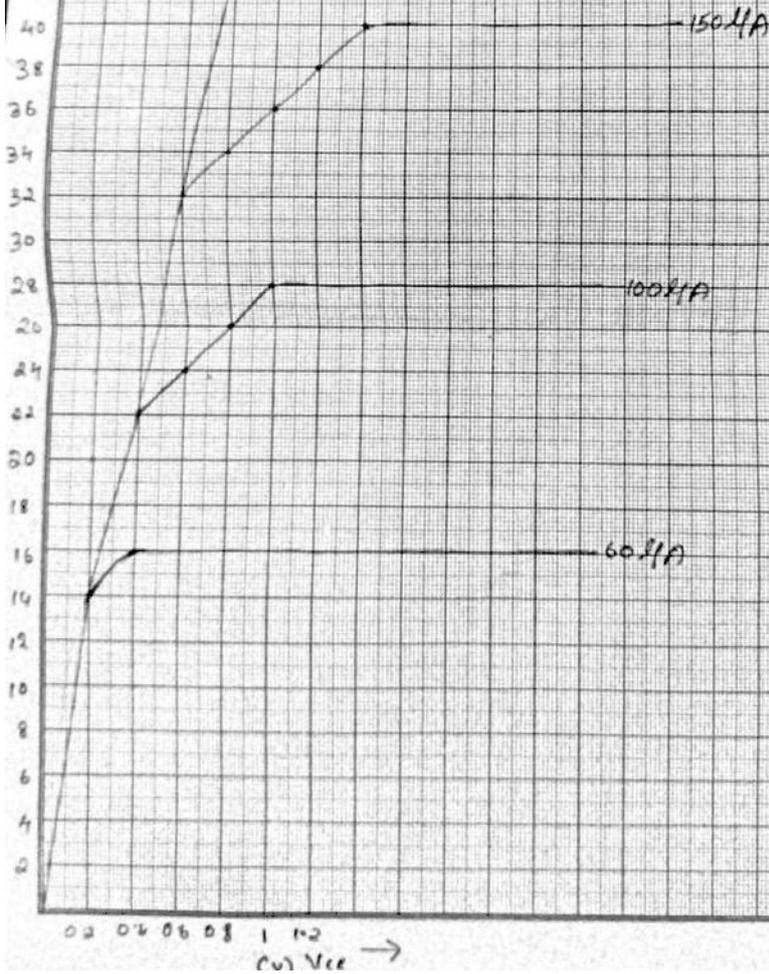
OUTPUT CHARACTERISTICS

$I_B=0 \mu\text{A}$		$I_B=100 \mu\text{A}$		$I_B=150 \mu\text{A}$	
V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)
0	0	0	0	0	0
0.2	14	0.2	20	0.2	24
0.4	16	0.4	22	0.4	28
0.6	16	0.6	24	0.6	32
0.8	16	0.8	26	0.8	34
1	16	1	28	1	36
1.2	16	1.2	28	1.2	38
1.4	16	1.4	28	1.4	40
1.6	16	1.6	28	1.6	40
1.8	16	1.8	28	1.8	40

OUTPUT CHARACTERISTICS
OF CE CONFIGURATION

Scales: X-axis: 10div = 0.2V
Y-axis: 10div = 2mA

(46)
 $I_c \uparrow$



Calculations from the Graph

To obtain input resistance find ΔV_{BE} and ΔI_B

For a constant V_{CE} on one of the input characteristics;

$$\begin{aligned}\text{Input impedance} &= \Delta V_{BE} / \Delta I_B = (0.6 - 0.5) / (60 - 10) \\ &= 0.1 / 50 = 0.002 \Omega\end{aligned}$$

$$\begin{aligned}\text{Reverse voltage gain} &= \Delta V_{EB} / \Delta V_{CE} = (0.6 - 0.5) / (0.4 - 0.2) \\ &= 0.1 / 0.2 = 0.5\end{aligned}$$

To obtain output resistance find $\Delta I_C / \Delta V_{CB}$ at a constant I_B .

$$\begin{aligned}\text{Forward current gain} &= \Delta I_C / \Delta I_B = (16 - 14) / (20 - 10) \\ &= 2 / 10 = 0.2\end{aligned}$$

3.3 Results

- a. The input resistance = 0.002Ω
- b. The reverse voltage gain = 0.5
- c. The forward current gain = 0.2

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CE configuration. We have also included the observations and graphs of the same.

CHAPTER-4

CHARACTERISTICS OF COMMON BASE CONFIGURATION

INTRODUCTION

In this chapter we try to find out the input and output characteristics of Common base (CB) configuration experimentally and compare it to theoretical values.

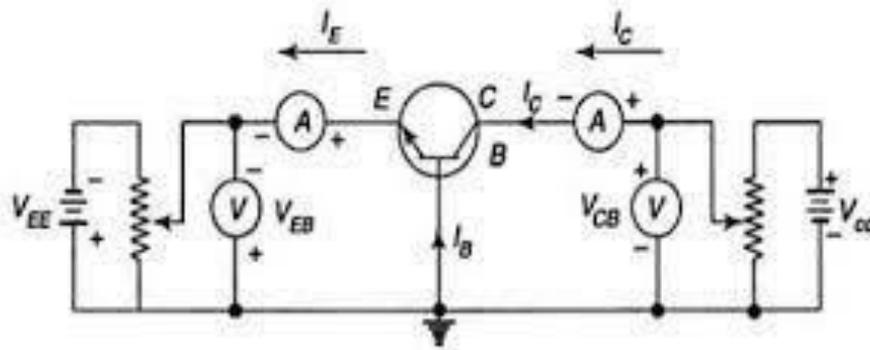
Aim

To study the input and output Characteristics of a transistor in a CB configuration.

Apparatus

Transistor BC 107, Rheostat, Analogue Ammeter, Analogue Voltmeter, Connecting wires.

Circuit Diagram



4.1

Procedure

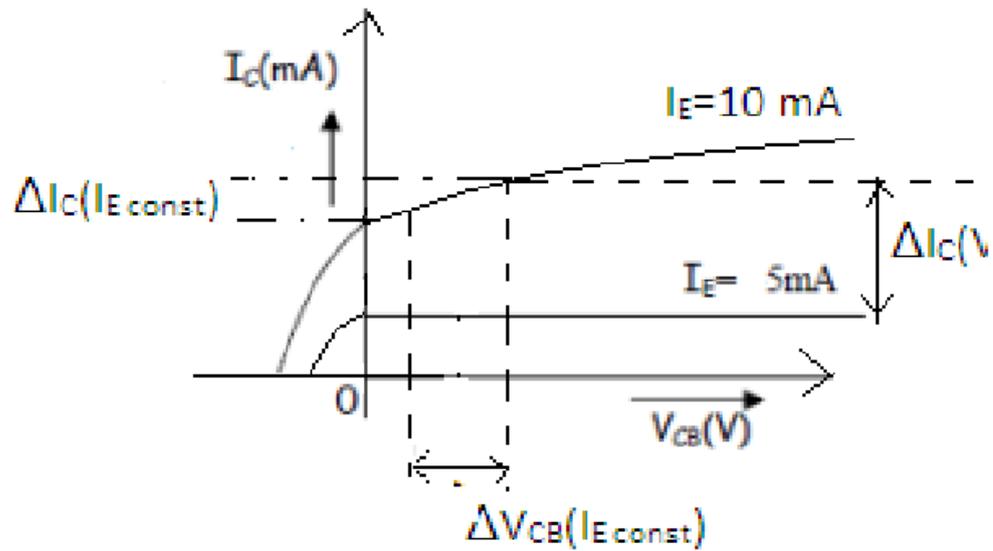
a) To find Input Characteristics:

Connect the circuit as shown in the circuit diagram. Keep output voltage V_{CB} constant by varying rheostat. Varying rheostat gradually, note down emitter current (I_E) and emitter-base voltage (V_{EB}). Step size is not fixed because of the nonlinear curve. Repeat above procedure for different constant value V_{CB}

b) To find Output Characteristics:

Connect the circuit as shown in the circuit diagram. Keep emitter current (I_E) by varying resistance in rheostat and note down collector current I_C and collector-base voltage (V_{CB}). Repeat the procedure for different constant values of I_E Plot the input characteristics for different values of V_{CB} by taking V_{EB} on X-axis and I_E on Y-axis taking V_{CB} as constant parameter. Plot the output characteristics by taking V_{CB} on X-axis and I_C on Y-axis taking I_E as a constant parameter.

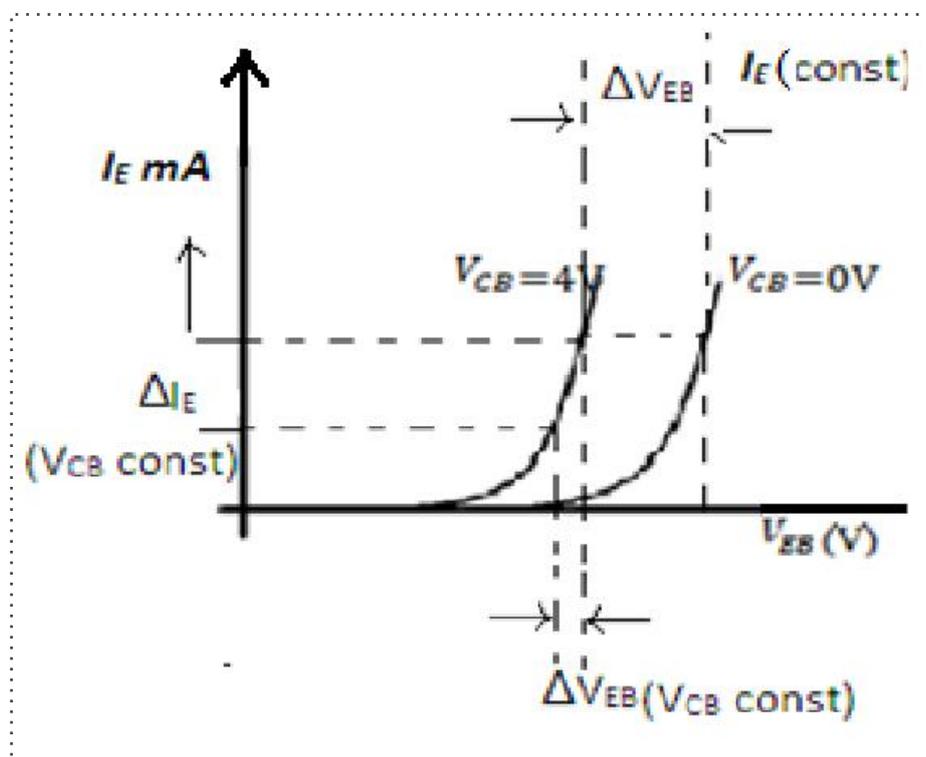
Graph



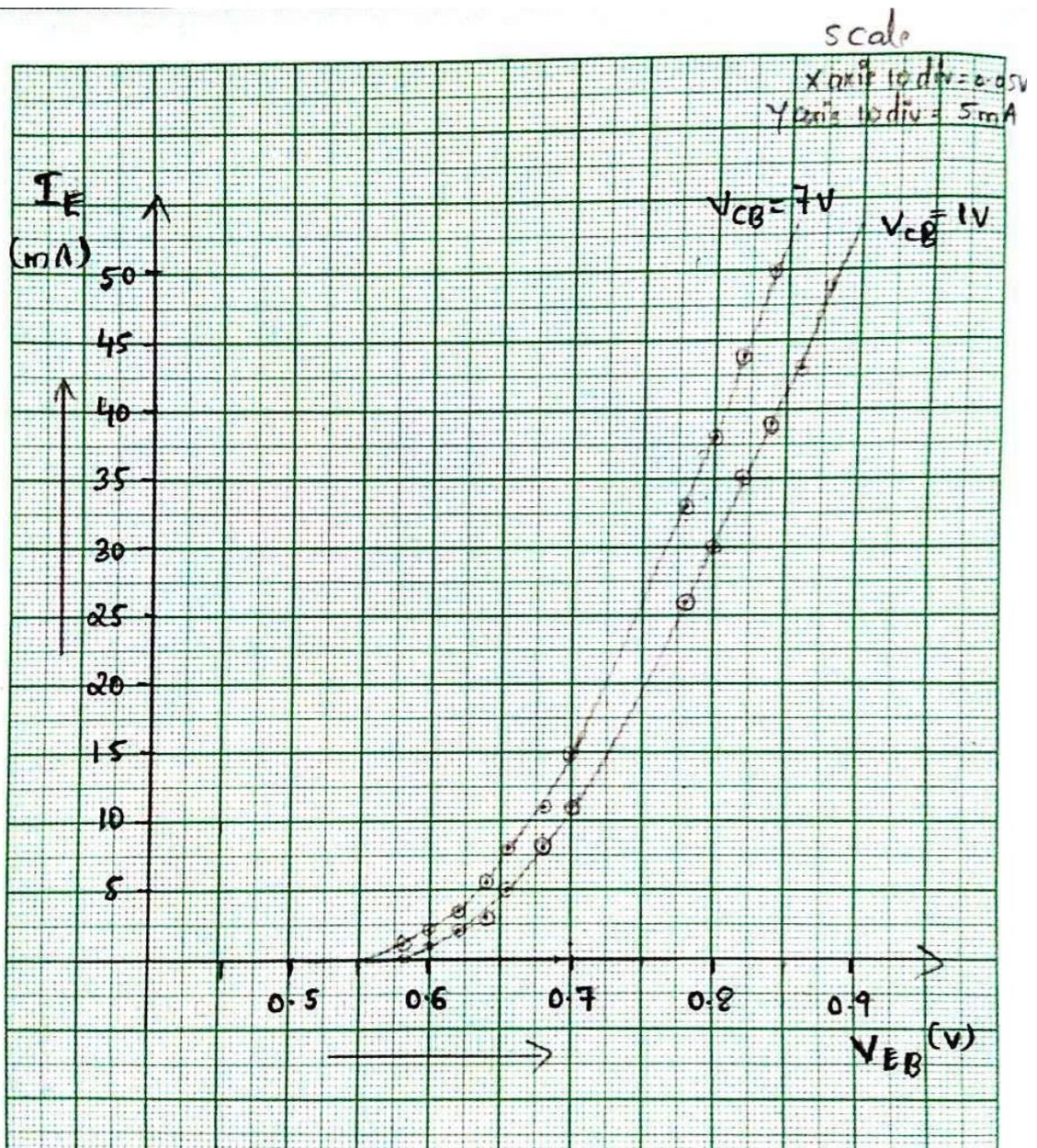
4.2 Observations

INPUT CHARACTERISTICS

$V_{cb} = 1 \text{ V}$		$V_{cb} = 7 \text{ V}$	
$V_{EB} \text{ (V)}$	$I_E \text{ (mA)}$	$V_{EB} \text{ (V)}$	$I_E \text{ (mA)}$



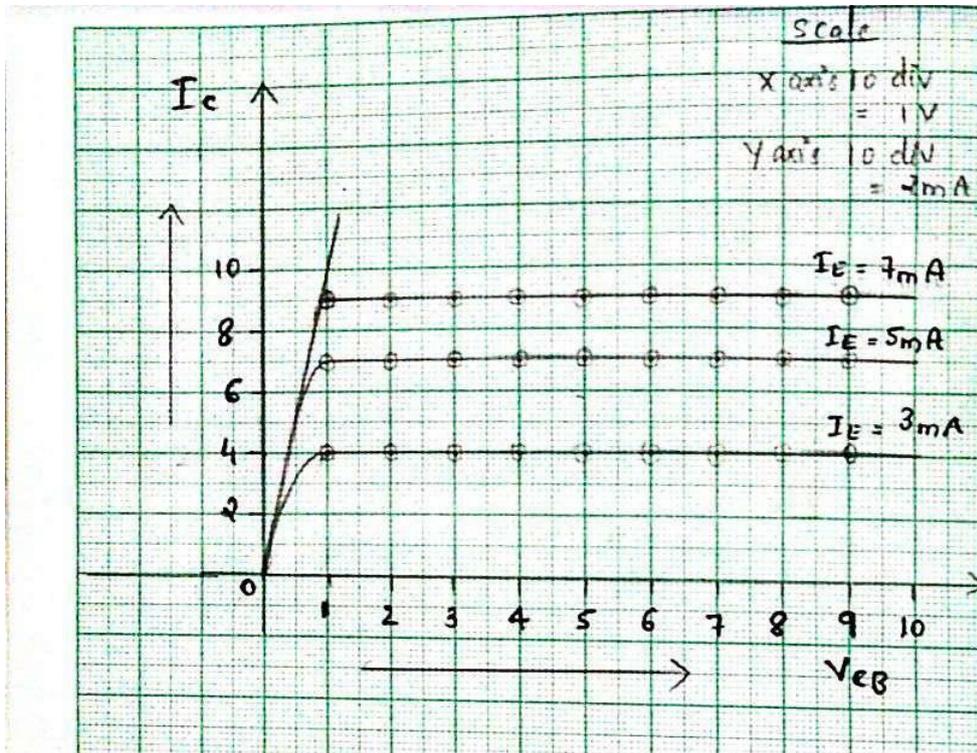
0.58	0	0.58	1
0.6	1	0.6	2
0.62	2	0.62	3.5
0.64	3	0.64	5.5
0.66	5	0.66	8
0.68	8	0.68	11
0.7	11	0.7	15
0.72	14	0.72	18
0.74	18	0.74	23
0.76	22	0.76	28
0.78	26	0.78	33
0.8	30	.8	38
0.82	35	.82	44
0.84	39	.84	50
0.86	43	.86	Out of range
0.88	49		
0.9	Out of range		



OUTPUT CHARACTERISTICS

$I_E = 3 \text{ mA}$		$I_E = 5 \text{ mA}$		$I_E = 7 \text{ mA}$	
V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)
0	4	0	7	0	9
1	4	1	7	1	9
2	4	2	7	2	9

3	4	3	7	3	9
4	4	4	7	4	9
5	4	5	7	5	9
6	4	6	7	6	9
7	4	7	7	7	9
8	4	8	7	8	9
9	4	9	7	9	9



Calculations from the Graph

1) Input characteristics:

$$\text{Input Impedance} = \Delta V_{EB} / \Delta I_E = (0.88 - 0.84) / (50 - 49)$$

$$= 0.25 / 1 = 0.25 \Omega$$

$$\begin{aligned}\text{Reverse voltage gain} &= \Delta V_{EB} / \Delta V_{CB} = (0.64 - 0.62) / (3 - 2) \\ &= 0.02 / 1 = 0.02\end{aligned}$$

2) Output Characteristics:

$$\text{Forward Current gain} = \Delta I_C / \Delta I_E = (9-7)/(7-5) = 2/2 = 1$$

4.3 Results

- a. The Input resistance = 0.25 Ω
- b. The Reverse Voltage gain = 0.02
- c. The Forward Current gain = 1

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CB configuration. We have also included the observations and graphs of the same.

CHAPTER-5

CHARACTERISTICS OF COMMON COLLECTOR CONFIGURATION

INTRODUCTION

In this chapter we will be discussing about the input and output characteristics of Common Collector Configuration

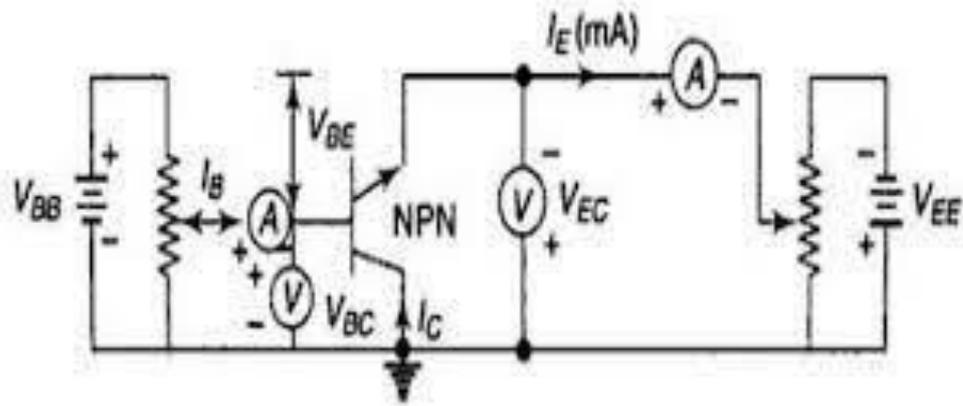
Aim

To study the input and output characteristics of a transistor in a common collector configuration(CC).

Apparatus

Transistor BC 107, Rheostat, Analogue ammeter, Analogue voltmeter, Connecting wires

Circuit Diagram



5.1 Procedure

a) Input Characteristics:

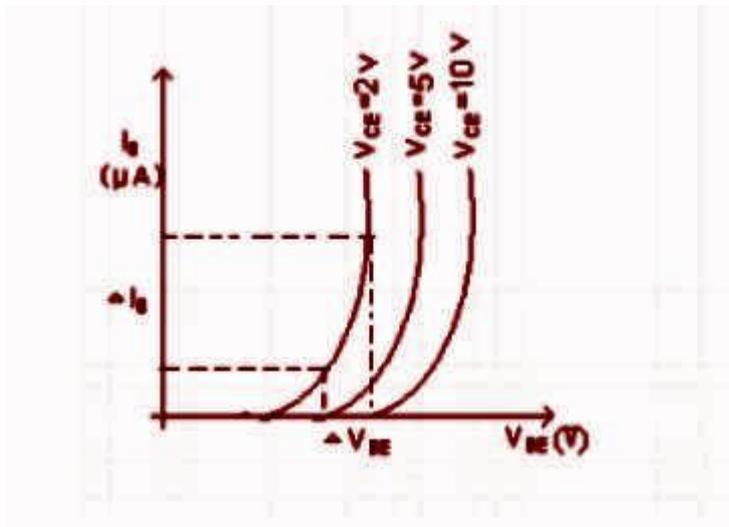
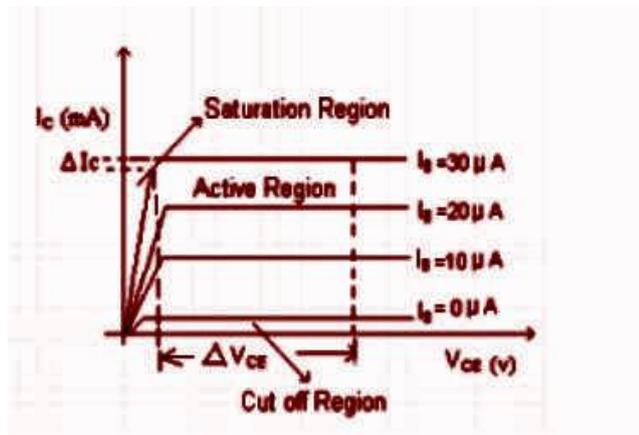
Connect the circuit as shown in the circuit diagram. Keep output voltage V_{CE} as constant rheostat. Varying gradually, note down base current I_B and emitter-base voltage (V_{BE}). Step size is not fixed because of the nonlinear curve. Repeat the experiment for different constant values of V_{CE} .

b) Output Characteristics:

Fix base current, I_B at constant value. Vary the output voltage in steps. Measure the voltage V_{CE} and current I_C for different values. Repeat the experiment for different constant values of I_B . Draw output static characteristics for tabulated values.

Plot the input characteristics for different values of V_{CE} by taking V_{BE} on X-axis and I_B on Y-axis taking V_{CC} as constant parameter. Plot the output characteristics by taking V_{CE} on X-axis and I_C on Y-axis taking I_B as a constant parameter.

Graph



Input Characteristics

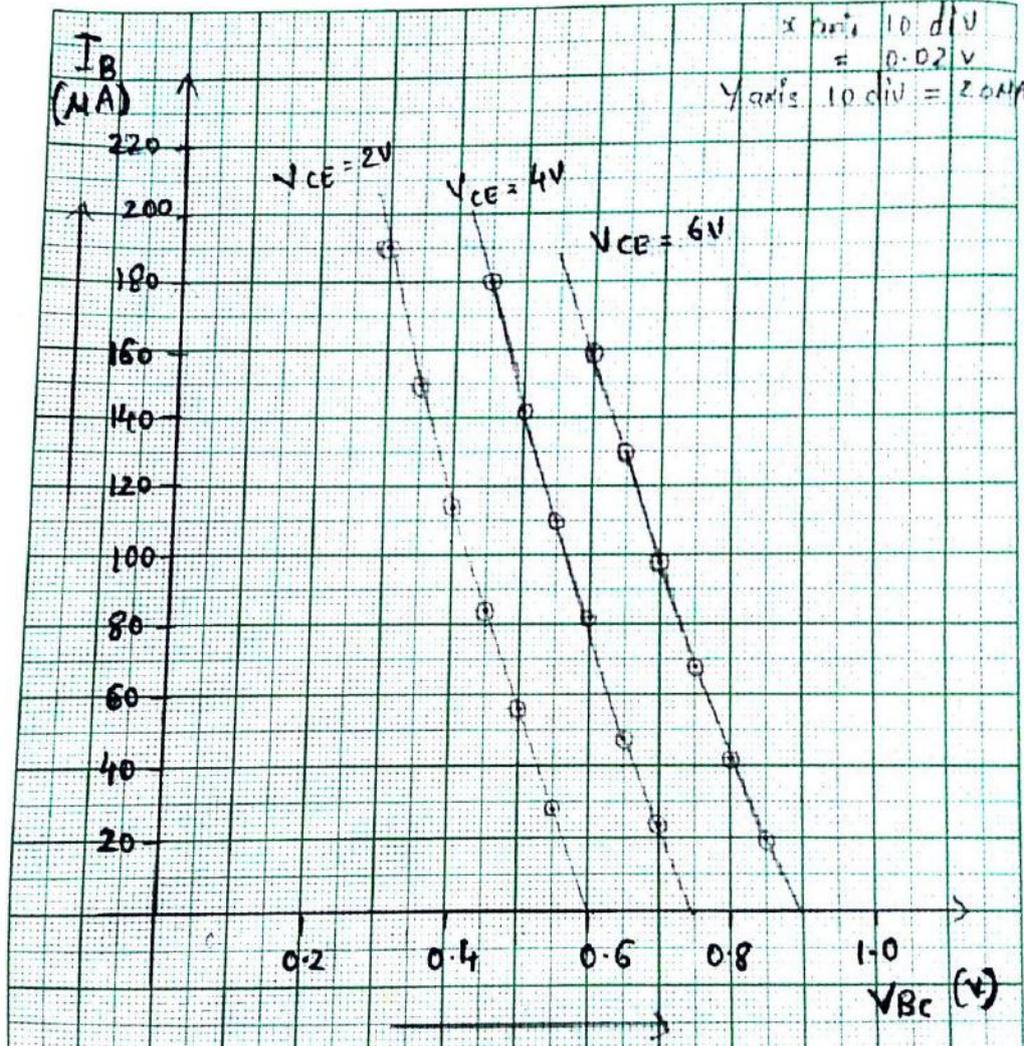
Output Characteristics

5.2 Observations

INPUT CHARACTERISTICS

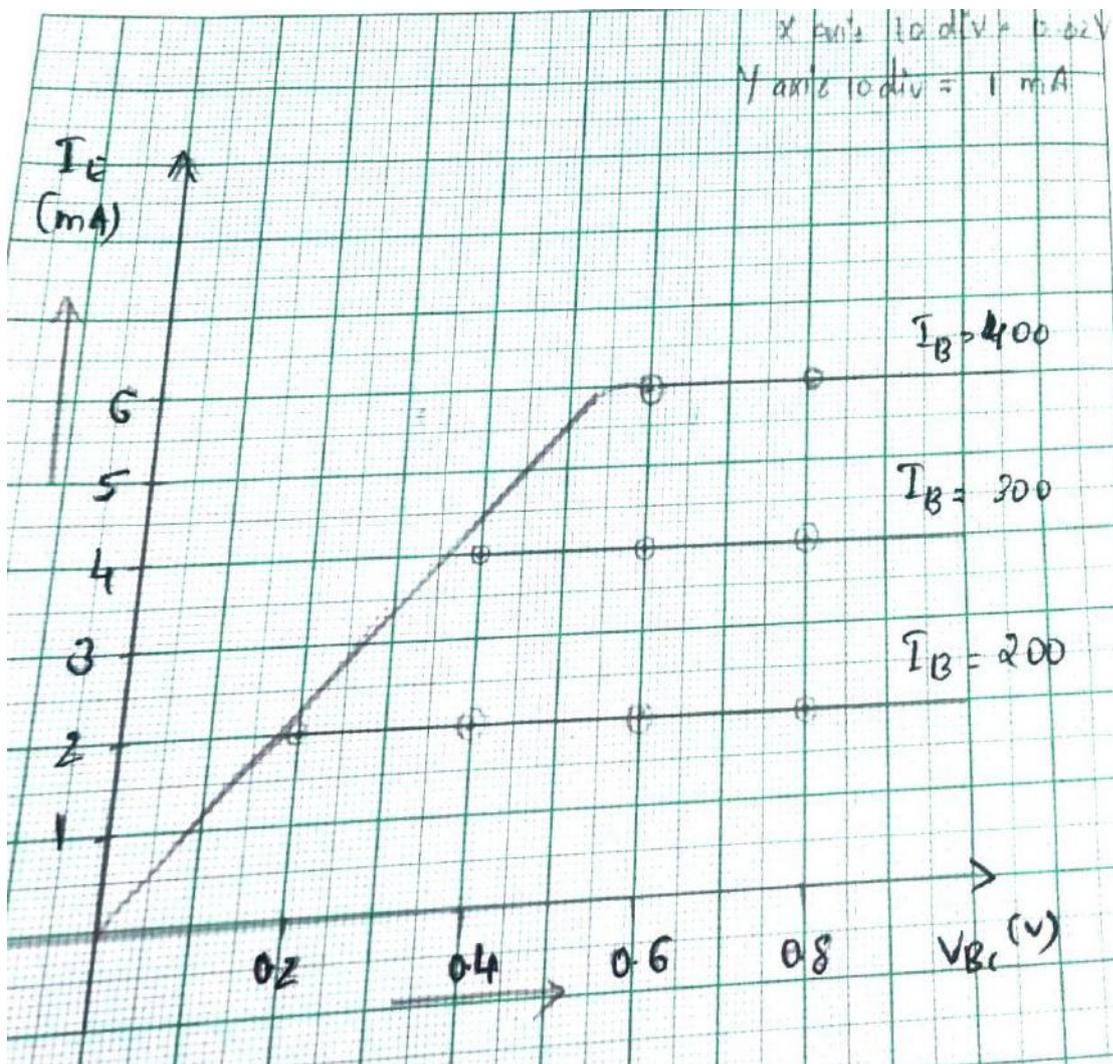
$V_{EC} = 2V$		$V_{EC} = 4V$		$V_{EC} = 6V$	
V_{BC} (V)	I_B (μA)	V_{BC} (V)	I_B (μA)	V_{BC} (V)	I_B (μA)
0.9	0	0.75	0	0.6	0
0.85	20	0.7	24	0.55	28
0.8	42	0.65	48	0.5	56
0.75	68	0.6	82	0.45	84
0.7	98	0.55	110	0.4	114
0.65	130	0.5	142	0.35	150
0.6	160	0.45	180	0.3	190

Scale



OUTPUT CHARACTERISTICS

$I_B = 200 \mu A$		$I_B = 300 \mu A$		$I_B = 400 \mu A$	
$V_{BC} (V)$	$I_E (mA)$	$V_{BC} (V)$	$I_E (mA)$	$V_{BC} (V)$	$I_E (mA)$
0	0	0	0	0	0
0.2	2	0.2	2	0.2	2
0.4	2	0.4	4	0.4	4
0.6	2	0.8	4	0.6	6
0.8	2	2	4	0.8	6



Calculations from the Graph

a. Input resistance = $\Delta V_{BC} / \Delta I_B = 0.5/20 = 0.025\Omega$

b. Reverse voltage gain = $\Delta V_{BC} / \Delta V_{EC} = 0.15/2 = 0.075$

c. Forward current gain = $\Delta I_E / \Delta I_B = 2/100 = 0.02$

5.3 Results

- a. Input Resistance = 0.025Ω
- b. Reverse Voltage Gain = 0.07
- c. Forward Current Gain = 0.02

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CC configuration. We have also included the observations and graphs of the same.

CHAPTER-6

SUMMARY AND FUTURE PROSPECTS

6.1 SUMMARY

In this project we conducted a detailed study of characteristics of the transistor in different configurations i.e, common emitter configuration, common base configuration and common collector configuration.

In Common emitter configuration, the emitter is grounded and it is the common terminal for both the input and output. The base is used as input terminal and collector is used as output terminal. In common emitter configuration current gain and voltage gain are calculated.

In Common base configuration the base is grounded and it acts as the common terminal. Here emitter is the input terminal and collector is the output terminal. In common base configuration output voltage gain is calculated .

In common collector configuration the collector is grounded and it is the common terminal for both the input and output. Here base is input terminal and emitter is the output terminal.

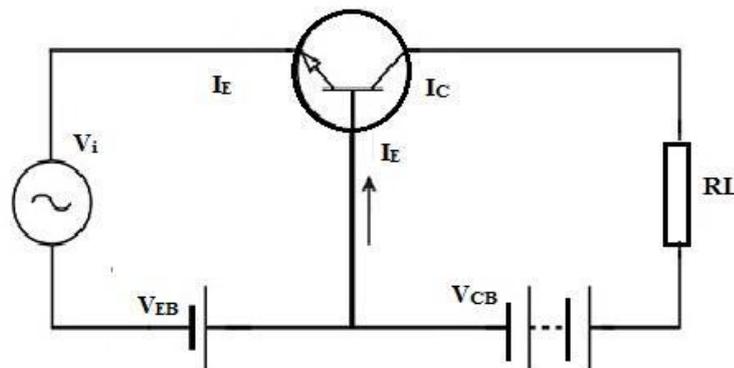
Common Emitter (CE)	Common Base (CB)	Common Collector (CC)
Emitter is grounded.	Base is grounded.	Collector is grounded.
Current gain (β) in CE configuration is given by $\beta = \Delta I_C / \Delta I_B$ We got $\beta = 0.2$	Current gain (α) in CB configuration is given by: $\alpha = \Delta I_C / \Delta I_E$ Here $\alpha = 1$	The current gain is calculated as , $\gamma = \Delta I_E / \Delta I_B$ We got $\gamma = 0.02$
Input resistance is obtained 0.002Ω	Input resistance is obtained as 0.25Ω	Input resistance is obtained as 0.025Ω
The reverse voltage gain is given by: $\Delta V_{EB} / \Delta V_{CE} = 0.5$	The reverse voltage gain is given by: $\Delta V_{EB} / \Delta V_{CB} = 0.02$	The reverse voltage gain in CC configuration is given by $\Delta V_{BC} / \Delta V_{EC} = 0.07$
It is used as audio frequency	It is used for amplification purposes.	. It is used for impedance matching

6.2 FUTURE PROSPECTS OF PRESENT WORK

- ❖ **Transistor as an Amplifier:** An amplifier circuit can be defined as a circuit that amplifies a signal. The amplifier's input is either a voltage or a current, and the output is an amplifier input signal. A transistor amplifier is an amplifier circuit that uses a transistor . Transistor amplifier circuits are used in a variety of applications, including audio, radio, and optical fibre communication.

- ❖ **Transistor as an Amplifier Circuit:** A transistor can be used as an amplifier by boosting the strength of a weak signal. One may gain a sense of how a transistor circuit operates as an amplifier circuit by looking at the transistor amplifier circuit below.

The input signal can be applied between the emitter-base junction and the output across the R_c load in the collector circuit in the circuit below.



Always remember that the input is forward-biased, while the output is connected reverse-biased for proper amplification. Thus, we apply DC voltage (V_{EE}) to the input circuit in addition to the signal, as indicated in the above diagram. Generally, the input circuit often has low resistance; a small change in signal voltage at the input causes a considerable change in the emitter current. Because of the transistor's action, a change in the emitter current will result in a change in the collector circuit. The flow of collector current through a R_c currently generates a huge voltage across it. As a result, the weak signal applied at the input circuit will be amplified at the collector circuit in the output. The transistor acts as an amplifier in this manner.

- ❖ **Microphone:** Our voice or sound wave is converted to an electronic signal by the microphone, which is a transducer. The magnitude of the sound wave varies with time according to our voice because it does not

have a constant value. Because of the small alternating voltage created by the microphone, the electrical output of the microphone varies in response to sound waves, as the base current I_b varies. This means that a slight change in I_b can induce a huge change in I_c . When the microphone output is fed into the transistor as an input, the variable collector current I_c flows into the loudspeaker, and we know that if the transistor's input changes, the output of the transistor will fluctuate dramatically. As a result, the transistor enhances the microphone's electronic signal. Although the frequency remains constant, the amplitude of the sound wave from the loudspeaker is greater than that of the sound waves fed into the microphone.

❖ **Transistor Used as a Switch:** BJT Transistors can be used to manage DC power to a load by acting as a switching device. The controlling current flows between the emitter and the base, whereas the switched (controlled) current flows between the emitter and the collector.

To brief other practical application of transistors, it includes:

- Transistors are used in oscillators and modulators as amplifiers.
- Transistors are used in Radio-frequency circuits for wireless systems.
- Transistor switches are used in Burglar alarms, industrial control circuits, memories and microprocessors.
- They are used in Sub Wordline Driver (SWD) to produce low frequency currents.
- MOSFETs are used in Chopper circuits.
- JFET, MOSFET can act as a passive element like Resistor.

The first announcement of the transistor's development was made with absolutely no fanfare. Originally, the integrated circuit was supposed to be solely valuable in military applications. Investors in the microprocessor pulled

out before it was built, believing it would be a waste of money. The transistor and its descendants have always been discounted, despite the fact that they have shown to be more capable than anyone anticipated. Today's predictions also suggest that the transistor's capabilities are limited. This time, the expectations are that transistors will not be able to shrink any farther than they are now. Then again, in 1961, scientists predicted that no transistor on a chip could ever be smaller than 10 millionths of a metre -- and on a modern Intel Pentium chip they are 100 times smaller than that.

With the benefit of hindsight, such predictions appear absurd, and it's easy to imagine that today's predictions will sound just as absurd thirty years from now. However, recent size limit predictions are based on some very basic physics, such as the size of the atom and the electron. Because transistors operate on electric current, they must constantly be large enough to allow electrons to pass through.

On the other hand, all that's really needed is a single electron at a time. It would be phenomenally small for a transistor to operate with only one electron, but it is theoretically possible. Future transistors could make contemporary circuits appear as large and bulky as vacuum tubes are now. The trouble is that once gadgets get that small, everything moves according to quantum mechanics' principles, which allows electrons to perform some strange things. In such a small device, the electron behaves more like a wave than a single particle. It would smear out in space as a wave, and it may even tunnel through the transistor without actually acting on it.

Despite this, researchers are actively working on new ways to produce such tiny devices, forsaking silicon and all current production methods. Single electron transistors are what they're called, and depending on whether or not they're keeping an electron, they're termed "on" or "off." (At this level, transistors are only employed as binary coding switches, not as amplifiers.) In reality, the quantum weirdness of the ultra-small might be exploited by such a minuscule device. Instead of merely "on" or "off," the electron might be configured to have three positions: "somewhere between on and off." This would pave the way for

whole new types of computers. However, there are currently no practical single electron transistors.

Miniaturisation is possible even without new technology. Present transistors are expected to be at least twice as small by 2010 if current manufacturing procedures are improved. Intel's latest processor has nearly a billion transistors, implying that four times as many transistors on a chip are theoretically achievable. Computers with chips like this would be far "smarter" than they are now.

Transistors are the most basic electronic components that can be found in every device. They've grown in size and performance over the last 30 years. Their capacity to behave as a switch or to amplify current or voltage has allowed them to be used in a wide range of applications, including logic gates in computer processors and sound amplifiers. The ability to hold more electronics in one's hand than could be contained in a large building in the days when vacuum tubes were the only active devices available is perhaps transistors' most important contribution. They have made it possible to hold more electronics in one's hand than could be contained in a large building in the days when vacuum tubes were the only active devices available. As a result, complex functionality may now be packed into small packages—computers, cell phones, automotive engine controllers, and a variety of other devices.

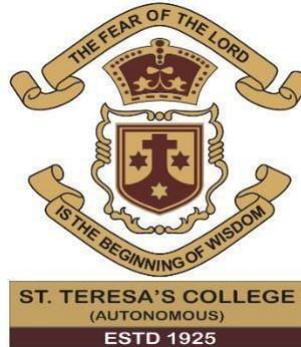
A continuous process of research and development is underway to improve transistor performance parameters and to identify new semiconductor materials other than silicon. Transistors are being created to assist rapid technological advances such as wireless charging and energy conversion. Transistors are still being studied extensively around the world, as reducing the size and power consumption of individual transistors on a chip can result in quick profits. Researchers have already produced extremely small transistors made of only a few molecules in the lab, including one that uses only a single electron. They've also shown that transistors constructed of plastic are feasible, and that they could be even cheaper and more shock-resistant than conventional electronics.

Increasing transistor densities on chips (which manufacturers desire) is expected to be achieved in the near future via improving fabrication techniques for classic semiconductor devices.

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**REREADING GRAND NARRATIVES:
AN ECOFEMINIST ANALYSIS OF UTTARA KANDA AND *KANCHANA SITA***



Project submitted to St. Teresa's College (Autonomous) in partial fulfilment of the requirement for the degree of BACHELOR OF ARTS in English Language and Literature

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DECLARATION

I hereby declare that this project entitled “Rereading Grand Narratives: An Ecofeminist Analysis of Uttara Kanda and *Kanchana Sita*” is the record of bona fide work done by me under the guidance and supervision of Dr. Jeena Ann Joseph, Assistant Professor, Department of English.

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CERTIFICATE

I hereby declare that this project entitled “Rereading Grand Narratives: An Ecofeminist Analysis of Uttara Kanda and *Kanchana Sita*” by Prescia Gladwin is a record of bona fide work carried out by her under my supervision and guidance.

Dr. Jeena Ann Joseph

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March 2022

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Rereading Grand Narratives:
An Ecofeminist Analysis of Uttara Kanda and *Kanchana Sita*

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St. Teresa's College (Autonomous), Ernakulam

Register No: AB19ENG017 (2019-22)

March 2022

Supervising Teacher: Dr. Jeena Ann Joseph

The study titled “Rereading Grand Narratives: an Ecofeminist Analysis of Uttara Kanda and *Kanchana Sita*” examines the nature of relationships as defined by power and gender in Uttara Kanda and its play and movie adaptation, *Kanchana Sita*. The play *Kanchana Sita* won the Sahitya Akademi award in 1969 and the movie was a critical success. The first chapter traces the origins and types of ecofeminism. It incorporates some of the tenets of Vandana Shiva and Josephine Donovan and focuses on their concepts of Prakriti-Purusha and the absent-referent respectively. Chapter 2 surveys the ramifications of the rupture between man and his surroundings in Uttara Kanda, and the play and movie *Kanchana Sita*, through the comparison of the episodes of Sita's banishment, the killing of Shambuka, Aswamedha, the second trial of Sita and her union with nature. It draws a parallel between the different 'isms' of domination in the three main episodes. The purpose is to illuminate the injustice inherent in a system that works for the welfare of a privileged group. In doing so, it strives for the peaceful co-existence of diverse and non-dominant groups. The study, therefore, seeks to re-evaluate the deeds and disposition of the characters using the ecofeminist theory.

ACKNOWLEDGEMENT

I thank God Almighty for showering his abundant blessings and keeping me well during the course of my project.

I would like to express my gratitude towards Dr. Lizzy Mathew, Principal, St Teresa's College (Autonomous) for her support.

I am deeply indebted to my supervisor, Dr. Jeena Ann Joseph, Assistant professor, Department of English, St Teresa's College (Autonomous), whose immense patience, constant support and instant responses made possible the timely completion of my project.

I am extremely grateful for her valuable guidance and constructive feedback.

I extend my special thanks to Dr. Latha K Nair, Head of the Department of English, St Teresa's College (Autonomous) for her constant encouragement and motivation.

I would like to express my heartfelt appreciation to Dr. Tania Mary Vivera, for giving us a strong base on Research Methodology and all the other faculty members of the department for their support.

Finally, I wish to convey my deepest love and gratitude to my dear parents and peers, only with whose moral support could I find the inspiration to pen down my research.

Prescia Gladwin

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Introduction

Seneca once said, “Religion is regarded by the common people as true, by the wise as false, and by rulers as useful”. Religious texts encompass some kind of universal truth and lessons but other unconscionable practices and ideologies must be analyzed and debated. Instead, all that is written is either misinterpreted or taken as the ultimate truth and measure of justice. This becomes the basis for discrimination and consequent intolerance towards those who are not like oneself.

Ramayana is an ancient Sanskrit epic attributed to Valmiki, written between 500 BCE and 100 BCE. It follows the quest of Prince Rama to save his wife Sita from a demon called Ravana. It is considered to be a great literary piece of India and the religious text of the Hindus. The text under study, Uttara Kanda is the seventh and final canto of this epic. Though nature and women find a place in the epic works of India, the nature of their representation ought to be brought under the critical lens. C.N. Sreekantan Nair, a renowned Malayalam playwright reassesses Uttara Kanda in *Kanchana Sita*, a play written in 1961. He portrays Rama as a tragic victim of totalitarian power, sustained by the creation of an ‘other’. G. Aravindan captures the essence of the play in his Malayalam film of the same name directed in 1977.

Chapter 1 “Foregrounding the Marginalized” covers the ecofeminist theory propounded by Vandana Shiva and Josephine Donovan. It gives a brief introduction to ecofeminism including its types and origins and sketches the eastern and western concepts of Purusha-Prakriti and the absent referent respectively. It also looks at other theorists who reinforce these concepts and explores their ideas.

Chapter 2 “Re-examining Uttara Kanda and *Kanchana Sita*” gives a summary and the

historical context of Uttara Kanda of Ramayana and the play *Kanchana Sita*. It then goes on to analyze both these chapters through the ecofeminist lens incorporating the concepts dealt with by Chapter 1. It compares the treatment, role and perception of women, nature, animals and the marginalized in *Kanchana Sita* and Uttara Kanda by examining the episodes of the expulsion of Sita, Agni Pariksha, Aswamedham, Shambuka's killing and the second trial of Sita. The sections of the banishment of Sita and her second trial analyze the moral and spiritual changes in the relationship between Rama and Sita in Uttara Kanda and the play. While in the former Rama is invincible and his actions justified by the shield of power, position and gender construct, in the latter, he is humanized, censured and torn between guilt and rajyadharma. Sita's humane version is seen through the eyes of Urmila in the play. While in the former, Sita descends into the earth to prove her chastity, in the latter, she more assertively joins and merges with nature. While both the play and Uttara Kanda affirm Sita's power through the miracle, it is only in the former that the conduct of a second trial is abhorred and depicted as a tragedy. Sita is stripped of her humanity and feelings. The comparison of the episodes of Aswamedham and Shambuka's killing tries to scrutinize the objectification of the horse and Shambuka by applying the concept of the absent referent. On the whole, the intention is to identify how the power relations naturalize the subjugation and oppression of women, nature and the marginalized.

The study aims to bring out the reprehensible actions of powerful men in Uttara Kanda in the light of the play and the ecofeminist framework. The play digs to a deeper level and examines the character of Rama and the consequences of his actions on the marginalized. It perceives the underlying hegemony and de-objectifies women and nature. It throws light on how Rama is an error-prone victim and perpetrator of patriarchy which leads to the deglorification of his actions. The movie focuses on the conflicts faced by Rama under the pressure of patriarchy.

Chapter 1

Foregrounding the Marginalized

Ecofeminism or ecological feminism is a multi-perspective branch of feminism that analyses the profound correspondence between women and the natural world. It deals with the underlying patriarchal forces responsible for the destruction of nature as well as the subjugation of women and other marginalized communities. Although ecofeminism as a concept first evolved in the 60s through the collective experience of women, it made headway with the coinage of the term by Françoise d'Eaubonne. Her work *Le Féminisme ou la Mort* in 1974 and other groundbreaking novels by feminists concerned with ecology paved the way for the formulation of this broad, inclusive and flexible theory.

Feminist studies and ecology have been separate areas of study until the 60s when women started recognizing the intricate relations between themselves and nature. In addition to being the victims of man's avarice, they were also the source and sustenance of life as against man's violence and destruction. The proposal to combine feminism and environmentalism received further impetus from the series of conferences held in the US in the latter half of the 1970s. This interdisciplinary approach discloses inseparable patterns of oppression between naturism (domination of nature) and other isms of domination which would have been impossible if dealt with separately. Thus, ecofeminism strives for the liberation and assertion of women and nature.

For a long time, women and nature (which includes every natural organism and element) have been objectified and marginalized. Society has been forever belittling their worth and taking their work for granted. Ecofeminist theory attempts to identify and uncover instances of othering, subsequently enhancing the cultural and social standing of women and nature. It tries to overcome the ontology of domination by invalidating the binary oppositions

such as culture/nature, male/female, and mind/body. The former elements are valorized, thereby giving them a free hand to control the other. According to Donna Haraway, acknowledging nature and women as active subjects instead of objectifying them is one way to overcome the dualisms employed to “naturalize” exploitation (199). Appreciating diversity and non-violence are the essential means of challenging patriarchy’s claim to universalism. Ecofeminist theory thus calls for an integrated and egalitarian society where no group dominates the other.

Among the different branches of ecofeminism, the first to take shape was cultural ecofeminism. It traces women’s sensitivity towards environmental degradation to their close communion with nature. Some cultural ecofeminists argue that it is the reproductive function of women which links them to nature and enables them to actively launch environmental campaigns. In sharp contrast to this focus on women’s essential link with nature, social ecofeminism claims that women’s identities are social constructs based on diverse factors such as age, race and sexual orientation. Taking an intermediate position is material ecofeminism which holds both the biological nature and the social construct responsible for the women-nature correlation. Radical ecofeminists maintain that patriarchy assigns similar characteristics to women and nature to degrade them. Men misuse language to feminize nature as well as depersonalize women. This includes the use of phrases such as the rape of nature, virgin forests, pussy and bitch. Spiritual ecofeminism is concerned with the role of religions in giving man the upper hand over all creation. It overlaps cultural ecofeminism in that it celebrates the relationship between women and nature referring to the ancient Goddesses. It also upholds the interconnection of the ‘living’ Earth with all its creatures and promotes the ethic of caring.

In the east, women were the primary victims of environmental disasters and destruction. Vandhana Shiva, the most prominent ecofeminist of India, actively participated in the Chipko movement of the 70s. Women left behind in their homes were threatened by the erosion resulting from the mindless destruction of the nearby forests under British rule. However, they identified with this exploitation and channeled their concern into the movement. Ecofeminism crystallized in India around this time. On the other hand, in the west, ecofeminism emerged from the consequences of employing nuclear weapons in the Cold War. Women campaigned against the use of arms and violence. The nuclear power plant disaster at 3 mile island in Pennsylvania causing serious radioactive pollution urged women in the US to congregate at the first ecofeminist conference in 1980.

Vandana Shiva has been criticized for being an essentialist who emphasized the intimate relationship between women and nature. She takes a materialist stance in recognizing the biological and social role of women in providing sustenance. She deals with the concept of Prakriti-Purusha. According to her, Prakriti is the “principle of activity and creativity” and Purusha is the “masculine principle” (Shiva 37). The feminine principle, Shakti, is the primordial energy and its manifestation is called nature or Prakriti. Shiva claims that all forms of life emerge from the union of the dual aspects of being, Purusha and Prakriti (37). These two principles are the inextricable complements of one another in woman, nature and man. This is supported by Rajni Kothari’s observation that the feminine principle is not limited to women but is the creative force embodied in all living things irrespective of gender (Kothari 9). This concept eliminates the western notion of duality, considered by most ecofeminists to be the principal reason for subjugation. This duality constructs everything that is not masculine as feminine and sidelines it for domination. Consequently, many feminists renounced their feminine traits to acquire a place in the man’s world. This

reinforced the patriarchal definition of women as fragile, inactive and worthless. Vandana Shiva opposes such anti-essentialist stances.

With the advent of science, capitalism and development began the objectification of nature for exploitation, the marginalization of women and the consequent death of Prakriti. Along with this misuse of nature comes the threat to the survival of women who primarily depend on it to sustain their families. Shiva exemplifies this by citing the effects of rampant deforestation and the consequent resource shortages on women. Destined to perform domestic work, women were forced to undertake the back-breaking and time-consuming work of collecting water and fuel. According to her, the destruction of our life support systems in the name of development and progress is the process of maldevelopment (Shiva 4). It devalues all work unaccompanied by profits as non-productive such as those that do not contribute to the nation's GDP. Consequently, the work of women and nature was neglected. Carrying water, gathering firewood and performing domestic chores, seen as women's work, were degraded. These constitute the reductionist paradigm that suppresses women's knowledge. She elucidates this statement with examples. While a free-flowing river is considered unproductive material, building dams 'develop' it. Along the same lines, the distribution of water by the engineering man is deemed productive over the manual labour by water women (3). Similarly, hunter men were considered the protectors of society over women who undertook the life-sustaining activity of gathering food which was more important according to Elizabeth Fisher's studies. Maria Mies finds that this elevation of the predatory activity of hunting forms the basis of man's destructive relationship with nature. Thus, recovering the feminine principle of non-violence is the first step to emancipating women and nature and destroying the reductionist categories to halt maldevelopment. This can be achieved in three ways: acknowledging nature as an active organism, seeing women as productive beings and diverting the energy of men from destructive pursuits to life-enhancing

activities. Vandana Shiva maintains that women have first-hand knowledge of the pitfalls of progress and recognizes the significance of nature as the prerequisite for the survival of the human species.

Josephine Donovan, an American scholar of feminist theory and animal ethics on a literary level, discusses the need for eliminating the ontology of domination stemming from dualism. She regards the concept of the absent referent as useful in this enterprise. The absent referent is the elided real-world entity signified by the signifier which is a word or symbol. Carol Adams exemplifies this using the signifier meat and the absent referent animal in the text *meat-eating* (qtd. in Donovan 162). The signifier reduces the referent to an object thereby supporting carnivorism. Literary texts too act as a means of obscuring the literal. Writers such as William Wordsworth deny the valuable existence of nature in itself- the thou-ness of nature by distorting reality using figurative language. Former literary criticisms such as structuralism and formalism also exhibited the ontology of domination by treating books as corpses, in contrast to the reader-response theories. Thus nature and women are depicted as objects, ready to be molded at man's will. The aim is to emancipate the object or the absent referent from domination by destructive signifiers and to restore them to the text. Hence, Ecofeminists urge writers to tell the thing- i.e. to reinstate the living presence of the absent referent to reclaim its equal standing with the signifier. Cixous calls those texts feminine which gives voice to these absent referents (169). Giving them a voice does not mean extending the human language to non-human entities and negating their dialects, but verbally describing them as a different living entity.

Keeping these in mind, Donovan draws upon three main concepts to formulate an ecofeminist theoretical base. One is Martin Buber's I-Thou relationship expanded in Bakhtin's dialogic theory. According to Buber, this diverse relationship is explicitly found in

narratives that are capable of handling the complex web of I-thou relations. It is dialogical where both I and thou have unique respectable realities, in contrast to the one-sided relationship of I-it. Second is Iris Murdoch's idea of attentive love, a tool for knowing the thou and respecting the difference. It tries to reveal the position of the 'other' as a being with desires. This will limit the tendency to view the referent as an object. The third is the notion of critical erotics as explored by Carol Bigwood. She defines the erotic as the source of feminine power; higher feelings emanating from the joy of being a woman. Hence it locates the phenomenological body or living body, the body in close communion with the surroundings, within a person and not in the visible biological object (Bigwood 50).

The theories discussed above aim for the same goal through different means. Ultimately, the purpose of these theories referred to by the umbrella term 'ecofeminist theories' is to draw attention to the realities of the oppressed beings and strive for the peaceful co-existence of diverse and non-dominant groups. Be it global warming and unprecedented climate changes or violence against women, it is the need of the hour to make amends to the thoughtless and selfish mindset of men. Each day brings in its wake a new form of environmental and human destruction which needs to be resolved before things go haywire. The first step is to identify exploitation. Reinterpreting the dominant discourses in the light of these theories and creating new inclusive and multi-perspective works will open people's eyes to the naturalized abuse of imaginary power and its negative consequences.

Chapter 2

Re-examining Uttara Kanda and *Kanchana Sita*

Literature is significant in universalizing the male perspective and patriarchal ideologies. A major part of this is contributed by the religious texts which are read, recited, and studied almost every other day. They are thus internalized by a sizeable population in their everyday life. They were shielded from alternate readings and criticisms by the perpetuated aura of divinity surrounding them for quite some time. Considering the period in which they are written, it is unsurprising to come across Rama's unjust treatment of Sita in Ramayana and the censure of homosexuality in the Bible and the Quran among other similar attitudes. But it is crucial to rethink the diminishing relevance of such views in the 21st century. Therefore, these holy texts which give privileged men the upper hand over the rest of the creation must be reread from radically different perspectives and certain invalid ideologies must be identified and retold in line with the ideas of the contemporary age.

The present chapter attempts to investigate the factors underlying the normalized oppression of women, nature and the marginal groups by the men wielding power. To do so, it compares the Uttara Kanda of Ramayana with its play and movie adaptations, *Kanchana Sita*. Both reinterpretations are taken into account as the latter employs dialogues while the movie focuses more on emotions and internal conflicts. Also, analyzing the verbal and visual aspects distinguishes the status of man, woman and nature in Uttara Kanda from that in *Kanchana Sita*. The latter disputes the glorified acts of Rama supposed to restore justice and revalues nature and women by asserting the parallel between them.

By applying the Indian concept of ecofeminism, this chapter aims to prove that embracing the intermingled presence of Prakriti and Purusha in all organisms reduces the tendency to dominate others. The separation of Purusha from Prakriti i.e. the rupture of these

two principles in men creates an imbalance in the dual aspects. Men tend to suppress the latter as 'irrational' and 'weak'. They identify the Prakriti in women and nature and apply such labels to exploit them. This categorization demeans them and justifies their objectification and subsequent exploitation to satisfy man's needs. While in the modern world, it is science, capitalism and development which led to the subjugation of Prakriti, in Uttara Kanda, it is the greed for power, statecraft and the maintenance of Ram Rajya that caused its death. Hence, *Kanchana Sita* by addressing these issues aims for a higher sort of harmony where all beings are considered equal and mutually dependent for survival.

Before moving on to the narrative, it is important to look at the origin of Ramayana to understand the socio-political context of the text. Ramayana is believed to be set in the Treta Yuga and composed around the 5th century BCE. India was then facing invasion by the Aryan civilization who established their settlement in the north, forcing the non-Aryans to flee to the untamed south. This is mentioned in the play by Kausalya "My son [Rama] taking to Bark-skin--Did it not result in the southern part of Bhaarata and Lanka coming under the Aryan sovereignty" (Nair 132). Because of the struggles of the non-Aryans to adapt to the harsh environment in the South and their distinct features, it is believed that the Aryans othered and categorized them as Rakshasas and Asuras in ancient Indian epics. The hierarchical system prevalent in this age gave indisputable power to those in the upper strata of society. Women were commonly utilized as a pawn in the wily statecraft. The forest, though portrayed as a place of refuge and rest in the Ramayana, is not free from power politics. This is where Shambuka is killed, the horse is sacrificed and Sita is abandoned.

Uttara Kanda is the last book of the epic Ramayana which deals with the return and subsequent coronation of Rama to the throne of Ayodhya. The reign of Rama, the second ordeal of Sita, the killing of Shambuka and the performance of Aswamedha Yagna are the

significant events taken under study. The sixth book, Yuddha Kanda narrates the battle between Ravana and Rama, and the consequent defeat of Ravana. After Sita is 'saved' from Ravana who had held her captive for one year, she is subjected to Agnipariksha to prove her chastity. She passes the test and returns to Ayodhya with Rama and Lakshmana. Rama gets back his kingdom from his elder brother Bharatan and is consecrated as the king by Vashishta. After ten thousand years of prosperous Ram Rajya rule where one found the subjects happy and fulfilled, Sita becomes pregnant. Prompted by Rama, Sita reveals that she would like to spend a day at the hermitage by the banks of river Ganga. However, Rama soon receives the news of his subjects' displeasure at his reunion with Sita who they presumed to have lost her chastity after her long stay with Ravana. To prevent further disgrace to his name and fame, he orders Lakshmanan to abandon Sita in the forest under the pretext of fulfilling her desire. Lakshmanan having dutifully carried out the order confesses the truth to Sita who mourns her misfortune but willingly accepts the predicament to save Rama's 'honor'. Rama continues to rule the kingdom, wiping out any threat to its reputation. It is around this time that he kills Shambuka, a Shudra who performs penance against the norm. Meanwhile, Valmiki offers refuge to Sita who gives birth to Lava and Kusha in his hermitage. He brings them up and teaches them the slokas of Ramayana which he composes in the Dandaka forest. Rama performs the Aswamedha Yagna with a golden statue of Sita to prove his imperial sovereignty. Lava and Kusha chant the Ramayana at this event and Rama invites Sita back to Ayodhya. However, he decides that she must give an oath of her chastity, this time in front of his subjects. A helpless Sita invokes the Earth goddess who accepts her on a celestial throne. Rama is mind-blown and distressed by this unexpected disappearance of Sita. Uttara Kanda ends with Rama ascending heaven from the river Sarayu after completing his goal of killing Ravana and ruling the earth for eleven thousand years.

Kanchana Sita written by C.N. Sreekantan Nair and later made into a film by G.

Aravindan adopts a humanist perspective of life and nature in contrast to the power-blinded and mindless statecraft of Rama dictated by the Kulaguru Vasishtan, who goes to any extent to preserve justice. The play begins with a conversation between Urmila and Kausalya. They discuss the possibility of Rama and Lakshmana meeting Sita on his way back from a mission to the Dandaka forest. However, when they return without visiting Sita, Urmila furiously and boldly questions their indifference. Following this is the debate on the conduct of Aswamedham which requires the presence of Rama's wife. Vasishtan insists that Rama marry for a second time specifically to help him perform the ritual. Princess Kasi's name is put forth as a possible bride and orders are sent to summon her father. Rama undergoes intense conflict over this suggestion. Urmila and Kausalya on hearing this discuss the fairness of such considerations. After a heated debate, Bharatan comes to meet Rama after twelve years. He too spurns the suggestion of another wife and refuses to participate in Aswamedham without Sita. Meanwhile, the sacrificial horse is seized and tied up by Lavan. While dealing with his mischief, Lakshmanan meets Valmiki and Sita. After his departure, Valmiki attends the Aswamedham with Lavan and Kusan where they attract attention by reciting the Ramayana. They ask Rama where Sita Devi is and why she is replaced with a metal stone. Rama embraces them and promises to accept Sita on the condition that she takes an oath of her chastity in front of his subjects. On hearing this, Sita cries out in pain and asks the earth to protect her pride. She disappears and the play ends with Valmiki's assertion that Sita is non-perishable and is nature itself. The movie adaptation of this play subtly highlights the downside of Rama's deeds and portrays his emotional conflicts.

The main episode of the banishment of Sita, which offers myriad opportunities to explore the imbalance of Prakriti-Purusha is the main subject of criticism in the play and the movie. It is this which leads to one of the conflicts in Aswamedham Yagna where Sita is

replaced by her golden statue. The play opens with Valmiki's poem cursing the hunter who killed one of the Krauncha birds while mating. Valmiki is distressed by the lack of sight of the hunter who overlooks the right of the birds to lead their own life. He emphasizes the existence of nature as an active living entity (establishing the I-thou relationship), signified by lovemaking. On the other hand, the hunter establishes an I-it relationship. He treats them as objects to satisfy his greed and kills them to exhibit his physical strength.

In Uttara Kanda, a few years after Rama banished Sita, he goes to the Dandaka forest on his quest for Shambuka. However, there is no mention of Sita who was exiled to the forest. Nair makes Urmila take this up in the play. After Rama and Lakshmanan's return without meeting Sita, She asks her husband if they had not heard "the heartbroken cry of the bird separated from its mate" (Nair 136). Here the bird refers to Sita separated from Rama. Thus Nair employs Valmiki's poem as a metaphor for Sita's exile in the Dandaka forest. Sita is equated to a bird (nature) which indicates the oneness of the emotions of all creatures which in turn highlights their value as independent living beings.

Like the hunter, Rama treats Sita as an object. Despite his claims of love, he completely ignores her misery and dictates her will. After Rama saves her from Ravana, he proclaims

But, lady, 'twas not love for thee that led mine army o'er the sea...I battled to
 avenge the cause of honor and insulted laws. My love is fled, for on thy fame
 lies the dark blot of sin and shame... How should my home receive again a
 mistress soiled with deathless stain? How should I brook the foul disgrace,
 Scorned by my friends and all my race? (Griffith 2497-98)

Hearing this, Sita chooses to undergo Agnipariksha to prove her chastity. However, Rama remains ruthless. This shows his mistrust towards Sita and his unwillingness to accept her voice. Allowing Sita to undergo this peril also shows that he cherishes her chastity more than her life. Things turn outrageous when Rama banishes a pregnant Sita, threatened by the rumors challenging her chastity even after her success in the test. The conflict between his personal and kingly obligations materializes in the movie when Rama tells Urmila “Sita’s husband is only a servant of the public” (*Kanchana Sita* 00:14:56- 15:00). In the play, she says that this collapse of human compassion is a great misfortune for Aryavamsam.

Uttara Kanda portrays Rama as miserable without Sita. However, he was more concerned about himself and the glory of his reign. Lakshmanan is found consoling him saying “Whilst thou canst control thyself and thy mind, shouldst thou not be able to bear this trifling pain of separation? Leading men like thyself are never overwhelmed by all these things” (Dutt 1736). This hints at the idea that men, especially if they wish to be deemed powerful, ought to suppress their emotions. Rama’s status as a leading man, in terms of wealth and power, and his need to maintain this position instigates his unjust actions in Uttara Kanda. By abandoning Sita, he strives to establish himself as an ideal king who values his subjects and kingdom over his relations. Valmiki attacks this saying, “The royal will has no power to upset the life of the universe” (Nair 161). Even Kausalya, Rama’s mother, suggests that Sita’s exile could be for the glory of Aryavamsam. This absurd claim is disputed by Urmila, “So, most probably, if the wife is thrown to the mercy of the forest boars, all the seven continents may come under Aryan sovereignty” (132). Kinship entails certain privileges. In addition to these, they acquire the key to abuse their power without retribution. As a king, he has the right to destroy lives. He can hunt animals and kill non-dominant groups when they transgress man-made rules. Urmila says “You are the hunter. O king! Do

you remember Tara and Mandodari cursing you? Do you also remember the heartbroken sobs of the women of the demon clan?" (169).

Like the hunter blinded by passion, Rama was blinded by power and fame. Both men gain a sense of self as separate. This separate self operates on the basis of "an ethic of rights or justice" (Gaard, *Ecofeminism* 2). Subsequently, they look at the "undeveloped nature and female" (1) as different and inferior to themselves. The hunter finds it his right to use his weapon against the birds for his pleasure. Similarly, Rama focuses on invented justice rather than natural compassion.

The concept of Prakriti-Purusha can be applied to the play. In the play, the women-nature relationship is a model for the I-Thou relationship. Urmila describes Sita's generous attitude towards a wounded deer while in the forest, which is in contrast to the I-It relationship. "Sita saw it, her heart melted at its plight [I-thou relation]; She took it and looked after it. At the hermitage, the deer would never leave Sita's side" (Nair 137). Here, Sita's ethical conduct stems from her interconnected sense of self which entails care for the deer. The deer recognizes Sita's act of kindness and reciprocates her love by staying with her. On the other hand, Rama is detached from his surroundings. Although he was accompanied and helped by Sita during his exile in the Dandaka forest, he overlooks her plight and banishes her for no fault of hers. This shows how he takes Sita's sacrifice and kindness for granted. It is considered her duty to serve her husband and to accept his demands without questioning. "If ordered to jump into fire...they must jump" (132). The value of women and nature is measured by their service to men. Their only role is supposed to be fulfilling man's needs.

The disconnection of Rama from the non-dominant group is further indicated by Lakshmanan's reply to Urmila, "A king searching for a royal deer!" (Nair 137) when she asks

Rama, the guardian of the sorrowing one if he did not notice the wounded deer in the forest. However, she reminds him that it is the same king who went in search of a golden deer, which led to the abduction of Sita by Ravana. Also, while the forest sustained both Rama and Sita during his exile, it is Sita who develops an understanding of nature. This close connection between Sita and nature is supported by Urmila's statement that the peacocks, Krauncha birds and does in the Dandaka forest will enquire after their beloved friend Sita. While Rama is said to protect everyone and distribute gifts generously, all these are done as part of his imperial duty, keeping his superiority in mind and not as a fellow creature. To him, the deer becomes an 'object' worthy of attention only when it invokes the pleasure of hunting in him.

Women are perceived in a similar manner. Sita was acknowledged only as Rama's wife, to serve him and to bear him sons. He exploited her desire to see the hermitage and the peaceful sages, ordering Lakshmanan to use it as an excuse to lead her to the forest. Kausalya says "A woman alone can remind a man of her presence" (Nair 134). This shows how women and nature are expected to exist for man's sake. When Urmila expresses her hope that Rama will call Sita back, Kausalya replies, "That single-minded concentration is the glory of Aryavamsam..." (132). Urmila constantly receives blessings from sages for sons. In the movie too, Rama says, "May you bear sons" (*Kanchana Sita* 00:13:06-10). This confirms that it is not the life that is valued but the use of that life, the contribution it could make to the glory of the kingdom. It is the absence of sons to continue Aryavamsam that worries Kausalya more than the plight of Sita. This shows how the only loss brought about by her exile is the absence of heirs. A male heir is preferred since he would procure benefits for the kingdom in the form of single-minded conquests and wealth.

Urmila's retorts discuss the relationship between women, men and nature. There is a reiteration of 'woman is nature' in the dialogues of Kausalya and Valmiki. This shows how all things are ultimately made up of the same essence combining Purusha and Prakriti. Neither is superior. At one point, Urmila wonders if Purusha and Prakriti are separate, "What about man. Is he different from nature?" (Nair 134). To clarify this, she asks Rama if the koels of Panchavati coo even now; he says, "Child! Do the ears of a king have time to listen to that sweet music?" (137). His retort underlines the ideology that both nature and women are mere objects of beauty reserved for periods of recreation in a kingly life. Even the well-being of Sita is ignored. When Urmila questions this, Lakshmanan says he did not notice the hermitage of Valmiki as he was leading the army. Thus, men see themselves as important beings with more serious pursuits like conquering and waging wars and helping others if it profits them in some way like how saving Sita from Ravana helped Rama gain immortal fame. He says, "It was not for her sake. It was important for the security of Aryans to vanquish the clan of Malyavans..." (139). Similarly, nature which threatens man's position is destroyed like Shambuka or sacrificed for man's well-being like the horse. Rama tells Urmila, "Punishing are the demands of royal justice. Even to give up or to kill, it seeks not the consent of the conscience" (139). This highlights how men find those acts worthy which bring out their "masculine side". Tending and protecting a "trivial" thing like the deer is too "feminine" (Prakriti) while fighting wars and hunting are valiant preoccupations that are capable of gaining people's awe and respect and strengthening their superior position.

Urmila also draws a parallel between Sita and the deer killed before her kidnapping. While Rama's arrow struck the deer dead, Sita continues to suffer from the miseries Rama inflicted upon her. Rama is responsible for both their mishaps. More than voicing the helplessness of the victims, Urmila calls for the preservation of the dignity every living being deserves. She realizes the ramifications of the race for power and hopes that the innocence of

Panchavati will transform the king into a human being. Here innocence refers to the state free from corruption.

Another instance of the separation of Purusha from Prakriti is demonstrated by the equation of the court built on granite and stone to that of the heart of the men seated inside. The justice of kings is the justice of the wheel of power. Urmila says, “Ayodhya is soulless without Sita. Those who have souls will be crushed under that wheel” (Nair 133). It is those attributes that are assigned to both women and nature to degrade them, that are reclaimed as the soul, the spiritual elixir of life and upheld in the play. Nature and Sita are portrayed as one. But this is to enhance their significance. They are portrayed as indestructible. They are as or maybe more important than physical strength and power that are associated with men. In the play, traits associated with women and nature, Prakriti is validated as what makes one human. Prakriti is the soul without which Ramrajyam is simply granite stones. The great sages attribute Rama’s physical strength to his divinity. They say he was born to fight demons, break Vishnu’s bow, marry the daughter of Mithila, and liberate people by putting the lower castes in their place. However, in the play, Urmila’s questions do put him at unease. At one point, he asks Lakshmana if the Godavari still has its exuberance reflecting upon Urmila’s inquiry if he knew the changes in nature. He tries to acknowledge the miseries inflicted upon Sita and nature but is overpowered by avarice. Unlike Uttara Kanda, one is shown Rama’s conflicting self. In the former, all his feelings are shallow, but in the play and especially the movie, his internal struggles are brought out alongside nature’s living presence. There is a thirty-second-long scene of Rama running across a vast and plain land in mad agony, calling out loud for Sita, silhouetted against the setting sun and a tree (*Kanchana Sita* 00:16:40-17:19). This can be interpreted as the impossibility of men to exist without women and nature. The web of life is brought into focus here. Men cannot ignore or sideline nature and women; if they do it will lead to their destruction. Hanuman says that Sita and Ram are

not two different beings. Hence he calls them Sitaram. This signifies the highly favored co-existence of Prakriti and Purusha.

By introducing Urmila and Kausalya as strong female defenders of Sita, Nair draws our attention to the lack of agency and role for women in Uttara Kanda. They question the existing power structures. The play also acknowledges Shambuka's wife who plays a small but significant role. Sita too appears as a resilient woman of will and strength of character. Urmila, Lakshmanan's wife and Sita's sister is described as having "dignified, piercing eyes, an expression of permanent despondence" (Nair 130) and appears as such in the movie (*Kanchana Sita* 00:09:38-15:08). She is praised by sages for her excellent scholarship. Yet when she poses serious questions, she is repeatedly dismissed as a "child" (Nair 137) or called "impertinent" (*Kanchana Sita* 00:14:27) by her husband. Despite this, she pricks Rama's conscience to a great extent. Kausalya also plays a significant role throughout the play. Although she has internalized some of the patriarchal notions, she rejects Sita's second ordeal. A conversation between the two women and the descriptions of their actions and emotions acknowledge them as separate living beings as against the Ramayana which constantly manipulates women to form an identity through their husbands. Along with them, Valmiki, Hanuman and Bharatan too rebuke Rama's command to abandon Sita.

In the play, justice is sought for Sita in the form of Urmila. Sita is not a desperate woman who cannot survive without Rama. She is capable of higher morale acts like saving the deer. Only here do we see a doing Sita- a person of her own will and conscience. She describes scenes of nature to Urmila. In Uttara Kanda, she is mostly portrayed as a beautiful and miserable woman constantly meditating on Rama, self-sacrificing and accepting punishments for his sake. Her life in the forest is rarely portrayed. Just as nature is all-

pervasive yet invisible, her banishments pervade throughout Uttara Kanda, but little of her emotions and trials are narrated.

While Ramayana often uses figurative language to describe nature, the play calls attention to its 'thou-ness'. Formerly, nature was also used as an aesthetic object to compare humans with. There are beautiful descriptions of nature but when Rama associates himself with it, there is a pervading sense of superiority. However, in the play, nature is described in the active voice as in the following confrontation of Hanuman with Rama.

Where is the Sitaram whom Panchavati's greenery and flowers worshipped
with their souls? The Sitaram whom the flocks of birds rocked to sleep,
singing poems? The Sitaram who were blessed with light from the sky and
food from the Earth...? (Nair 172)

Considering the episode of Shambuka's killing in Uttara Kanda and its treatment in the play and the movie, a difference in the perspective of this incident becomes apparent. A Brahman boy dies at an early age which is not supposed to happen in prosperous Rama Rajyam. In the Treta age, only Kshatriyas and Brahmans were allowed to perform penance. The rest, the Vaishyas and Shudras were considered the 'others' and reduced to 'lesser beings'. The vulnerability stems from this position at the bottom of the social hierarchy. Hence when a Shudra performs penance somewhere in Ayodhya, the sages consider this transgression as a bad omen and link it to the boy's death. This turns out to be a disgrace to Rama since he, the valiant king of Ayodhya, fails to prevent this child's death. To revoke his mistake and prove his 'strength', he goes to the Dandaka forest and kills Shambuka after confirming that he is a Shudra performing penance to attain heaven. The Brahman boy is to have resurrected at the expense of Shambuka's life. Rama is called "divine Purusha" and his slaying of Shambuka is

praised as “God-like work” (Dutt 1793). Thus Rama’s aggressive act is condoned in the name of “the greater good” (Gaard, *Ecofeminism* 254).

Rama is said to have protected his subjects by killing Shambuka. This raises the question of Shambuka’s identity in Uttara Kanda. Is he not a subject? How is the hierarchy valid? Are only the elite subjects worthy of protection? Is heaven only for the Brahmans and Kshatriyas? This kind of oppression stems from the hierarchy which is created by the self/other dichotomy. People like us must be respected and those different from us deserve to be exploited and oppressed. Overcoming this dichotomy and embracing plurality is what ecofeminists identify as the solution for building a non-patriarchal world. If Shambuka was seen as a human (not as the other) having equal right to perform penance, the innocence of his act would have surfaced. Instead, his penance which has nothing to do with the death of a completely unknown boy is blamed and he is victimized.

In the movie, Shambuka’s wife, desperate to save her husband, falls at Rama’s feet as he raises his bow and asks him not to do it (*Kanchana Sita* 00:04:31-05:00). Here, Rama’s sense of empathy is aroused and he refrains from killing Shambuka. This becomes a gesture of care rather than a “restraint of aggression” (Gaard, *Ecofeminism* 255). However, Vasishtan constantly warns him that he made a mistake by not performing his duty. When Rama tells Vasishtan that Shambuka’s wife pleaded for compassion, he rebukes him saying that a king’s compassion must be the pitiless preservation of justice and his royal Dharma, the welfare of the people. Consequently, Shambuka gets killed later and his wife curses Rama just before the Aswamedham. Thus, the elevation of merciless royal dharma is a major justification for the oppression.

In Uttara Kanda, he is identified by the signifier ‘Shudra’ which supports his low status (except when he introduces himself to Rama). The absent referent is Shambuka, a

human being with an individual self. In the play, he is referred to as Shambuka and this identity heightens the injustice of Rama's murder. Bharatan reproves his slaying saying, "What a pity! The truth is that the only person who died because of Shambuka's penance is Shambuka himself" (Nair 167).

Aggressive conduct is merely restrained in a patriarchal kingdom and not prohibited. Hunting is a restrained activity accepted around the time Ramayana was written. However when two rakshasas, presumably tribes, 'devoured' deers for food, king Saudasa himself engaged in hunting, espied and killed one of them. On the other hand, the exploits of kings are praised and appreciated. Thus, while the killing of an animal particularly for pleasure is customarily condemned, it is honored when performed by the kings. Similarly, while killing a fellow human being is outrageous, it is honored when kings carry it out in the name of preserving justice. They are repeatedly exalted as the slayer of enemies in the Ramayana. Most often, the 'enemies' of this system turn out to be the lower castes like Shambuka or the 'barbaric demons' who are presumed to be the original aboriginals.

G. Aravindan subverts this perspective by casting tribal men and women as the epic heroes. He alters the predominant view that power lies in the hands of a few upper-caste Aryan men. The actors belonged to Rama Chenchu Dravidian tribe situated primarily in the tribal areas of Andhra Pradesh, where the movie is set. They lead a simple, traditional life based on hunting and gathering. He also projects the traditional music (*Kanchana Sita* 00:18:27-19:21) and dance (00:25:20-27:48) of the aboriginals. This asserts and proclaims the identity and customs of the tribal people.

The episode of the Aswamedham Yagna also needs to be viewed through an ecofeminist critical lens. It generally refers to horse sacrifice for man's redemption. In Uttara Kanda, it is performed to prove Rama's imperial sovereignty. It is called the great sacrifice

which cleanses one of all sins. Thus the constructed role of animals, just as for women, is to serve or to be served up. Be it the Krauncha birds, the deer or the horse which was sacrificed, all of them are reduced to passive objects. This is exemplified by the fact that the horse is beautifully decked to please the gods and earn the reward. The laws of Rama Rajyam sanction the killing of animals if done in a ritualized manner. Thus religious rituals reinforce the process of othering. The use of the signifier “sacrificial horse” (Dutt 1902) normalizes the horse as an object meant for sacrifice. The entire process luxuriously takes place and witnesses the distribution of abundant wealth. The monkeys, who take part in Aswamedham, are either real monkeys or the Vanaras who were a race of forest-dwelling people. Thus living in harmony with nature is seen as primitive and uncivilized. Also addressing the forest-dwellers as monkeys degrades them to an inferior position, making it easier to establish superiority over them.

Another element of concern is the replacement of Sita with a golden statue. The title ‘*Kanchana Sita*’ (Golden Sita) is based on this incident. The presence of a life partner is necessary for Aswamedham. However, since Rama banished Sita and he was not willing to marry again, he replaced her with a pure golden statue. The gold refers to Sita’s purity. This reinforces women’s role as objects, to fulfill their husband’s desires. Thus, Uttara Kanda emphasizes more on the female body and faithfulness to one’s husband. Her form and purity are represented by the statue and hence it can replace Sita. However, in the play, this is taken up as outrageous. When Lakshmanan reveals this to Valmiki, he asks, “Is the better half of king Ramachandran just metal, mere lifeless material? A being without any consciousness, or thoughts, an unquestioning, lifeless lump! After all, king Ramachandran’s heart is also metal isn’t it?” (Nair 162). In the sacrificial plot, Bharatan says, “On this side we have the granite stone of Rama...” Hanuman replies, “...in this Kosala kingdom, are not there any human

beings, O king?” and “Where is the Sitaram whom Panchavati’s greenery and flowers worshipped with their souls?” (172).

The movie interestingly projects the melancholic images of dead Shambuka (lying on his wife’s lap) and the slaughtered horse successively (*Kanchana Sita* 1:15:59-16:50). Following these two is the image of the golden statue of Sita behind the sacrificial fire (1:16:52-17:02). This depicts how the force operating behind all three kinds of oppression is the same (upper caste male superiority ideology). Thus, in the movie, Rama who is responsible for all three injustices is depicted as thoughtfully staring at the sacrificial fire through deeply troubled eyes and a wrinkled forehead.

Now investigating the second trial of Sita, it can be found that in Uttara Kanda, Rama’s desire for a second trial is praised as “wondrous words”. Valmiki says, “What Rama has said shall be satisfied. Husband is the greatest god for women. So Sita shall carry out his behests” (Dutt 1907). This shocking patriarchal attitude is subverted in the play. When Rama expresses his desire, Valmiki bursts out saying, “Stop! What a sin! Does the fire need a witness to proclaim its ability to burn...Even great Hanuman witnessed it” (Nair 179). Urmila exclaims that his demand is an insult to the whole of womanhood and a broken-hearted Kausalya welcomes Sita saying, “My blessed Raman has insulted a mother” (180).

In the epic, despite the little reference to a ‘spiritual earth goddess’, her presence variously called goddess Gaia, Madhavi, Vasundhara and Dharani affirms female power, body and will. When Rama asked Sita to take an oath of chastity in front of his people, she tells the Earth goddess to receive her if she is chaste. The earth opens up and she is grandly received. However, what is problematic is the idea that Sita was expected to be pure and true to Rama who repeatedly disowns her. Although the reception of Sita, celebrated by nature can be seen as a manifestation of her strength and virtue, this does not make the men repent.

Only a miracle could move the hard-hearted people who rejoiced in her chastity, after having put her through immense misery. Rather than reproving Rama, people praised and consoled him. Rama, like Appanna in Nagamandala, does not realize his mistake but is simply aghast at the disappearance of Sita. He pleads with Vasundhara to bring Sita back and threatens her saying he will give her the “fruits of her negligence” (Dutt 1912). He calls her acknowledgment of Sita’s dignity, negligence. This shows how he still considered Sita and nature as weak, meant to be a source of comfort and pleasure to men. When Sita lived with him, he banished her for his own sake. Now that she is no longer there to dance to his tune, he hypocritically says that he wishes to live with her. Another irony is how Rama wants Sita to prove her chastity but when nature confirms her oath, he curses the goddess. He says, “I shall deluge the Earth with waters...” (1912). This also indicates his sense of superiority over nature.

In the play, however, Rama is answerable to the protesting Urmila, Kausalya, Valmiki, Bharatan, and Hanuman. From a hero, he falls to a vulnerable position. As a fallible human being, he struggles between his dharma and rajya dharma. Only Vasishtan, the Brahman, constantly advises and supports him. Although this fills him with doubt, the deep-rooted greed for power and his kingdom makes him stick to his decision. He tells her to do it “for the well-being of Saketam [Ayodhya]” (Nair 180). How is her chastity (which was already proved once) supposed to be good for the kingdom? By attaching irrational importance to a woman’s chastity, Uttara Kanda reduces her value to her reproductive function alone, which in turn provides an excuse to subordinate her. In the play, Sita does not take the oath. Instead, she declares “Let this Earth crack open and protect this woman’s pride” (180). In contrast to the celebration and grandeur described in Uttara Kanda, the scenario turns gloomy in the play. Dark rumbling rainclouds covers the Earth. Thunder and strong gusts of wind rage over this injustice. This shows how nature reproaches Rama’s

behavior and upholds its power confirmed by Valmiki as “Sita does not perish...Sita is nature itself...” (181).

The final spiritual journey of Rama is retold in the epilogue in the movie. Haunted and guilt-ridden by his hideous crimes, Rama commits suicide by submerging himself in the river Sarayu, in a final effort to achieve peace and redemption. He leaves behind his pursuit of material wealth and merges with the all-pervading Prakriti. Rama with his hair let loose and a sacrificial fire held in one hand strides along the river Sarayu under the crimson glare of the setting sun. This pensive mood is amplified by the continual strain of wistful prayers in the background. As Rama steeped in repentance steps into the water and treads towards the setting sun (signifying the descent of his power and life) the music rises in intensity, until the camera blurs the scene as Rama dissolves into an obscure shadow, in communion with the sun and the sea, merging into sheer whiteness (*Kanchana Sita* 1:23:41-26:44).

Using Purusha-Prakriti as a conceptual framework, this chapter analyzes the underlying patterns of exploitation in the episodes of the expulsion and second trial of Sita, killing of Shambuka, and Ashwamedha. Sita, the horse and Shambuka are associated with Prakriti and shunned by Rama’s male bigotry. The play and movie uphold this Prakriti. It analyses how the absent referent becomes a tool for subjugation. The question of agency is resolved in the play. It employs the marginalized characters named Urmila, Queen Kausalya and Bharathan as dissenters. The movie turns people’s attention to the omnipresence of Prakriti or energy which intervenes and prevents destruction. Sita, nature and Shambuka are united as victims of male hegemony. The cruelty of the punishment meted out on them is acknowledged through the portrayal of the turmoil experienced by Rama. By comparing and contrasting Uttara Kanda and *Kanchana Sita*, the chapter finds a solution to the end of male hegemony in the ultimate union of Prakriti and Purusha.

Conclusion

Kavalam Narayana Panicker observes, “The overpowering presence of Sita, who was never shown in the movie, as nature and the final culmination with Purusha was a grand theme that was never before or again attempted in Indian cinema” (qtd. in “Children”). The play *Kanchana Sita* won the Sahitya Akademi award in 1969 and the movie was a critical success. A comparative study of both the versions of *Kanchana Sita* with the Uttara Kanda of Ramayana reveals a pattern connecting the exploitation of women, nature and the marginalized communities. The first chapter outlines a theoretical framework of ecofeminism. It traces the origins and the different types of ecofeminism. It then incorporates some of the tenets of Vandana Shiva, Josephine Donovan and other western ecofeminists. The focus is on the concepts of Prakriti-Purusha and the absent-referent.

The second chapter summarizes the Uttara Kanda of Ramayana and *Kanchana Sita*. It then compares the portrayal of the episodes of the banishment of Sita, the killing of Shambuka, Aswamedham and the second trial of Sita in the play and the Uttara Kanda. This comparison using the tool of ecofeminism brings to the forefront the difference in the perspectives of C.N. Sreekantan Nair and Valmiki. While Ramayana justifies domination as a part of man’s duty, the play adopts a critical view of Rama’s decisions. This inturn shows how the play *Kanchana Sita* successfully subverts the status of male domination which infiltrates the Ramayana. It can be called feminine in the sense that it gives voice to the absent referent and makes the invisible, unequal relationships conspicuous through the perspective, conflicting thoughts and emotions of the otherwise sidelined characters of Ramayana- Urmila, Queen Kausalya, Bharatan and Hanuman. Rama is censured and the politics of power is abhorred. While Ramayana evokes a sense of awe in the readers, the play induces pity for Rama and disgust for the patriarchal norms. It applies the concept of Purusha-Prakriti. It analyses how Prakriti is associated with women and nature which are then

marginalized, taken for granted, objectified and exploited. Thus, Sita, the horse in Aswamedham and Shambooka labelled as Prakriti fall prey to Rama's male bigotry. The question of agency is resolved in the play. The movie evaluates such practices which form the foundations of social stereotypes and hegemonic relationships.

The application of the ecofeminist theory to the play and movie *Kanchana Sita* reveals the construct of justice and power as the underlying sources of all 'isms' of domination including naturism. Rama wavering in his decision to kill Shambuka, the flare-up of protest over the use of Golden Sita, Urmila's campaign for Sita as a person of will, the question of humanity over justice, the censure of Rama's power politics and the exploitation of all three (Sita, horse and Shambuka) in the name of the welfare of the king, kingdom and its people subvert the unquestioned position occupied by Rama in Uttara Kanda. The oppressions in all three episodes are linked. A look at the final episode of Sita's second trial and the intervention of nature provides a clear distinction between the self-serving Rama in Uttara Kanda and the flawed, humanized Rama torn between respect for his partner and Rajyadharma in the play. While Uttara Kanda pities Sita and justifies Rama's action, the play exalts Prakriti and Sita's willing union with nature. It criticizes Rama's alienation from Prakriti. The movie attempts to unify Prakriti with Purusha and achieves equality.

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Project Report

On

**A STUDY ON MATHEMATICAL MODELING
OF NUMERICAL WEATHER FORECASTING**

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

MATHEMATICS

by

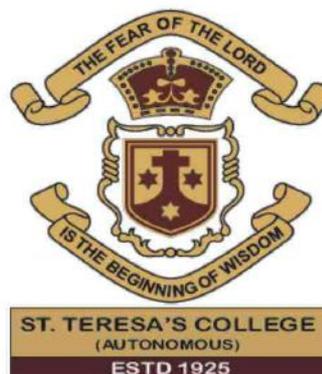
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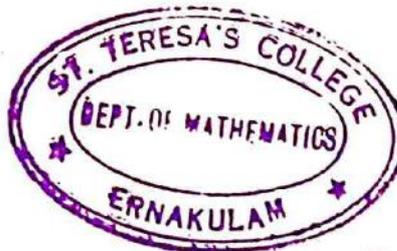


CERTIFICATE

This is to certify that the dissertation entitled, **A STUDY ON MATHEMATICAL MODELING OF NUMERICAL WEATHER FORECASTING** is a bonafide record of the work done by Ms. **PRIYA FRANCIS** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

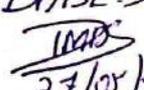
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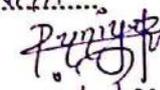

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of NISHA OOMMEN, Assistant Professor, Department of Mathematics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.

Date: 27-05-2022



PRIYA FRANCIS

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ACKNOWLEDGEMENTS

I must mention several individuals who encouraged me to carry this work. Their continuous invaluable knowledgeable guidance throughout the course of this study helped me to complete the work up to this stage

I am very grateful to my project guide NISHA OOMMEN for the immense help during the period of work

In addition, very energetic and competitive atmosphere of the Department had much to do with this work. I acknowledge with thanks to faculty, teaching and non-teaching staff of the department and Colleagues.

I also very thankful to HoD for their valuable suggestions, critical examination of work during the progress.

Ernakulam.

Date: 27-05-2022



PRIYA FRANCIS

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Chapter 1

Introduction and History

1.1 History

The history of numerical weather prediction considers how current weather conditions as input into mathematical models of the atmosphere and oceans to predict the weather and future sea state has different over the years. The roots of numerical weather prediction can be traced back to the work of Vilhelm Bjerknes, a Norwegian physicist who has been called the father of modern meteorology. In 1904, he published a paper suggesting that it would be possible to forecast the weather by solving a system of nonlinear partial differential equations. A British mathematician named Lewis Fry Richardson spent three years developing Bjerknes's techniques and procedures to solve these equations. In 1920s, it was not until the advent of the computer and computer simulation that computation time was reduced to less than the forecast period itself. ENIAC was used to create the first forecasts via computer in 1950, and over the years more powerful computers have been used to increase the size of original datasets as well as include more difficult versions of the equations of motion. The development of global forecasting models led to the first climate models. The development of limited area models facilitated developments in forecasting the tracks of tropical cyclone as well as air quality in the 1970s and 1980s. Because the output of forecast models based on atmospheric dynamics needs corrections near ground level, model output statistics [MOS] were developed

in 1970s and 1980s for individual forecast points. The MOS apply statistical techniques to post-process the output of dynamical models with the most recent surface observations and the forecast points climatology. This technique can correct for model resolution as well as model biases. Even with the increasing power of supercomputers, the forecast skill of numerical weather models only extends to about two weeks into the future. Since the density and quality of observations together with the chaotic nature of the partial differential equations used to calculate the forecast introduce errors which double every five days. The use of model ensemble forecasts since the 1990s helps to define the forecast uncertainty and extend weather forecasting farther into the future than otherwise possible.

1.2 Introduction

Weather forecasting can be defined as the act of predicting future weather conditions or an effort to indicate the weather conditions which are expected to occur. Weather forecasting is the application of Science and Technology to predict the state of the atmosphere for a future time and a given location. Human beings have attempted to predict the weather informally for times, and formally since at least the nineteenth century. Weather forecasts are made by collecting qualitative data about the present state of the atmosphere and using scientific understanding of atmospheric processes to project how the atmosphere will change within the next few hours. Once, an all-human endeavour based mainly upon changes in barometric pressure, current weather conditions and sky conditions, forecast models are now used to fix future conditions.

The dynamics of the atmosphere is governed by physical, chemical, and even Biological processes which are commonly described by systems of time and space dependent nonlinear partial differential equations. Since this kind of mathematical description is slightly complicated, the form of the equations' exact solution is usually unknown. In order to explore its properties or to compute its approximation, further Math-

ematical methods are needed. The resulting atmospheric models are then to forecast the weather situation, the concentration of an air pollutant, or even the changes in climate.

There are two well-known NWP models namely, National Weather Service's Global Forecast System (GFS) and the European Centre for Medium-Range Weather Forecast, known as ECMWF model. These models are also known as the American and European Models, respectively. It is generally mentioned at some context that European models has produced most accurate global weather forecasts.

Chapter 2

Numerical Weather Prediction

Numerical weather prediction uses mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions. Post processing techniques such as model output statistics have been developed to improve handling of errors in numerical predictions.

Both the significance of weather forecasts and the need of knowing more about atmospheric developments were understood equally soon after the first wind warnings were published. But very few people realised that mathematics could be used to describe these processes and produce more exact forecasts than synoptic meteorology ever could. In the early 20th century, scientists, in particular vilhelm Bjerknes and Lewis Fry Richardson, established numerical weather forecasting, which is based on applying physical laws to the atmosphere and solving mathematical equations associated to these laws. The discovery of chaos theory and not least the development of computers greatly improved the quality of forecasts. Today, meteorologists constantly improve the various forecasting models designed by the world's leading weather services.

2.1 Numerical Weather Prediction Equations

The Primitive Equations are used as the forecast equations in NWP models. Vilhelm Bjerknes first recognized that numerical weather prediction was possible in principle in 1904. He proposed that weather

prediction could be seen as an initial value problem in mathematics. Since equations direct how meteorological variables change with time, if we know the initial condition of the atmosphere, we can solve the equations to obtain new values of those variables at a future time (i.e., make a forecast). To represent an NWP model in its simplest form, we can write:

$$\frac{\Delta A}{\Delta t} = F(A) \quad (2.1)$$

Where ΔA gives the change in a forecast variable at a particular point in space. Δt gives the change in time (how far into the future we are forecasting), $F(A)$ represents terms that can cause changes in the value of A . This equation means that the change in forecast variable A during the time period t is equal to the cumulative effects of all processes that force A to change. Future values of meteorological variables are solved for by finding their initial values and then adding the physical forcing that acts on the variables over the time period of the forecast. This is stated as

$$A^{forecast} = A^{initial} + F(A)\Delta t \quad (2.2)$$

where $F(A)$ stands for the combination of all of the kinds of forcing that can occur.

2.2 Primitive Equations

Primitive Equations are used as the forecast equations in NWP models.

2.2.1 Momentum Equations

$$\frac{\partial u}{\partial t} = -u \frac{\partial u}{\partial x} - v \frac{\partial u}{\partial y} - w \frac{\partial u}{\partial z} - \frac{1}{\rho} \frac{\partial p}{\partial x} + fv \quad (2.3)$$

$$\frac{\partial v}{\partial t} = -u \frac{\partial v}{\partial x} - v \frac{\partial v}{\partial y} - w \frac{\partial v}{\partial z} - \frac{1}{\rho} \frac{\partial p}{\partial y} - fu \quad (2.4)$$

$$\frac{\partial w}{\partial t} = -u \frac{\partial w}{\partial x} - v \frac{\partial w}{\partial y} - w \frac{\partial w}{\partial z} - \frac{1}{\rho} \frac{\partial p}{\partial z} - g \quad (2.5)$$

Where u is the Zonal velocity – velocity in the east-west direction

tangent to the sphere, v is the meridional velocity – velocity in the north-south direction tangent to the sphere, w is the vertical velocity, ρ is the density, p is the pressure, f is the Coriolis force, g is the acceleration of gravity.

2.2.2 Thermodynamic Equation

$$\frac{\partial T}{\partial t} = -u \frac{\partial T}{\partial x} - v \frac{\partial T}{\partial y} - w \frac{\partial T}{\partial z} + T \quad (2.6)$$

Where T is the temperature.

2.2.3 Mass Continuity Equation

$$\frac{\partial P}{\partial t} = -u \frac{\partial P}{\partial x} - v \frac{\partial P}{\partial y} - w \frac{\partial P}{\partial z} - \rho \Delta V \quad (2.7)$$

Where p is the pressure, ρ is the density

2.2.4 Ideal gas law

$$P = \rho RT \quad (2.8)$$

where P is the pressure, ρ is the density, R is the gas constant, T is the temperature.

2.2.5 Hydrostatic equation

$$P_1 = P_0 e^{-\frac{gz_1}{RT}} \quad (2.9)$$

Chapter 3

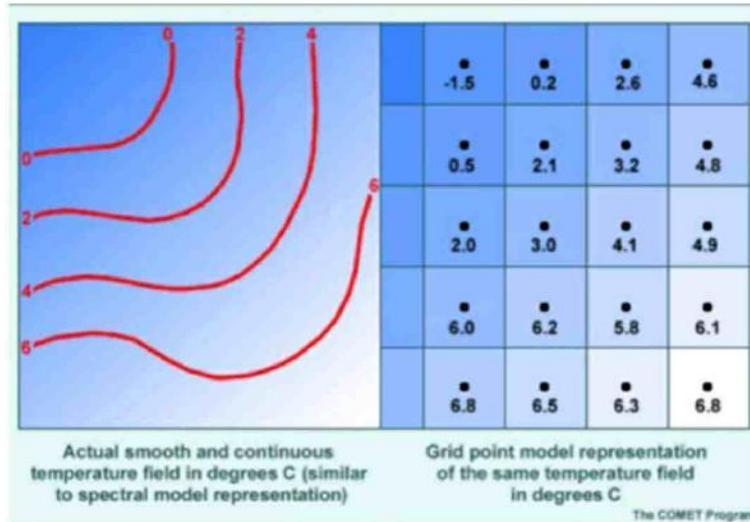
Numerical Weather prediction models

An Atmospheric model is a mathematical model made around the full set of Primitive Equations which rule atmospheric motions. Most atmospheric models are numerical. i.e. they are Equations of motion. The horizontal domain of a model is either Global, covering the entire Earth or Regional(limited area), covering only part of the Earth.

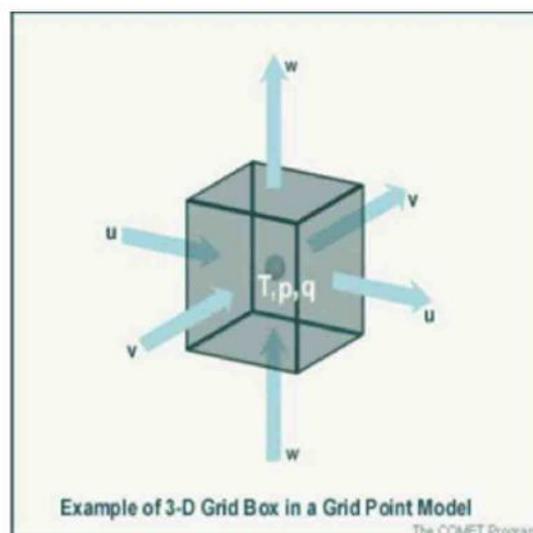
The different types of models run are:

3.1 Grid Point Model

In the real atmosphere, wind, pressure, temperature, and moisture differ from location to location in a smooth, constant way. Grid point models, however, make their calculations on a fixed collection of spatially disconnected grid points. The values at the grid points actually represent an area average over a grid box. The continuous temperature field shown in the next graphic, therefore, must be represented at each grid point as shown by the black numbers in the right panel of the previous graphic. The temperature value at the grid point represents the grid box volume average.



Grid point models really represent the atmosphere in three-dimensional grid cubes, such as the one shown below. The temperature, pressure, and moisture (T , p , and q), shown in the centre of the cube, represent the average conditions throughout the cube. The east-west winds (u) and the north-south winds (v), located at the sides of the cube, represent the average of the wind components between the centre of this cube and the centre of the adjacent cubes. Similarly, the vertical motion (w) is represented on the upper and lower faces of the cube. This procedure of variables within and around the grid cube (called a staggered grid) has advantages when calculating derivatives. It is also physically spontaneous, average thermodynamic properties inside the grid cube are represented at the centre, whereas the winds on the faces are associated with changes into and out of the cube.



Grid point models must use difference methods to solve the forecast equations. In the real atmosphere, advection regularly occurs at very small scales. The greater the distance between grid points, the less likely the model will be able to detect small-scale variations in the temperature and moisture fields. The lack of resolution introduces errors into the solution of the finite difference equation. Shortages in the ability of the finite difference approximations to calculate gradients and higher order derivatives exactly are called Truncation Errors.

3.1.1 Shapes of Grids

Richardson's effort of predicting weather using grid points set the stage for future development of grids in different shapes. In order to accommodate the spherical shape of the earth and represent the equations more exactly and efficiently, there are different grid shapes used in numerical models.

Rectangular / Square Grids

The rectangular or square grids is the most commonly used grids in the NWP models. The rectangular grid is simple in nature but suffers from the polar problem where the lines of equal longitude known as meridians, converge to points at the poles. The poles are unique points and may cause violations of global conservation laws within the model. To maintain computational stability near the poles, small integration time-steps could be used, but at great expense. The high resolution in the east-west direction near the poles would be wasted because the model uses lower resolution.

A rotated grid can overcome the polar problem for limited area models, but for global models, other grid shapes are used. For example, Kurihara proposed to use 'skipped' or 'Kurihara' grid. Unfortunately use of the Kurihara grid causes fake high pressure to develop at the poles. As a result, their use has been strictly limited or abandoned in finite difference models. However, problems due to the use of the Kurihara grid can be resolved by using more accurate numerical schemes. In the late 60's and early 70's, the application of quasi-uniform grids

was proposed as a method to avoid the polar problem of the grid-point models. For example, the Global Forecasting System (GFS) model has roughly a square grid near the equator, a more rectangular grid in the mid-latitudes, and a triangular grid near the poles, eventually converging to a point at the poles. Another example of a model that uses the rectangular grid type is the North American Mesoscale Model (NAM). When compared to the resolution of the GFS, the NAM does not have a grid stretching problem since the model calculates variables close to the poles. This is due to the NAM not depending on a latitude-longitude system for creating its grid bounds and accepting a more precise horizontal measurement system. The other problem with the latitude-longitude grid is the need for special filters to deal with the pole singularities. They also do not scale well on massively parallel computers.

TRIANGULAR GRIDS

Triangular grids are not used as often in models as are rectangular grids. One form of quasi-uniform grid whose base element is a triangle is the spherical geodesic grid. Icosahedral grids, first introduced in the 1960s, give almost homogeneous and quasi-isotropic coverage of the sphere. The grid is made by dividing the triangular faces of an icosahedron into smaller triangles, the vertices of which are the grid points. Each point on the face or edge of one of the faces of the icosahedron is surrounded by six triangles making each point the centre of a hexagon. The triangular faces of the icosahedrons are arranged into pairs to form rhombuses, five around the South Pole and five around the North Pole. The poles are chosen as two pentagonal points where the five rhombuses meet. The main advantage of the geodesic grids is that all the grid cells are nearly the same size. The uniform cell size allows for computational stability even with finite volume schemes.

HEXAGONAL GRIDS

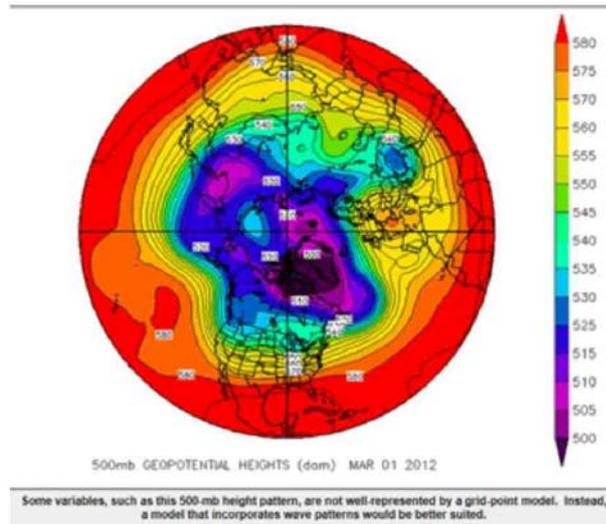
Similar to triangular grids, hexagonal grids are also not used as often as the rectangular/square grids. In this method, variables are calculated at each grid intersection between different hexagons, in addition to be-

ing calculated in the centre of the hexagonal grid. Sadourney describes in detail how the spherical icosahedral-hexagonal grid is constructed. They solved the non-divergent barotropic vorticity equation with finite difference methods on the icosahedral-hexagonal grids. Majewski et al. develops an approach that uses local basis functions that are orthogonal and conform perfectly to the spherical surface. A study done by Thuburn shows a method of creating a global hexagonal grid, but then using a finite differencing method to calculate the rate-of-change of different variables without having to create triangles within the hexagonal grids. The space differencing scheme using the icosahedral-hexagonal grid gives a satisfactory approximation to the analytical equations given an initial condition and remains nonlinearly stable, for any condition.

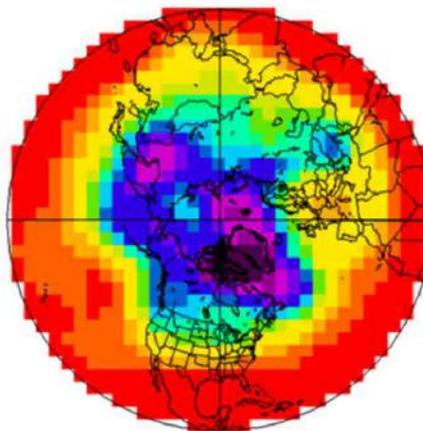
Thuburn also noted that his method may not be as exact as those which included an additional point in the centre of the hexagonal grid, but his method was computationally faster, and was able to accurately show the polar regions since there was no need of stretching the grid in that region. The other advantages of the hexagonal grid are: (i) Removes the polar problem. (ii) Permits larger explicit time steps. (iii) Most isotropic compared to other grid types. (iv) Conservation of quantities in finite volume formulation. Can be generalized easily to arbitrary grid structures.

3.2 Spectral Model

Spectral models represent the spatial variations of Meteorological variables as a finite series of waves of Differing wavelengths Consider the map below that shows the 500 – mb height pattern for March 1, 2012. From this polar stereographic perspective, we can see many long waves located around the globe.



Now we can see a gridded version of this height data

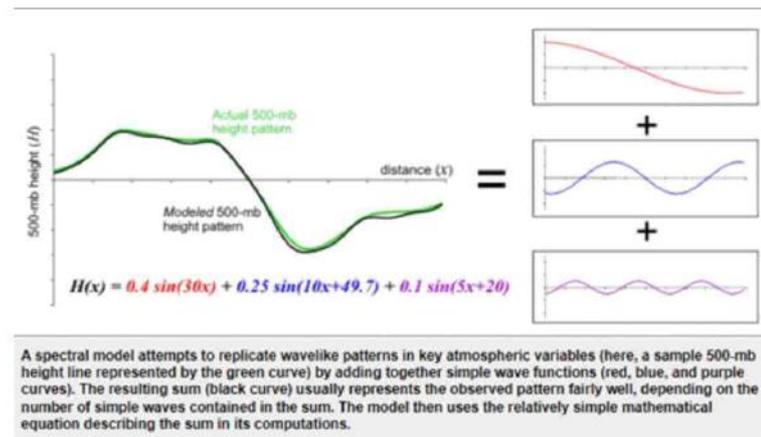


One of the first things is that we have almost completely lost the sense of the waves that make up the pattern. Furthermore, by gridding the data in such a way, some of the better features of the height patterns have vanished. Since many variables in the atmosphere can be pictured by wave-like structures [rather than square boxes]. It turns out there is a numerical weather prediction model that uses waves instead of grid boxes, a SPECTRAL MODEL.

The primary spectral model used by the National Centres for Environmental Prediction is the Global Forecast System, or GFS, for short. Rather than dividing the atmosphere into a series of grid boxes, the GFS describes the present and future conditions of the atmosphere by solving mathematical equations whose graphical solutions consist of a series of waves.

The important concept of the Spectral modelling lies in the idea that any wavelike function can be replicated by adding various basic waves together.

Let's see an example, The green line as an actual 500-mb height line, for example, stretch across the U.S. and represent a long-wave point and trough. A spectral model first approximates this pattern by adding together a set of simple wave functions in this example, variations of a trigonometric function called the "sine" are used. We were able to closely duplicate the green curve by adding together three different wave functions (the red, blue, and purple curves). The resulting black curve is fairly close to the green curve and has a simple equation (mathematically speaking, of course) that a computer has no difficulty interpreting.



Thus, the first step in using a spectral model is to analyse the present patterns in the observed atmospheric variables and then closely replicate these patterns using sums of simple wave functions. One advantage to this approach is that the way in which wave functions change in space and time is well known. This mathematical fact helps to prove a major advantage of spectral models that they run faster on computers. Given these computational time savings, spectral models better give themselves to longer-range forecasts than grid-point models like the NAM [North American Mesoscale Model]. Grid-point models push modern supercomputers to their limits just to mix out a respectable three or four-day forecast. However, the GFS is routinely run out to 384 hours (16 days) four times a day (starting at 00 UTC, 06 UTC, 12 UTC and

18 UTC). One final advantage of spectral models is that their solutions are available for every point on the globe, rather than being tied to a regular grid collection.

3.3 Hydrostatic Model

Most grid point models and all spectral models in the current operational NWP models are hydrostatic. This means that no vertical accelerations are calculated clearly. The hydrostatic assumption is valid for synoptic- and global-scale systems and for some mesoscale phenomena. An important exception is deep convection, where resistance becomes an important force. Hydrostatic models account for the effects of convection using statistical parameterizations approximating the larger-scale changes in temperature and moisture caused by non-hydrostatic processes.

The main advantage of hydrostatic models, it can run fast over limited area domains, providing forecasts in time for operational use.

3.4 Non-Hydrostatic Model

Currently, most non-hydrostatic models are grid point models. They are generally used in forecast or research problems requiring very high horizontal resolution (from tens of meters to a few kilometres) and cover relatively small domains.

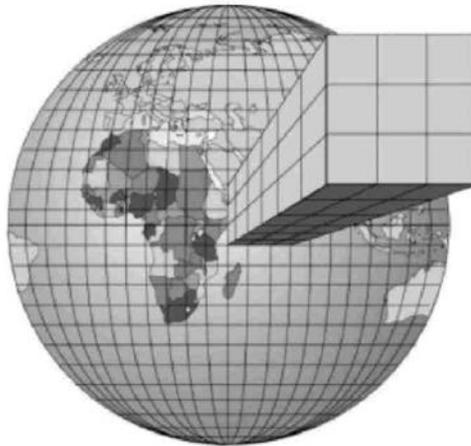
Use of the non-hydrostatic primitive equations, directly forecasting vertical motion used for forecasting small scale phenomena. Predict realistic looking, detailed mesoscale structure and consistent impact on surrounding weather, resulting in either superior local forecasts or large errors.

Chapter 4

Mathematical methods used in weather forecasting

4.1 Finite Difference method

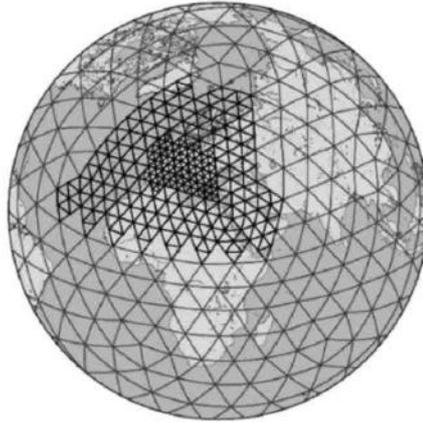
The traditional grid structure is based on dividing the Earth's surface into a large number of squares, such that there is a high air column above each square,



A rectangular grid around the Earth with air columns above the surface.

The atmosphere is then divided into a number of layers, resulting in a three-dimensional grid, in which the primitive equations can be solved for each grid point. In general, the layers are much thinner close to the Earth's surface than the layers in the upper atmosphere, as most weather events happen relatively close to the ground. Processes in the upper atmosphere influence the weather, so the whole of the atmosphere

has to be considered in a forecasting model. Most models also include several hidden layers, so as to take the air and water exchange between atmosphere and ground into account. Over the years, the resolution of the grids has become higher (i.e. the edge length of each square has become smaller).



A triangular grid as used by the DWD.

The world's leading weather services such as the British Met Office and the German DWD use three different grids, a global grid crossing the whole planet, a so-called regional model covering Europe (and North America in the case of the Met Office's model), and a local model covering the UK or Germany, respectively. The regional model of the DWD has a resolution of 7 km, and the local model has a resolution of up to 2.8 km (the Met Office's models have coarser resolution as the Met Office does not work with non-hydrostatic equations). Both of these local models, and all of the Met Office models, are based on a rectangular grid, whereas the DWD's global model is based on a triangular grid with a 40 km resolution. The great advantage of the triangular grid is that the primitive equations can be solved in air parcels close to the poles without any problems, as opposed to the rectangular grid, where the longitudes approach each other, resulting in wrong calculations.

Generally, in a terrain following coordinate system, the grid-spacing in the λ -direction is given by $\Delta\lambda$, similarly $\Delta\phi$ and $\Delta\zeta$ represent the spacing in the ϕ -direction and the ζ -direction respectively. As in, λ

denotes the longitude, ϕ denotes the latitude and ζ is the height coordinate. The position of the grid points in the computational space is defined by,

$$\lambda_i = \lambda_0 + (i - 1)\Delta\lambda \quad i = 1, \dots, N_\lambda \quad (4.1)$$

$$\phi_j = \phi_0 + (j - 1)\Delta\phi \quad j = 1, \dots, N_\phi \quad (4.2)$$

$$\zeta_k = k \quad k = 1, \dots, N_\zeta \quad (4.3)$$

Here, N_α is the number of grid points in the α -direction, λ_0 and ϕ_0 are the values of λ and ϕ in the southwest corner of the model domain.

Now, the primitive equations have to be re-written in finite difference form. For this, we need to define approximations to the derivatives at a definite grid point x_l in terms of finite differences. The value of a variable ψ at x_l is given by ψ_l and the finite difference for ψ_l is given using the values of ψ_{l+1} and ψ_{l-1} , i.e. the values at the two adjacent grid points. The behaviour of these two terms can be defined using Taylor expansion:

$$\psi_{l+1} = \psi_l + \psi'_l \Delta x + \psi''_l \left(\frac{\Delta x^2}{2!}\right) + \psi'''_l \left(\frac{\Delta x^3}{3!}\right) \quad (4.4)$$

$$\psi_{l-1} = \psi_l - \psi'_l \Delta x + \psi''_l \left(\frac{\Delta x^2}{2!}\right) - \psi'''_l \left(\frac{\Delta x^3}{3!}\right) \quad (4.5)$$

Subtracting the second from the first expansion gives the centred finite difference approximation to the first derivative of ψ_l

$$\psi'_l = \frac{\psi_{l+1} - \psi_{l-1}}{2\Delta x} + E \quad (4.6)$$

The term,

$$E = \left(\frac{\Delta x^2}{3! * 2!}\right)(2\psi''_l) \quad (4.7)$$

gives the truncation error and can be omitted since it is small. However, the lowest power of the difference of x , Δx , in E gives the order

of the approximation. This scheme has order 2. As mentioned above, the higher the order, the more accurate the approximation. In general, centred finite difference approximations are better than forward or backward approximations, which can also be derived from the Taylor expansions for ψ_{l+1} and ψ_{l-1} . Solving the first expansion for ψ'_l gives the forward approximation:

$$\psi'_l = \frac{\psi_l - \psi_{l-1}}{\Delta x} + E \quad (4.8)$$

These schemes both have order 1, but there are conditions where it is favourable to use these approximations instead of a centred approximation. It is also possible to derive the finite difference approximations to the second and third derivatives of ψ_l .

Not only space, but also time has to be discretized, and time derivatives can also be denoted as finite difference approximations, that is in terms of values at distinct time levels. A time step is denoted by Δt , and a discrete time level is given by $t_n = t_0 + n\Delta t$ with t_0 being the initial time for integration. The grid point value of the variable ψ_l at time t_n is denoted by ψ_l^n and its derivative can be expressed as a centred finite difference approximation:

$$\left(\frac{\partial\psi}{\partial t}\right)^n = \frac{\psi_l^{n+1} - \psi_l^{n-1}}{2\Delta t} + O \quad (4.9)$$

Again, O represents the truncation error and can be omitted.

There are two different finite difference schemes, the explicit scheme and the implicit scheme. The explicit scheme is much easier to solve than the implicit one, as it is possible to compute the new value of ψ_l at time $n+1$ for every grid point, provided the values of ψ_l are known for every grid point at the current time step n . But the choice of the time step is limited in order to keep the scheme constant. The implicit scheme, on the other hand, is absolutely constant, but it results in a system of simultaneous equations, so is more difficult to solve. Both explicit and implicit schemes are used in current forecasting models.

The approximations described above are very simple examples showing the general idea of finite differences. When the primitive equations

are expressed in terms of finite differences, the equations soon become very long and take some computational effort to solve. Explicit time integration can be made more effective, though, by applying a so-called mode-splitting technique. This means that the primitive equations are subdivided into forcing terms f_ψ referring to slowly varying modes and source terms s_ψ directly related to the fast-moving sound waves:

$$\frac{\partial\psi}{\partial t} = f_\psi + s_\psi \quad (4.10)$$

The terms f_ψ are integrated over big time steps Δt . These time steps are then subdivided into several small-time steps Δt , over which the terms s_ψ are integrated. In the case that $s_\psi = 0$, we get, using a $2\Delta t$ bound interval,

$$f_n^\psi = \frac{\psi^{n+1} - \psi^{n-1}}{2\Delta t} = f_\psi(\psi^{n-1}, \psi^n, \psi^{n+1}) \quad (4.11)$$

representing a set of equations that can be solved using Gaussian elimination. For equations including acoustically active terms, i.e. where acoustic and gravity waves have to be taken into account, the finite difference is given by,

$$S_\psi^m + f_\psi^m = \frac{\psi^{m+1} - \psi^m}{\Delta\tau} \quad (4.12)$$

The superscript m is the time step counter for the integration over the small-time steps ΔT within the bound interval used above.

The term f_ψ^n is constant throughout the small-time step integrations, but the value of ψ_{n+1} is not known before the last one of these integrations has been completed. Therefore, the finite difference for $f^{n\psi}$ has to be re-written as,

$$f_n^\psi = \frac{\overline{\psi^{n+1}} - \psi^{n-1}}{2\Delta t} = f_\psi(\psi^{n-1}, \psi^n, \overline{\psi^{n+1}}) \quad (4.13)$$

The term $\overline{\psi^{n+1}}$ is the result of a process called averaging. We assume that the mean value of ψ^{n+1} does not vary as fast with respect to both space and time than deviations from the mean would. The notation for

averaging is

$$\overline{\psi^{a\phi}} = \frac{1}{2}[\psi(\psi + a\frac{\Delta\phi}{2}) + \psi(\phi - a\frac{\Delta\phi}{2})] \quad (4.14)$$

with a being an integer. The notation is similar for the longitude ψ .

If we re-write the primitive equations using finite differences, we get a linear tridiagonal system of simultaneous equations which can be written in the general form,

$$A_k\overline{\psi}_{k-1}^{n+1} + B_k\overline{\psi}_k^{n+1} + C_k\overline{\psi}_{k+1}^{n+1} = D_k \quad (4.15)$$

The terms A_k , B_k and C_k are matrix diagonals, whereas D_k is an inhomogeneous term including the appropriate boundary conditions. The equation system can be solved for using a solving method based on Gaussian elimination and back-substitution.

4.2 The Spectral method

The spectral method was already invented in the 1950s, but it took a while before the method was applied in forecasting models. In 1976, the Australian and Canadian weather services were the first ones to accept this method, which is now used by a range of weather services across the globe. The European Forecasting Centre ECMWF adopted it in 1983. One of the advantages of the spectral method is that the primitive equations can be solved in terms of global functions rather than in terms of approximations at specific points as in the finite difference method. For the ECMWF, this is the better option as they need a global model in order to produce medium-range weather forecasts. For the spectral method, the atmosphere has to be represented in terms of spectral components. In the ECMWF model, the atmosphere is divided into 91 layers (in comparison, the DWD's and the Met Office's global models have 40 layers), with the number of layers in the boundary layer equalling the number of layers in the uppermost 45 km of the atmosphere. The partial differential equations are represented in terms of spherical harmonics, which are truncated at a total wave number of 799. This corresponds to a grid length of roughly 25 km (the DWD's

and the Met Office's global model has a resolution of 40 km). While using the spectral method, we assume that an unknown variable ψ can be approximated in terms of a sum of $N+1$ linearly dependent basis functions $\psi_n(x)$:

$$\psi \approx \psi_N = \sum_{n=0}^N a_n \phi_n(x) \quad (4.16)$$

When this series is substituted into an equation of the form $L\psi = f(x)$, where L is a differential operator, you get a so-called residual function:

$$R(x : a_0, a_1, \dots, a_N) = L\Psi_N - f \quad (4.17)$$

The residual function is zero when the solution of the equation above is exact, therefore the series coefficients should be chosen such that the residual function is minimised, that it is as close to zero as possible. In the majority of cases, polynomial approximations, such as Fourier series or Chebyshev polynomials, are the best choice, but when it comes to weather forecasting, the use of spherical coordinates demands that spherical harmonics are used as expansion functions. This increases the difficulty of the problem, and the computational effort required to solve it. A simple example that can be solved in terms of a Fourier series shows the idea of the spectral method. One of the processes described by the primitive equations is advection (which is the transport of for instance heat in the atmosphere), and the non-linear advection equation is given by

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} = 0 \quad (4.18)$$

This can be re-written in terms of the longitude λ :

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial \lambda} = 0 \quad (4.19)$$

Having chosen appropriate boundary conditions, the equation can be expanded in terms of a finite Fourier series:

$$u(\lambda, t) = \sum_{m=-M}^M u_m(t) e^{im\lambda} \quad (4.20)$$

where the u_m are the complex expansion coefficients and M is the maximum wave number. The advection equation then,

$$\sum_{m=-M}^M \frac{du_m}{dt} e^{im\lambda} + \sum_{m=-2M}^{2M} F_m e^{im\lambda} = 0 \quad (4.21)$$

where F_m is a series in terms of them.

As each of the terms on the left-hand side of the equation has been truncated at a different wave number, there will always be a residual function. There are several methods which convert differential equations to distinct problems, for example the least-square method or the Galerkin method, and which can be used in order to choose the time derivative such that the residual function is as close to zero as possible.

It is difficult to calculate the non-linear terms of a differential equation in the setting of the spectral method, but you can get around this problem by using a so-called transform method. Most commonly, Fast Fourier Transforms are used, but in principle all transform methods make it possible to switch between a spectral representation and a grid-point representation. Using a transform method requires three steps, which will be shown for the non-linear term,

$$u \frac{\partial u}{\partial \lambda} \quad (4.22)$$

In the advection equation above. Firstly, the individual components of the non-linear term u and

$$D = \frac{\partial u}{\partial \lambda} \quad (4.23)$$

are expressed in terms of spectral coefficients at discrete grid points λ_i ,

$$u(\lambda_1) = \sum_m u_m e^{im\lambda_1} \quad (4.24)$$

$$D(\lambda_1) = \sum_m im u_m e^{im\lambda_1} \quad (4.25)$$

Secondly, the advection term, that is the product of these components,

is calculated at every grid point in the discretised space

$$F(\lambda_1) = u(\lambda_1)D(\lambda_1) \quad (4.26)$$

Then you can return to the spectral space and calculate the Fourier coefficients,

$$F_m = \frac{1}{2\pi} \sum_1 F(\lambda_1) e^{im\lambda_1} \quad (4.27)$$

This procedure has to be done at every time level, so results in a significant amount of calculation. Furthermore, products with more than two components suffer from aliasing, meaning that waves that are too short to be resolved for a certain grid resolution falsely appear as longer waves. Still, using transform methods is necessary in order to solve differential equations in spectral space. As mentioned above, a dependent variable ψ has to be expanded in terms of spherical harmonics rather than Fourier coefficients when spherical coordinates are used. Spherical harmonics $Y_n^m(\lambda, \phi)$ are the angular part of the solution to Laplace's equation. The vertical components of velocity

$$u_z \equiv \frac{dz}{dt} \quad (4.28)$$

transform like scalars, so can be expanded in terms of spherical harmonics straightaway. It is slightly more complicated for the horizontal components

$$u_\lambda \equiv \frac{d\lambda}{dt} \text{ and } u_\psi \equiv \frac{d\psi}{dt} \quad (4.29)$$

$$U = u_\lambda \sin\phi = \sum_{m,n}^{\infty} u_{m,n} Y_n^m(\lambda, \phi) \quad (4.30)$$

$$V = u_\psi \sin\phi = \sum_{m,n}^{\infty} v_{m,n} Y_n^m(\lambda, \phi) \quad (4.31)$$

with the spherical harmonics

$$Y_n^m(\lambda, \phi) = e^{im\lambda} P_n^m(\phi) \quad (4.32)$$

$$Y_n^{-m}(\lambda, \phi) = e^{-im\lambda} P_n^m(\phi) (-1)^m \quad (4.33)$$

where m and n are non-negative integers such that $n \geq m$. Here, m is the zonal wave number, and n is the total wave number. The term $P_n^m(\phi)$ is the associated Legendre function used in spherical harmonics (but will not be explained here). In general, spectral method algorithms are more difficult to program than their finite difference counterparts, also the domains in which they are used have to be regular in order to keep the high accuracy of this method. However, the spectral method has a number of advantages, for example, there is no pole problem when the method is used. At the poles, the solutions to differential equations become infinitely differentiable, therefore the poles are usually excluded from the spectral space, which actually simplifies the method. Furthermore, it can handle finite elements of higher orders than the finite difference method can. As a result, the solutions of many problems are very precise. The high accuracy also results in the fact that the models do not need as many grid points as in the finite difference method, and computers on which the method is run require less memory space. Summing up, the spectral method gives much more accurate results than the finite difference method. Many weather services still use the finite difference method though because it is much easier to implement.

4.3 Finite Element method

A third technique for finding approximate solutions to partial differential equations and hence to the primitive equations is the finite element method. It is quite similar to the spectral method in that a dependent variable ψ is defined over the whole domain in question, rather than at discrete grid points used in the finite difference method. Furthermore, a finite series expansion in terms of linearly independent functions approximates the variation of ψ within a specified element (e.g. a set of grid points). Unlike the spectral method, the basic functions are not globally, but only locally non-zero, also they are low-order polynomials

rather than high-order polynomials. The domain for which the partial differential equations have to be solved is divided into a number of subdomains, and a different polynomial is used to approximate the solution for each subdomain. These approximations are then combined into the primitive equations. A condition for the finite element method to work, however, is that ψ is continuous between neighbouring elements. The fact that only low-order polynomials can be used is reflected in the relatively low accuracy, but the amount of necessary calculations is much smaller than for finite differences or for spectral methods. On the other hand, there are a number of choices for the basic functions, and depending on which functions are used, the finite element method can give very accurate results when it is applied to irregular grids. Thus, the use of this method is not restricted to triangular and rectangular grids only as the finite difference method. This is probably more important in engineering and fluid dynamics, where this method is most widely used. However, scientist is constantly trying to improve existing and find new mathematical methods that model atmospheric processes better than the methods in use nowadays.

Chapter 5

Applications of Atmospheric Models

5.1 Climate Modeling

A climate model is a computer program designed to simulate Earth's climate in order to understand and predict its behaviour. Climate models are mainly based on a set of mathematical equations that describe the physical laws which rule the behaviour of the atmosphere and ocean, and their interactions with other parts of Earth's climate system. (e.g. land surface and ice sheets). Processes for which fundamental equations are not known or which occur at scales smaller than the grid resolution (e.g. clouds, vegetation) are represented actually. The mathematical equations define how variables such as temperature, pressure, and wind change over time. These equations are solved using very large supercomputers. Observations are also used to develop the models, mainly in the testing phase. These observations come from tools such as ocean signals, weather balloons, satellites, and instrumented commercial aircraft. When the forcing factors (e.g. intensity of the sun, concentrations of greenhouse gases, dust from volcanic eruptions) are prescribed to the model, they can be used to simulate the past and present climates, and possible future climates given situations of future anthropogenic emissions. The models represent Earth's climate by dividing the surface, ocean and atmosphere into a grid. Imagine

each part of the Earth has its own box. In global models the spacing (or size) of these boxes is typically in the range of 100-300 km. In regional climate models the spacing is typically smaller, 10-50 km. For each box, the change in a variable (such as wind, temperature, or rainfall) over a specified amount of time is calculated. The time step (the amount of time between each calculation) depends on the size of the grid boxes and is usually a few minutes to about half an hour in order to solve the equations with sufficient accuracy. Models can be made up of millions of grid boxes, and are run over many thousands of time steps. This can result in the simulations taking months to produce. A number of simulations (an ensemble) are made for each scenario to estimate the mean climate and the uncertainty due to natural climate variations. The climate system is very complex. Models allow us to test theories in a controlled environment. Climate models can help us predict how the climate might differ in the future. They can improve our understanding of variables such as temperature, precipitation, oceanic currents and sea ice cover. Climate models are the only scientific tool with the potential for making regional predictions about future climate. We are confident that models provide useful information because they are based on well-known physical laws and reproduce many features of the observed climate, including how it has changed in the past.

5.2 Air Quality Modeling

Air quality dispersion modelling uses computer simulation to predict air quality concentrations from various types of emission sources. For pollutants emitted through a stack, it considers the emission rate, stack height, stack diameter, and stack gas temperature and velocity, as well as the effect of nearby buildings and terrain. Other emission sources like vehicle traffic or wind erosion from storage loads are represented as 2-dimensional area sources or 3-dimensional volume sources. Air quality dispersion models use meteorological data such as temperature, wind direction, and wind speed to calculate concentrations. Modelling is often used to predict possible impacts on air quality from new or adapting

emission sources. Model predicted concentrations are compared with the national and state ambient air quality standards to ensure protection of Minnesota's air quality in light of potential future emissions. Modelling can also be used to site ambient air monitors and inform human health and ecological risk valuations.

Chapter 6

Conclusion

Numerical forecast is known for the accurate data as observed during the forecast at the beginning of its run or at initial conditions we can say. As it is known that weather changes rapidly from one place to another, tomorrow's weather is definitely influenced by today's weather, and similarly next week's weather can be affected by today's weather a continent away. Therefore, lots of worldwide data is required to make the predictions. Numerical Weather Prediction is imprecise because the equations used by the models to simulate the atmosphere are not accurate. It leads to some error in predictions. Moreover, as we do not receive many weather observations from mountain regions or over the oceans, therefore, many gaps persist in the initial data. And so, the computer's prediction of how that initial state will evolve will not be entirely accurate if initial conditions were not completely known.

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SIGN LANGUAGE RECOGNITION USING CNN

**ST. TERESA'S COLLEGE (AUTONOMOUS)
AFFILIATED TO MAHATMA GANDHI UNIVERSITY**



PROJECT REPORT

In partial fulfilment of the requirements for the award of the degree of

**BCA (CLOUD TECHNOLOGY AND INFORMATION
SECURITY MANAGEMENT)**

By

Priyaja Premdas- SB19BCA016

&

Sruthy Xavier-SB19BCA022

**III DC BCA (CLOUD TECHNOLOGY AND INFORMATION SECURITY
MANAGEMENT)**

Under the guidance of

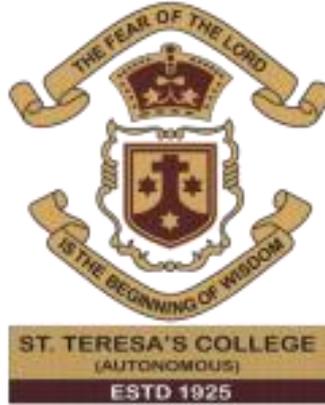
Mrs. Archana Menon P

DEPARTMENT OF COMPUTER APPLICATIONS

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DECLARATION

We, undersigned hereby declare that the project report, **Sign Language Recognition Using CNN**, submitted for partial fulfilment of the requirements for the award of degree of BCA St. Teresa's College (Autonomous), Ernakulam (Affiliated to Mahatma Gandhi University), Kerala is a bonafide work done by us under supervision of Mrs. Archana Menon P. This submission represents our ideas in our own words and where ideas or words of others have been included. We have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to the ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not previously formed the basis for the award of any degree, diploma or similar title of any other University.

Ernakulam

March 2022

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CERTIFICATE

This is to certify that the report entitled **Sign Language Recognition Using CNN** submitted by **Priyaja Premdas** and **Sruthy Xavier** to St. Teresa's College, Cochin in partial fulfilment of the requirements for the award of the Degree of BCA in CT & ISM is a bonafide record of the project work carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Archana Menon P
9/4/22
ARCHANA MENON P
Internal Supervisor

[Handwritten Signature]
External Supervisor

[Handwritten Signature]
For Head of the Department

ACKNOWLEDGEMENT

First and foremost, we thank God Almighty for his blessings. We take this opportunity to express our gratitude to all those who helped us in completing this project successfully. We wish to express our sincere gratitude to the Manager **Rev. Dr. Sr. Vinitha CSST** and the Principal **Dr. Lizzy Mathew** for providing all the facilities.

We express our sincere gratitude towards the Head of the department **Mrs. Raji S Pillai** and the Course coordinator **Mrs. Sheeba Emmanuel** for the support. We deeply express sincere thanks to our project guide **Mrs. Archana Menon P** for her proper guidance and support throughout the project work.

We are indebted to our beloved teachers whose cooperation and suggestion throughout the project helped us a lot. We thank all our friends and classmates for their support.

We convey our hearty thanks to our parents for the moral support, suggestion and encouragement.

ABSTRACT

A Sign Language is one of the ways to communicate with deaf people. In this work sets, included features and variation in the language with locality have been the major barriers which has led to little research being done in ISL. One should learn sign language to interact with them. Learning usually takes place in peer groups. There are very few study materials available for sign learning. Because of this, the process of learning sign language learning is a very difficult task. The initial stage of sign learning is Finger spelled sign learning and moreover, are used when no corresponding sign exists or signer is not aware of it. Most of the existing tools for sign language learning use external sensors which are costly. Our project aims at extending a step forward in this field by collecting a dataset and then use various feature extraction techniques to extract useful information which is then input into various supervised learning techniques. Currently, Sign language is one of the oldest and most natural form of language for communication, but since most people do not know sign language and interpreters are very difficult to come by, we have come up with a real time method using neural networks for fingerspelling based American sign language. In our method, the hand is first passed through a filter and after the filter is applied the hand is passed through a classifier which predicts the class of the hand gestures. Our method provides 95.7 % accuracy for the 26 letters of the alphabet.

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LIST OF ABBREVIATIONS

SL NO.	ABBREVIATIONS	EXPANSION
1	ASL	American Sign Language
2	BANZSL	British, Australian and New Zealand Sign Language
3	CSL	Chinese Sign Language
4	LSF	French Sign Language
5	JSL	Japanese Sign Language Syllabary.
6	LSE	Spanish Sign Language
7	LSM	Mexican Sign Language
8	ML	Machine Learning
9	HTML	Hypertext Markup Language
10	RDBMS	Relational Database Management System
11	SVM	Support Vector Machine,
12	PCA	Principal Component Analysis
13	LDA	Linear Discriminant Analysis
14	GUIs	Graphical User Interfaces
15	PC	Personal Computer
16	RTM	Release to Manufacturing
17	API	Application Programming Interface

CHAPTER -1

INTRODUCTION

To establish a communication or interaction with Deaf and Mute people is very important nowadays. These people interact through hand gestures or signs. Gestures are basically the physical action form performed by a person to convey some meaningful information. Gestures are a powerful means of communication among humans. In fact, gesturing is so deeply rooted in our communication that people often continue gesturing when speaking on the telephone. There are various signs which express complex meanings and recognising them is a challenging task for people who have no understanding for that language.

It becomes difficult finding a well experienced and educated translator for the sign language every time and everywhere but human-computer interaction system for this can be installed anywhere possible. The motivation for developing such helpful application came from the fact that it would prove to be of utmost importance for socially aiding people and how it would help increasingly for social awareness as well. The remarkable ability of the human vision is the gesture recognition, it is noticeable mainly in deaf people when they communicate with each other via sign language and with hearing people as well. In this paper we take up one of the social challenges to give this set of mass a permanent solution in communicating with normal human beings.

Sign language is categorized in accordance to regions like Indian, American, Chinese, Arabic and so on and researches on hand gesture recognition, pattern recognitions, image processing have been carried by supposedly countries as well to improve the applications and bring them to the best levels.

1.1 Sign Language

Sign languages (also known as signed languages) are languages that use the visual-manual modality to convey meaning. Sign languages are expressed through manual articulations in combination with non-manual elements. Sign languages are full-fledged natural languages with their own grammar and lexicon. Sign languages are not universal and are usually not mutually intelligible with each other, although there are also similarities among different sign languages. Linguists consider both spoken and signed communication to be types of natural language, meaning that both emerged through an abstract, protracted aging process and evolved over time without meticulous planning. Sign language should not be confused with body language, a type of nonverbal communication.

Wherever communities of deaf people exist, sign languages have developed as useful means of communication, and they form the core of local Deaf cultures. Although signing is used primarily by the deaf and hard of hearing, it is also used by hearing individuals, such as those unable to physically speak, those who have trouble with spoken language due to a disability or condition (augmentative and alternative communication), or those with deaf family members, such as adults. Linguists distinguish natural sign languages from other systems that are precursors

to them or obtained from them, such as invented manual codes for spoken languages, home sign, "baby sign", and signs learned by non-human primates.

1.2 Types of Sign Language :

1.2.1 Sign Language Alphabets from Around the World

- American Sign Language (ASL)
- British, Australian and New Zealand Sign Language (BANZSL)
- Chinese Sign Language (CSL)
- French Sign Language (LSF)
- Japanese Sign Language (JSL) Syllabary.
- Arabic Sign Language.
- Spanish Sign Language (LSE)
- Mexican Sign Language (LSM)

1.2.2 American Sign Language

American Sign Language is a natural language that serves as the predominant sign language of Deaf communities in the United States and most of Anglophone Canada. ASL is a complete and organized visual language that is expressed by facial expression as well as movements and motions with the hands.

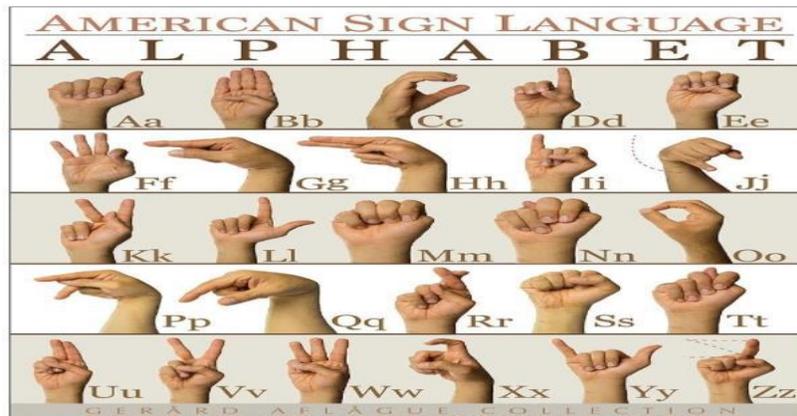


Fig 1.2.1 American Sign Language

1.2.3 British, Australian and New Zealand Sign Language (BANZSL)

Auslan (Australian Sign Language) is a beautiful language. It is the sign language used in Australia and is related to British Sign Language (BSL) and New Zealand Sign Language (NZSL). These three signed languages descended from the same parent language and are part of the BANZSL language family.

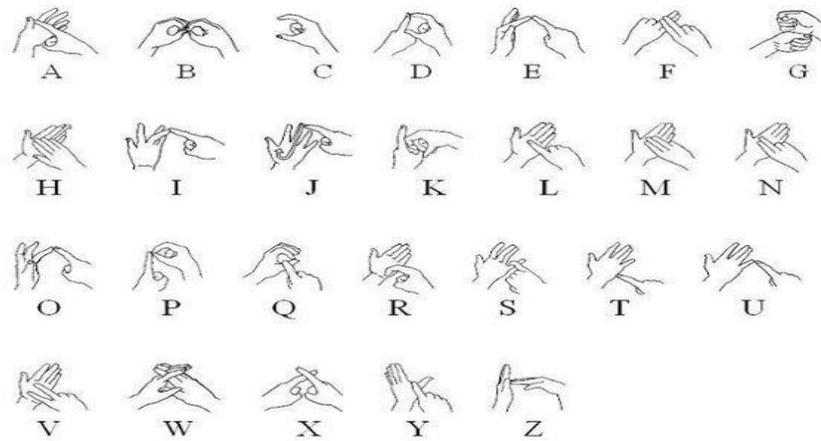


Fig 1.2.2 British, Australian and New Zealand Sign Language (BANZSL)

1.2.4 Chinese Sign Language (CSL)

Chinese Sign Language (CSL) Probably the most-used sign language in the world (but there is currently no data to confirm this), Chinese Sign Language uses the hands to make visual representations of written Chinese characters. The language has been developing since the 1950s.

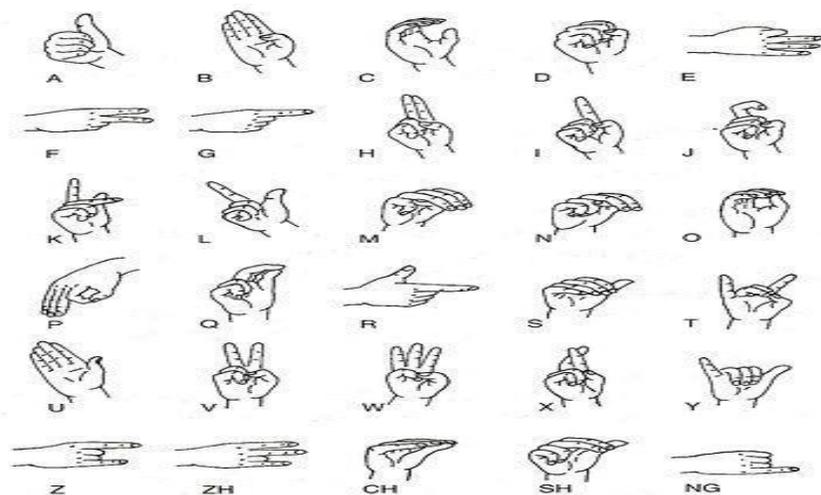


图 8 汉语手指字母

Fig 1.2.3 Chinese Sign Language

1.2.5 French Sign Language (LSF)

French Sign Language is similar to ASL – since it is in fact the origin of ASL – but there are minor differences throughout. LSF also has a pretty fascinating history.

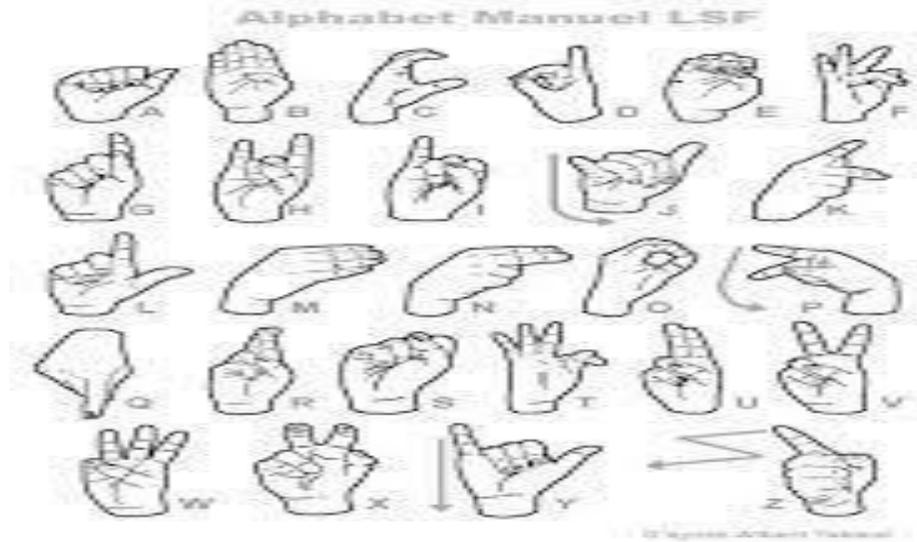


Fig 1.2.4 French Sign Language

1.2.6 Japanese Sign Language (JSL) Syllabary

The Japanese Sign Language (JSL) Syllabary is based on the Japanese alphabet, which is made up of phonetic syllables. JSL is known as Nihon Shuwa in Japan.

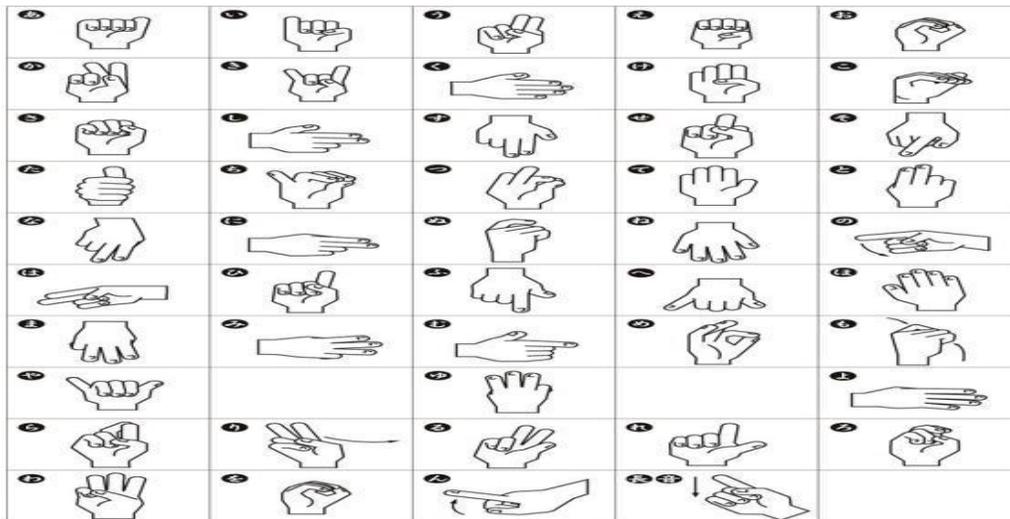


Fig 1.2.5 The Japanese Sign Language

1.2.7 Arabic Sign Language

The Arab sign-language family is a family of sign languages across the Arab Mideast. Data on these languages is somewhat scarce, but a few languages have been distinguished, including Levantine Arabic Sign Language.



Fig 1.2.6 The Arab sign-language

1.2.8 Spanish Sign Language (LSE)

Spanish Sign Language is officially recognized by the Spanish Government. It is native to Spain, except Catalonia and Valencia. Many countries that speak Spanish do not use Spanish Sign Language! (See Mexican Sign Language below, for example)

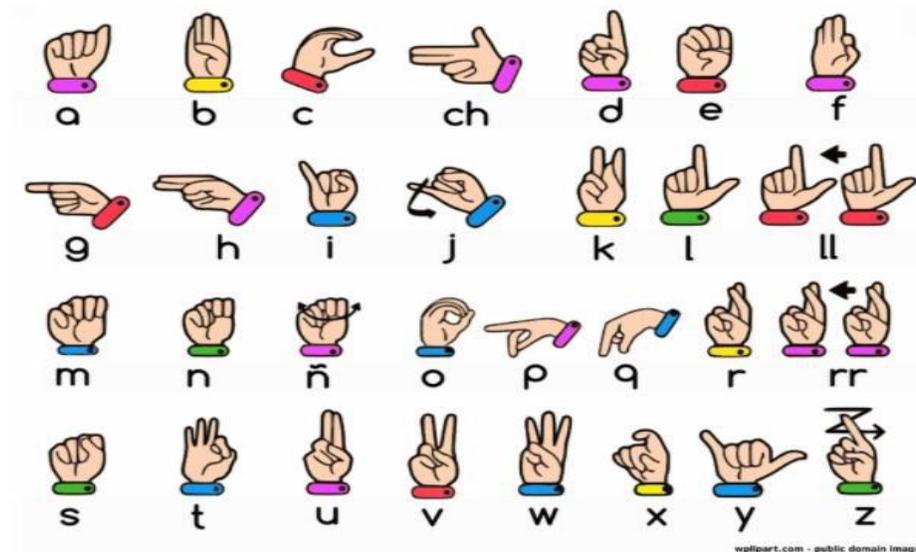


Fig 1.2.7 Spanish Sign Language

1.2.9 Mexican Sign Language (LSM)

Mexican Sign Language ('lengua de señas mexicana' or LSM) is different from Spanish, using different verbs and word order. The majority of people who use Mexican Sign Language reside in Mexico City, Guadalajara and Monterrey. Variation in this language is high between age groups and religious backgrounds.



Fig. 1 Mexican Sign Language (ESMA) [2]

Fig 1.2.8 Mexican Sign Language

1.3 Machine Learning

Machine learning is the study of computer algorithms that can improve automatically through experience and by the use of data. It is seen as a part of artificial intelligence.

1.3.1 Machine Learning (ML) Algorithms:

- Linear regression
 - Logistic regression
 - Decision tree
 - SVM algorithm
 - Naive Bayes algorithm
 - KNN algorithm
 - K-means
 - Random forest algorithm
- **Linear Regression:** Linear Regression is a supervised machine learning algorithm where the predicted output is continuous and has a constant slope. It's used to predict values within a continuous range, (e.g., sales, price) rather than trying to classify them into categories (e.g., cat, dog).
 - **Logistic Regression:** Logistic regression is a supervised learning classification algorithm used to predict the probability of a target variable. The nature of target or dependent variable is dichotomous, which means there would be only two possible classes.

- **Decision Tree:** Decision Tree algorithm in machine learning is one of the most popular algorithms in use today; this is a supervised learning algorithm that is used for classifying problems. It works well classifying for both categorical and continuous dependent variables. In this algorithm, we split the population into two or more homogeneous sets based on the most significant attributes/ independent variables.
- **SVM (Support Vector Machine) Algorithm :** SVM algorithm is a method of classification algorithm in which you plot raw data as points in an n-dimensional space (where n is the number of features you have). The value of each feature is then tied to a particular coordinate, making it easy to classify the data. Lines called classifiers can be used to split the data and plot them on a graph. Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning.
- **Naive Bayes Algorithm :** A Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. Even if these features are related to each other, a Naive Bayes classifier would consider all of these properties independently when calculating the probability of a particular outcome. A Naive Bayesian model is easy to build and useful for massive datasets. It's simple and is known to outperform even highly sophisticated classification methods.
- **KNN (K- Nearest Neighbour's) Algorithm:** This algorithm can be applied to both classification and regression problems. Apparently, within the Data Science industry, it's more widely used to solve classification problems. It's a simple algorithm that stores all available cases and classifies any new cases by taking a majority vote of its k neighbours. The case is then assigned to the class with which it has the most in common. A distance function performs this measurement. KNN can be easily understood by comparing it to real life.
Things to consider before selecting K Nearest Neighbours Algorithm:
 - KNN is computationally expensive
 - Variables should be normalized, or else higher range variables can bias the algorithm
 - Data still needs to be pre-processed
- **K-Means :** It is an unsupervised learning algorithm that solves clustering problems. Data sets are classified into a particular number of clusters (let's call that number K) in such a way that all the data points within a cluster are homogenous and heterogeneous from the data in other clusters.
- **Random Forest Algorithm :** A collective of decision trees is called a Random Forest. To classify a new object based on its attributes, each tree is classified, and the tree "votes" for that class. The forest chooses the classification having the most votes (over all the trees in the forest).

Each tree is planted & grown as follows:

- If the number of cases in the training set is N , then a sample of N cases is taken at random. This sample will be the training set for growing the tree.
- If there are M input variables, a number $m \ll M$ is specified such that at each node, m variables are selected at random out of the M , and the best split on this m is used to split the node. The value of m is held constant during this process.
- Each tree is grown to the most substantial extent possible. There is no pruning.

1.4 Deep Learning

Deep learning is the one category of machine learning that emphasizes training the computer about the basic instincts of human beings. In deep learning, a computer algorithm learns to perform classification tasks directly on complex data in the form of images, text, or sound. These algorithms can accomplish state-of-the-art (SOTA) accuracy, and even sometimes surpassing human-level performance. They are trained with the large set of labelled data and neural network architectures, involving many layers. Moreover;

- Deep Learning is a prime technology behind the technology such as virtual assistants, facial recognition, driverless cars, etc.
- The working of deep learning involves training the data and learning from the experiences.
- The learning procedure is called 'Deep', as with every passing minute the neural networks rapidly discover the new levels of data. Each time data is trained, it focuses on enhancing the performance.
- With the increasing depth of the data, this training performance and deep learning capabilities have been improved drastically, and this is because it is broadly adopted by data experts.

Along with the ample number of benefits, threats also surface due to the unexplored capabilities of deep learning. Deep learning utilizes supervised, semi-supervised and unsupervised learning to train from the data representations. The functionality of deep learning relies on the below points:

- It imitates the functionality of a human brain for managing the data and forming the patterns for referring it in decision making.
- The trained dataset can be interconnected, diverse and complex in nature.
- The larger the data set, the more efficient the training that directly impacts the decision making.

1.4.1 Advantages of Deep Learning

- Ability to generate new features from the limited available training data sets.
- Can work on unsupervised learning techniques helps in generating actionable and reliable task outcomes.
- It reduces the time required for feature engineering, one of the tasks that requires major time in practicing machine learning.

- With continuous training, its architecture has become adaptive to change and is able to work on diverse problems.

1.4.2 Disadvantages of Deep Learning

With the increasing popularity, deep learning also has a handful of threats that needs to be addressed:

- The complete training process relies on the continuous flow of the data, which decreases the scope for improvement in the training process.
- The cost of computational training significantly increases with an increase in the number of datasets.
- Lack of transparency in fault revision. No intermediate steps to provide the arguments for a certain fault. In order to resolve the issue, a complete algorithm gets revised.
- Need for expensive resources, high-speed processing units and powerful GPU's for training the data sets.

1.4.3 Examples of Deep Learning

- **Virtual Assistants:** The core functionality that requires translating the speech and language of the human's speech, is deep learning. The common examples of virtual assistants are Cortana, Siri, and Alexa.
- **Vision for Driverless, Autonomous Cars:** In order to navigate an autonomous car, say, a Tesla, one needs a human-like experience and expertise. To understand the scenarios of roads, the working of signals, pedestrians, significances of different signs, speed limits and many more situations like these, a large amount of real data is required. With the large data, the efficiency of the algorithms will be improved which will subsequently increase the decision-making flow.
- **Service and Chat Bots:** The continuous interaction of chatbots with human beings for providing customer services requires strong responses. To respond in a helpful manner with all the tricky questions and apt response, deep learning is required for training algorithms.
- **Translations:** Translating the speech automatically in multiple languages requires deep learning supervision. This is a helpful mechanism for tourists, travellers, and government officials.
- **Facial Recognition:** Facial recognition has many features from being used in the security to the tagging mechanism/feature used on Facebook. Along with the importance, it has its fair share of issues as well. For example, to recognize the same person with weight gain, weight loss, beard, without a beard, new hairstyles, etc.

- **Shopping and Entertainment:** All the shopping applications like Amazon and Myntra and entertainment applications like Amazon Prime and Netflix store your data and buying habits to show the suggestions for future buying and watching. It always comes as a title “You may like to watch/buy”. The more data is inputted in the Deep learning algorithm, the more efficient it becomes in decision making.
- **Pharmaceuticals:** Customizing medicines based on the particular genome and diseases. Deep learning has widened the scope of such applications and has gained the attention of the largest pharmaceutical companies. Besides that, other deep learning applications are fraud detection, virtual recognition, healthcare, entertainment and many more.

1.5 Machine learning vs Deep learning

Although Deep learning is the one category of machine learning and artificial intelligence, still there are many bases to differentiate between them. The primary goal is to provide an optimized algorithm to increase the efficiency in working. The differences would be best explained through tabular form, as given below;

<u>S.No</u>	<u>Attributes</u>	<u>Deep Learning</u>	<u>Machine learning</u>
1	Definition	It is a subset of machine learning with the constant focus on achieving greater flexibility through considering the whole world as a nested hierarchy of concepts.	It is a sub-branch of Artificial intelligence. It allows the machines to train with diverse datasets and predict based on their experiences.
2	Working mechanism	Neural networks help in interpreting the features of data and their relationships in which important information is processed through multiple stages of processing the data.	It utilizes automated algorithms to predict the decisions for the future and modeling of functions based on the data fed to it.
3	Management	All the algorithms are self-directed after the implementations for result fetching and data analysis.	All the analysis is managed by analysts to evaluate different variables under the multiple datasets using ML algorithms.
4	Practical examples	Practical examples are virtual assistants, shopping & entertainment, facial recognition, translations, pharmaceuticals, and vision for	Practical examples are speech recognition, medical diagnosis, statistical arbitrage, classification, prediction, and extraction.

		driverless vehicles.	
5	Data points	Data points are used for analysis usually numbered in millions.	Data points are used for analysis usually numbered in thousands.
6	Training time	Considering larger parameters, deep learning takes a long time for training.	Machine learning algorithms usually take less time for analysis, ranging from a few minutes to hours.
7	Considered algorithms	It makes use of neural networks.	It utilizes algorithms like multiple linear regression, random forest, and KNN.
8	Output	The output is usually diverse like a score, an element, classification, or simply a text.	The output for this algorithm is usually a numeric value like a classification.

1.6 Working of Deep Learning

Deep learning algorithms utilizes supervised and unsupervised learning algorithms to train the outputs through the delivered inputs.

See the image below, these circles represent neurons that are interconnected. The neurons are classified into three different hierarchies of layers termed as Input, Hidden and Output Layers.

- The first neuron layer i.e., input layer receives the input data and passes it to the first hidden layer.
- The hidden layers perform the computations on the received data. The biggest challenge under neural networks creation is to decide the number of neurons and a number of hidden layers.
- Finally, the output layer produces the required output.

1.7 Working network of Deep Learning

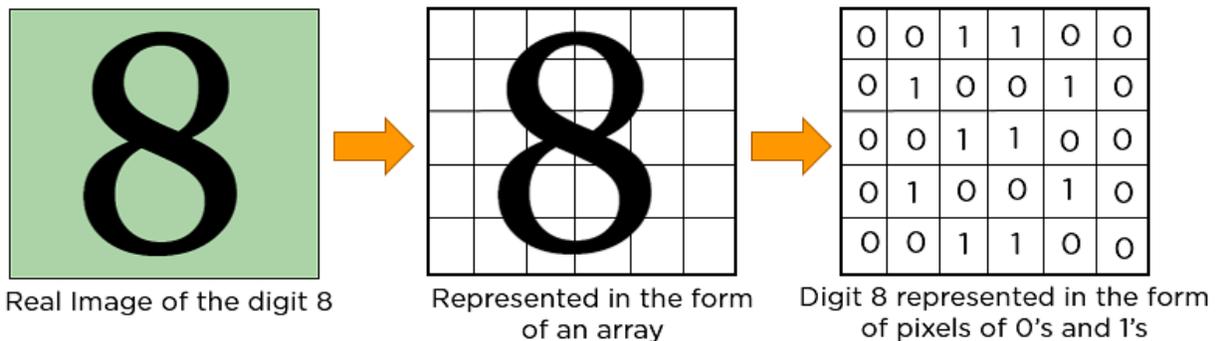
This is the basic flow of working. Now, comes the point where the method of computation is explained. Every connection between the neurons consists of weights, it denotes the significance of the input values. In order to standardize the outputs, an activation function is used for training the network, two important measures are considered. The first is to create a large data set and the second is large computational power. The 'Deep' in deep learning signifies the number of hidden layers the model is using to train the data set.

Working of Deep learning can be summed up in four final points:

- ANN asks a combination of binary True/False queries.
- Extracting numeric values from blocks of data.
- Sorting the data as per the received answers.
- A final point is marking/labelling the data.

1.8 Convolutional Neural Network (CNN)

A convolutional neural network is a feed-forward neural network that is generally used to analyse visual images by processing data with grid-like topology. It's also known as a ConvNet. A convolutional neural network is used to detect and classify objects in an image. In CNN, every image is represented in the form of an array of pixel values.



1.9 Layers in a Convolutional Neural Network

A convolution neural network has multiple hidden layers that help in extracting information from an image. The four important layers in CNN are:

- Convolution layer
 - ReLU layer
 - Pooling layer
 - Fully connected layer
- **Convolution Layer**

This is the first step in the process of extracting valuable features from an image. A convolution layer has several filters that perform the convolution operation. Every image is considered as a matrix of pixel values.

Consider the following 5x5 image whose pixel values are either 0 or 1. There's also a filter matrix with a dimension of 3x3. Slide the filter matrix over the image and compute the dot product to get the convolved feature matrix.

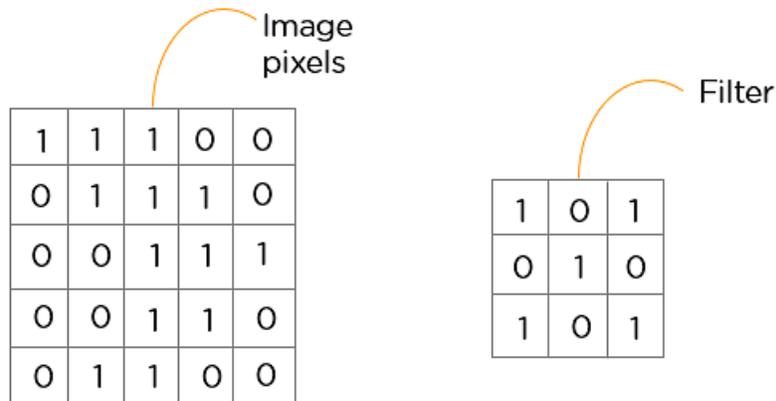


Fig 1.9.1

▪ ReLU layer

ReLU stands for the rectified linear unit. Once the feature maps are extracted, the next step is to move them to a ReLU layer. ReLU performs an element-wise operation and sets all the negative pixels to 0. It introduces non-linearity to the network, and the generated output is a rectified feature map. Below is the graph of a ReLU function:

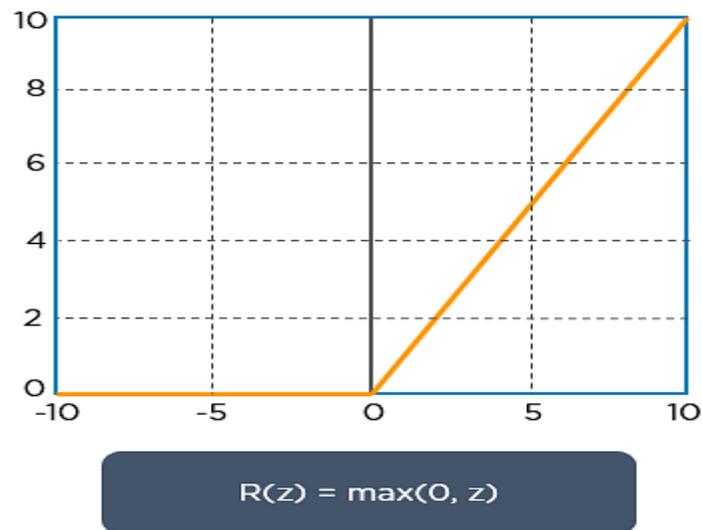


Fig 1.9.2

The original image is scanned with multiple convolutions and ReLU layers for locating the features.

▪ Pooling Layer

Pooling is a down-sampling operation that reduces the dimensionality of the feature map. The rectified feature map now goes through a pooling layer to generate a pooled feature map.

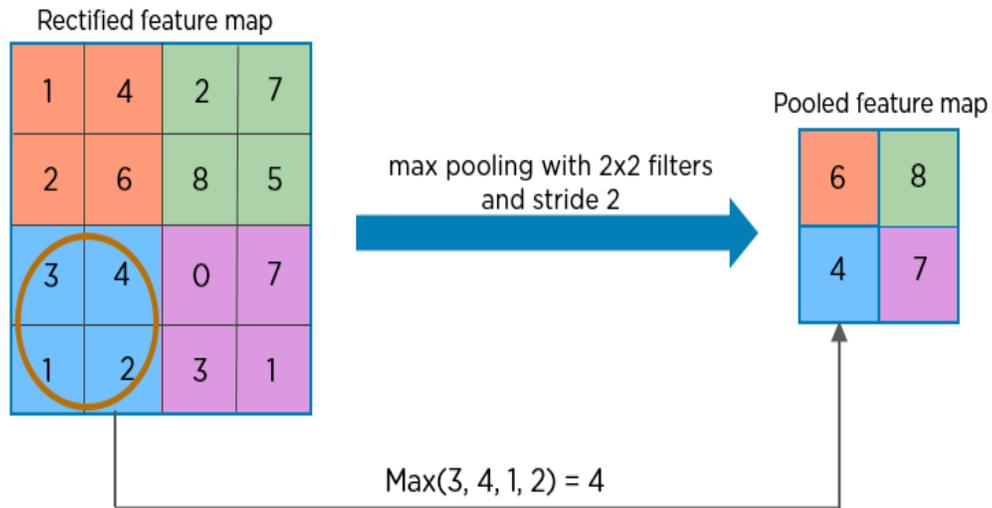


Fig 1.9.3

The pooling layer uses various filters to identify different parts of the image like edges, corners, body, feathers, eyes, and beak.

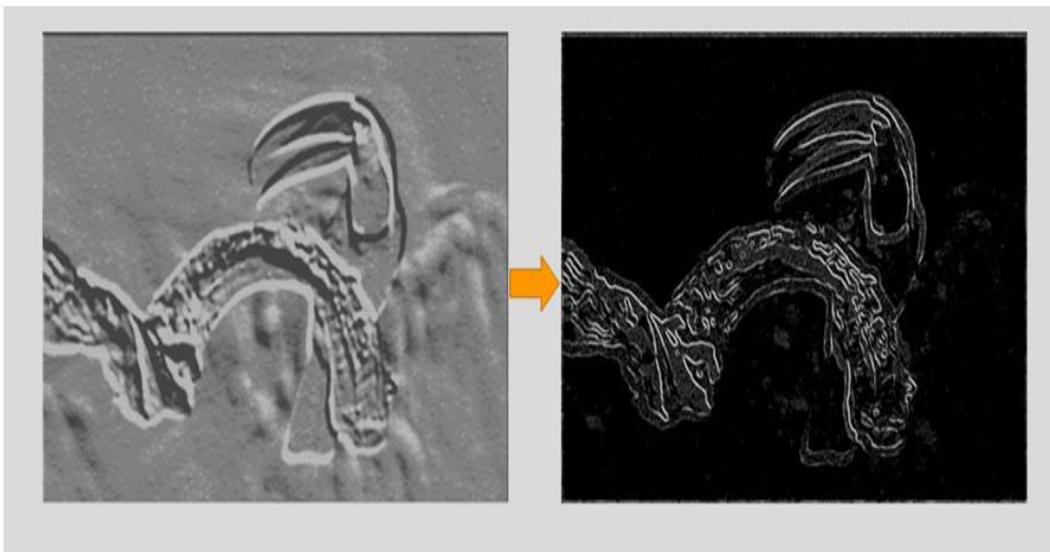


Fig 1.9.4

Here's how the structure of the convolution neural network looks so far:

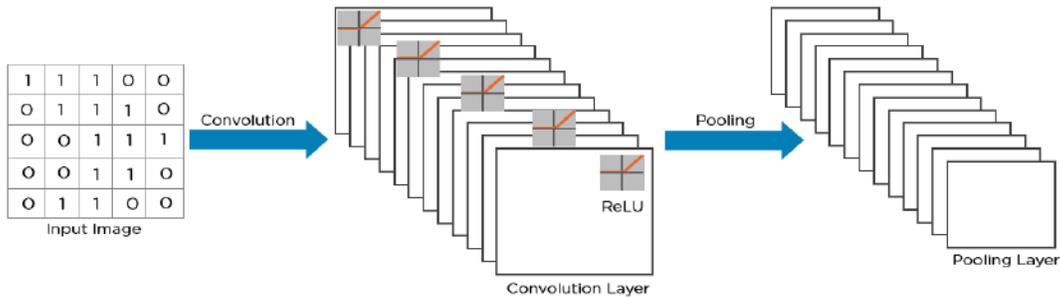


Fig 1.9.5

The next step in the process is called flattening. Flattening is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector.

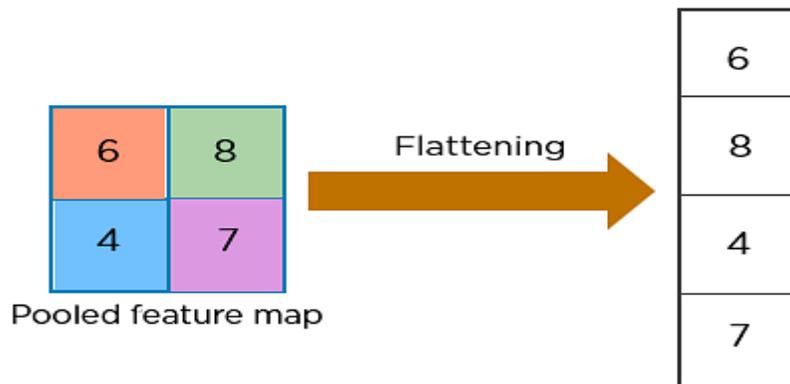


Fig 1.9.6

- **Fully Connected Layer:**

In convolution layer, neurons are connected only to a local region, while in a fully connected region, we will connect all the inputs to neurons.

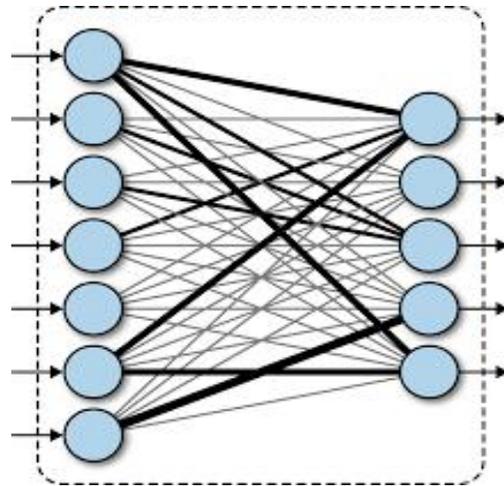


Fig 1.9.7

CHAPTER - 2

LITERATURE SURVEY

A lot of research has been done in the corresponding field of American Sign Language (ASL), but unfortunately the same cannot be said for ISL. Sign Language is one of the ways to communicate with deaf people. In this work sets, included features and variation in the language with locality have been the major barriers which has led to little research being done in ISL. One should learn sign language to interact with them. Learning usually takes place in peer groups. There are very few study materials available for sign learning.

Because of this, the process of learning sign language learning is a very difficult task.[1] The initial stage of sign learning is Finger spelled sign learning and moreover, are used when no corresponding sign exists or signer is not aware of it. Most of the existing tools for sign language learning use external sensors which are costly. The project aims at extending a step forward in this field by collecting a dataset and the use various feature extraction techniques to extract useful information which is then input into various supervised learning techniques.[2] Currently, this project have reported fourfold cross validated results for the different approaches, and the difference from the previous work done can be attributed to the fact that in our fourfold cross validation, the validation set Correspond to images of a person different from the persons in the training set.

Lack of standard datasets, occluded features and variation in the language with locality have been the major barriers which has led to little research being done in ISL [3]. This project aims at extending a step forward in this field by collecting a dataset from a deaf school, and then use various feature extraction techniques to extract useful information which is then input into various supervised learning techniques. Currently, this project has reported fourfold cross validated results for the different approaches, and the difference from the previous work done can be attributed to the fact that in fourfold cross validation, the validation set correspond to images of a person different from the persons in the training set.

Deaf and dumb people communicate among themselves using sign languages, but they find it difficult to expose themselves to the outside world. [4] proposes a method to convert the Indian Sign Language (ISL) hand gestures into appropriate text message. In this paper the hand gestures corresponding to ISL English alphabets are captured through a webcam. In the captured frames the hand is segmented and the neural network is used to recognize the alphabet. The features such as angle made between fingers, number of fingers that are fully opened, fully

closed or semi closed and identification of each finger are used as input to the neural network. Experimentation done for single hand alphabets and the results are summarized.[5] is an effort towards studying the challenges in classification of characters in Indian Sign Language (ISL). A lot of research has been done in the corresponding field of American Sign Language (ASL), but unfortunately the same cannot be said for ISL. Lack of standard datasets, occluded features and variation in the language with locality have been the major barriers which has led to little research being done in ISL.

This project aims at extending a step forward in this field by collecting a dataset from a deaf school, and then use various feature extraction techniques to extract useful information which is then input into various supervised learning techniques. Currently, they have reported fourfold cross validated results for the different approaches, and the difference from the previous work done can be attributed to the fact that in this fourfold cross validation, the validation set correspond to images of a person different from the persons in the training set. Even after more than two decades of input devices development, many people still find the interaction with computers an uncomfortable experience. Efforts should be made to adapt computers to our natural means of communication: speech and body language. [6] proposed a real-time vision system within visual interaction environments through hand gesture recognition, using general-purpose hardware and low-cost sensors, like a simple computer and an USB web camera, so any user could make use of it in his office or at home. The basis of this method is a fast detection process to obtain the meaningful hand region from the whole image, which is able to deal with a large number of hand gestures against different indoor backgrounds and lighting condition, and a recognition process that identifies the hand gestures from the images of the normalized hand.

The most important part of the recognition method is a feature extraction process using local linear embedding. [7] This paper includes experimental evaluations of the recognition process of 30 hand gestures that belong to Chinese sign language (CSL) alphabet and discusses the results. Experiments show that the new approach can achieve a 90% average rate and is suitable for real-time application.[8] Hand gesture is an active area of research in the computer vision, mainly for the purpose of sign language recognition and Human Computer interaction. In this paper, a method for hand gesture recognition of Indian sign language is proposed. The accurate classification of hand gestures plays a vital role to develop an efficient hand gesture recognition system. [9] To implement this approach they have utilized a simple web camera to capture hand gesture images. An attempt is made to propose a system to recognize alphabets characters (A-Z) and numerals (0-9) using Histograms of Oriented Gradients (HOG) features.

The purpose is to implement the algorithm of extracting Histogram of Gradient Orientation (HOG) features and these features are used to pass in neural network training for the gesture recognition purpose. [10] A gesture recognition system is such a system that recognizes and differentiates between ‘gestures. These gestures can be any type of facial or body gestures. Various facial expressions constitute facial gestures.[11] Similarly the various gestures that can be made using our hand, or the palm to be more specific are called ‘HAND GESTURES’ Sign languages are the most raw and natural form of languages could be dated back to as early as the advent of the human civilization, when the first theories of sign languages appeared in history. It has started even before the emergence of spoken languages. Since then, the sign language has evolved and been adopted as an integral part of our day-to-day communication process.

Now, sign languages are being used extensively in international sign use of deaf and dumb, in the world of sports, for religious practices and also at work places. Gestures are one of the first forms of communication when a child learns to express its need for food, warmth and comfort. [12] In the approach for hand detection combines threshold-based color detection with background subtraction. They can use AdaBoost face detector to differentiate between faces and hands as they both involve similar skin-color. They can also extract necessary image which is to be trained by applying a filter called Gaussian Blur (also known as Gaussian smoothing). The filter can be easily applied using open computer vision (also known as OpenCV) and is described in [13]. For extracting necessary image which is to be trained they can use instrumented gloves as mentioned in [14]. This helps reduce computation time for Pre-Processing and gives us more concise and accurate data compared to applying filters on data received from video extraction.

CHAPTER - 3

EXISTING SYSTEM

3.1 OVERVIEW

In this existing system, the programming language used is python. A Sign Language is one of the ways to communicate with deaf people. In this work sets, included features and variation in the language with locality have been the major barriers which has led to little research being done in ISL. One should learn sign language to interact with them. Learning usually takes place in peer groups. There are very few study materials available for sign learning. Because of this, the process of learning sign language learning is a very difficult task.

The initial stage of sign learning is Finger spelled sign learning and moreover, are used when no corresponding sign exists or signer is not aware of it. Most of the existing tools for sign language learning use external sensors which are costly. Our project aims at extending a step forward in this field by collecting a dataset and then use various feature extraction techniques to extract useful information which is then input into various supervised learning techniques. Currently, they have reported fourfold cross validated results for the different approaches, and the difference from the previous work done can be attributed to the fact that in our fourfold cross validation, the validation set correspond to images of a person different from the persons in the training set. Minimizing the verbal exchange gap among D&M and non-D&M people turns into a want to make certain effective conversation among all. Sign language translation is among one of the most growing lines of research and it enables the maximum natural manner of communication for those with hearing impairments. A hand gesture recognition system offers an opportunity for deaf people to talk with vocal humans without the need of an interpreter. The system is built for the automated conversion of ASL into textual content and speech.

In this project they have primarily focus on producing a model which can recognize Fingerspelling based hand gestures in order to form a complete word by combining each gesture. Communication is one of the basic requirements for survival in society. Deaf and dumb people communicate among themselves using sign language but normal people find it difficult to understand their language. Extensive work has been done on American sign language recognition but Indian sign language differs significantly from American sign language. ISL use two hands for communicating whereas ASL uses single hand for

communicating. Using both hands often lead to security of features duet overlapping of hands. In addition to this, lack of datasets along with variance in sign language with locality has resulted in restrained efforts in ISL gesture detection.

3.2 FLOW CHART

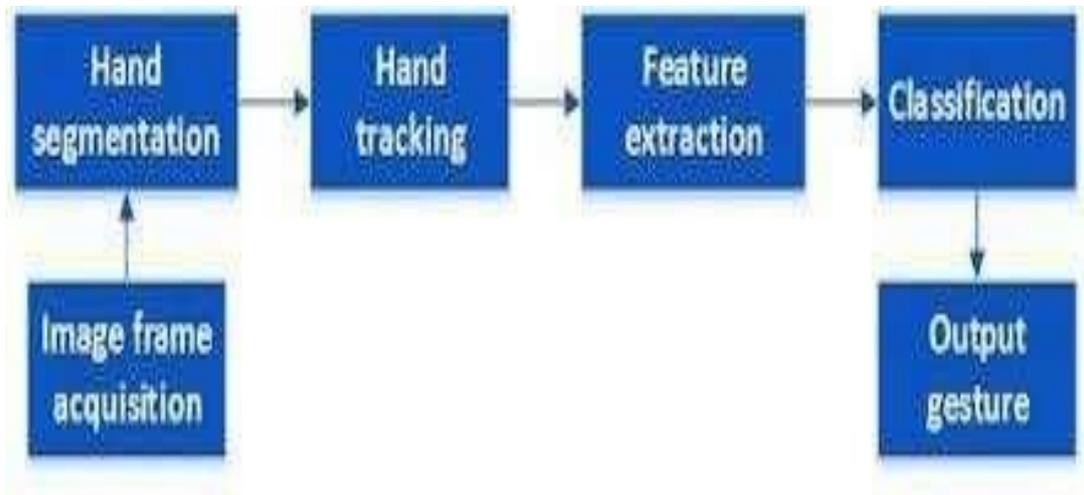


Fig:3.2

3.3 DRAWBACKS

- The changes we made from the existing system was machine learning algorithm which the models used was SVM algorithm so SVM algorithm is not suitable for large data sets.
- SVM does not perform very well when the data set has more noise i.e., target classes are overlapping. In cases where the number of features for each data point exceeds the number of training data samples, the SVM will underperform which increased the complexity of the model as we the accuracy of the model so we changed into SVM ML algorithm. Because it performs well on the put of sample data. The SVM algorithm had been specifically conceived to avoid issues like the curse of dimensionality.
- The project was made with Indian Sign Language ,but in Indian sign language they use both One finger and two finger SL's so we changed into American Sign Language (ASL).
- Time Consuming

CHAPTER – 4

PROPOSED SYSTEM

4.1 OVERVIEW

Sign language is one of the oldest and most natural form of language for communication, but since most people do not know sign language and interpreters are very difficult to come by, we have come up with a real time method using neural networks for fingerspelling based American sign language. In our method, the hand is first passed through a filter and after the filter is applied the hand is passed through a classifier which predicts the class of the hand gestures. Our method provides 95.7 % accuracy for the 26 letters of the alphabet.

American sign language is a predominant sign language Since the only disability Deaf and Dumb (hereby referred to as D&M) people have been communication related and since they cannot use spoken languages, the only way for them to communicate is through sign language. Communication is the process of exchange of thoughts and messages in various ways such as speech, signals, behaviour and visuals. D&M people make use of their hands to express different gestures to express their ideas with other people. Gestures are the non-verbally exchanged messages and these gestures are understood with vision. This nonverbal communication of deaf and dumb people is called sign language. A sign language is a language which uses gestures instead of sound to convey meaning combining hand-shapes, orientation and movement of the hands, arms or body, facial expressions and lip-patterns. Contrary to popular belief, sign language is not international. These vary from region to region. Minimizing the verbal exchange gap among D&M and non-D&M people turns into a want to make certain effective conversation among all. Sign language translation is among one of the most growing lines of research and it enables the maximum natural manner of communication for those with hearing impairments. A hand gesture recognition system offers an opportunity for deaf people to talk with vocal humans without the need of an interpreter. The system is built for the automated conversion of ASL into textual content and speech.

In our project we primarily focus on producing a model which can recognize Fingerspelling based hand gestures in order to form a complete word by combining each gesture.

4.2 SYSTEM REQUIREMENTS

Product: Sign Language Recognition

4.2.1 SOFTWARE REQUIREMENTS

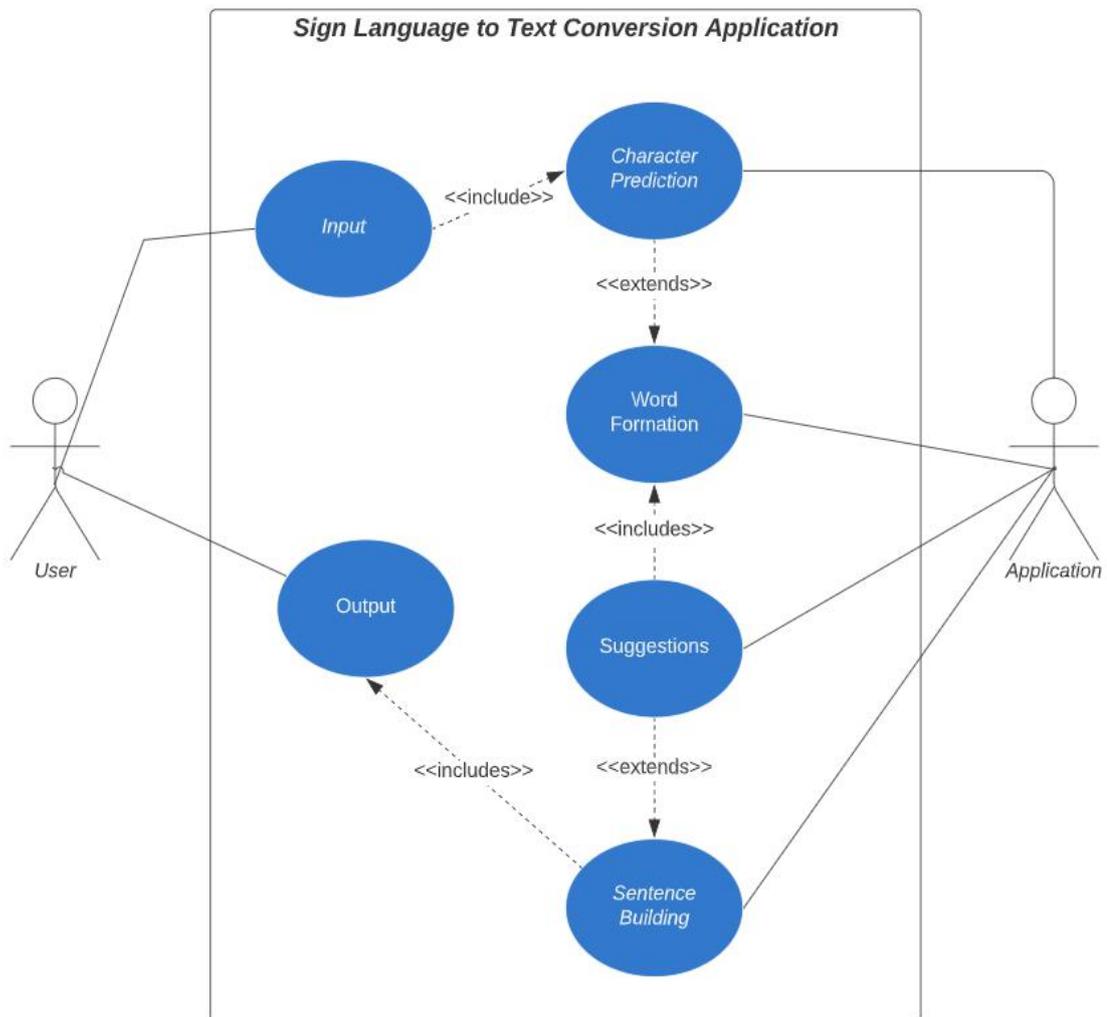
- Windows 8.0 and above
- MySQL
- HTML

- Python

4.2.2 HARDWARE REQUIREMENTS

- Web Cam
- I3 Processor
- 2GB RAM
- Monitor
- Mouse

4.3 BLOCK DIAGRAM



4.4 SYSTEM WORKING

- Whenever the count of a letter detected exceeds a specific value and no other letter is close to it by a threshold, we print the letter and add it to the current string(In our code we kept the value as 50 and difference threshold as 20).
- Otherwise, we clear the current dictionary which has the count of detections of present symbol to avoid the probability of a wrong letter getting predicted.
- Whenever the count of a blank(plain background) detected exceeds a specific value and if the current buffer is empty no spaces are detected.

- In other case it predicts the end of word by printing a space and the current gets appended to the sentence below.

CHAPTER 5

SYSTEM SPECIFICATIONS

5.1 SOFTWARE SPECIFICATIONS

5.1.1 HTML



Fig:5.1

The Hypertext Markup Language, or HTML is the standard markup language for documents designed to be displayed in a browser. Web receive HTML documents from a web server or from local storage and render the documents into multimedia web pages. HTML describes the structure of a web page semantically and originally included cues for the appearance of the document.

HTML elements are the building blocks of HTML pages. With HTML constructs, images and other objects such as interactive forms may be embedded into the rendered page. HTML provides a means to create structured documents by denoting structural semantics for text such as headings, paragraphs, lists, links, quotes and other items. HTML elements are delineated by tags, written using angle brackets. Browsers do not display the HTML tags, but use them to interpret the content of the page.

HTML can embed programs written in a scripting language such as JavaScript, which affects the behaviour and content of web pages. Inclusion of CSS defines the look and layout of content. The World Wide Web Consortium (W3C), former maintainer of the HTML and current maintainer of the CSS standards, has encouraged the use of CSS over explicit presentational HTML since 1997. A form of HTML, known as HTML5, is used to display video and audio, primarily using the <canvas> element, in collaboration with JavaScript.

5.1.2 MySQL



fig: 5.2

MySQL tutorial provides basic and advanced concepts of MySQL. Our MySQL tutorial is designed for beginners and professionals. MySQL is a relational database management system based on the Structured Query Language, which is the popular language for accessing and managing the records in the database. MySQL is opensource and free software under the GNU license. It is supported by Oracle Company.

Our MySQL tutorial includes all topics of MySQL database that provides for how to manage database and to manipulate data with the help of various SQL queries. These queries are: insert records, update records, delete records, select records, create tables, drop tables, etc. There are also given MySQL interview questions to help you better understand the MySQL database.

MySQL is currently the most popular database management system software used for managing the relational database. It is open-source database software, which is supported by Oracle Company. It is fast, scalable, and easy to use database management system in comparison with Microsoft SQL Server and Oracle Database. It is commonly used in conjunction with scripts for creating powerful and dynamic server-side or web-based enterprise applications. It is developed, marketed, and supported by **MySQL AB, a Swedish company**, and written in and . MySQL is a (RDBMS) software that provides many things, which are as follows:

- It allows us to implement database operations on tables, rows, columns, and indexes.
- It defines the database relationship in the form of tables (collection of rows and columns), also known as relations.
- It provides the Referential Integrity between rows or columns of various tables.
- It allows us to updates the table indexes automatically.
- It uses many SQL queries and combines useful information from multiple tables for the end-users.

▪ **MySQL Features**

MySQL is a relational database management system (RDBMS) based on the SQL (Structured Query Language) queries. It is one of the most popular languages for accessing and managing the records in the table. MySQL is open-source and free software under the GNU license. Oracle Company supports it.

The following are the most important features of MySQL:

- **Relational Database Management System (RDBMS):** It is a relational database management system. This database language is based on the queries to access and manage the records of the table.
- **Easy to use:** MySQL is easy to use. We have to get only the basic knowledge of SQL. We can build and interact with MySQL by using only a few simple SQL statements.
- **It is secure:** MySQL consists of a solid data security layer that protects sensitive data from intruders. Also, passwords are encrypted in MySQL.
- **Client/ Server Architecture:** MySQL follows the working of a client/server architecture. There is a database server (MySQL) and arbitrarily many clients (application programs), which communicate with the server; that is, they can query data, save changes, etc.
- **Free to download:** MySQL is free to use so that we can download it from MySQL official website without any cost.
- **It is scalable:** MySQL supports multi-threading that makes it easily scalable. It can handle almost any amount of data, up to as much as 50 million rows or more. The default file size limit is about 4 GB. However, we can increase this number to a theoretical limit of 8 TB of data.
- **Speed:** MySQL is considered one of the very fast database languages, backed by a large number of the benchmark test.
- **High Flexibility:** MySQL supports a large number of embedded applications, which makes MySQL very flexible.
- **Compatible on many operating systems:** MySQL is compatible to run on many operating systems, like Novell NetWare, Windows* Linux*, many varieties of UNIX* (such as Sun* Solaris*, AIX, and DEC* UNIX), OS/2, FreeBSD*, and others. MySQL also provides a facility that the clients can run on the same computer as the server or on another computer (communication via a local network or the Internet).
- **Allows roll-back :** MySQL allows transactions to be rolled back, commit, and crash recovery.
- **Memory efficiency:** Its efficiency is high because it has a very low memory leakage problem.
- **High Performance:** MySQL is faster, more reliable, and cheaper because of its unique storage engine architecture. It provides very high-performance results in comparison to other databases without losing an essential functionality of the software. It has fast loading utilities because of the different cache memory.

5.1.3 Windows

Microsoft Windows, is a group of several graphical operating system families, all of which are developed, marketed, and sold by Microsoft. Each family caters to a certain sector of the computing industry. Active Windows families include Windows NT and Windows Embedded; these may encompass subfamilies, e.g., Windows Embedded Compact (Windows CE) or Windows Server. Defunct Windows families include Windows 9x, Windows Mobile and Windows Phone.

Microsoft introduced an operating environment named Windows on November 20, 1985, as a graphical operating system shell for MS-DOS in response to the growing interest in graphical user interfaces (GUIs). Microsoft Windows came to dominate the world's personal computer (PC) market with over 90% market share, overtaking Mac.

5.1.5 Windows XP

The next major version of Windows NT, Windows XP, was released on October 25, 2001. The introduction of Windows XP aimed to unify the consumer-oriented Windows 9x series with the architecture introduced by Windows NT, a change which Microsoft promised would provide better performance over its DOS-based predecessors. Windows XP would also introduce a redesigned user interface (including an updated Start menu and a "task-oriented" Windows Explorer), streamlined multimedia and networking features, Internet Explorer 6, integration with Microsoft's .NET Passport services, modes to help provide compatibility with software designed for previous versions of Windows, and Remote Assistance functionality.

At retail, Windows XP was now marketed in two main editions: the "Home" edition was targeted towards consumers, while the "Professional" edition was targeted towards business environments and power users, and included additional security and networking features. Home and Professional were later accompanied by the "Media Centre" edition (designed for home theatre PCs, with an emphasis on support for DVD playback, TV tuner cards, DVR functionality, and remote controls), and the "Tablet PC" edition (designed for mobile devices meeting its specifications for a tablet computer, with support for stylus pen input and additional pen-enabled applications). Mainstream support for Windows XP ended on April 14, 2009. Extended support ended on April 8, 2014. After Windows 2000, Microsoft also changed its release schedules for server operating systems; the server counterpart of Windows XP, Windows Server 2003, was released in April 2003. It was followed in December 2005, by Windows Server 2003 R2.

- **Windows Vista**

After a lengthy development process, Windows Vista was released on November 30, 2006, for volume licensing and January 30, 2007, for consumers. It contained a number of new features, from a redesigned shell and user interface to significant technical changes, with a particular focus on security features. It was available in a number of different editions, and has been subject to some criticism, such as drop of performance, longer boot time, criticism of new

UAC, and stricter license agreement. Vista's server counterpart, Windows Server 2008 was released in early 2008.

5.1.6 Windows 7

On July 22, 2009, Windows 7 and Windows Server 2008 R2 were released as RTM (release to manufacturing) while the former was released to the public 3 months later on October 22, 2009. Unlike its predecessor, Windows Vista, which introduced a large number of new features, Windows 7 was intended to be a more focused, incremental upgrade to the Windows line, with the goal of being compatible with applications and hardware with which Windows Vista was already compatible. Windows 7 has multi-touch support, a redesigned Windows shell with an updated taskbar, a home networking system called Home Group, and performance improvements.

5.1.7 Windows 8 and 8.1

Windows 8, the successor to Windows 7, was released generally on October 26, 2012. A number of significant changes were made on Windows 8, including the introduction of a user interface based around Microsoft's Metro design language with optimisations for touch-based devices such as tablets and all-in-one PCs. These changes include the Start screen, which uses large tiles that are more convenient for touch interactions and allow for the display of continually updated information, and a new class of apps which are designed primarily for use on touch-based devices. Other changes include increased integration with cloud services and other online platforms (such as social networks and Microsoft's own OneDrive (formerly SkyDrive) and Xbox Live services), the Windows Store service for software distribution, and a new variant known as Windows RT for use on devices that utilise the ARM architecture. An update to Windows 8, called Windows 8.1, was released on October 17, 2013, and includes features such as new live tile sizes, deeper OneDrive integration, and many other revisions. Windows 8 and Windows 8.1 has been subject to some criticism, such as removal of the Start Menu.

5.1.8 Windows 10

On September 30, 2014, Microsoft announced Windows 10 as the successor to Windows 8.1. It was released on July 29, 2015, and addresses shortcomings in the user interface first introduced with Windows 8. Changes include the return of the Start Menu, a virtual desktop

system, and the ability to run Windows Store apps within windows on the desktop rather than in full-screen mode. Windows 10 is said to be available to update from qualified Windows 7 with SP1 and Windows 8.1 computers from the Get Windows 10 Application (for Windows 7, Windows 8.1) or Windows Update (Windows 7).

On November 12, 2015, an update to Windows 10, version 1511, was released. This update can be activated with a Windows 7, 8 or 8.1 product key as well as Windows 10 product keys. Features include new icons and right-click context menus, default printer management, four times as many tiles allowed in the Start menu, Find My Device, and Edge updates. In February 2017, Microsoft announced the migration of its Windows source code repository from Perforce to Git. This migration involved 3.5 million separate files in a 300-gigabyte repository. By May 2017, 90 percent of its engineering team now uses Git, in about 8500 commits and 1760 Windows builds per day.

5.1.9 Python Sublime text

Sublime Text is a shareware cross-platform source code editor with a Python application programming interface (API). It natively supports many programming languages and markup languages, and functions can be added by users with plugins, typically community-built and maintained under free-software licenses.

The following is a list of features of Sublime Text:

- "Go to Anything," quick navigation to files, symbols, or lines
- "Command palette" uses adaptive matching for quick keyboard invocation of arbitrary commands
- Simultaneous editing: simultaneously make the same interactive changes to multiple selected areas
- Python-based plugin API
- Project-specific preferences
- Extensive customisability via JSON settings files, including project-specific and platform-specific settings
- Cross-platform (Windows, macOS, and Linux) and Supportive Plugins for cross platform
- Compatible with many language grammars from Text Mate.

CHAPTER 6

MODULE DESCRIPTION

6.1 ADMIN

- **Login**

Login or entry available to the user of a discussion forum or website with special rights to control or restrict the activity of other users. The admin can login into the admin page using the admin login credentials and can view the users details.

- **View User**

The admin can view the number of users registered into the webpage (Insight) and can see the details of the users such as name, address, phone number and email address.

6.2 USER

- **Register**

User registration systems are screens, forms, or profile pages that request information from a user to create a web-based account or profile. A user registration system generally asks a user to create a username and password, and possibly answer other security questions as well.

A new user can register on the webpage (Insight) by providing information such as their name, address, phone number, and email address.

- **Login**

Logins are used by websites, computer applications, and mobile apps. They are a security measure designed to prevent unauthorized access to confidential data. When a login fails (i.e., the username and password combination does not match a user account), the user is disallowed access. Many systems block users from even trying to log in after multiple failed login attempts. The user can now login into the Insight by providing the credentials such as login id/name and password.

- **Show Gestures**

A gesture is a movement of the hand, arms, or other body part that is intended to indicate or emphasise something. After logging in, the user can select the Gestures option, which will open the camera to show gestures.

6.3 TABLES

- **REGISTRATION TABLE**

FIELD NAME	FIELD TYPE	DESCRIPTION
user_id	Int (11)	To store the unique id of user which is a primary key
login_id	Int (11)	To store the unique id of user which is a foreign key
First Name	varchar(50)	To store the first name of user
Last Name	varchar(50)	To store the last name of user
Phone Number	Varchar(50)	To store phone number
Email Address	varchar(70)	To store email address

- **LOGIN TABLE**

FIELD NAME	FIELD TYPE	DESCRIPTION
login_id	int(11)	To store the unique id of user which is a foreign key
Username	varchar(50)	User name of the user
Password	varchar(50)	Password of the user
Type	varchar(50)	To know whether it is user or admin

CHAPTER 7

SYSTEM DESIGN ARCHITECTURE

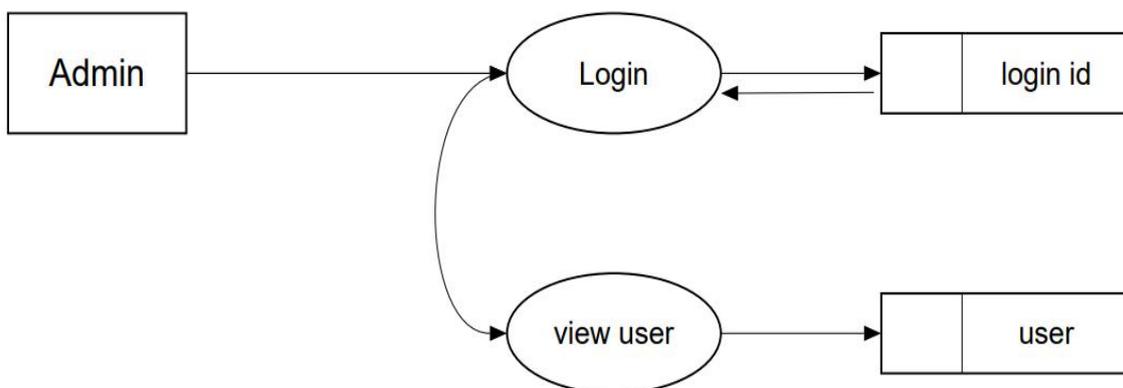
Level 0 :



Fig 7.1. Basic abstract of System

Level 1 :

- Level 1.1



- Level 1.2

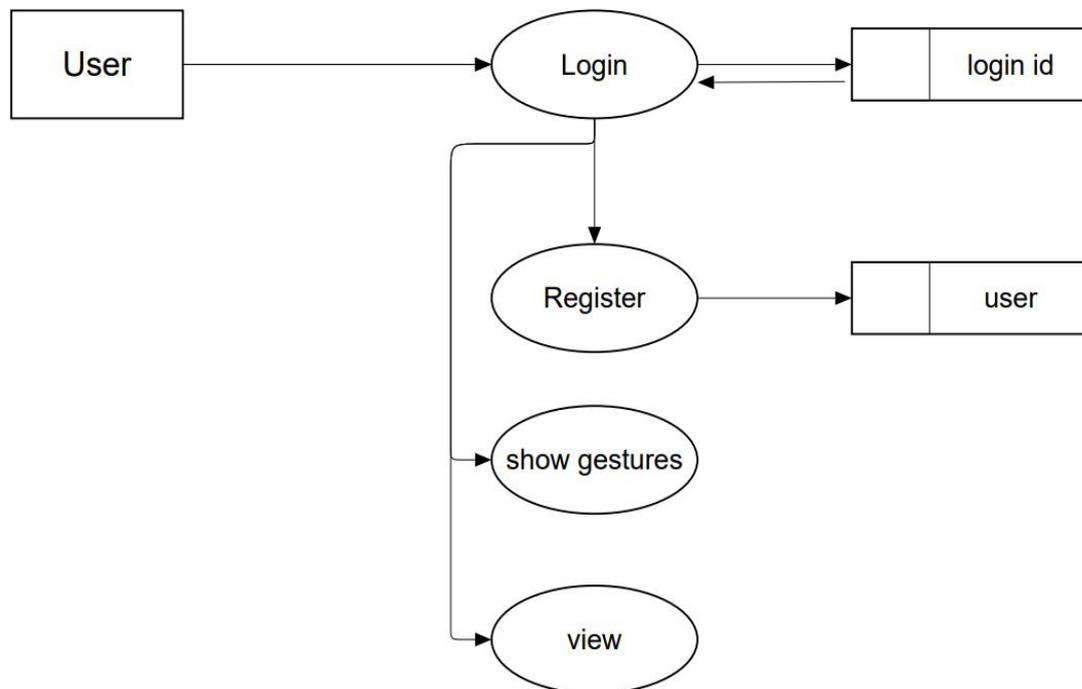


Fig 7.2 Working of System

7.1 Feasibility Study

Feasibility study is made to see if the project on completion will serve the purpose of the organisation for the amount of work, time and effort spent on it. Study lets the developer foresee the future of the project and its usefulness. Finding out whether a new system is required or not. The study is carried out to the best system that meet performance requirement. This entails identification, description and evaluation of candidate system and selection for the best system for the job. It simply identifies whether the proposed system is feasible to the organisation or not.

There are three aspects in the feasibility study portion of the preliminary investigation:

- i) Technical feasibility
- ii) Economic feasibility
- iii) Operational feasibility

7.1.1 Technical Feasibility

Voice assistant for visually impaired must be evaluated from technical viewpoint first. The assessment of this feasibility must be based on outline design of the system requirement in the terms of input, output, programs and procedure having identified an outline system, the

investigation must go on to suggest the type of equipment , required method of developing the system, method of running the system once it has been designed. The project should be developed such that the necessary functions and performance are achieved within the constraints. The project is developed with latest technology. There are only minimal constraints involved in this project.

7.1.2 Economic Feasibility

Here an evaluation of development cost weighted against the ultimate income or benefit derived from the developed system. The cost for the development of the project has been evaluated and we want to check that the cost does not exceed.

Beneficial cost of the system. The economic and financial analysis is used for evaluating the effectiveness of the candidate system. This project also undergone economic feasibility study and found that it is feasible. So, the cost for development does not exceed its beneficial cost. This brought to as the conclusion that the system is economically feasible in the context.

7.1.3 Operational Feasibility

In operational feasibility the entire application is checked whether the system will be used if it is developed and implemented. Also, it is checked whether there will be resistance from user that may undermine the possible application benefits. There is no barrier for implementing the system. The system also helps to access the information immediately as need arises. Thus, the system is found to be operational feasible.

CHAPTER 8

IMPLEMENTATION

8.1 User Activity

Step 1: Open the website

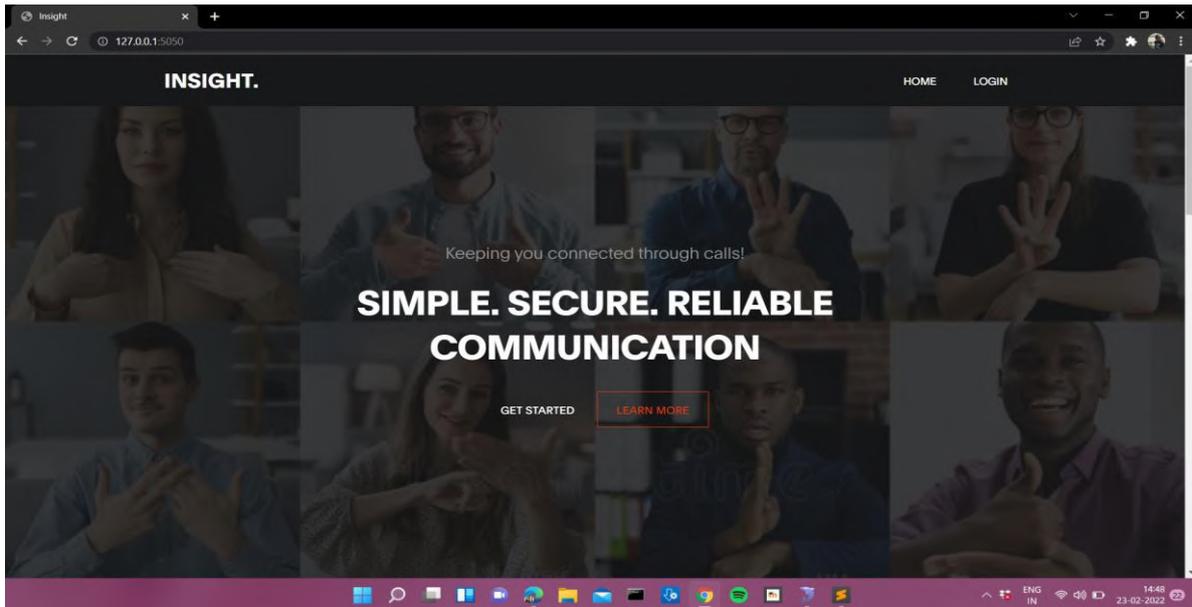


Fig:8.2.1 Homepage

Step 2: Click on register if you are new user or else login by entering the credentials.

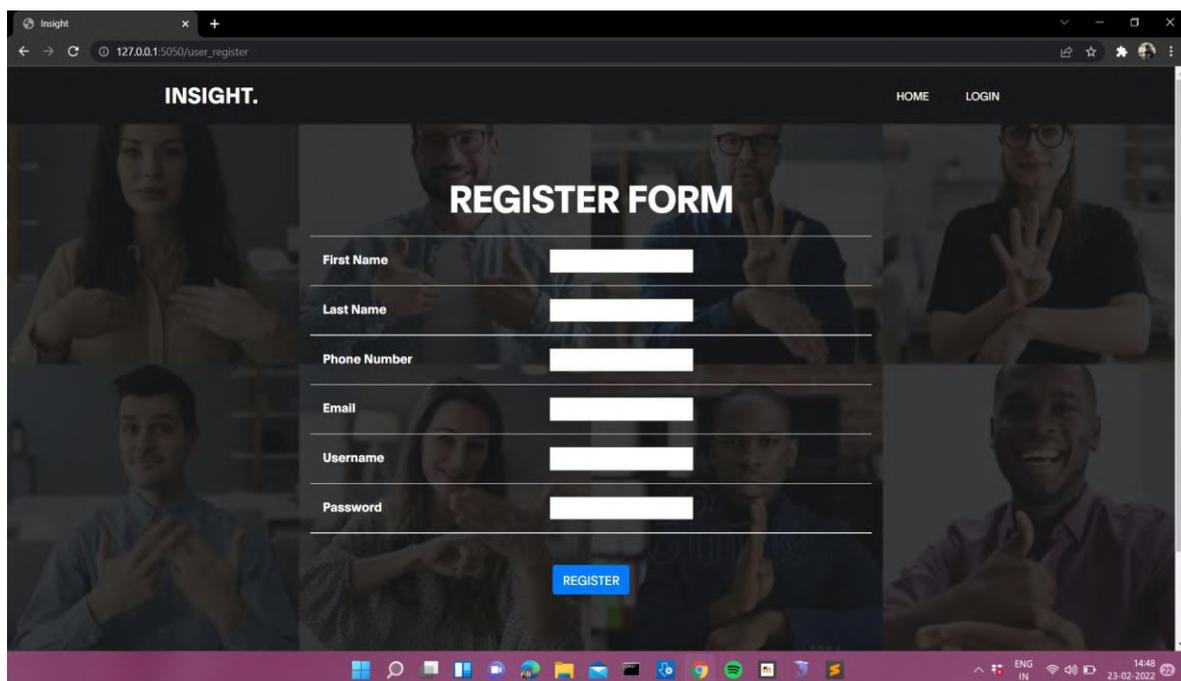


Fig:8.2.2 Registration Form

Step 3: Login after registration. You will be directed to home page.

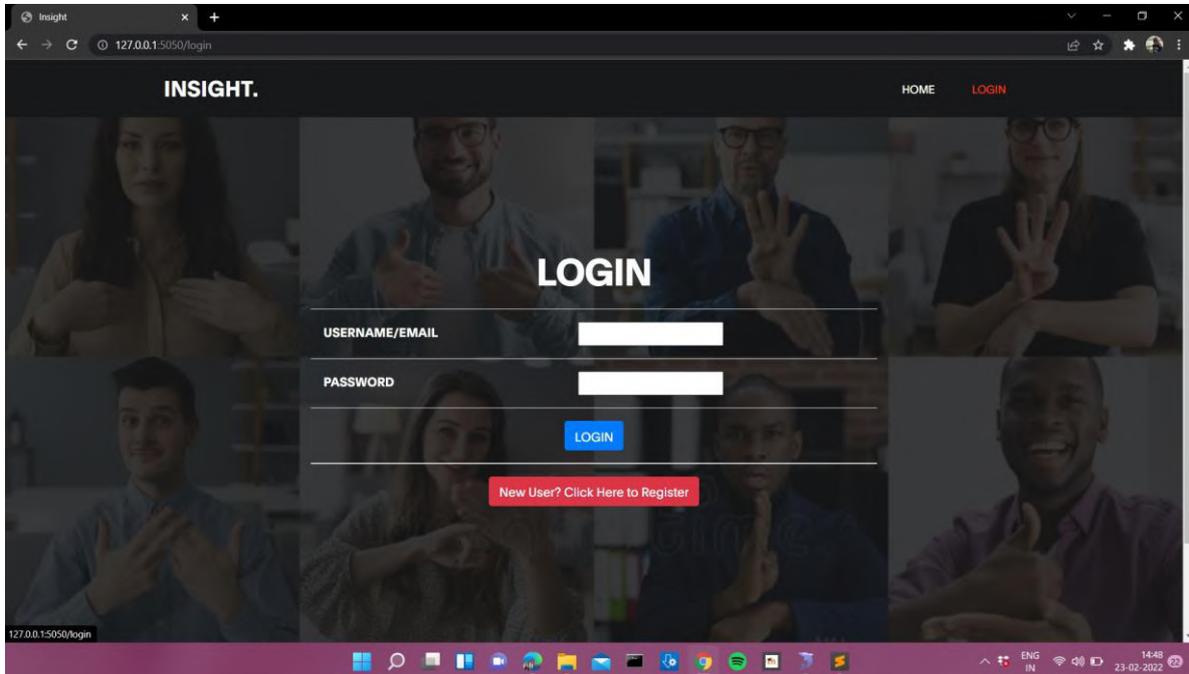


Fig:8.2.3 Login

Step 4: Select Gesture option on right side and the camera will be open.



Fig:8.2.4 Gesture Recognition

8.2 Admin Activity

Step 1: Login with admin login id and password.

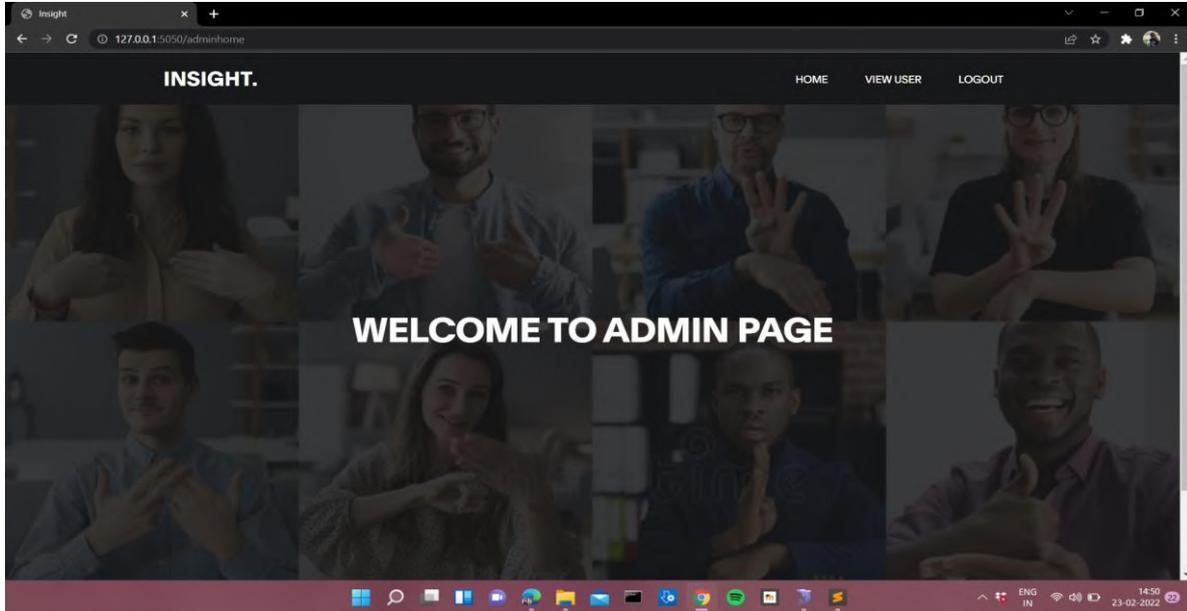


Fig:8.3.1 Admin Home

Step 2: Click on View Users on right side.

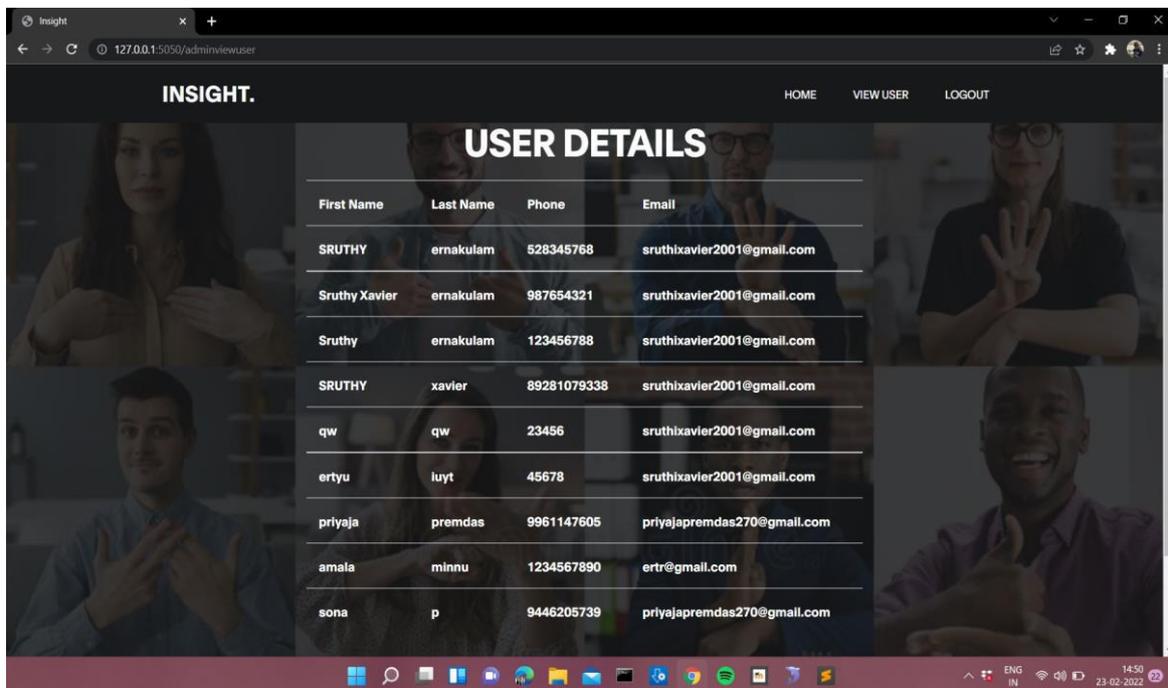


Fig:8.3.2 User Details

CHAPTER 9 CONCLUSION

People who are deaf or deaf-blind use sign language as a means of communication. A sign language is made up of a variety of gestures made up of different hand shapes, movements, and orientations, as well as facial expressions. They communicate using sign language. In different parts of the world, people use different sign languages. They are few in number when compared to spoken languages. In this project, we created a platform for deaf and dumb where they can communicate using their main key sign language. Our project is a sign language recognition platform using CNN algorithm. We achieved final accuracy of **98.0%** on our data set. We have improved our prediction after implementing two layers of algorithms wherein we have verified and predicted symbols which are more similar to each other. This gives us the ability to detect almost all the symbols provided that they are shown properly, there is no noise in the background and lighting is adequate.

9.1 FUTURE SCOPE

Our proposed work is expected to recognise the sign language and convert it into the text. Still, there's still a lot of scope for possible future work. The system can be useful for static ASL numeral signs only. The ASL recogniser system cannot be considered as a complete system, as for complete recognition of sign language, we have to include ASL alphabets, words and sentences. These signs can be included in future. Also, other feature extraction algorithms like Wavelet transform, Invariant moments, Shape lets descriptors and other existing methods can be included in conducting experiments for improvement in the results. Other classifiers like multi class Support Vector Machine (SVM), Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) or a combination of these classifiers can be included in conducting experiments to improve the recognition.

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APPENDIX

Main Code:

```
# Importing the Libraries
Required import os import string

# Creating the directory Structure

if not os.path.exists("dataSet"):
    os.makedirs("dataSet")

if not os.path.exists("dataSet/trainingData"):
    os.makedirs("dataSet/trainingData")

if not os.path.exists("dataSet/testingData"):
    os.makedirs("dataSet/testingData")

# Making folder 0 (i.e., blank) in the training and testing data folders respectively

for i in range (0):    if not
os.path.exists("dataSet/trainingData/" + str(i)):
    os.makedirs("dataSet/trainingData/" + str(i))

    if not os.path.exists("dataSet/testingData/" + str(i)):
os.makedirs("dataSet/testingData/" + str(i))

# Making Folders from A to Z in the training and testing data folders
respectively
```

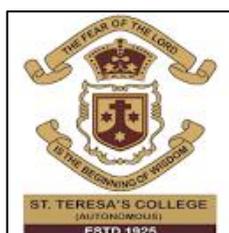
```
for i in string.ascii_uppercase:
    if not os.path.exists("dataSet/trainingData/" + i):
        os.makedirs("dataSet/trainingData/" + i)

    if not os.path.exists("dataSet/testingData/" + i):
        os.makedirs("dataSet/testingData/" + i)
```


**COMPARITIVE PHYTOCHEMICAL STUDY OF AQUEOUS EXTRACTS
OF AERIAL PARTS OF SELECTED INVASIVE SPECIES COMMONLY
FOUND IN KERALA**

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF BACHELOR OF SCIENCE IN BOTANY

BY
PRIYANKA RAJAN
REG.NO:AB19BOT029



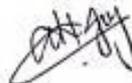
DEPARTMENT OF BOTANY
ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM – KERALA
2019-2022

CERTIFICATE

This is to certify that the dissertation entitled 'COMPARITIVE PHYTOCHEMICAL STUDY OF AQUEOUS EXTRACTS OF AERIAL PARTS OF SELECTED INVASIVE SPECIES COMMONLY FOUND IN KERALA' submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Botany is an authentic record of the work carried out by PRIYANKA RAJAN during her B.Sc. course from 2019-2022 under the guidance and supervision of Miss Anu Joy, Department of Botany, St. Teresa's College (Autonomous), Ernakulam.



Dr. Liza Jacob
Head of the Department
Department of Botany
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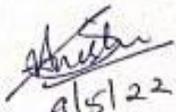
Ms. Anu Joy
Guest Lecturer
Department of Botany
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Ernakulam



Place : Ernakulam

Date : 9-05-2022

External Examiners

1.  Anila ✓
9/5/2022
2. Anisha. S 
9/5/22

DECLARATION

I, PRIYANKA RAJAN declare that the dissertation entitled 'COMPARITIVE PHYTOCHEMICAL STUDY OF AQUEOUS EXTRACTS OF AERIAL PARTS OF SELECTED INVASIVE SPECIES COMMONLY FOUND IN KERALA' is an authentic research work carried out by me under the supervision and guidance of Miss Anu Joy, Guest Lecturer, Department of Botany, St. Teresa's College (Autonomous), Ernakulam, in partial fulfillment of requirements for the award of B.Sc Degree in Botany and no part of it has previously formed the basis for the award of any degree, diploma or associate ship in any institution.

Place : Ernakulam

Date : 9-05-2022



PRIYANKA RAJAN

ACKNOWLEDGEMENTS

I thank the Almighty God for the numerous favours and mercies bestowed upon me, particularly during the project's duration.

I am grateful to Dr. Liza Jacob, Head of the Department of Botany, St. Teresa's College (Autonomous), Ernakulam, for her invaluable and unselfish aid and encouragement throughout the dissertation process.

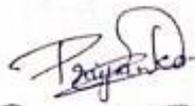
I express my gratitude to Miss Anu Joy, Guest lecturer, Department of Botany, St. Teresa's College (Autonomous), Ernakulam.

I am grateful to all other teachers in the Department of Botany, St. Teresa's College (Autonomous), Ernakulam for their timely suggestions and constant support.

I express my gratitude to all Non-teaching staff of Department of Botany, St. Teresa's College (Autonomous), Ernakulam for their kind assistance and support throughout this project.

Archana C S , T B Niladevi

Last but not least, I express my heartfelt thanks to all my friends and well-wishers who assisted me in completing this project.


Priyanka Rajan

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1. 2. Introduction

Despite the advances in research and remarkable growth and development in allied disciplines such as medical science, environmental science, and so on, we still face many obstacles in treatment due to a shortage of medicines for certain diseases. Plants have been utilised as medicine all across the world. Changes in the natural cycle and their consequences on health in all forms of life have caused a worrisome sign all over the world in the present day situation. Attempts are being made to reduce the negative effects by raising public knowledge, which is then used to execute the maximum usage of plant medications in daily life.

Many types of organic pharmaceuticals have been widely used to save humans from life-threatening diseases, but these organic treatments still have a variety of side effects, including kidney failure, heart failure, and nervous breakdown. As a result, it is high time to change our medical lifestyle to one that is more environment friendly, and we should rely on plant drugs found in nature. Traditional herbalists utilise a variety of herbs in specific formulas to treat a variety of ailments and disorders. According to WHO estimates, about 80% of the population relies on medicinal plants for primary healthcare. Plants are known to be an important component of indigenous medical systems such as Ayurveda, Unani and Siddha.

1.1 Invasive species

Any non- native species that significantly alters or disrupts the ecosystems it colonises is referred to as an invasive species, also known as an imported species, alien species, or exotic species. Although such species may arrive in new places as a result of natural migration, they are frequently introduced as a result of the actions of other species. The most common ways invasive plants, animals, microorganisms, and other species are moved to new environments are through human activities such as global commerce and the pet trade. Through their impact on agriculture, forestry, fisheries, and natural systems, which are major sources of livelihood in underdeveloped nations, invasive alien species worsen poverty and pose a threat to development.

Invasive plants are plants that have been introduced into places outside of their natural environment by humans, either purposefully or unintentionally. These species have the potential to spread quickly, posing a threat to native species. Invasive plant species reduce the diversity of native plants, reduce water availability, and degrade soil nutrient quality. When an alien plant invades a habitat, it alters the environment's conditions. It accomplishes this by altering the levels

of light, solar radiation, and temperature in the infected areas. For a variety of species, the quality and availability of food, shelter, nesting locations, basking sites, and perches changes. They can also cause significant alterations in native flora, such as changes in fire frequency, nitrogen cycling, water availability, and soil erosion.

1.2 Significance of phytochemical screening of invasive species

Phytochemical screening aids in the discovery of plant extract constituents and the one that predominates over the others, as well as the search for bioactive compounds that can be employed in the development of therapeutic medications. Plant compounds, also known as phytochemicals, play a crucial part in their growth and development and defend plants against insects and other pathogens. Invasive species frequently take all of the nutrients and minerals from neighbouring plants, resulting in plants that are more nutrient and medicinally rich. Invasive plants have more therapeutic potential, according to studies, and can thus be used for pharmacological purposes. More ever when it used for the pharmacological purpose, ther threat to natural ecosystem by the invasion of these species can be reduced considerably. *Antigonon leptopus*, *Wedelia trilobata* and *Tridax procumbens* are commonly found invasive species in Kerala.

1.3 *Antigonon leptopus*, Hook. & Arn.

1.3.1 Systematic position (Bentham and Hooker's system of classification, 1862-1883)

Kingdom	: Plantae
Class	: Dicotyledonae
Subclass	: Monochlamydeae
Series	: Curvembryae
Family	: Polygonaceae
Genus	: <i>Antigonon</i>
Species	: <i>leptopus</i>

1.3.2 General description

Antigonon leptopus, also known as coral vine, Coralita or San Miguelito vine, is a flowering plant belonging to Polygonaceae (buckwheat) family. The plant has its origin from the tropical woods of America. The term is Greek in origin and it most likely alludes to the stem's squat or angled feature, which is thin, green, hairy, angled and grooved. This perennial vine, cultivated as an ornamental for its showy flowers, but which when neglected can grow quickly over other vegetation, spreading beyond its area of introduction.

A. leptopus is a perennial vine that is grown as an ornamental for its brilliant blossoms, but if left unattended, it can swiftly take over other vegetation and spread beyond its original range. As an invasive vine, it is included in the Global Compendium of Weeds (Randall, 2012) and classified as one of the most aggressive weeds occurring in tropical and peninsular ecosystems (Langeland *et al.*, 2008; Burke and Di Tommaso, 2011). This plant can reproduce sexually through seeds and vegetatively through stems and underground tubers (USDA-NRCS, 2011). Its ability to survive as a weed is aided by its dual reproductive behaviour (Raju *et al.*, 2001). By displacing native species, affecting community structures, and altering ecological roles. *A. leptopus* has the ability to modify and collapse native plant ecosystems. *A. leptopus* smothers native trees, outcompetes understory species, and changes fire regimes (Langeland *et al.*, 2008; USDA-NRCS, 2011). *A. leptopus* is currently classified as a "weed" in the United States (USDA-NRCS, 2012), as a pest in Australia (Queensland Department of Primary Industries and Fisheries, 2011), and as an invasive species in South Africa, Kenya, Tanzania, Cuba, Bahamas, Puerto Rico, Lesser Antilles, and a number of Pacific islands.

1.3.3 Taxonomic description

Woody climber, with tuberous root, stem angular, glabrescent. Leaves alternate, blade 3-8 cm long, 1.5-5 cm broad, hastate-ovate, triangular or cordate-ovate, simple, hairy above, densely towards margin, glabrescent below; petiole 1-2 cm long. Inflorescence a raceme ending into a branched tendril. Flowers showy; pedicel 3-8 mm long with sparsely spreading simple hairs. Perianth segments 5, bright pink, 6-15 mm long, 3-7 mm broad, very reticulately veined. Stamens 8, 3-7 mm long, sparsely hairy throughout; anthers oblong. Carpels 3; ovary ovoid, trigonous, glabrous, 3-4 mm long; styles 3 with capitate stigma. The nut is 0.5 mm long.

1.3.4 Uses

Antigonon leptopus is one of several plants that have traditionally been used to treat a variety of ailments. Different components of the plant, including the roots, aerial portions, leaves, and seeds are used for ethnomedical purposes. Cold and flu symptoms are relieved by drinking a hot tea made from the aerial portions (A.oberali *et al* 2018). In many places, tea made from the aerial portions of *Antigonon leptopus* is used as a cold and pain reliever.

1.4 *Wedelia trilobata* (L.) A. S. Hitchc. (Syn. *Silphium trilobatum* L.)

1.4.1 Systematic position (Bentham and Hooker's system of classification, 1862-1883)

Kingdom	: Plantae
Class	: Dicotyledonae
Subclass	: Gamopetalae
Series	: Inferae
Order	: Asterales
Family	: Asteraceae
Genus	: <i>Wedelia</i>
Species	: <i>trilobata</i>

1.4.2 General description

Wedelia is flowering plant genus in the sunflower family. Commonly called creeping-oxeyes. *Wedelia trilobata* is procumbent, perennial herb found in wet places in Uttar Pradesh, Assam, Andhra Pradesh and along the coastal areas. It is found in the plains district of Madras presidency, China and Japan.

1.4.3 Taxonomic description

It is a scabrous, procumbent perennial soft herb with high camphor like odour and has a gorgeous growth. It is a perennial herb of 0.3-0.9 m high, stem procumbent at base and rooting at lower nodes. Leaves are opposite, sessile, 2.5-7.5 by 1-2.8 cm lanceolate-oblong, entire or irregularly crenate-serate, scabrous with short white hairs and base tapering. Heads of flowers, 2-3.2 cm diameter, solitary, peduncles 2.5 -15 cm long erect, slender, slightly thickened beneath the heads. Flowers are yellow, Involucral bracts in 2 series; outer oblong, 5-8, 2-3 mm, acute or obtuse at the apex, appressed pubescent; inner lanceolate, 5-7, 1-2.5 mm. Ray florets few; corolla 6-8, 3-4 mm long. Rooting at lower nodes; stems are reddish, the ray florets are triquetrous; disc florets are compressed. Pappus a minute, irregularly marginated, withered cup at maturity.

1.4.4 Uses

They have been used as folklore medicines for treating various ailments like hepato protective efficacy, jaundice, diarrhoea, cough etc... The decoction of plants is used for uterine

haemorrhage and menorrhagia. Leaves work as tonic to cure cough, skin disease etc... The fruits, stem and leaves are used in childbirth and in treatment of bites and stings, fever and infection. Leaves are also used for the treatment of kidney dysfunction, colds, wounds and amenorrhea. Leaves are also used in dyeing hairs and in promoting hair growth. Its leaves can be used in treatment of dermatological disorders, cough, headache, hair loss, lice, strengthening the nervous system, lack of blood, digestive system disorders. The leaves are used in dyeing grey hair and in promoting the growth of hair. *Wedelia trilobata* has great importance in Ayurvedic, Siddha and Unani Systems of Traditional Medicine. It is edible, used dried and powdered in capsules

1.5 *Tridax procumbens* L.

1.5.1 Systematic position (Bentham and Hooker's system of classification, 1862-1883)

Kingdom	: Plantae
Class	: Dicotyledonae
Subclass	: Gamopetalae
Series	: Inferae
Order	: Asterales
Family	: Asteraceae
Genus	: <i>Tridax</i>
Species	: <i>procumbens</i>

1.5.2 General description

Tridax procumbens originated in Central America but now occurs throughout the tropics and subtropics. It was reportedly introduced into Nigeria as an ornamental in the early 1900s and later spread from there to many other tropical countries. It occurs in many environments but is particularly well adapted to coarse-textured soils in tropical regions. In locations with tropical or semi-tropical climates, this plant can be found in fields, meadows, croplands, disturbed areas, lawns, and roadside. It is found at elevations from sea level to over 2000 m, often as a weed of roadsides, waste land, fallow land and crops. The plant is invasive in part because it produces a large number of these achenes, up to 1500 per plant, each of which can catch the wind in its pappus and travel a considerable distance. It is classified as a Noxious Weed in the United States and is regulated under the Federal Noxious Weed Act.

1.5.3 Taxonomic description

Tridax procumbens is a perennial herb that has a creeping stem which can reach from to 8-30 inches (20-75 cm) long. The leaves of *Tridax procumbens* are opposite, pinnate, oblong to ovate, and 1-2 inches (2.5-5 cm) long with cuneate bases, coarsely serrate margins, and acute apexes. *Tridax procumbens* flowers have white rays and yellow disk flowers. They are about 0.4-0.6 inches (1-1.5 cm) wide, and held on a 4-12 inches (10-30 cm) long stalk. Flowering occurs in spring. Fruits are achenes that are dark brown to black in color, oblong, and 0.08 inches (2 mm) long, each with a head of pappus bristles that vary from 0.12-0.24 inches (3-6 mm) long. The fruits has stiff hairs on one end and a feathery, plumelike white pappus on the other. Scales or pappus are used to symbolise the calyx.

1.5.4 Uses

Tridax procumbens has been used in India for centuries as a wound healer, anticoagulant, antifungal, and insect repellent. The juice obtained from the leaves is administered directly on wounds. Its leaf extracts were utilised in folk medicine to treat infectious skin problems. In Ayurvedic medicine, it is used to treat liver problems, hepatoprotection, gastritis, and heartburn. In some parts of India, indigenous healers utilise *Tridax procumbens* to cure boils, blisters, and cuts. The leaves are antiseptic, haemostatic and parasiticide. They are used as a treatment against bronchial catarrh, dysentery and diarrhoea. The leaf powder combined with that of *Cicer arietium* in a 2:1 ratio is taken orally to treat diabetes. A fine paste of the leaves is applied externally to reduce swelling of hemorrhoids and to stop bleeding. The leaves sap is applied topically to sores and ulcers.

1.6 Objectives of the present study

- To find out the phytochemical constituents in the invasive species commonly found in Kerala such as *Tridax procumbens*, *Wedelia trilobata*, *Antigonon leptopus*
- To carry out a comparative study of phytochemicals present in the selected invasive plant species for the present study.

REVIEW OF LITERATURE

Udupa et al., (1991) reported the usage of *Tridax procumbens* as a herbal drug for wound cure in various ayurvedic formulations.

Lans (1996) and Block et al. (1998) in their studies revealed that *W. trilobata* has been historically used for amenorrhoea as they contain diterpene (kaurenoic acid), eudesmanolide lactones and luteolin in their leaves and stems.

Neraliya and Gaur (2004) discovered that extract of *A. leptopus* has high juvenoid activity against the filarial mosquito in their investigation.

Huang *et al.*, (2006) and Neelam *et al.*, (2014) reported that phytomedicines can be developed as an alternative and are relatively inexpensive than modern drugs.

Dhanabalan *et.al* (2008) showed the presence of phytochemicals such as Alkaloids, Tannins, Saponin, Steroid, Phlobatannin, Terpenoids, Flavonoids and Cardiac glycosides form the methanolic extract of leaves of *T. procumbens* Linn.

Ikewuchi Jude *et al.*, (2009) reported six phytochemical from the leaves of *Tridax procumbens* Linn. The leaves of *Tridax procumbens* were screened for the presence of bioactive molecules. They had high flavonoids, alkaloids, hydroxycinnamates, tannins and phytosterols, moderate benzoic acid derivatives and lignans, and low carotenoids contents.

Ayyappa Das *et.al* (2009) was reported eight secondary metabolites from the aqueous and Methanolic leaf extract of *Tridax procumbens* Linn.

Balekar *et al.* (2014) stated that *Wedelia trilobata* could cure hepatitis, restore digestion and infection. It contains secondary metabolites which have antibacterial, antifungal, anti-plasmodium, antidiabetic, hepatoprotective, antipyretic-analgesic and antitumor properties.

Balekar et al. (2014) in his studies reported that for the treatment of varieties of ailments, *W. trilobata* L. has long been used as traditional medicine in South America, China, Japan and India.

Kanthal *et al.*, (2016) found that the chloroform fraction of a methanol extract of *A. leptopus* leaves to have dose-dependent anthelmintic efficacy against an earthworm model. The methanolic extract was more active than the other extracts in terms of anthelmintic activity.

Udayaprakash *et al.*, (2018) examined the the preliminary phytochemical and antibacterial activities of *Antigonon leptopus*. The extracts had considerable antibacterial and antifungal action against all of the pathogens tested, and the effect was compared to that of penicillin and nystatin, two common antibiotics.

3. MATERIALS AND METHODS

For the present study, the aerial parts of three invasive species were collected from three different localities of Ernakulam District-(PANANGAD,NEDUNGAD,FORTKOCHI) in the month of march. It is then shade dried for three days and then powdered. The powdered plant samples were stored in labelled bottles. For the phytochemical screening tests, aqueous extracts of these samples were prepared by mixing about 3 g in 20 mL of distilled water.

Test for alkaloids

Mayer's test- Take 100 microliter extract was taken in a test tube in a test tube to which 2 ml of dilute HCl was added and 1 ml of Mayer's reagent was added in drop wise manner .Yellow buff or cream colour precipitate indicated the presence of alkaloid.

Wagner's test- To small amount of extract solution add 2 ml of dilute HCl and 1 ml of Wagner's reagent was added in a drop wise manner. The reddish brown precipitate showed the presence of alkaloid.

Dragendroff's reagent test- To 200 microliter of extract, add 2 ml of dilute HCl and 1 ml of reagent was added in a test tube, the orange brown precipitate showed the presence of alkaloid.

Test for Flavonoids- To 5ml of the extract, 1ml of 10% of NaOH solution was added, yellow colour turning to colourless is an indication of presence of flavonoids.

Test for Anthraquinones- To 1 ml of the extract, 2 ml of KOH solution was added, pink colour shows the presence of anthraquinone.

Test for Saponins- About 2ml of 1% NaHCO₃, was added to 1 ml of extract and was shaken vigorously. Lather like formation persistent for some time indicated the presence of saponins.

Test for Tannins- 1 gm of sample was added with 100 ml of distilled water boiled and cooled. Then 1% of FeCl₃ was added drop wise to the aqueous solution. Green black precipitate showed the presence of tannins.

Test for phlobatannin- Fresh leaves powder of plant was grinded with distilled water to make aqueous solution. Then the mixture was filtered and filtrate was taken as sample. 1 ml of aqueous 1% HCl was added to the 1 ml of sample followed by boiling. A red precipitate was the indication of phlobatannin.

Test for terpenoids- 400 µl of chloroform was added to 1 ml of extract. Then 2-3 drops of H₂SO₄ was added. Reddish brown color showed the presence of terpenoids.

Test for cardiac glycoside (Keller Killani test) - About 5 ml of the extract was mixed with 2 ml of glacial acetic acid containing 1 drop of FeCl₃ solution. To this 1 ml of concentrated H₂SO₄ was slowly from the sides of the test tube. Formation of brown ring at the interphase indicated the

presence of cardiac glycoside.

Test for Coumarins- 3 mL of 10 % NaOH was added to 2 mL aqueous plant extract and yellow colour was observed in positive results.

Test for phenol

Ferric chloride test- 1 ml extract is dissolved in 1 ml distilled water or ethanol, and then added few drops of ferric chlorides solution. Phenolic solution showed Red, Blue, green, Purple coloration.

Test for steroids- 1 ml extract is dissolved in 1 ml distilled water or ethanol, and then added few drops of ferric chlorides solution. Phenolic solution showed Red, Blue, green, Purple coloration.

The results of various phytochemical tests conducted in the plants were tabulated and used for comparative analysis. The photographs of the test results were taken.

4. RESULTS

The present study was based on the phytochemical screening of the aqueous extracts of three invasive species commonly found in Kerala such as *Antigonon leptopus*, *Wedelia trilobata* and *Tridax procumbens*. In order to check the presence of phytochemicals, eleven tests were conducted. They were for alkaloids, coumarins, flavonoids, tannins, saponins, glycosides, anthraquinones, terpenoids, steroids, phlobotanins, and phenol.

The aqueous extracts of aerial parts of *Antigonon leptopus* showed the presence of alkaloids, saponins and glycosides and phenol. The aqueous extracts of aerial parts of *Wedelia trilobata* showed the presence of alkaloids, flavonoids, terpenoids, glycosides and phenols. The phytochemical screening tests for *Tridax procumbens* showed the presence of Alkaloids, terpenoids, saponins, coumarins and phenols from its aqueous extraction (Table 01)

From the study, it was observed that all these three invasive plants extracts showed presence of alkaloids and phenols. Steroids, Phlobatannins, Tannins and Anthraquinones were absent in the three plants. *A.leptopus* showed least number of phytochemicals whereas *W.chinensis* and *Tridax procumbens* showed highest number of phytochemicals.

Table 1 shows the results of phytochemical tests conducted in the three invasive plant species
(+ indicates Presence and – indicates Absence)

Phytochemicals	<i>Antigonon leptopus</i>	<i>Wedelia trilobata</i>	<i>Tridax procumbens</i>
Alkaloids	+	+	+
Flavonoids	-	+	-
Steroids	-	-	-
Terpenoids	-	+	+
Saponins	+	-	+
Coumarins	-	-	+
Glycoside	+	+	-
Phlobotannins	-	-	-
Tannins	-	-	-
Anthraquinone	-	-	-
Phenol	+	+	+

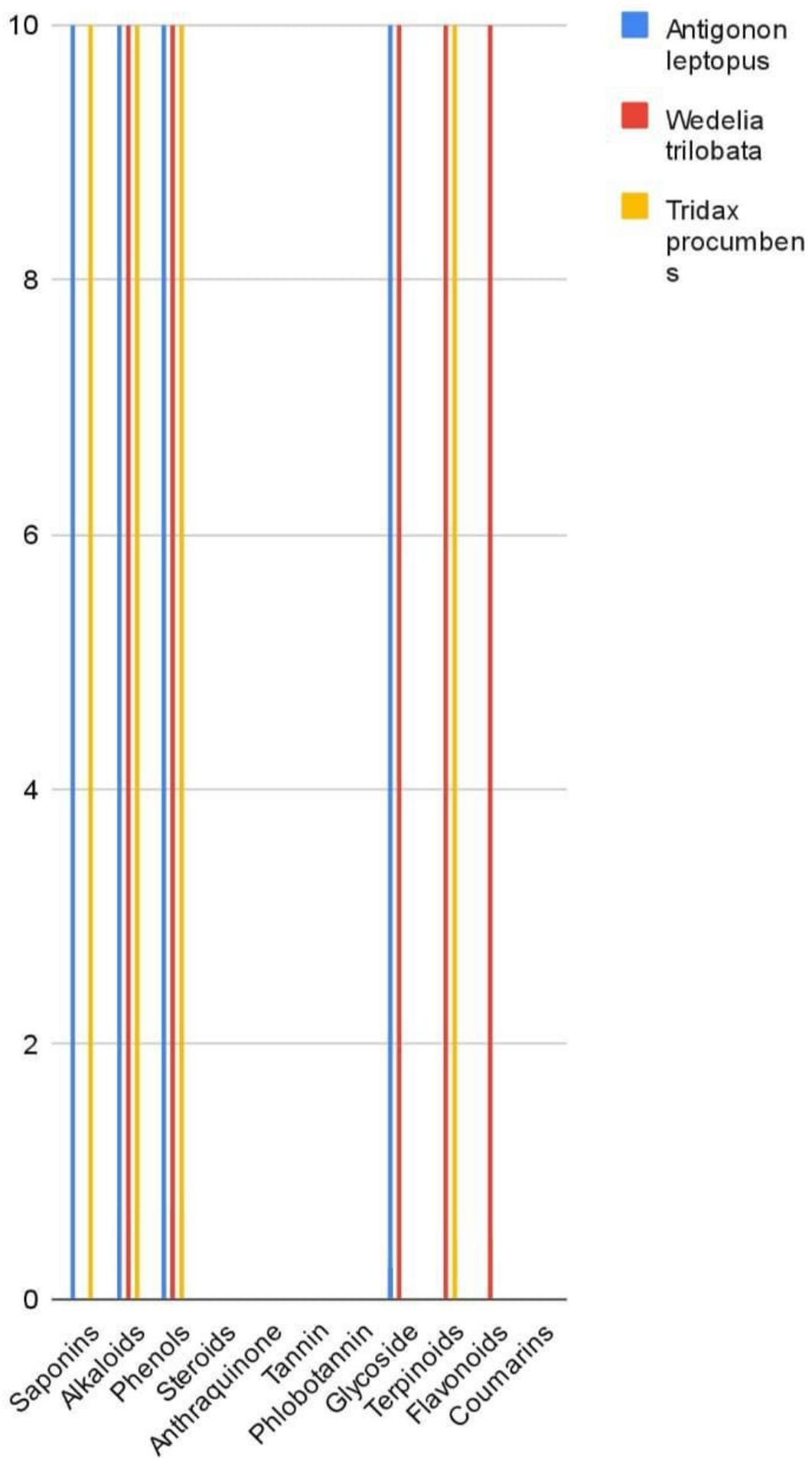


PLATE 01- Habit of Invasive species selected for the study

***Antigonon leptopus*- Habit**



***Wedelia trilobata*- Habit**



***Tridax procumbens*- Habit**



PLATE 02 shows the phytochemical tests conducted in the aqueous extracts of aerial parts of *Antigonon leptopus*.

A.Test for phlobatannin **B.** Test for Anthraquinones **C.**Test for Saponins **D.**Test for Tannins



A



B



C



D

PLATE 03 shows the phytochemical tests conducted in the aqueous extracts of aerial parts of *Antigonon leptopus*.

A. Test for Alkaloids



B. Test for Terpenoids



PLATE 04 shows the phytochemical tests conducted in the aqueous extracts of aerial parts of *Wedelia trilobata*.

A. Phenol **B.** Alkaloid **C.** Terpenoids **D.** Saponins



A



B

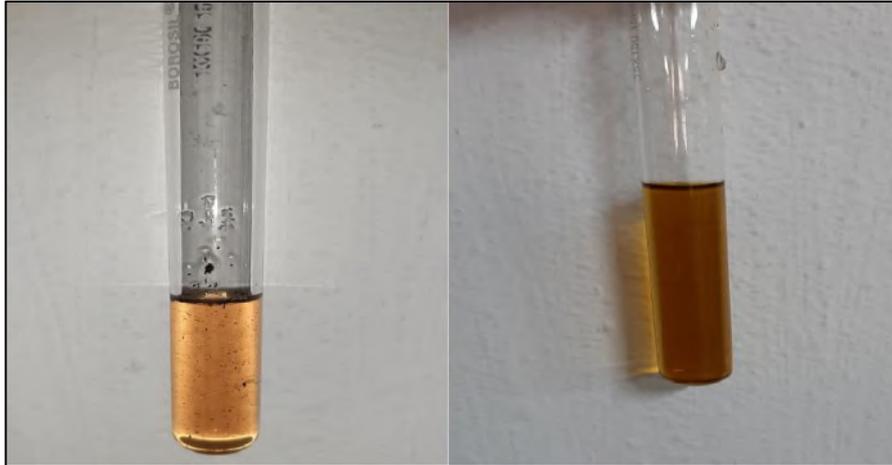


C



D

PLATE 05 shows the phytochemical tests conducted in the aqueous extracts of aerial parts of *Wedelia trilobata*.



A

B

A- Phlobotanins **B-** Anthraquinones



C

D

C - Flavanoids, **D -** Coumarins

PLATE 3 shows the phytochemical tests conducted in the aqueous extracts of aerial parts of *Tridax procumbens*



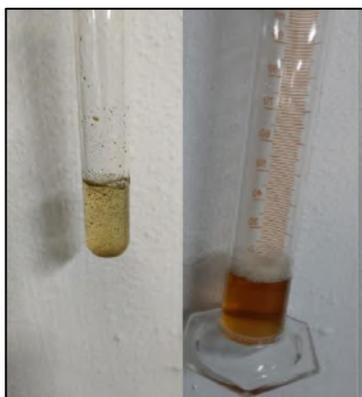
A B C

A - Anthraquinone B - Alkaloid C - Phenol



A B C D

A – Steroids B – Flavanoids C- Terpenoids D – Glycoside



A B

A- Tannin B - Saponin

5. DISCUSSION

Due to risk of adverse effects encountered with the use of synthetic antibiotics, medicinal plants may offer an alternative source for cure of diseases. This study shows the importance and need to continuously research plants especially invasive plants known to be a threat to the natural ecosystem for the discovery and creation of new conventional medicines.

The present study emphasizes the phytochemical reports on *W. trilobata*. Tannin, saponins, flavonoids, phenolic, terpenoids constitute major classes of phytoconstituents of this plant. The strong occurrence of polyphenolic compounds such as flavonoids, tannins, terpenoids, phenols and saponins are reported to contribute to strong antioxidant and anti-inflammatory activities specifically by the ethanolic leaf and stem extracts of *W. trilobata* (HB shruthi *et al* 2011)

Tridax procumbens has a long history of traditional use but isolation and evaluation of each phytochemical has not been properly related to its pharmacological properties and could show difficulty in reproducibility after isolation and evaluation. Future research needs to focus on the connection between specific phytochemical and their effects on various ailments. *T. procumbens* still has many important properties that remain to be discovered. (H.Mathison *et al* 2018)

We can comprehend the strong presence of alkaloids, saponins, and cardiac glycoside from the extract of stem plant portion after studying species *Antigonon leptopus*. The seed of the *Antigonon leptopus* is dried and consumed as food, and the dried seeds are utilised in the construction of baskets. It's also used to treat a variety of human ailments, including the common flu (influenza), menstrual cramps, and a variety of other symptoms. Lipid peroxidation is inhibited by extracts from leaves and flowers. *Antigonon leptopus* is used to treat a variety of disorders because of its antioxidant, antiinflammatory, and analgesic qualities (A. Husan *et al* 2017)

The importance of pharmacognosy has been widely felt in recent times. Unlike taxonomic identification, pharmacognostic study includes parameters which help in identifying

adulteration in dry powder form also. Pharmacognostic studies ensures plant identity, lays down standardization parameters which will help and prevents adulterations. Such studies will help in authentication of the plants and ensures reproducible quality of herbal products which will lead to safety and efficacy of natural products.

6. SUMMARY AND CONCLUSION

The study of medicinal plants and their indigenous use in the world has been increasing. The conservation and utilisation of biological resources are found to be one of reliable approaches to drug discovery. Invasive plants are plants that have been intentionally or accidentally introduced into areas outside of their natural habitat by humans.

These species have the potential to spread quickly, putting native species at risk. Native plant diversity is reduced, water availability is reduced, and soil nutrient quality is degraded as a result of invasive plant species.

In the present study, three invasive plant species - *Antigonon leptopus*, *Wedelia trilobata*, and *Tridax procumbens* often found in Kerala, were studied using phytochemical screening of aqueous extracts of their aerial parts. Eleven tests were carried out to check for the presence of phytochemicals. Alkaloids, coumarins, flavonoids, tannins, saponins, glycosides, anthraquinones, terpenoids, steroids, phlobotannins, and phenol were among the substances studied.

According to the findings of the study, Alkaloids, saponins, glycosides, and phenol were found in aqueous preparations of *Antigonon leptopus* aerial parts. Alkaloids, flavonoids, terpenoids, glycosides, and phenols were found in aqueous preparations of *Wedelia trilobata* aerial parts. *Tridax procumbens* aqueous extraction yielded alkaloids, terpenoids, saponins, coumarins, and phenols, according to phytochemical screening tests.

This study was a preliminary means of testing the phytochemicals of the invasive species which are abundant and prospect to study their medicinal use and management or control as well. The investigation and research on invasive species might bring to the scientific world many useful remedies for treatment and cure of human sufferings. Others areas that have yet to be studied in depth include, but are not limited to yield of extraction, concentration and physiological activity of these phytochemicals. Discoveries in these areas will provide important information that could be used by the health community for preventative medicine and/or the discovery of new drugs.

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**ST.TERESA'S COLLEGE
(AUTONOMOUS)
ERNAKULAM**



**FINAL YEAR M.Sc PHYSICS
PROJECT REPORT
2020-2022**

**REVIEW ON POLYMER BASED HOLOGRAPHIC
RECORDING MEDIUM**

PROJECT REPORT

Submitted by
RESHMA PRAKASH
Register No: AM20PHY013

Under the guidance of
DR.SANTHIA

In partial fulfillment of the requirement for the award
Of
**MASTERS OF SCIENCE IN
PHYSICS**



**ST.TERSAS'S COLLEGE (AUTONOMOUS),
ERNAKULAM, KOCHI-682011**

**REVIEW ON POLYMER BASED
HOLOGRAPHIC RECORDING MEDIUM**

ST. TERESA'S COLLEGE
(AUTONOMOUS)
ERNAKULAM



MSc PHYSICS
PROJECT REPORT

Name : RESHMA PRAKASH
University Register No : AM20PHY013
Year of work : 2021 - 2022

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Staff Member in Charge



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Submitted for the university examination held in St. Teresa's college (Autonomous) Ernakulam.

Examiners

1) Dr. Issac Paul

2) Dr. Gishamol Mathew

Date: 14.06.2022

**ST.TERESA'S COLLEGE
(AUTONOMOUS)
ERNAKULAM**



CERTIFICATE

This is to certify that the project report title "**REVIEW ON POLYMER BASED HOLOGRAPHIC RECORDING MEDIUM**" submitted by RESHMA PRAKASH, towards partial fulfillment of the requirements for the award of the degree of Masters of Physics is a record of bonafide work carried out by them during the academic year 2020-2022

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PLACE: Ernakulum

DATE:

DECLARATION

I, **RESHMA PRAKASH**, Register No.AM20PHY013, hereby declare that this project entitled "**REVIEW ON POLYMER BASED HOLOGRAPHIC RECORDING MEDIUM**", is an original work done by me under guidance of **Dr.SANTHI. A**, Assistant Professor, Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam in partial fulfillment for the award of the Degree of Bachelor of Physics, I further declare that this project is not partly or wholly submitted for any other purpose and the data included in the project is collected from various sources and are true to best of my knowledge.

PLACE: Ernakulam
DATE:

Reshma Prakash

ACKNOWLEDGEMENT

With immense pleasure, I express my deep sense of gratitude to the great God Almighty without whose divine blessings this work would have been never completed. I express my sincere gratitude towards Dr. Santhi. A, Assistant Professor, Department of Physics and Centre For Research, and Smt. Frincy Francis, Research Scholar for their valuable guidance in the formation and successful completion of our study. I owe my sincere thanks to all other teachers and lab assistants for providing the facilities in completing this project and for their helping hands .I sincerely thank my parents for their guidance and support.

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CHAPTER- 1

Review on polymer based holographic recording medium

1.1 INTRODUCTION

The inspiring example of laser technology, Holography is now spreading in data storage and other engineering applications. A brief review on the available literature on polymer-based recording media is given in the context of its contribution towards the realization of theoretical predictions of holography. A general introduction on holographic material is given in this chapter. The requirement of recording medium and the advantage of polymer recording medium are presented.

Photopolymers were first introduced as a holographic recording material by Close et.al in 1969, Since then numerous systems have been examined, but only a small number have become commercially available, Polymer materials have several advantages. Because thick layers can be fabricated they act as true volume materials giving high diffraction efficiency and good angular selectivity. Most of the materials are self-developing or require only some simple post-processing, such as an exposure to light or heat treatment. This eliminates the need for wet chemical development, which makes

photopolymers suitable for applications such as holographic embedded photopolymer waveguides, and holographic data storage

1.2 IMPORTANCE OF HOLOGRAPHIC TECHNOLOGY.

Holography is a very useful tool in many areas, such as in commerce, science, medicine, and industry. Holographic technology is on the dawn of quick evolution in various new areas including artificial intelligence, optical interconnects, medical practice, holographic weapon sight, night vision goggles, games etc. So, holograms are not just 3D images!

Storage requirements all over the world are exploding. Making data storage one of the biggest challenges in the expanding multimedia market. For more than 30 years optical storage by a volume holography has been the 'Holy Grail' of photonics. The next generation of data storage system is expected to use optical holography to store information throughout the three-dimensional volume of a material. Combining high storage densities, fast transfer rates, with reliable, low-cost media, makes holography poised to become a compelling choice for next generation storage and content distribution needs. In addition, the flexibility of the technology allows the development of a wide variety of holographic storage products that ranges from hand held devices for consumers to storage products for the enterprises. Optical data storage systems have significant merits over the existing digital system in the level of security achieved. The parallel processing and encryption/ decryption of two-dimensional pages have made secure holographic data bases superior to the existing digital technologies.

Holographic optical elements are diffractive structures that are constructed holographically by the interference of two beams of light. The second beam corresponds to the image beam which is supposed to exit the HOE upon its playback. Optical elements such as lenses, beams splitters, diffraction gratings and filters can be produced by holographic imaging. The HOEs have the advantage of being low cost (small size and light weight) and are easily reproducible by embossing polymer materials. HOEs can duplicate most of the functions provided by glass optics if optical system operates over narrow spectral bandwidth or requires chromatic dispersion. we have realized certain optics that could not be produced with previous optical technologies. Area such as optical sensors, optical Interconnect, optical information processing, fiber optics, optical scanners, optical disc pickup heads, and solar concentrators have benefited from the use of a Hoes. As stated earlier, the advantages of HOEs are multifold. Firstly, since the HOEs are thin and planar, the optical systems can be made more compact. Secondly, several elements performing complicated functions can be integrated into one HOE. The

frontline recording materials for the fabrication of HOEs have been the conventional silver halide emulsions, material such as dichromate gelatin (DCG), photoresist and photo polymers etc. have been employed in the fabrication of the HOEs. The most commercially available silver halide materials have faded away from the market. Recently, **Mikhaylova**, introduced the use of photo polymer holographic writing in electronics speckle pattern shearing interferometry

The use of small holograms in credit cards which are made to prevent falsification has made holograms have well known concept. Hologram show up more and more often on tickets and original covers. Important areas of application or barcode readers in shops, warehouses, libraries and so on, which is based on holographic components like optical gratings.

In the aircraft industry head up displays are an important example of holographic technology. Headache this place helps the pilot so they do not need to look down on to the instrument panels, because the instruments are projected on to the wind screen with the help of holographic technology, make flying easier.

The unique advantage of holographic interferometry rises from the fact that holography permits storing a wavefront for reconstruction at a later time. Wavefronts which are originally separated in time or space or even wavefronts of different wavelength, can be compared by holographic interferometry. As a result, changes in shape of quiet rough surfaces can be studied by interferometric precision. One of the most important applications of holographic interferometry is nondestructive testing. visually reveals structural folds without damaging the specimen. Holographic interferometry has also proved its utility in aerodynamics, heat transfer and plasma diagnostic etc.

Holography finds Its application in medicine also. Techniques are used by medical doctors. Doctors use three-dimensional holography CAT scans to make measurements without invasive surgery. Holographic interferometric techniques have been widely applied with success for the study of different parts of human body including cornea, tooth mobility, basilar membrane, joint chest and bones. Endoscopic holography is a powerful tool for non-contact high resolution imaging and measurements inside the natural cavities of human internal organs. The internal hologram recording endoscope produces full three dimensionality of the reconstructed image with a large focal depth. This technique can be used for cellular Structure analysis and may even substitute biopsy in tumor diagnosis.

Today there are hundreds of potential applications for holography and it is hard to deny that indeed art is an excellent application. Holography has been used to make an archival recording of valuable and fragile museum artefacts. Holography has been used by artist to create pulsed holographic portraits as well as other works of arts

1.3 CHALLENGES

Although holography was conceived in 1948, it was not considered a potential storage technology until the development of the laser in the 1960 s. While data storage using volume holography has been proposed long ago it has failed to become a commercial technology because of lack of combat laser systems, methods, detectors, input devices and recording medium.

Laser

Though a variety of lasers have been used for holography over the years, a data storage system that is commercially available requires a compact, efficient and ultimately low-cost source. The main requirements are coherence and wavelength compatibility with the material. Conventional semiconductor lasers, though compact and efficient, generally lack the coherence length required for holography. Similarly, gas laser light Argon can be used in the laboratory to characterize materials, but they need for external cooling, the large size, and immense power requirements preclude their use in real systems. Now the problems have almost overcome.

Methods

Traditional multiplexing strategies proposed previously result in complex systems which are difficult to implement. More importantly, geometric constraint severely limited the maximum density in the media. The introduction of shift multiplexing, which was conceived at Caltech led to a paradigm shift in holographic storage system design concepts. The idea of accessing holograms by symbol translation of the media in a manner similar to a conventional disc drives greatly simplified device architecture concepts.

Detectors

Speed and cost are crucial for the output device. Since the last few years several components essential to the development of any viable holographic storage system have been developed. The three

ki devices are low cost, highly coherent laser sources, a high-speed height through put input device, and finally high-speed, low-cost output device. Although high speed CCD detectors have been developed; the prospect for low-cost type performance devices is questionable.

Data input devices

SLM is used to display the data to be stored in a two-dimensional page format. Suitable devices developed for the display industry have recently coming into existence. Materials or media: there has been no viable material for this technology. Media for holographic storage has long been one of the primary focus points for researchers.

1.4 MEDIA FOR HOLOGRAPHY

Any material used to record a hologram must respond to exposure to light which cause change in its optical properties. In the absorption or amplitude modulating materials the absorption constant changes as a result of exposure.

In the phase modulating materials, there is no absorption of light and the entire incident light is available for image formation, while the incident light is significantly absorbed in an amplitude modulating material. Thus, a phase material can produce a higher efficiency than an amplitude material. A practical recording media can be considered as a combination of these phase modulating and amplitude modulating material.

The media performance is assessed in terms of parameters like diffraction efficiency (DE), sensitivity, resolution, signal to noise ratio (SNR), temporal stability etc.

For real time applications like digital data storage. For the commercial availability of material, it should be economic with ease of fabrication steps.

Diffraction Efficiency

The diffraction efficiency of a hologram is defined as the ratio of the power diffracted into the desired image to that illuminating the hologram. Diffraction efficiency is proportional to the square of the gradient of the amplitude Transmittance T versus exposure E curve as well as to the squares of input modulation and modulation transfer function. The maximum diffraction efficiency is obtained where

the slope of the T versus E curve is steepest. This is usually at a slightly higher exposure than that corresponds to the steepest part of the T versus E curve.

Sensitivity

The sensitivity can be defined in terms of the square root of efficiency in writing plane wave, unity modulation depth gratings with a given fluence It , where I is the total intensity in W/cm^2 and t is the exposure time.

Dynamic Range

It refers to the total response of the medium when divided up among many holograms multiplexed in a common volume of the Material. Though a number of materials were developed, most of the currently available recording media have been optimized for display rather than data storage applications. The requirement for a media for digital holographic data storage arises from the page-wise recording and recovery of digital data and the three-dimensional nature of holography. Media must (i) be optically flat and of low scatter so that pages of data can be imaged through the material, recorded and recovered with low probabilities of error; (ii) have adequate dynamic range to support the overlap of large numbers of holograms, each with sufficiently high diffraction efficiencies to ensure high data read rates; (iii) be thick enough to support the independent storage of large numbers of holograms to yield high densities; (iv) exhibit high photosensitivity to yield high data write rates; and (v) undergo limited changes in their dimensions and bulk refractive index (RI) upon recording to ensure the fidelity of data recovery.

Several holographic recording media are under investigation for last four decades. Silver halide photographic emulsions are still the most widely used recording material for holography, mainly because of its relatively high sensitivity, high resolving power and the commercial availability. Though greater than 70% efficiency could be achieved in Agfa Gevaert 8E75 HD and Kodak 649F plates, it requires wet chemical development and hence cannot be used in data storage devices and other real time applications. DCG is one of the best holographic recording materials because of its well-known properties: high DE, large capacity for RI modulation, high resolution, high signal to noise ratio, and good environmental stability (with a cover plate or a thin protective coating). A major shortcoming of DCG, limited spectral sensitivity, has overcome by dye doping.

But just like silver halide emulsions, gelatin also require wet developing process and the energy requirement is very high. An alternating material, silver halide sensitized gelatin, combines the relatively high sensitivity of photographic materials and low scattering and high light stability.

Photoresists, light sensitive (UV-500 nm) organic films which yield a relief image after exposure and development, are employed in holography mainly for the production of master plates for embossed holograms and for manufacturing holographic gratings. It requires wet chemical processing and its sensitivity in the blue region is very low. Another class of materials of interest is photochromics. Though the material is reversible, organic photochromics are prone to fatigue and a limited life. Inorganic photochromics are grain free and have high resolution and it requires no processing and can be erased and reused almost indefinitely. But their use has been limited so far by their low diffraction efficiency and low sensitivity.

Photo thermoplastics which are reversible and uses thermal fixing process have reasonably high sensitivity and efficiency. But the equipment required for charging and heating the layer is very expensive and the resolution of the material is limited to 1000 line/mm.

However, the difficult crystal growth and sample preparation required for inorganic crystals has limited the widespread use of these applications. Due to its cost and the impermanence of holograms written therein; it is unlikely to be included in a commercial product.

For a long time, organic materials have found importance in holography. Biological materials like bacteriorhodopsin (photochromic retinal protein), have been used for many applications in optical image processing, such as optical memories and real time holography. Now-a-days the materials include photopolymers, photorefractive polymers, photo addressable polymers, polymers dispersed liquid crystal etc.

Photorefractive Polymers

Rapid advances in the field of Photorefractive polymers and composites have led to the development of high-performance materials with refractive index modulations approaching 0.01 and diffraction efficiency is close to 100%. The effect arises when charge carriers, photogenerated by a spatially modulated light intensity, separated by drift and/or diffusion processes and become trapped to produce a nonuniform space-charge distribution. The resulting internal space-charge electric field then

modulates to create a phase grating, or hologram, which can diffract a light beam. These types of holograms are dynamic, that is, they may be erased and rewritten.

To produce the Photo resistive effect, the material should consist of a photoinduced charge generator, a transporting medium, trapping sites, and molecules that provide optical nonlinearity.

The first proven polymeric material was made in 1990 and was composed of an optically nonlinear epoxy polymer bisphenol-A-di glycidl ether 4-nitro-1,2-phenylenediamine, which was made photoconductive by doping with 30 wt.% of the hole transport agent diethylamino benzaldehyde diphenyl hydrazone

The first milestone in this field occurred with the report by the IBM group, having a net gain and Diffraction efficiency of 1% in 125micro meter thick samples of the composite FDEANST: PVK: TNF. Shortly after that Arizona group reported on a composite based on photoconductor PVK: TNF: doped with the chromophore DMNPAA with 6% efficiency. By improving the sample fabrication conditions, enabling higher fields to be applied, these composites exhibited nearly 100% Diffraction efficiency, net gain coefficients of 200cm^{-1} and fully reversible index modulation amplitudes of 0.007 with a response time of 100-500 ms.

The most commonly used polymer binder is poly (vinyl carbazole) (PVK). High-performance material of this class was developed by using inert polymers like poly (methyl methacrylate) (PMMA) and biphenyl-A-polycarbonate. PR polymers are alternatives to their inorganic or semiconductor counterparts owing to their low cost, ease and flexibility of fabrication, large size, and superior performance, one of the limitations is high voltage requirement.

1.5 Photo addressable Polymers

In principle all materials that react to light with a change of specific properties can be described as photo addressable polymers (PAPs). These PAPs are basically azobenzene containing liquid crystalline copolymers. Polyacrylates, polymethacrylates, polycarbonates, polyurethanes, polyimides and aliphatic polyesters have been investigated as the main chain. Azobenzene chromophores exist in two isomeric states: the long rod like trans form and the bent cis configuration. The isomerization can be induced by light in both directions, from trans to cis and from cis to trans, whereas the CIS isomer can also undergo a thermal back relaxation to the thermodynamically more stable trans isomer. Illumination leads to a series of trans-cis-trans isomerization cycles, resulting in a photo-stationary

equilibrium that depends on the wavelength of the actinic light and the temperature of the sample. Photoinduced reversible surface-relief-gratings have been well documented as a unique and fascinating property of azobenzene-containing polymers. This is a well-known candidate for both polarization holography and photolithography. Upon exposure to an interference pattern, large surface modulations can be produced on azo polymer films. superimposed inscriptions with beams having different wavelengths or polarization directions.

Polymer Dispersed Liquid Crystals

Liquid crystals (LCs) are an interesting medium for exploring electro-optical effects due to their large dielectric anisotropy and optical birefringence. There has been a fascinating marriage of two polymer-related technologies over the past few years: photopolymer holography and polymer-dispersed liquid crystals (PDLCs) (73-74). The result is a new type of material known as holographic PDLC (H-PDLC). Intriguing features of this material include its high index modulation, true volume hologram character, unique anisotropic nature, and electro-optical behavior. Generally, an H-PDLC sample is made by sandwiching the pre-polymer syrup between two glass slides coated with a transparent conductor. The diffraction efficiency of the recorded hologram can be controlled by applying an electric field across an H-PDLC cell. Pre-polymer syrups are typically a combination of a fast-curing multifunctional monomer, a photo initiator dye, a Co-initiator, a reactive diluent, and a liquid crystal. The choice of a suitable photo initiator dye for free radical polymerization is challenging as few dyes are available for use in the visible region (450-650 nm). Rose Bengal acetate ester has been found to be useful for writing gratings using Ar laser lines (476, 488, 514nm) or a Verdi laser line (532 nm). Other photo initiators used for making H-

PDLC gratings with the Ar laser lines are di bromo fluorescein and diethyl aminocoumarin. There are a number of problems associated with these long wavelength dyes in terms of thermal and photochemical stability and bleaching speed.

Two classes of monomers have been used for H-PDLC formulation, one based on free-radical addition polymerization reaction and the other, a combination of free-radical and step-growth mechanism. Free radical addition polymerization of multifunctional monomers leads to formation of polymer of high molecular weight Urethane resins with functionality ranging from 2 to 6 were also used.

Another class of monomers used in H-PDLC gratings is the commercially available Norland resins. These contain polyfunctional thiols and allenes and undergo a combination of free-radical and step-growth polymerization. widely used resin in PDLC research is NOA 65(Norland Optical Adhesive). Though efficiencies of the order of 70% were obtained, its resolution is limited. There is one report of an H-PDLC reflective display device using a smectic liquid crystal. The efficiency obtained for H-PDLC containing rose Bengal (RB) as photo initiator and n-Phenylglycine as co initiator showed only 12% diffraction efficiency, whereas 18% diffraction efficiency was reported for an azo-dye doped polyimide (20nmthick)

Photopolymers

The term photopolymerization means the initiation by light of a chain polymerization process. In the more general sense, photopolymerization implies the increase of molecular weight caused by light. Photopolymers are photoactive materials capable of recording spatial variations in light intensity through irreversible changes. Both the phase and the amplitude information needed for hologram recreation are stored.

Photopolymers have been exploited in a variety of applications requiring versatile holographic storage media, such as data storage, HOES, and waveguides. it is widely believed that the high sensitivity, low cost, and versatility of photo polymeric media would enable more widespread commercial applications of holography

Photopolymerization is a chemical process by which small molecules or monomers are combined to make very large molecules or polymers. Photopolymer can be activated through a photosensitizer to exhibit refractive index changes due to polymerization or cross-linking. Photopolymers can be classified into two, photopolymerizable materials and photo-cross linkable materials.

Photopolymerizable Media

Photopolymerizable systems for recording holograms typically comprise one or more monomers, a photoinitiation system, and an inactive component often referred to as binder. The photoinitiation system comprises a photosensitizing dye and a co initiator. The resulting formulation is typically a viscous fluid, or a solid with a low glass transition temperature.

The basic recording mechanism involves several stages: photoinitiation, propagation and termination. The photopolymerization begins by absorption of light by the photo initiator, which results in the

formation of primary free amine radicals. A second electron transfer between the amine and the radical and a protonation process give rise to leuco form (colorless form) of the dye.

In the second step of the initiation, cation radical loses a proton to become the c-amino radical. In the second stage (propagation), the c-amino radical is subsequently adding to the carbon-carbon double bonds of the monomer unit to form a growing radical of one repeat unit in length, and thus initiates the polymerization reaction. Monomer depletion in the exposed regions causes a concentration gradient, which then induces monomer diffusion from the unexposed regions.

When the photopolymer is exposed to an interference pattern, the monomers in the constructive interference region get polymerized. Because of the polymerization in the exposed regions, diffusion of monomer occurs from the destructive to constructive interference region.

Two separate paths exist for termination. The first is the normal bimolecular combination, in which two growing macro radicals come together and terminate. The second path for termination is disproportionate, in which a labile atom is transferred from one polymer radical to another.

Binder

Monomers and the photoinitiation system are usually mixed with a third component, binder, to form a photo initiator system. The binder is sometimes a polymer that is included to modify the viscosity of the formulation, to aid sample preparation and to enhance holographic exposure. Though the binder is not directly involved in the photochemical reaction, the selection of binder is an important factor. The binder should be insensitive to humidity and environmental changes.

Polymeric materials such as PMMA, Polydiacetylene, PVK, poly (vinyl alcohol) (PVA), poly (acrylic acid) (PAA). polythiophene, Poly (vinyl chloride) (PVC) etc. have been investigated for holographic applications. Binders can also be small molecules or oligomers polymeric binder. A recording medium of millimeter thickness or more and exhibiting high photoinduced RI change is required to

achieve high storage density by recording multiple volume holograms, separated from each other by the Bragg effect, in the same spatial location. For holographic data storage, the major limitations imposed by organic polymeric binders are the limited thickness of the medium, usually less than 200 micrometers, and temperature and light induced dimensional changes that can distort the holograms

and degrade the fidelity with which the stored images can be retrieved. An approach to prepare thicker photopolymers is to use resins consisting of two independent photopolymerizable systems.

To increase the rigidity of the material, higher levels of crosslinking are required, which decreases diffusional mobility of the monomer in the resin and degrades holographic properties of the photopolymer. The shrinkage observed during UV curing in a holographic solgel material was attenuated with the inclusion of tetra methyl orthosilicate. A photopolymerizable glass can also be used as the binder

Monomer

Monomers are incorporated to the polymerizable recording media to establish high Δn due to refractive index modulation. Vinyl monomers such as acrylate and methacrylate esters are used in most photopolymer systems. Vinyl polymerization can be initiated by ionic species as well as free radicals, but almost all examples of photopolymerization are of a free-radical in nature.

Monomers capable of polymerizing by cationic ring opening polymerization (CROP) mechanism have recently been applied to volume holographic recording. The holographic disk developed by Aprilis, Inc. was based on a CROP polymer.

Photoinitiation System

Holographic photopolymer systems typically use at least two different molecules to form a photoinitiation system that is sensitive to the recording wavelength. A photo initiator generally comprises of a photosensitizing dye and a charge transfer agent.

Dye

A dye is a colored substance that can be applied in solution or dispersion to substrate; thus, giving it a colored appearance. The absorption of light by colored substance is due to electronic transitions between different orbitals within the molecule and the wavelengths absorbed are determined by energy differences between the orbitals. Every dye or pigment therefore exhibits a pattern of absorption plotted as ordinate against wavelength as abscissa and this graph is the characteristics of the coloring matters. A structural change which causes the absorption band to longer wavelengths is called bathochromic shift. The reverse shift, towards shorter wavelength is known as a hypochromic effect.

The dye molecule contains two groups: the chromophore and auxochrome. The chromophore is a group of atoms which control the color of the dye. The auxochrome is a salt forming group, which helps to improve the color of the dye. The chromophore is usually electron withdrawing, and auxochromes are normally electron donating. Examples of these include the nitro, nitroso, azo, ethylene and carbonyl groups and it will be seen that all are unsaturated. Compounds containing such groups are known as chromogens and they do not behave as dyes unless they are also substituted by basic or weakly acidic groups such as $-NH_2$, $-NH(CH_3)$, $-N(CH_3)_2$, or OH .

When the photopolymer material is exposed to laser beam, in addition to the RI change, absorbance modulation also takes place. With the proper choice of photosensitizer, holograms can be recorded throughout the spectral range from 400nm to 650 nm. A variety of dyes have been used as sensitizer which include methylene blue (MB), yellowish eosin, rose bengal (RB), chrysoidine, fluorescein, erythrosin B (ErB), methyl orange, mordant yellow, malachite green, brilliant green, riboflavin, rhodamine 6G etc. To form a true molecular dispersion, the dye and other matrix additives must be compatible. Among the different dye doped systems, MB doped polymers are of special interest owing to its sensitivity to the commonly available He-Ne laser.

MB is a basic dye belonging to thiazine group. The dye is commonly known as tetramethyl thionine and to an organic chemist it is 3,7-bis-(dimethylamine) phenanthroline chloride and to some histologists it is Swiss blue. It is a dark green colored powder having a molecular weight of 319.86 and the absorption peak, if pure resides at 668nm and 609 nm. The absorption peak at pH values of 0.65, 2.10, 3.4, 6, 8.2 is at 880, 665nm, 880 nm, 880 nm and 840 nm respectively. At neutral pH the absorption peak is at 665 nm. The absorption peak was at the orange red region of the spectrum for a pH value of 2.0. An orange color basic dye is observed in highly basic solution of $pH > 13$. The photochemical reduction of Methylene blue results in the formation of leuco state through the photoreduction of intermediate state.

Yingjin et al. observed the photoinduced hydride transfer reaction between Methylene blue and leuco crystal violet under steady illumination of visible light and of photosensitization by benzophenone and alpha-nitronaphthalene with UV light. The kinetics and thermodynamics of electron transfer reaction of dye with metal ions are also reported. The free energy for the self-exchange reaction of metal ions as well as the quantum yield for the radical was evaluated.

Somer et al. observed the photoreduction of Methylene blue and thionine in water by red light. Reaction energy consideration requires two photons to reduce each Methylene blue molecule. They also studied the influence of light intensity and MB concentration on the rate constant, and proposed two photon mechanisms involving a long-lived dimmer intermediate state

Co-initiator

As the direct initiation of polymerization by light is difficult and has a poor yield, the initiation is usually achieved by radical or cationic polymerization and it requires the use of a photo initiator (dye and charge transfer agent). The cation radical of the charge transfer agent (electron donor) produced during laser exposure initiates the polymerization reaction. Electron donors (EDs) like diphenyl iodonium chloride, p-toluene sulphinate, acetylacetone, triethanolamine (TEA) etc. are used as charge transfer agent.

The idea behind the use of these additives is the fact that radicals that are generated by photoexcitation and inhibit the polymerization process interact with introduced additives to form new radicals active in polymerization.

Photo-Crosslinking Polymers

Photo cross linkable systems constitute a major class of materials for many applications like production of HOE, fiber optic couplers, laser scanners and optical interconnects. There are two kinds of photo cross linkable systems: those made of gelatin and those of polymers. These subsystems are also called biopolymers and synthetic polymers respectively, DCG has some limitations such as low environmental stability and rigorous procedures of wet processing.

When the polymer film is exposed to laser beam, the photo initiator undergoes photochemical reactions and crosslinks with the polymer matrix.

Because of their unique properties such as transparency, homogeneity and photochemical stabilities, they constitute important media for non-linear optical devices. In metal ion doped polymers, the first step is the absorption of light by the metallic center. The primary mechanism in most cases is an electron transfer in the excited state.

The accepted scheme is that light irradiation reduces the sensitizer Cr^{+6} to Cr^{+3} first, and then Cr^{+3} cross links polymeric molecules, which enhances the RI, reduces the solubility of the exposed regions and creates the hologram.

It was discovered that polysaccharide polymer of linear structure sensitized with ammonium dichromate possess good holographic properties. The material has useful characteristics such as good environmental stability, simple fabrication, high diffraction efficiency (50% after processing), and high resolution (6000 lines/mm). Other dichromate materials, such as cellulose triacetate, pectin, gum, Arabic, and starch are also good materials for recording holograms. With its special properties, such as strong relief modulation, stratified sensitivity, strong real-time effect, etc., dichromate cellulose triacetate has obtained some preliminary applications in HOEs.

1.6 Literature survey on photopolymer materials for holographic recording

Volume phase holograms in photopolymers have found many potential applications in optical data storage, optical data processing and the production of HOEs. Compared with other holographic materials, photopolymers have the great advantage of recording and reading holograms in real time and the spectral sensitivity could be easily changed by simply changing the sensitizing dye. Also, these materials possess characteristics such as good light sensitivity, real time image development, large dynamic range, good optical properties, format flexibility, and low cost.

The first photopolymer recording systems for holography, as proposed in the late sixties and early seventies, were based on metal acrylate solution contained in recording cells. The photopolymer system developed by Close et al. was based on acrylates solution sensitized with methylene blue, diffraction efficiency of 45% was obtained for an exposure energy of 30 mJ/cm^2 at 643 nm. The recorded holograms were stabilized by post exposure using xenon flash lamp (3 mJ/cm^2) and thermal fixing. Improvements in the performance of acrylamide (AA m)

photopolymers were achieved by crosslinking with ethylene bisacryl amide and by photoreduction with Triethanol amine, acetyl acetone and hydroquinone. With the incorporation of triethanolamine,

65% diffraction efficiency was obtained at 50mJ/cm² whereas the efficiency obtained for acetyl acetone incorporated solution was only 20%. A photo polymer consists of liquid acrylic monomer, a cellulosic binder, a photo initiating system and a plasticizer was reported. A liquid photopolymer containing a 1:1 mixture of 4,5-diiodosuccinyl fluorescein and MB, which upon visible-light irradiation shows a clear enhancement in the sensitivity and the polymerization rate is also reported.

Dye Sensitized Pol vinyl alcohol

Polyvinylalcohol films has many optical uses, which result from its lack of color, its clarity and its high transmission in the near infrared and ultraviolet. Polyvinyl alcohol films can be oriented to give high degree of birefringence and high tensile strength in the stretch direction. Additional properties which account for its versatility are its hydrophilic character, easy dyeability, ability to be Crosslinked. Polyvinyl alcohol came into use as hologram recording material from late 70's onwards. Its many hydroxyl groups cause it to have high affinity to water, with strong hydrogen bonding between the intra and intermolecular hydroxyl groups, greatly impeding its solubility in water. Aqueous solution of Polyvinyl alcohol is considered as a molten gel.

Aqueous solution of Polyvinyl alcohol of high degree of hydrolysis increase the viscosity with time, and may finally gel. The viscosity of solution increases with concentration and decreases with temperature.

The high viscosity of Polyvinyl alcohol solution enables its use as a binder in the photopolymer system and thick films could be fabricated with Polyvinyl alcohol. Polyvinyl alcohol film is hard and brittle at low humidities, but soft and tough at high humidities

O'Neill et al. have studied the mechanism of hologram formation in acrylamide-photopolymer. Gallego et al. carried out the three-dimensional analysis of holographic memories on Polyvinyl alcohol(PVA) films. Polyvinyl alcohol systems have been reported with different sensitizing dyes and other matrix additives.

Carretero et al. observed a decrease in the transmittance curves as a function of the age of the polymer film consists of MBA.

Blaya et al. described the mechanism of grating formation in MBPVA films and obtained 80% efficiency in their polymer system fabricated using CAMAG scientific thin layer chromatography plate coater.

Blaya et al. presented the holographic characterization of the MBPVA incorporated with a Crosslinker, N,N-dihydroxyethylenbisacrylamide (DHEBA).

The photopolymerizable film used in their experiment was prepared using a TLC coater and the drying period was 20hrs. The gratings recorded using 633 nm He-Ne laser by keeping the beam ratio as 1:1 and spatial frequency as 1100 lines/mm showed 70% diffraction efficiency

Neumann et al. described a simple technique suitable for the direct laser writing of surface relieves in dry photopolymerizable film comprised of Acrylamide, MB, TEA and PVA dissolved in ethanol and water.

Fimia et al. developed holographic photopolymer systems consist of Acrylamide, Zinc acrylate and MBA as monomers, a photo initiator system consist of Methylene blue in 4:1 ratio and p-toluensulfonic acid and they obtained -35% efficiency using He-Ne laser.

Later **Belendez et al.** analyzed the noise gratings formed on MB: RB -acrylamide system. Among the different sources of noise in holography, self-induced noise gratings are due to scattering from inhomogeneities in the recording material and have an important spurious effect on volume holography.

Mallavia et al. reported that an ion pair isolated from Methylene blue acted as the photo initiator in the photopolymer formulation. This photopolymer system showed wide spectral response and obtained 30% diffraction efficiency at 514nm and 60% diffraction efficiency at 633 nm. VA/Acrylamide films were also fabricated with yellowish eosin as sensitizing dye.

Garcia et al. studied the influence of beam ratio and intensity on the optical quality of transmission holograms of diffuse object stored in eosin doped polyvinyl alcohol systems. They used a SNR of 0.94 with a diffraction efficiency of 13% for a beam ratio of 2 0 and intensity of 1.2mW/em .The variation in transmittance produced when a photopolymer is irradiated with a pulsed laser was analyzed and diffraction efficiency is (60%) .

The second order Fourier component of the Refractive index formed in phase diffraction gratings recorded in eosin doped PVA/acrylamide was studied by **Neipp et al.**

Gallego et al. determined the temporal evolution of diffraction efficiency of a hologram stored in an eosin doped Polyvinyl alcohol/Acrylamide /dimethyl acrylamide (DMAA) photopolymer system by measuring the angular response of the hologram immediately after exposure and in subsequent hours.

Gallego et al. proposed several methods to eliminate the residual monomer in eosin/Polyvinylalcohol/Acrylamide m films in order to stabilize the holographic gratings. The residual dye and residual monomer are the main problems in achieving high diffraction efficiency stable under white light.

The surface relief formation in a photopolymer containing AA m is reported by **Boiko et al.**

Jallapuram et al. studied the effect of binder molecular weight. on the Diffraction efficiency and found that it had no substantial improvement of De at higher spatial frequencies.

The spatial resolution of the polymer system was found to be increased with MBA concentration.

Gong et al. developed a PVA based holographic recording material composed of ErB as dye, TEA as electron donor, AAm and N hydroxymethyl acrylamide as monomers. The recording was obtained by the copolymerization of AAm and HMA and an efficiency of nearly 50% were

Sheriff er al investigated the angular multiplexing in doped PVA/AAm formulated in the Centre for Industrial and Engineering Optics (CIEO) with a view of further optimization for holographic data storage. An investigation of the photoinduced surface relief modulation in thin and thick layers of an AAm based photopolymer system developed at the CIEO was reported. Post-exposure of the gratings

PVA/AAm films sensitive to 500-630 nm was fabricated with methyl violet as photo initiator. The recording characteristics of the holographic film were examined and the compositions were optimized. Only 8% efficiency was obtained and the recorded gratings gradually disappeared on storage. Ability of a diffraction grating recording in photo polymer material was proven at the late 1960 of the last century and it was also show that the grating growth is caused by the diffusion process .

The mode proposed **zhao.et.al describe** the evolution of grating formation in photopolymer using the four harmonic expression of a standard one-dimensional diffusion.

colvin et al. Presented the quantitative model to describe the formation of volume holograms in a polymeric medium containing polymerizable acrylate monomer that undergrowth spatial modulated gelatin as a result of exposure to visible beam.

Sheridan.et.al developed the nonlocal polymerization driven diffusion model, which extended Zhao model to include nonlocal spatial response.

Renotte.et.al applied nonlocal diffusion model to successfully model higher harmonic grating components in polymer materials

Sutherland.et.al examined effect of shrinking and swelling and outlined an extension to the non local diffusion model

Kelly.et.al carried out temporal analysis of grating formation in PAA/PVA films.this is done by analyzing attenuation of light in depth.

The main drawback of an AAm based photopolymer as far as the environment is concerned is the AAm, a substance which has been known to be carcinogenic for many years. So a photopolymer system which is less toxic than AAm system has been developed. The new photopolymer formulation consists of 5'-riboflavin monophosphate as Dye, sodium acrylate as monomer, DHEBA as crosslinker. The new system showed 50% efficiency at 300mJ/cm²

Azo dyes like chrysodine and mordant yellow 3R on PVA were found to be erasable with DE of about 27%. A linear polyol incorporated eosin PVA system with 15% Diffraction efficiency was reported by **Ponce et al.**

Metal Ion Doped PVA

Metal ions such as Ferrie (Fe) and Dichromate (Cr+%) have been used in conjunction with PVA for recording holograms in real time. The photochemistry of Cr has been investigated over decades and it has been generally accepted that the photo reduction of Cr leads to Cr⁺ in the presence of organic-reducing substances like secondary alcohols. From the earlier works done on DCPVA, **Duncalf and Dunn** suggested that the in solubilization of DCPVA after exposure was caused by complex formation between Cr with PVA. **Ziping et al.** recorded holograms of 30% efficiency on DCPVA and developed a technique to fix the holograms by heat treatment. **Lelievre et al.** recorded holograms with polarized light and obtained 30% diffraction efficiency **changkakoti. et al.** employed two simple techniques of development using ethyl alcohol and have achieved 60% Diffraction efficiency for fixed holograms.

Maniavannan et al studied the influence of different chemical parameters (e.g:pH and electron donors) on DCPVA and 70% efficiency was obtained using 488 nm Ar laser The EDs influence significantly the Diffraction efficiency of recorded holograms.

The ferric salt photoreduces to the ferrous form as a result of photoreduction of the dye in the presence of an **ED. Sugawara et al.** devised a photosensitive liquid system with a mixture of AAm, MBA coupled with Ferric ion and tert-butyl hydroperoxide. This recording system is sensitive from 200-500 nm and exhibits high diffraction efficiency.

Manivannan et al. presented Fe³⁺ doped PVA systems for hologram recording Although volume holograms recorded in Fe: PVA films exhibited a high peak diffraction efficiency of - 80%

Polyacrylic acid

Another synthetic polymer which is very attractive in holography is PAA doped with metal ions and organic dyes

Photosensitive materials comprising of acrylic acid and catalyst are used to record holograms in the presence of laser beam. Volume transmission holograms have been recorded in polymer films.

Photoinduced holographic surface relief gratings have been fabricated using 442nm laser and they are obtained without any chemical treatment or wet processing.

Ushamani et al. fabricated MB sensitized polymer film by blending both PVA and PAA in 7:3 ratio. The storage life of gratings recorded on MBPVA/PAA blend was better than that of MBPVA films. The effect of different EDs on the sensitivity and efficiency of MBPVA/PAA blend also was studied. Later, the development of dichromated blend of PVA/PAA is also reported.

Polyvinyl chloride

Ushamani et al. reported the feasibility of using PVC matrix as an optical recording medium by making it as copper acetate complexed methylene blue sensitized polyvinyl chloride (CMBPVC) films. Later a systematic analysis on the effect of pH on the bleaching property and Diffraction efficiency of CMBPVC were presented. Direct imaging done on pure and CMBPVC films revealed the optical quality of the film.

Unlike in other matrices, the change of state occurring to the dye molecules (MB) on laser irradiation is permanent in PVC and it exists in the leuco form itself. Since the material was not comprised of any

monomer or ED as in the conventional photopolymerizable recording medium, the only contribution to the recording mechanism was the absorbance modulation.

The gratings recorded on the CMBPVC films showed an efficiency of 4.46% at 1500 mJ/cm for the intensity ratios of the first order diffracted beam to that of the transmitted beam. Though change in absorbance on storage (after laser exposure) is not observed in this material, the recorded grating vanished within few hours.

Polymethyl methacrylate

Photopolymer comprising PMMA (poly (methyl methacrylate)) as the base is primarily sensitive to some region of the visible spectrum with sensitizers such as p-benzoquinone.

To alleviate the shrinkage effect in thick materials, some techniques for fabricating photopolymer materials have been proposed and demonstrated. Among these recording materials, PMMA is one of the most popular polymer bases for the binder, due to its good dimensional stability and good optical quality. Recent research has shown that PMMA doped with phenanthrenequinone (PQ) could be very attractive for volume holographic recording because it is easy to form in bulk with negligible photochemically induced dimensional change and good optical quality.

Commercially Available Polymers

In order to respond to today's growing demand, a number of photopolymers have been commercialized. It includes photopolymers developed by DuPont, Polaroid, Aprilis etc.

Among commercially available photopolymer materials DuPont's dry photopolymers seem to have gained the highest popularity. The DuPont polymers are coated on Mylar polyester film of 25um thickness. A removable cover sheet of 25um Mylar or 60um PVC film is used to protect the slightly tacky photopolymer. The photopolymer thickness typically ranges from 10-50um.

Potential applications for optical storage and interconnection systems have been reported on Dupont's polymer. The commercial photopolymers designed for holographic recording by Dupont have been studied extensively and provide excellent material photosensitivity and Refractive index contrast.

Loungnot et al have developed a solvent-free system with small multifunctional acrylate monomers. As only thin media (<50 µm) can be prepared, these films are unsuitable for high-density data storage.

Aubrecht et al. studied the recording of holographic volume diffraction gratings in Du Pont's photopolymer HRS-150 both theoretically and experimentally.

Moreau.et.al investigated the recording dynamics of omni-Dex photopolymer film from DuPont and different experiments detailed that lead to the determination of material kinetic parameters.it is fully characterized by peritrophic multiplexing. In recent years many photopolymer materials are developed for recording holograms.

wang.et.al developed blue sensitive photopolymer system that consist of camphor quinine as photosensitizer.

Yagi.et.al of NIT photonics laboratory proposed thin film multilayer waveguide holographic memory card.**Hirabayashi.et.al** developed a two-color absorption photopolymer in which hologram could be recorded by simultaneous irradiation with a 660nm interference light.

C.S Rajesh et.al portraits the eosin doped polyvinyl alcohol /acrylamide material when another dye methylene blue was incorporated into the photopolymer system by the inclusion of methylene blue it was possible to extend the absorption range.also it enhanced the entire properties of the system.(2018)

Jisha developed selfwritten waveguide in methylene blue sensitized polyvinyl alcohol/acrylamide photopolymer material.(2008)

Debopriyo Ghoshal et.al developed methylene blue /PVA composite film for flexible ,wider scale uv –visible cut off filter (2019)

H M Zidan et.al studied photodegradation of methylene blue with PVA/PVP blend under ultraviolet light irradiation.

Beena mary john.et .al reported the efficiency difference between MBPVC and copper acetate doped methylene blue sensitized film (CMBPVC)

The inclusion of nanoparticles also contributes rapid buildup of fixed holograms which give high stability and sensitivity.In order to respond to industrial demand, in application like holographic data storage, display, optical waveguides, much emphasis has to be put on to develop new polymerizable material with high sensitivity and high efficiency.

1.7 Conclusion

Importance of holographic technology in the modern era is presented in this paper description of available recording media with special mention to photopolymer is explained. a detailed review on polymer-based recording is presented.

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CHAPTER 2

Holographic recording films

Introduction

The word Nano is derived from the Greek word 'nanos' meaning dwarf. Nano refers to 10^{-9} or 1 billionth. It refers to a nanometer, which is one of the scales of atomic diameters.

Nanotechnology is the study of the controlling of matter on an atomic and molecular scale. Generally it deals with structured sized 100 nm or smaller in at least one dimension. It is very diverse ranging from extensions of conventional device physics to completely new approaches based on molecular self assembly.

The first use of the concepts found in nanotechnology was in "There's plenty of Room at the bottom". a talk given by physicist Richard Feynmann at an American physical society meeting in Caltech in 1959. He described the process by which individual atoms can be manipulated and molecules might be developed using one set of precise tools to build and operate another proportionally smaller set and so on down to the needed scale . Tokyo science University professor Norio Taniguchi in 1974 defined nanotechnology as mainly consisting of the processing of separation, consolidation and deformation of materials by one atom or by one molecule. Nanotechnology and Nanoscience got started in the early 1980s with two major developments; the birth of cluster science and the invention of the scanning tunneling microscope (STM). This development led to the discovery of fullerenes and carbon nanotubes.

Two main approaches are used in nanotechnology : bottom up approach and top down approach. In the bottom up approach materials and devices are build from molecular components which assemble themselves chemically by principles of molecular recognition. In the top down approach, nano objects are constructed from larger entities without atomic level control . Areas of Physics such as nanoelectronics , nanomechanics and nanophotonics have evolved during the last few decades to provide a basic scientific foundation of nanotechnology.

A number of physical phenomena become pronounced as the size of the system decreases. These include statistical mechanical effects as well as quantum mechanical effects. Quantum effects become dominant when the nanometer size range is reached. Additionally a number of physical properties change when compared to macroscopic systems. One example is the increase in surface area to volume ratio altering mechanical, thermal and catalytic properties of materials.

The bottom up approach utilizes the concept of molecular self-assembly and/ or Supramolecular chemistry to automatically arrange themselves into some useful confirmation. The concept of

molecular recognition is especially important as molecules can be designed so that a specific configuration is favored due to non-covalent intermolecular forces.

Molecular nanotechnology, sometimes called molecular manufacturing, describes engineered nano systems operating on the molecular scale. It is especially associated with the molecular assembler, a machine that can produce a desired structure or device atom-by-atom using the principle of mechanosynthesis.

APPLICATIONS

With nanotechnology, a large set of materials and improved products rely on the change in the physical properties when the feature sizes are shrunk. Nanoparticles take advantage of their dramatically increased surface area to volume ratio. The various applications of nanotechnology include the following:

Medicine

The biological and medical research community have exploited the unique properties of nanomaterials for various applications. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful in biomedical research and applications. Nanotechnology can also be used for drug delivery. This is because materials can be synthesized to dimensions fitting the cell, tissues or DNA. If nanomaterials can be functionalized with appropriate functional group they can be directly targeted.

Chemistry and environment

Chemical catalysis and filtration techniques are two prominent examples where nanotechnology already plays a role. The synthesis provides novel materials with tailored features and chemical properties. In this sense, chemistry is indeed a basic Nano science. In a short term perspective, chemistry will provide novel "nanomaterials" and in the long run, superior processes such as "self assembly" will enable energy and time preserving strategies. Some of the greatest potential uses or applications for nanotechnology in the environment are sensors, treatment ,remediation and green nanotech manufacturing and engineering. These applications can be further categorized as either reactive to existing environment problems or proactive in anticipating and preventing future problems.

Energy

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving and enhanced renewable energy sources. Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but still they manage to use only 40% of solar energy. Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of band gaps.

Information and communication

Current high technology production processes are based on traditional top-down strategies, where nanotechnology has already been introduced silently. Nanotechnology is being used in the production of novel semiconductor devices and opto electronic devices. It is also used for increasing the memory capacity in devices.

2.2 THICK FILMS

Thin and thick film resistors are the most common types in the market. They are characterized by a resistive layer on a ceramic base. Although their appearance might be very similar, their properties and manufacturing processes are very different. The naming originates from the different layer thicknesses.

Thin film has a thickness in the order of 0.1 μm (micrometer) or smaller, while thick film is thousands times thicker. However, the main difference is the method used to apply the resistive film onto the substrate. Thin film resistors have a metallic film that is vacuum deposited on an insulating substrate. Thick film resistors are produced by firing a special paste onto the substrate. The paste is a mixture of glass and metal oxides. Thin film is more accurate, has a better temperature coefficient and is more stable. Therefore, it competes with other technologies that feature high precision, such as wire wound or bulk metal foil. On the other hand, thick film is preferred for applications where these high requirements are not critical since prices are much lower

Whatever be the film thickness limit an ideal film can mathematically be defined as a homogeneous solid material contained between two parallel planes and extended infinitely into direction (say X and y (but restricted along the third direction (x) which is perpendicular to the x - y plane. The dimension along x direction is known as film thickness (d or t). its magnitude may vary from the limit d to 0 to any arbitrary value or more. But always remaining much less than those along the other directions i.e; x and y . A real film, however deviates considerably from the ideal case since it's

two surfaces are never exactly parallel even when formed in the best experiment and deposition condition and also the material contained between the two surfaces are rarely homogeneous. Neither uniformly distributed nor of the same species a film name also contains some imperfection impurity, dislocation, grain boundaries and various other defects and may also be discontinuous. Some of this can be minimized by appropriate control of deposition condition but cannot all together be avoided.

Some of the factors which determine the physical, electrical, optical and other properties of a thick film are the following: rate of deposition, substrate temperature, environmental condition, residual gas pressure in the system, of the material to be deposited, inclusion of foreign matter in the deposit etc.

2.2.1 Thick film deposition techniques

Thick films are considered as dispersions, pastes, and inks being conductive, resistive or dielectric; however, for the time being, thick films include a wider group of inorganic and organic materials. Accordingly, the deposition processes can be divided into directed coating techniques, spreading coating techniques, and immersion coating techniques.

Spray coating

Spray coaters are devices that use atomization as the coating method. These devices turn the coating fluid into a mist and spray it onto the target.

Because of their sophisticated and diverse design, spray coaters have been used for a wide range of applications, from thin film coating of flat sheets such as transparent conductive films for touch panels, to solar cell components and semiconductor photoresist.

Spray coaters can be classified into three groups according to the spray method: Air spray systems, ultrasonic spray systems, and electrostatic spray systems.

Air spray systems use compressed air to change the coating fluid into a fine mist that is sprayed onto the target. A typical example is an air spray gun, which uses a similar mechanism.

Compressed air applies high pressure to the coating fluid discharged from the nozzle and the fluid then collides at a high speed with the remaining air. The coating fluid is split up and slowed down at that moment due to air resistance, and then changes into a mist before reaching the target.

Ultrasonic spray systems are equipped with a chip (atomization surface) at the end of the nozzle. The vibration generated by ultrasonic waves causes the coating fluid to spread over the chip, and ruffling occurs on the surface. When the ultrasonic output exceeds the surface tension, the fluid drops from the surface as a fine mist.

In electrospray systems, the coating fluid is charged with static electricity through the application of several thousands of volts in the nozzle. The fluid is then changed into a fine mist through electrostatic repulsion. The coating fluid mist is attracted to the surface of the target, which sits on a grounded stage. These systems can be used for fluids with varying viscosities as well as pastes, slurries, and fluids containing filler dispersion. The result is a uniform film of even on substrates with uneven surfaces

Aerosol deposition

Aerosol deposition method is a method to fabricate ceramic membranes, in which aerosol, or a mixture of fine ceramic particles with a diameter of around 1 micrometer and gas, is sprayed on a substance at a speed of around 150 to 400 m/sec to form membranes on it.

Typically, fabrication of ceramic membranes requires the ceramic materials, which are the ingredients of the membranes, and the object of membrane fabrication to be kept at a high temperature. In contrast, the aerosol deposition method can form membranes at room temperature, as it makes particles collide against a substance at a high speed and the resulting collision energy is used to form the membranes. This gives the method an advantage in that the object of membrane formation is not deteriorated by heat.

Research of this method has been under way over recent years, with the theme of reducing costs for practical applications.

Spin coating

Spin coating is a technique used to spread uniform thin films on flat substrates by centrifugal force. The apparatus used for spin coating is called a spin coater, or a spinner. A solution of material is dispensed onto the center of a wafer, which is then rotated at high speed.

Rotation continues until the excess solution spins off the substrate and the desired thickness of the film is left on the substrate. The applied solvent is usually volatile and evaporates during deposition. The

two main factors that define film thickness are the spin speed and the viscosity of the solution. Other factors considered include spin time, solution density, solvent evaporation rate, and surface wettability.

Spin coating is arguably the simplest and most commonly used method for solution deposition of metal oxide inks. In the spin process, drops of precursor solution or ink are dispensed on hydrophilic substrate, which then rotates to high angular velocities (hundreds to thousands of rpm) to spin off excess solution, resulting in thin and uniform film. During the spinning, solvent contained in the ink starts to evaporate, which facilitates the formation of solid-like gel film because of dramatically increased viscosity. The thickness (d) of the resultant gel film is mainly determined by the precursor viscosity (η), the angular speed ω (rpm)

The major advantages of spin coating include good reproducibility and easy integration with conventional lithography-based fabrication techniques. However, spin coating is limited in scalability and is not compatible for manufacturing of large area TFT arrays. Moreover, most of the ink ($\approx 95\%$) is wasted during the spinning process.

Doctor blade / tape casting method

Doctor blade coating is a technique used to form films with well-defined thicknesses. The technique works by placing a sharp blade at fixed distance from the surface that needs to be covered. The coating solution is then placed in front of the blade and the blade is moved across in-line with the surface, creating a wet film. The technique should ideally have solution losses of about 5%; however, practically, it takes time for optimal conditions to be found (Krebs, 2009).

The inks/pastes used in these processes usually require large amounts of binders and thickeners to produce the high viscosities (1000–10,000 mPa s) required for reproducible and reliable production of films

Dip coating

Dip coating is an industrial coating process which is used, for example, to manufacture bulk products such as coated fabrics and specialized coatings for example in the biomedical field. Dip coating is also commonly used in academic research, where many chemical and nano material engineering research projects use the dip coating technique to create film coatings.

The earliest dip-coated products may have been candles. For flexible laminar substrates such as fabrics, dip coating may be performed as a continuous roll-to-roll process. For coating a 3D object, it may simply be inserted and removed from the bath of coating. For condom-making, a former is dipped into the coating. For some products, such as early methods of making candles, the process is repeated many times, allowing a series of thin films to bulk up to a relatively thick final object

The final product may incorporate the substrate and the coating, or the coating may be peeled off to form an object which consists solely of the dried or solidified coating. As a popular alternative to Spin coating, dip-coating methods are frequently employed

Electrophoretic deposition (EPD)

Electrophoretic deposition (EPD), is a term for a broad range of industrial processes which includes electrocoating, cathodic electrodeposition, anodic electrodeposition, and electrophoretic coating, or electrophoretic painting. A characteristic feature of this process is that colloidal particles suspended in a liquid medium migrate under the influence of an electric field (electrophoresis) and are deposited onto an electrode. All colloidal particles that can be used to form stable suspensions and that can carry a charge can be used in electrophoretic deposition. This includes materials such as polymers, pigments, dyes, ceramics and metals

The process is useful for applying materials to any electrically conductive surface. The materials which are being deposited are the major determining factor in the actual processing conditions and equipment which may be used

EPD processes are often applied for the fabrication of supported titanium dioxide (TiO₂) photocatalysts for water purification applications, using precursor powders which can be immobilised using EPD methods onto various support materials. Thick films produced this way allow cheaper and more rapid synthesis relative to sol-gel films, along with higher levels of photocatalyst surface area

The process applies coatings which generally have a very uniform coating thickness without porosity.

Complex fabricated objects can easily be coated, both inside cavities as well as on the outside surfaces. Relatively high speed of coating., Relatively high purity x Applicability to wide range of materials (metals, ceramics, polymers,) Easy control of the coating composition.

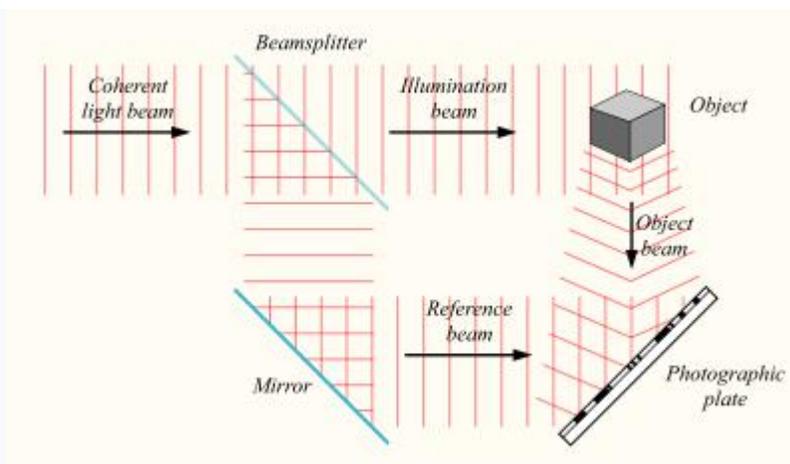
The process is normally automated and requires less human labor than other coating processes, Highly efficient utilization of the coating materials result in lower costs relative to other processes, The aqueous process which is commonly used has less risk of fire relative to the solvent-borne coatings that they have replaced, Modern electrophoretic paint products are significantly more environmentally friendly than many other painting technologies.

In addition to this sedimentation ,texturing ,polymerisation are the techniques used in fabrication of thick film

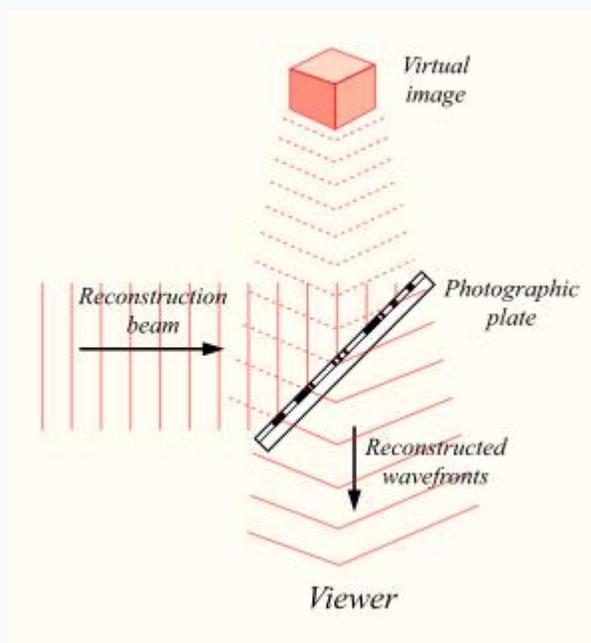
2.3 HOLOGRAPHY

Holography is a technique that enables a wavefront to be recorded and later re-constructed. Holography is best known as a method of generating three-dimensional images, but it also has a wide range of other applications. In principle, it is possible to make a hologram for any type of wave.

A hologram is made by superimposing a second wavefront (normally called the reference beam) on the wavefront of interest, thereby generating an interference pattern which is recorded on a physical medium. When only the second wavefront illuminates the interference pattern, it is diffracted to recreate the original wavefront. Holograms can also be computer-generated by modelling the two wavefronts and adding them together digitally. The resulting digital image is then printed onto a suitable mask or film and illuminated by a suitable source to reconstruct the wavefront of interest. Holography is based on the principle of interference. A hologram captures the interference pattern between two or more beams of coherent light (i.e. laser light). One beam is shone directly on the recording medium and acts as a reference to the light scattered from the illuminated scene.



Recording a hologram



Reconstructing a hologram

Holography is a technique that enables a light field (which is generally the result of a light source scattered off objects) to be recorded and later reconstructed when the original light field is no longer present, due to the absence of the original objects. In one common arrangement, the laser beam is split into two, one known as the object beam and the other as the reference beam. The object beam is expanded by passing it through a lens and used to illuminate the subject. The recording medium is located where this light, after being reflected or scattered by the subject, will strike it. The reference beam is expanded and made to shine directly on the medium, where it interacts with the light coming from the subject to create the desired interference pattern.

Like conventional photography, holography requires an appropriate exposure time to correctly affect the recording medium.

A hologram can be made by shining part of the light beam directly into the recording medium, and the other part onto the object in such a way that some of the scattered light falls onto the recording medium. The first element is a beam splitter that divides the beam into two identical beams, each aimed in different directions: One beam (known as the 'illumination' or 'object beam') is spread using lenses and directed onto the scene using mirrors. Some of the light scattered (reflected) from the scene then falls onto the recording medium. The second beam (known as the 'reference beam') is also spread through the use of lenses, but is directed so that it does not come in contact with the scene, and instead travels directly onto the recording medium.

Several different materials can be used as the recording medium. One of the most common is a film very similar to photographic film (silver halide photographic emulsion), but with a much higher concentration of light-reactive grains, making it capable of the much higher resolution that holograms require. A layer of this recording medium (e.g., silver halide) is attached to a transparent substrate, which is commonly glass.

A hologram represents a recording of information regarding the light that came from the original scene as scattered in a range of directions rather than from only one direction, as in a photograph. This allows the scene to be viewed from a range of different angles, as if it were still present . A photograph can be recorded using normal light sources (sunlight or electric lighting) whereas a laser is required to record a hologram. A lens is required in photography to record the image, whereas in holography, the light from the object is scattered directly onto the recording medium. A holographic recording requires a second light beam (the reference beam) to be directed onto the recording medium .A photograph can be viewed in a wide range of lighting conditions, whereas holograms can only be viewed with very specific forms of illumination.

2.3.1 TYPES OF HOLOGRAMS

Unlike ordinary images, holograms are images that resulted from interference and diffraction of light. It is a three-dimensional representation of a person or object used normally in communication or entertainment. In telecommunications, holograms are used mostly as an alternative to screens. A

hologram is an image formed when a point source of light (a reference beam) of fixed wavelength encounter light of the same fixed wavelength arriving from an object (the object beam).

There are three types of holograms: the reflection hologram, transmission hologram, and then the hybrid (combination of both).

Reflection hologram

The reflection hologram, in which a truly three-dimensional image is seen near its surface, is the most common type shown in galleries. The hologram is illuminated by a “spot” of white incandescent light, held at a specific angle and distance located on the viewer’s side of the hologram. Thus, the image consists of light reflected by the hologram. Recently, these holograms have been made and displayed in color—their images optically indistinguishable from the original objects.

Transmission hologram

The object and reference beam incident on holographic film is on the same side. It is less expensive if mass produced.

The typical transmission hologram is viewed with laser light, usually of the same type used to make the recording. This light is directed from behind the hologram and the image is transmitted to the observer’s side. The virtual image can be very sharp and deep. For example, through a small hologram, a full-size room with people in it can be seen as if the hologram were a window. If this hologram is broken into small pieces (to be less wasteful, the hologram can be covered by a piece of paper with a hole in it), one can still see the entire scene through each piece.

Hybrid hologram

There is no need for real object. Interference pattern is calculated digitally using computer algorithms. Between the reflection and transmission types of holograms, many variations can be made. One of such is the mathematics of holography is now well understood. Essentially, there are three basic elements in holography: the light source, the hologram, and the image. If any two of the elements are predetermined, the third can be computed. For example, if we know that we have a parallel beam of light of certain wavelength and we have a “double-slit” system.

2.3.2 Applications of Holography

Holography is not only used to make three-dimensional pictures and it does not confine itself to the visible spectrum. Microwaves are used to detect objects through otherwise impenetrable barriers. X-rays and ultraviolet light are used to detect particles smaller than visible light. This is how holography was discovered. Dr. Dennis Gabor is recognized as the inventor of holography when he used it to aid in his electron microscopy in 1947.

Holography is also used to detect stress in materials. A stressed material will deform, sometimes so minutely that it is not visible. A hologram can amplify this change since the light reflected off of the material will now be at a different angle than it was initially. A Comparison between the before and after holograms can determine where the greatest stress is. In Europe telephone credit cards use holograms to record the amount of remaining credit. Fighter pilots use holographic displays of their instruments so they can keep looking straight up. Museums keep archival records in holograms. One of the best uses for holography is candy. The candy's surface is etched into tiny prism-like ridges that display 3-D images in brilliant iridescent colors. Holography has even tried to make it into the movie business. Lastly, holography is used in a new kind of computer, an optical computer. Optical computers really are not so new in concept but they are far from perfected and are constantly changing with new technology. They are also far from commercially viable, though they say only in a few more year.

Art

Early on, artists saw the potential of holography as a medium and gained access to science laboratories to create their work. Holographic art is often the result of collaborations between scientists and artists, although some holographers would regard themselves as both an artist and a scientist.

Salvador Dalí claimed to have been the first to employ holography artistically. He was certainly the first and best-known surrealist to do so, but the 1972 New York exhibit of Dalí holograms had been preceded by the holographic art exhibition that was held at the Cranbrook Academy of Art in Michigan in 1968 and by the one at the Finch College gallery in New York in 1970, which attracted national media attention. In Great Britain, Margaret Benyon began using holography as an artistic medium in the late 1960s and had a solo exhibition at the University of Nottingham art gallery in 1969. This was followed in 1970 by a solo show at the Lisson Gallery in London, which was billed as the "first London expo of holograms and stereoscopic paintings".

Data Storage

Holographic data storage is a technique that can store information at high density inside crystals or photopolymers. The ability to store large amounts of information in some kind of medium is of great importance, as many electronic products incorporate storage devices. As current storage techniques such as Blu-ray Disc reach the limit of possible data density (due to the diffraction-limited size of the writing beams), holographic storage has the potential to become the next generation of popular storage media. The advantage of this type of data storage is that the volume of the recording media is used instead of just the surface.

Sensors and Biosensors

The hologram is made with a modified material that interacts with certain molecules generating a change in the fringe periodicity or refractive index, therefore, the color of the holographic reflection

Security

Holograms are commonly used for security, as they are replicated from a master hologram that requires expensive, specialized and technologically advanced equipment, and are thus difficult to forge. They are used widely in many currencies, such as the Brazilian 20, 50, and 100-reais notes; British 5, 10, and 20-pound notes; South Korean 5000, 10,000, and 50,000-won notes; Japanese 5000 and 10,000 yen notes, Indian 50, 100, 500, and 2000 rupee notes; and all the currently-circulating banknotes of the Canadian dollar, Croatian kuna, Danish krone, and Euro. They can also be found in credit and bank cards as well as on electronic products. They often contain textual or pictorial elements to protect identities and separate genuine articles

CHAPTER -3

Preparation and characterisation of holographic recording material using polymer

For the present study, poly vinyl alcohol and poly vinyl chloride were selected as base matrices and methylene blue was used as the photo initiator or dye. The materials used and the experimental procedures adopted in the present investigation are given in this chapter.

3.1 Materials Used

Photopolymer systems for recording holograms typically comprise one or more monomers, a photo initiator system and an inactive component often referred to as a binder. The following section describes the various constituents used for the fabrication of photopolymer films.

Host Matrices

Both poly (vinyl chloride) (PVC) and poly (vinyl alcohol) (PVA) were selected as the host matrices or binder. PVC, the leading plastic material, is a member of the large family of polymers broadly referred to as vinyls, all have the vinyl group ($\text{CH}_2=\text{CH}-$) in common. It is produced as a result of polymerisation of vinyl chloride. The polymerization of vinyl chloride can result in the formation of molecules with a number of isomeric forms $-(\text{CH}_2-\text{CHCl})_n$.

Dye

The photo initiator system comprises of a photosensitizer dye and a charge transfer agent. here, methylene blue (MB) was used as the photosensitizing dye. MB dye of microscopy grade was supplied by Qualigens. Chemically MB is 3, 7-bis (dimethyl amino) phenantholinium chloride. MB is a basic dye of thiazine group and is also known as swiss blue and tetramethyl thionine The absorption maxima of MB, if pure, reside at 668 nm and 609 nm.

Monomer

Different monomers were incorporated to the polymer matrices to

establish the grating formation induced by refractive index modulation. MBPVC films were fabricated with vinyl acetate (Lancaster) and butyl acrylate monomer.

3.2 FABRICATION OF FILM

The various techniques for coating polymer solution include dip coating, spin coating, doctor blading, gel casting, gravity settling, spraying etc.

Among these, in the present work gravity settling method was adopted. The method was easy to setup and the procedure was simple. The coating was done by pouring known volume of viscous solution on cleaned glass slides kept on a leveled surface. The solution equally spreads over the slides. The glass slides were covered to protect from dust. The films were fabricated at room temperature under normal laboratory conditions. Depending on the film constituents, the drying period varied from 24 to 48 hours

Sample is prepared under normal laboratory conditions. 10% solution of poly vinyl alcohol(10gram PVA in 100ml) .Filter 45 ml PVA from the above solution .Weigh 1.2 gram acrylamide ,0.3ml triethanol amine .Add it to 45ml PVA stir for 1.5 hours using magnetic stirrer at a temprature 65 degree.Simultenously weigh methylene blue ,prepare aqueous stock solution in methylene blue dye at 0.006M.Mix 0.1ml of dye solution to the measure TEA and AA.pour it to glass slide allow it to solidfy.

3.3 Optical Absorption Studies

When the polymer film is exposed to suitable wavelengths, the dye molecules in the exposed region are converted to the leucoform and as a result an absorbance modulation occurs in the exposed area. The absorption spectra of both unexposed films and exposed films were recorded using UV-Visible-NIR spectrophotometer. The absorption spectra were taken with the undoped polymer films as reference plate. The absorbance modulation was determined as the difference between absorbance before exposure and that after exposure .The dye molecules could exist in the leucoform itself, it returns to the original state or it is transferred to other states. UV-Visible spectral analysis was done to study the dye behavior on laser exposure in MBPVA and MBPVC films with different matrix

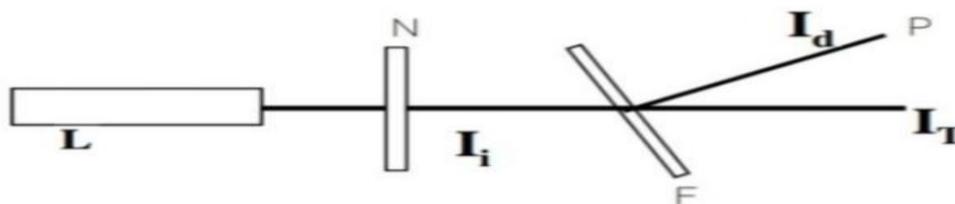
additives. To study the stability of this leuco form or the dye behavior on storage, absorption spectra of the exposed regions on storage was recorded.

3.4 Real time transmittance measurements

This is carried out to find out the material sensitivity by exposing the samples to suitable laser for a known time. The transmittance at regular intervals was monitored using a power meter. The relative transmittance T/T_0 was determined; where T is the real time transmittance of the sample on laser exposure and T_0 is the transmittance of the samples without dye. As the material sensitivity increases the transmittance increases at low exposures. From the relative transmittance, rate of bleaching could be found out by taking the slope of the relative transmittance Vs time curve at different times.

3.5 Diffraction Efficiency Measurements

Unexpanded laser (L) beam was allowed to fall on the grating recorded film (F) placed at Bragg's angle. The diffracted beam was observed on the screen at Bragg angle and its intensity was measured using power meter (P). The intensity of incident beam (I_i), diffracted beam (I_d) and directly transmitted beam (I_T) was measured. The diffraction efficiency was calculated as the ratio of the intensity of first order diffracted beam to that of the incident beam.



Experimental setup for diffraction efficiency measurements.

Where L-laser, N-ND filter, F- grating recorded film, P-power meter

The angular response of the recorded gratings was determined by varying the angle of reconstructed beam and by monitoring the diffracted beam intensity. As it was easier to control, the film was rotated instead of the laser beam. When gratings were recorded with single beam method, diffracted patterns

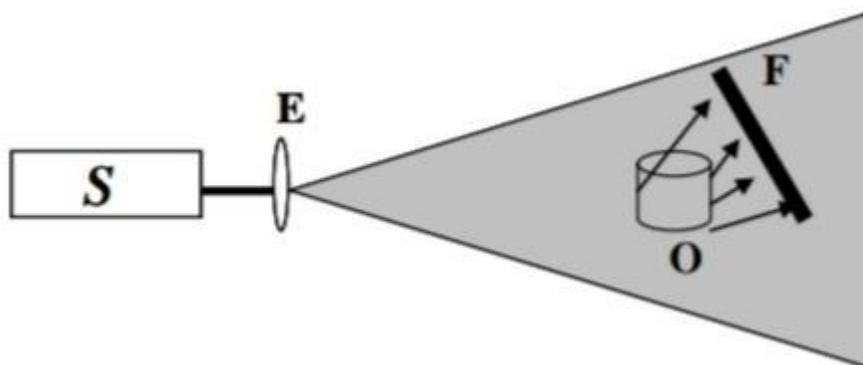
were visible on either side of the directly transmitted beam. As it was not possible to find out the interfering angle from the recording geometry, the spatial frequency was determined from the angle of diffraction. The diffracted pattern is focused to a screen placed behind the film.

3.6 Storage and Shelf Life

In dye doped films, the diffraction efficiency can be reduced or remained unaltered on storage. Storage life gives the idea that how long the material can hold (store) the recorded grating. The storage life of the grating was determined by measuring the diffraction efficiency of gratings after each day of grating formation. Shelf life is defined as the film properties on ageing of the samples. To study the shelf life of the film, gratings were recorded on the film on each day after film preparation and efficiency was determined. It includes optical absorption studies, refractive index measurements etc on each day after preparation of the film. It gives the idea that how long the material can be utilized.

3.7 Recording of Holograms

Transmission holograms were recorded on the polymer film using single beam technique. Laser beam (S) was expanded using a spatial frequency filter arrangement (E). Object (O) is placed in the path of the expanded laser beam and polymer film (F) is placed near the object at an angle. The laser beams scattered by the object act as the object wave and directly transmitted beam act as the reference wave. The position of the film was adjusted to collect maximum object wave. The reference wave and object wave interfere at the film and thus the hologram is created. The hologram was reconstructed by illuminating with an expanded laser beam.



The experimental technique used for recording transmission hologram. where S-Laser, E-beam expander with spatial filter, O-object, F-Polymer film.

So far we have tried to prepare films and obtained various conclusions

1.Procedure: 16 gram of PVA is dissolved in 160 ml of water. The solution was made at a temperature of 70° c. A magnetic stirrer was used for mixing pva in water. It was stirred for one hour.

Observation: The solution had lot of lumps in it.

Conclusion: The solution cannot be used for making a good film

2.Procedure: 10 gram of pva is dissolved in hundred ml water. The solution was made at a temperature of 65 degree Celsius. A magnetic sterer was used for mixing pva in water. It was stirred for 40 minutes. The solution of PVA was of good consistency. 45 ml of PVA was filtered out from the above solution.

1.2 gram of acrylamide and 0.3 ml triethanol amine was weighed out. It was added to the 45 ml PVA and the solution was stirred for 1.5 hours using a magnetic stirrer. An aqueous solution of methylene blue dye at 0.006 M was prepared. 0.1 ml of dye solution was added to the measured AA and TEA.

It was stirred for 1.5 hours using a magnetic stirrer. Then the solution was poured to clean and dry glass slides. It was kept for one day for soldification. A film was obtained. Film was subjected to grating studies

The diffraction efficiency measurements of the PVA-acrylamide dye sensitized photopolymer films were done by recording diffraction gratings on the film using the single beam analysis. The beam from the laser source was expanded using a beam expander and it was split into two by a beam splitter. One of the beam transmitted into a mirror placed in front of the beam splitter in order to make a phase difference and the other beam got reflected and allowed to fall on the photopolymer film. The reflected beam from the mirror was also directed to the film. The superposition of both of the beams created an interference pattern on the photopolymer film, which was the diffraction grating. The film was subjected to the laser beam for 10 minutes to record the diffraction grating.

According to the mechanism of grating formation, on exposing to the interference pattern the MB molecules get excited and electron transfer takes place between MB and triethanolamine that converts MB into leuco MB. Amine radical is also produced in this reaction that initiates polymerization reaction. Polymerization occurs at the region of constructive interference which results in a monomer concentration gradient. This allows the diffusion of the monomer from the unexposed to the exposed regions. Thus, polymerization causes refractive index modulation which leads to the grating formation. The absorbance modulation takes place during exposure and results in the grating formation.

The unexpanded beam from the laser source was allowed to fall on the film on which the grating had been recorded. The beam got diffracted by the grating and the diffracted beam was observed on the screen placed at Bragg angle. The intensity of the diffracted beam was measured using a Field Max II power meter. Diffraction efficiency was calculated as the ratio between the intensity of the first order diffracted beam (I_d) and the intensity of the incident beam (I_i).

Observation : The film didn't had diffraction grating.

Conclusion : The film cannot be used as a holographic recording medium

3. Procedure : the above procedure was followed by changing the temperature and amount of PVA. A film was obtained.

Observation: The film didn't had diffraction grating in it.

Conclusion : the film cannot be used as a holographic recording medium

4. Procedure: the above procedure was followed by changing the concentration of dye. The diffraction efficiency of the film was measured.

Observation: the film didn't had diffraction grating in it.

Conclusion: the film cannot be used as a holographic recording medium.

Conclusion

Photopolymer are promising material for use in holography. They have many advantages such as ease of preparation and are capable upto efficiency of 100%.carefull and prominent studies are needed in the preparation of photopolymer material for holographic studies . Suitable temperature is also necessary for the preparation of Holographic photopolymer materials.

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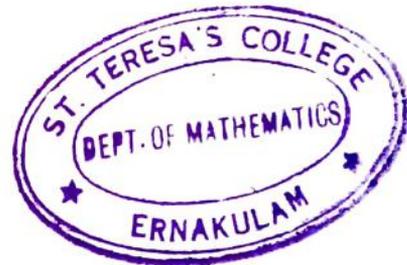
CERTIFICATE

This is to certify that the dissertation entitled, **MATHEMATICS IN CRIME SOLVING AND CRIME CONTROL** is a bonafide record of the work done by Ms. **LIZBEL JOSE** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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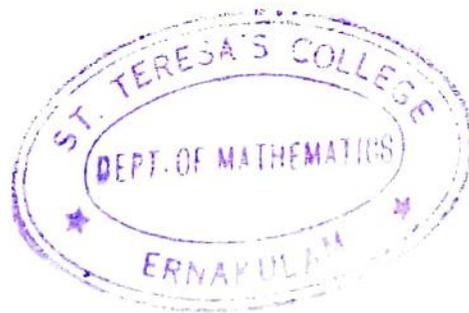
External Examiners

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Project Report

On

**MATHEMATICS IN CRIME SOLVING AND
CRIME CONTROL**

Submitted

in partial fulfilment of the requirements for the degree of

BACHELOR OF SCIENCE

in

MATHEMATICS

by

LIZBEL JOSE

(Register No. AB19BMAT040)

Under the Supervision of

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MARCH 2022

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of Dr. Susan Mathew Panakkal, Assistant Professor, Department of Mathematics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

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ACKNOWLEDGEMENT

Firstly I would like to thank god almighty for giving me grace to execute this project. I express my gratitude to our project guide **Dr.Susan Mathew Panakkal**,Department of Mathematics and Statistics, St Teresa's College, Ernakulam.I would like to mention the support and help offered by **Dr.Ursala Paul**,HOD,Department of Mathematics,St Teresas's College,Ernakulam.

I would also like to thank all other teachers of the Department of Mathematics and Statistics for their immense support throughout the course of completing this project.

I also thank my parents,friends,especially **My group Members** and all those who have given me the moral support and guidance which helped me to complete my project.This project would have been not possible without help of the above mentioned people.

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Chapter 1

PREREQUISITES

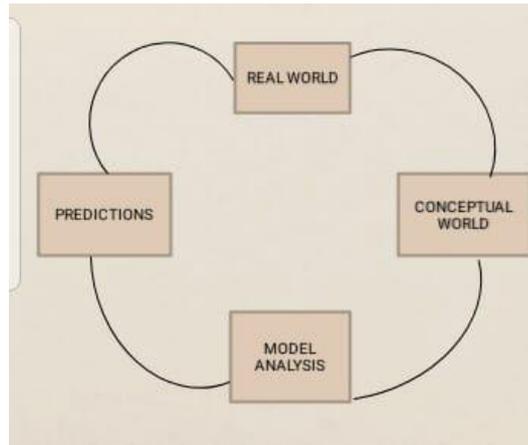
1.1 MATHEMATICAL MODELLING

1.1.1 INTRODUCTION

Mathematical Modelling is an important branch of mathematics. 'Model' is basically an imitation of real world objects . Modelling is a miniature representation of some object or a demonstration for reference of an object to be made. There are two types of models prototypic(physical model) and schematic(charts,graph,diagram etc). The manipulation of modelling and implementing it in mathematics helped in the betterment of various fields.

1.1.2 DEFINITION

Representation of real objects and phenomenon in mathematical language is stated as mathematical modelling. The subjects that cannot be studied or is difficult to study using normal theoretical methodology can be done using mathematical modelling



1.1.3 ADVANTAGE AND APPLICATION

Mathematical modelling comes to light when the theoretical method become :

- Time consuming
- Expensive
- Often dangerous
- Simply impossible

Mathematical modelling basically deals with analysing, predicting and insight of real world knowledge. As mentioned earlier it's application is beyond limit it is applicable in the field of Epidemiology, biological transpore , vehicular traffic etc.Consider the current situation of covid 19, it forced us to trace multiple things and track down and even predict the spread and new waves . Evidently, this won't be possible by simple experimental method as the real world object that we are dealing with is quite large.Hence, modelling is an unavoidable and powerful tool.

1.1.4 STEPS INVOLVED

- A problem from the real world is taken in account and is studied to make certain assumptions involving the parameters affecting the considered problem.
- Analytical and numerical analysis of the assumptions are made.
- A model is predicted for the same

- Both experimental and Intuitive validation is done.
- If valid, the model is accepted or else the process is repeated

Mathematical modelling is used in the project to study an existing model named Rossmo Model introduced by **Dr.Kim Rossmo**. The basic mathematical concept used in the generation of this model is **probability**.This was used to hunt down a serial rapist bringing Dr.Rossmo to limelight.

1.2 GRAPH THEORY

1.2.1 INTRODUCTION

In mathematics, Graph theory is a special branch of mathematics that deals with the pairwise relation of one object to other. A graph consists of vertices also known as nodes which are interconnected by edges. Graphs is a crucial field of study in mathematics.

1.2.2 DEFINITION

Graph Theory is used to study the relationship between different objects. A Graph $G(V,E)$ denotes the collection of graph with vertex $V(G)$ and edge $E(G)$.

1.2.3 GRAPH THEORY IN CRIME

We can analyse a crime using three elements of graph theory such as the vertex set, the edge set, and the incidence function that relates edges to vertices. The mathematics of graph theory explains that an edge can have an interconnection from one vertex to another if there is any connection between the entities. The prior step in crime solving is to locate different elements involved in the incident. These elements will be represented as vertices. When any two elements have any connection that connection is represented as an edge. The edge not only connects the vertices but acts as the initiator of that connection which results in graph with parallel edges.

1.2.4 APPLICATION OF GRAPH COLOURING

In graph theory, graph colouring is used to label the graph. The vertices, Edges and faces are denoted using colours without the adjacent of the above being labelled with same colours. This method of colouring is stated as *vertex colouring*, *edge colouring* and *face colouring* respectively. In crime solving this method can be used to interpret the connection between the collected evidences. An illustration of the same is explained later in this paper.

1.3 FORENSIC STATISTICS

1.3.1 INTRODUCTION

Forensic statistics refers to the application of probability, mathematical techniques and statistical concepts to the forensic data and the scientific evidence collected. Mathematics is an unavoidable part of Forensic science. The application of mathematics and statistics makes the scientific analysis of evidences methodical. Forensic investigators collect the evidences, analyse and document it using statistical methods.

Biological evidences such as DNA evidence, blood samples, hair samples, fingerprints, etc found at the crime scene are examined using various probability models to draw inferences from them. DNA profiling, fingerprint analysis, blood sample analysis, and statement analysis are major functionalities of forensic science that are deterministic in solving a crime. Forensic Statistics is widely used by Forensic Investigators and Legal practitioners to analyse statements and test the significance of evidences.

1.3.2 CONCEPTS INVOLVED

There are different mathematical and statistical techniques used to solve crimes. Some of the main mathematical principles used in crime solving are:-

- TRIGONOMETRY
- EXPONENTIAL & LOGARITHMIC FUNCTIONS
- CONDITIONAL PROBABILITY
- BAYES' THEOREM
- LIKELIHOOD RATIO

TRIGONOMETRY

Trigonometry studies the relationship between the angles and the length of sides of a right angled triangle. In Crime solving trigonometry is mainly used in Blood Spatter Analysis and it also helps in Ballistic Analysis.

BLOOD SPATTER ANALYSIS

Blood Spatter Analysis deals with the study of bloodstains. The bloodstains found at the crime scene are analysed by experts. Bloodstains develop a pattern due to the impact of multiple bloodstains originating from a single source, that is, from a gunshot or a stab wound. Working on these patterns, the investigators can trace back to the position of the victim when the crime occurred or the nature of the blood source. Blood Spatter Analysis is conducted in three steps using trigonometry.

1. Calculate the angle of impact after identifying a proper set of bloodstains.
2. The point of convergence of the bloodstains within the plane of the pattern is determined.
3. The point of convergence of the source is determined.

There are two scenarios under consideration to analyse the shape of the blood stain and calculate the angle of impact; first, the impact from a stationary source and second, the impact from a moving source.

STATIONARY SOURCE: Bloodstains take a spherical shape under a perpendicular impact. If the angle of impact is less than 90° then the blood drop is going to be elongated and elliptical in shape. The angle of impact θ is calculated using the formula

$$\sin \theta = \frac{\text{width}}{\text{length}}$$

MOVING SOURCE: Blood drops falling from a moving source like blood falling from the assailant or the moving wounded victim hits the ground with an impact

less than 90° . The components of velocity affect the angle of impact. The effective angle of impact θ is given by,

$$\tan \theta = \frac{V_g}{V_h}$$

Where, V_h is the horizontal component of velocity due to speed. V_g is the velocity component due to gravitational acceleration and is given by, $V_y = \sqrt{2gh}$ when g is the acceleration due to gravity and h is the drop height.

BALLISTIC ANALYSIS

Firearms involved in a crime are examined to discover evidences in forensic ballistic analysis. A variety of instruments and devices are also used in Ballistic Analysis. Trigonometry appears in the non-mechanical part of Ballistic Analysis. Bullet trajectories refer to the path travelled by the bullet after firing a gun. Studying the bullet trajectories the investigators can determine the position of the criminal at the time of crime and the height of the criminal.

EXPONENTIAL & LOGARITHMIC FUNCTIONS

An Exponential function $f(x) = a^x$ shows the relationship between 2 variables where a constant change in the independent variable induces a proportional change in the other variable. Logarithmic functions denoted by $f(x) = \log_a x$ are the inverse of exponential functions.

The exponential and logarithmic functions are two mathematical functions that play a significant role in forensic science. Rates of heating or cooling, or the rate of metabolizing of alcohol and drugs help to reach conclusions about the time elapsed since death.

CONDITIONAL PROBABILITY

The probability of an outcome or event happening, given another event has already occurred is defined as Conditional Probability. It is simply the relationship between the occurrence of two events. The theory of conditional probability studies the odds of an event occurring when another event has happened and the chances that both the events are connected. The formula for calculating the conditional probability of two events A and B is,

$$P\left(\frac{A}{B}\right) = \frac{P(A \cap B)}{P(B)}$$

$P\left(\frac{A}{B}\right)$ is pronounced as Probability of the occurrence of event A when B has already happened.

The theory of Conditional Probability plays a crucial role in Crime Solving. It has a wide range of application including studying the Witness reliability, Statement analysis and many more. Misinterpreting conditional probabilities can lead to statistical fallacies.

BAYES' THEOREM

Bayes' theorem is a special case or an application of Conditional Probability. Named after Thomas Bayes, the theorem explains the odds of an event happening in relation to any given conditions. The Bayes' formula can be used to solve complex problems in a well constructed and precise way whereas the formula for conditional probability can be used only for relatively simpler problems. Bayes' formula is given by,

$$P\left(\frac{A}{B}\right) = \frac{P\left(\frac{B}{A}\right) P(A)}{P(B)}$$

Bayes Formula helps to reach precise conclusions regarding the efficiency of evidences, strength of statements provided by the witness, and to check the validity of the assumptions used in solving a case.

LIKELIHOOD RATIO

In crime solving there are a few terms to be familiar of to understand Likelihood ratio. H is called Hypothesis, mainly two types here; H_p or Prosecution Hypothesis, and H_d or Defence Hypothesis and E is the evidence. Likelihood Ratio is defined as the ratio of the probability of E occurring when H_p is true, to the probability of occurrence of E given H_d .

$$LR = \frac{P\left(\frac{E}{H_p}\right)}{P\left(\frac{E}{H_d}\right)}$$

If $LR > 1$, it is in support of Prosecution Hypothesis, $LR < 1$, it is in support of Defence Hypothesis and when $LR = 1$ it is considered inadmissible. One of the major errors caused due to misinterpreting LR and Conditional probability is Prosecutor's Fallacy.

Chapter 2

CRIME SOLVING USING MATHEMATICAL MODELLING

2.1 ROSSMO MODEL

2.1.1 INTRODUCTION

Rossmo Model is developed by Dr. Kim Rossmo and is an application of mathematical modelling. The mathematical concept involved in the prediction is Probability. This is a blend of two entirely different subjects, mathematics and criminology. Here, the real world problem that we are dealing with is complex i.e., we have to hunt down a serial killer which is a social threat where the simple methods can end up in vain. A criminology concept lies the foundation on which the model is built, which is:

Criminals neither go too far to commit crime and also they never commit crime near their locality.

With this assumption he developed a formulae that sums up the probabilities of where the criminal is likely to live. A heat map was produced based on this inference which forms a heat zone of the probable residence of prime suspect. This was used and was succeeded in early 90's to hunt down a serial rapist. Since, we are challenging human being with a theoretical concept it has its drawbacks.

2.1.2 ROSSMO FORMULA

$$P_{ij} = k \sum_{n=1}^{(totalcrimes)} \left[\frac{\Phi_{ij}}{(|X_i - x_n| + |Y_j - y_n|)} + \frac{(1 - \phi_{ij})(B^{g-f})}{(2B - |X_i - x_n| - |Y_j - y_n|)^g} \right]$$

P_{ij} : Probability of the culprit to reside in the considered square

f,g : Constants chosen from past crime to work better

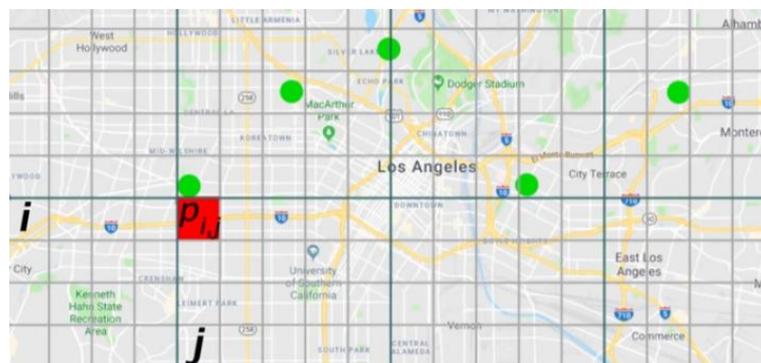
2B : Buffer zone formulated from past crimes.

B : Radius of the buffer zone.

ϕ_{ij} : Constant that is used to add weight to the formulae.

K : Empirically determined constant.

A grid map is taken for study. Here, the map is of Los Angeles. The crime spots are then marked in green. Assume a square in the grid as the residence of the culprit and mark it in Red. The column where the assumed square of the grid is present is marked as 'j' and the row in which it lies is marked as 'i'. P_{ij} is the probability of criminal to reside in the assumed square.

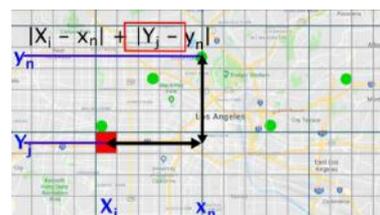


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The Rossmo formula is the summation of N past crimes that occurred in the (x_n, y_n) coordinates in the past.



source:<http://brilliant.org>



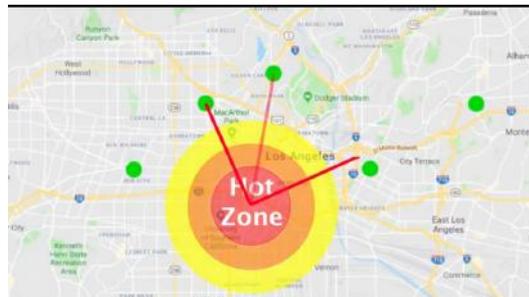
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Necessity of the two terms in the formula:

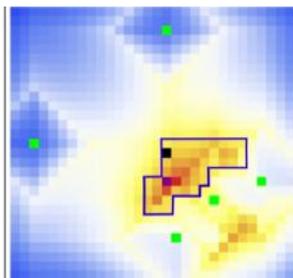
By criminology concept we already assumed that the criminal will not commit crime too close nor too far to the place where he is residing. So, a balance should be maintained in the formula.

- $|X_i - x_n|$: distance of crime scene from square considered in accordance with x axis.
- $|Y_i - y_n|$: distance of crime scene from square considered in accordance with y axis.

Let us consider the denominator of the first term in right hand side. This term is basically the distance between the assumed square and the crime spot. In this term as the distance increases the probability decreases. When we consider the second term, the distance is subtracted from the buffer zone. Therefore as denominator decrease probability of residence increase. This variation maintains a balance in accordance with the assumption made. The steps are repeated for every square in the grid. A heat map is developed with the help of the obtained data.



source:<http://brilliant.org>



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Here, a heat map is given which is developed using Rossmo Formula. This helped in finding out the residence of a 70's serial killer Richard Trenton Chase.

2.1.3 DRAWBACKS AND SUGGESTED MODIFICATION

Challenging human beings is indeed a big deal Here a theoretical concept is manipulated to do the same. Therefore it will have drawbacks. The aspects of human behaviour is complex and uncertain . Rossmo formula is used to track the residing place of the killer. We cannot be cent percent sure about the person to be present there. This increased the chances of modification.

Modification was proposed by Feroz shah Syed , Didong Li , Xun Zhang and Zhenhong Guo. This was about calculating **escape route of criminal** and the **Time and location of next crime**. This could help in strengthening of existing model.

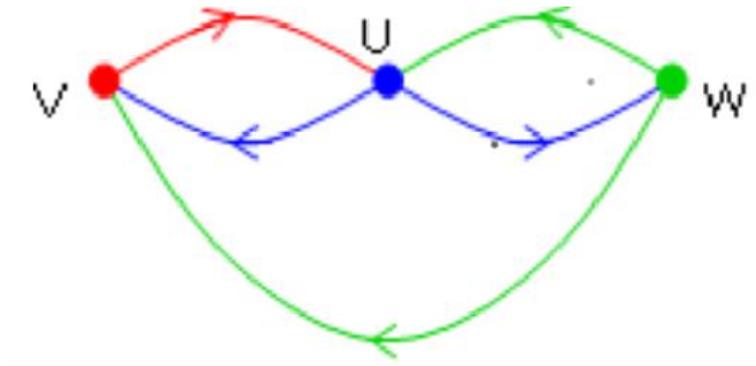
Chapter 3

CRIME PROBLEM USING GRAPH THEORY AND FORENSIC STATISTICS

3.1 GRAPH THEORY

Consider the scenario involving a crime where a jewellery shop has been subjected to robbery .Let us assume the suspects U , V and W as vertices . Assign the colours blue , red and green to the vertices. Suspect U says he is not the robber then lines to be drawn from U to V and W and assign colour blue . Suspect V says U is the robber then there is a line connecting from V to U and assign colour red . Suspect w says he is not the robber then lines to be drawn from W to U and V and assign colour green.

SUSPECTS	INVESTIGATION
U	I am not the robber
V	U is the robber
W	I am not the robber



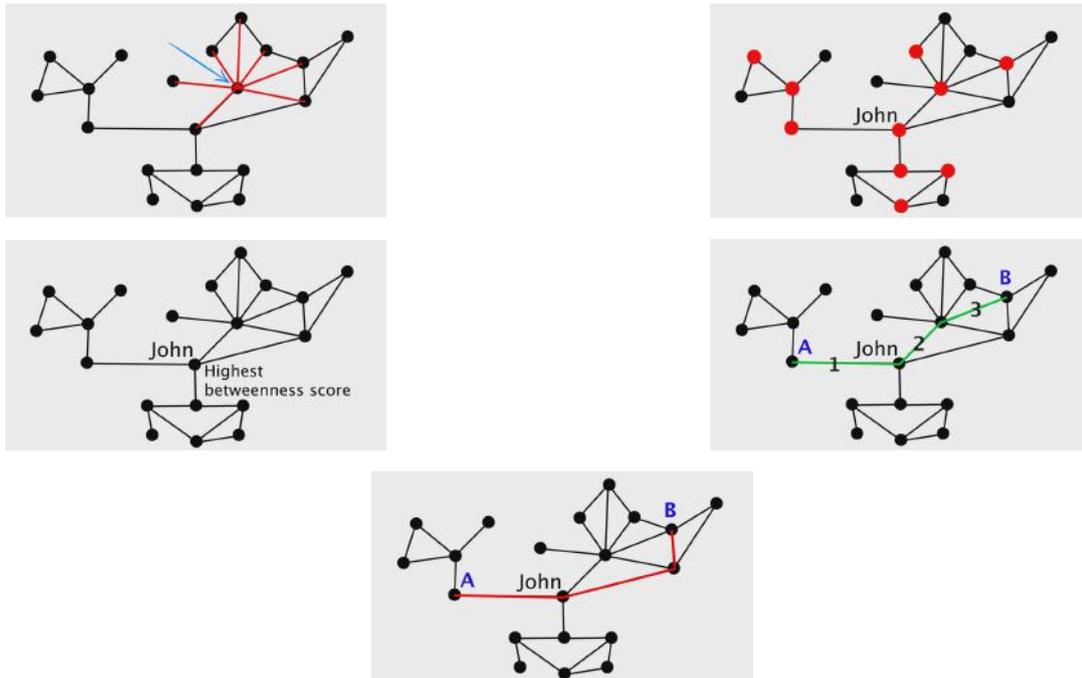
source:international journal of recent technology and engineering

This is the graph showing the connection between the attackers of the 9/11 attack through FBI investigation. What they did to prioritize people by law enforcement can be expressed in a simpler way using graphs.



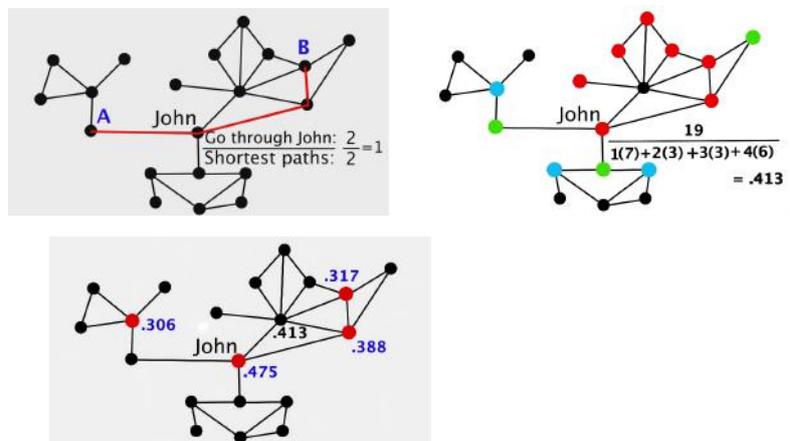
source:<http://brilliant.org>

Let's take the example of a school. All the students are connected in one way or the other whether it be social media, classes they share, close friendship and so on. For any two people let's say they are connected if they are close friends or in close contact with each other.



source:<http://brilliant.org>

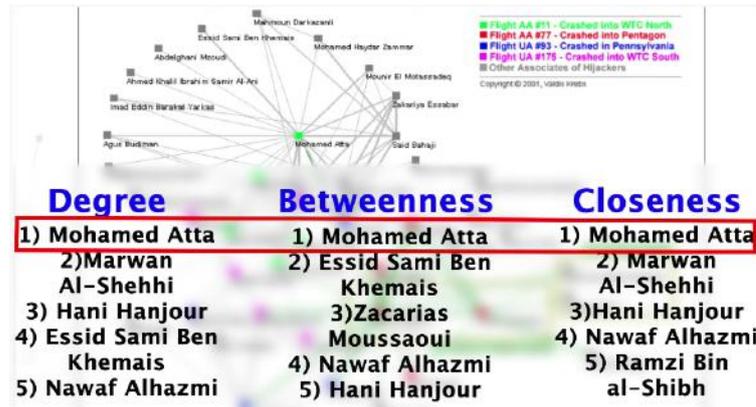
The dot to which the arrow is pointed in the first figure has most connections. But through further analysis we can see that John is the prime connection between the groups, without John no information can be passed. Here comes the importance of highest betweenness score and closeness centrality. Highest betweenness score is the score received to each nodes based on the number of shortest paths that passes through the node. consider the points A and B, the information from A reaches B through John by a number of ways among which two number of ways which is the shortest path with 3 edges. So the betweenness score of John is $\frac{\text{Gothroughjohn}}{\text{Shortestpath}} = \frac{2}{2} = 1$.



source:<http://brilliant.org>

In a connected graph closeness centrality of a node is a measure of centrality in a network calculated as a reciprocal of the sum of the length of the shortest path

between the node and all other nodes in the graph. Thus more central a node is the closer it is to all other nodes. When considering the given graphs the closeness centrality of John is greater compared to others. So from John we trace back to find out from where a news started spreading. Similarly, During 9/11 attack Mohammed Atta was found to have the highest degree, betweenness score and closeness centrality. So, he was the prime link in the attack.



source: <http://brilliant.org>

3.2 FORENSIC STATISTICS

1) A wounded criminal walks away from the crime scene with blood dripping from a wound on his arms forming elongated, elliptical bloodstain of width $7.2mm$ and length $9mm$. What is the walking speed of the criminal?

SOLUTION:

Angle of Impact θ is given by,

$$\sin \theta = \frac{\text{width}}{\text{length}}$$

$$\theta = \sin^{-1} \left(\frac{\text{width}}{\text{length}} \right)$$

$$\theta = \sin^{-1} \left(\frac{7.2}{9} \right)$$

$$\theta = \sin^{-1}(0.8) = 53^\circ$$

As the wound is on his arms we assume the drop height to be $1m$.

Then the vertical impact speed V_g is given by,

$$V_g = \sqrt{2gh}$$

given, $g = 9.8m/s^2$, $h = 1m$

$$V_g = \sqrt{2 \times 9.8 \times 1} = \sqrt{19.6} = 4.43m/s^2$$

when $\theta = 53^\circ$

$\tan \theta = \tan 53^\circ = 1.33$

$$\tan \theta = \left(\frac{V_g}{V_h} \right)$$

The horizontal speed can be calculated by,

$$V_h = \left(\frac{V_g}{\tan \theta} \right)$$

$$V_h = \left(\frac{V_g}{\tan 53^\circ} \right)$$

$$V_h = \frac{4.43}{1.33}$$

$$V_h = 3.33m/s^2$$

2) Magi's DNA profile matched with the DNA evidence discovered at the crime scene. Her identical twin Grace is the defendant. A DNA profile is of a type that is found in only 1 out of a billion people. Check the admissibility of the evidence and evaluate which hypothesis it is in support of.

SOLUTION:

H_p : The DNA source is Grace (Prosecution Hypothesis)

H_d : The DNA source is Magi (Defence Hypothesis)

E: The DNA evidence found matched with Magi's DNA profile.

The chances of a DNA match in siblings is one out of 10,0 whereas identical twins have the same DNA profile. Therefore Grace's DNA profile matches with Magi's DNA profile.

Hence,

$$P\left(\frac{E}{H_p}\right) = P\left(\frac{E}{H_d}\right)$$

Likelihood Ratio

$$LR = \frac{P\left(\frac{E}{H_p}\right)}{P\left(\frac{E}{H_d}\right)}$$

As both the probabilities are equal,

$$LR = 1$$

Since $LR = 1$,

- The evidence is inadmissible concerning the hypotheses.
 - It is neutral and supports neither of the hypotheses.
-

3) Jim is accused of a robbery. The probability that he is innocent is 59%. Timothy, Jim's friend who runs a shop near the crime scene is called on as the prime witness. Timothy's probability of saying the truth is 0.73. The probability of Timothy saying the truth when Jim is guilty is 0.42. What is the probability that Jim is actually guilty if Timothy lied?

SOLUTION:

Defining all the events involved in this problem,

G: Jim is guilty.

G': Jim is innocent.

T: Timothy says the truth.

T': Timothy lies.

$\frac{T}{G}$: Timothy says the truth when Jim is guilty.

$\frac{T'}{G}$: Timothy lies when Jim is guilty.

Here, we need to evaluate $P\left(\frac{G}{T'}\right)$,

$P\left(\frac{G}{T'}\right)$ is the probability of Jim being guilty when Timothy gives a false statement.

Given,

$$P(G) = 1 - 0.59 = 0.41$$

$$P(G') = 0.59$$

$$P(T) = 0.73$$

$$P(T') = 1 - 0.73 = 0.27$$

$$P\left(\frac{T}{G}\right) = 0.42$$

$$\begin{aligned} P\left(\frac{T'}{G}\right) &= 1 - P\left(\frac{T}{G}\right) \\ &= 1 - 0.42 = 0.58 \end{aligned}$$

$$P\left(\frac{G}{T'}\right) = \frac{P\left(\frac{T'}{G}\right) \times P(G)}{P(T')}$$

Substituting the values, we get,

$$P\left(\frac{G}{T'}\right) = \frac{0.58 \times 0.41}{0.27}$$

$$P\left(\frac{G}{T'}\right) = \frac{0.23}{0.27}$$

$$P\left(\frac{G}{T'}\right) = 0.88$$

Hence, the probability that Jim is guilty given Timothy says the truth is 0.88.

Chapter 4

CONTROLLING CRIME BY ANALYSING DATA MANIPULATION

In this fast moving world data plays pivotal role in day to day human activities. Data is considered as a resource, crime containing data manipulation must be strictly monitored and stringent actions must be taken against those fraudulent activities. As data is not merely a group of things or numbers but an asset.

4.1 BENFORD'S LAW

4.1.1 INTRODUCTION

In 1981, Canadian-American astronomer Simon Newcomb found out that the former pages of logarithmic table were much worn when compared to other pages. He published a result that the probability of a single number N being the leading digit of a number is $\log(N+1) - \log(N)$ based on his observation.

This was noticed by Frank Benford in 1938, a physicist and he tested the data from 20 different domains including surface area of 335 rivers, 104 physical constants, 1800 molecular weights, 308 numbers contained in an issue of Reader's digest etc. Total 20229 observations were used. Hence this discovery was named after Benford.

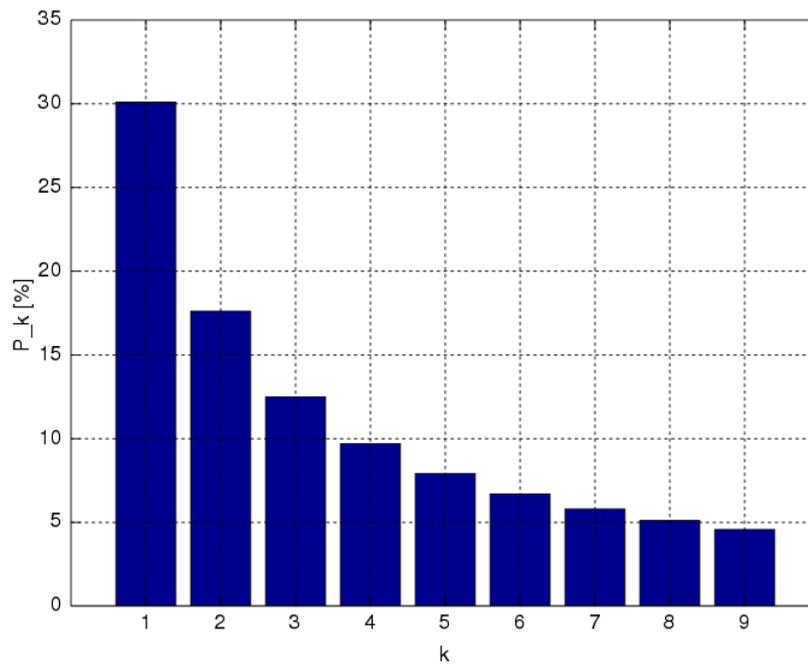
4.1.2 THEORY

Benford's law also known as Newcomb-Benford's law, law of Anomalous number or First digit law. Benford's law states that in a set of natural numbers the leading digit is more likely to be the number 1 the likelihood of leading digit be any other number decreases as it gets closer to number 9. Benford's law predicts the occurrence of digits in large sets of data. This law maintains that we can expect some digits to occur more often than other digits. For sets obeying Benford's law the number 1 appears as leading digit about 30% while the number 9 appears as leading digit less than 5%.

4.1.3 BENFORD'S LAW CONDITIONS

- The numbers in the data set should be the same objects -We cannot apply Benford's law when two different objects data is combined as one data set.
- There should be no built-in maximum or minimum to the numbers -We cannot apply Benford's law when the number is having a maximum or minimum limit.
- The numbers should not be assigned - In case of phone number, invoice number, car numbers Benford's law cannot be applied as they are assigned numbers.
- Does not apply for Uniform Distribution -In uniform distribution the occurrence of each number is about 11%

4.1.4 DISTRIBUTION OF FIRST DIGIT ACCORDING TO BENFORD'S LAW



source:<http://wikipedia.org>

- Each bar represents digits from 1 to 9
- Height of the bar is the percentage if the numbers that start with the digit.

d	$P(d)$	Relative size of $P(d)$
1	30.1%	
2	17.6%	
3	12.5%	
4	9.7%	
5	7.9%	
6	6.7%	
7	5.8%	
8	5.1%	
9	4.6%	

source:<http://wikipedia.org>

A set of numbers is said to satisfy Benford's Law if the leading digit $[d=1,2,\dots,9]$ occurs with probability

$$p(d) = \log_{10}(d+1) - \log_{10}(d) = \log_{10}[(d+1)/d] = \log_{10}(1 + 1/d)$$

4.2 APPLICATIONS

Live case study

From NSE 13th December data is taken. We will look into the total traded value, applied Benford's law then we will see that the real data set is exactly falling into these percentage. And a comparison between what Benford is saying and actual data is done.

	A	J	N	O	P	Q	R	S	T	U
1	SYMBOL	TOTTRDVAL	Ist Digit		Digit	Actual	Actual %	Benford	Diff	
2	20MICRONS	40,47,865	4		1	645	29.45%	30.10%	-0.07%	
3	21STCENMGM	5,71,621	5		2	384	17.53%	17.61%	-0.08%	
4	3IINFOLD	38,11,94,542	3		3	279	12.74%	12.49%	0.25%	
5	3MINDIA	2,98,51,519	2		4	207	9.45%	9.69%	-0.24%	
6	3PLAND	4,32,727	4		5	192	8.77%	7.92%	1%	
7	5PAISA	1,21,21,324	1		6	153	6.99%	6.69%	0.30%	
8	610GS2031	50,000	5		7	133	6.07%	5.80%	0.27%	
9	63MOONS	65,71,181	6		8	90	4.11%	5.12%	-1.01%	
10	667GS2050	69,700	6		9	107	4.89%	4.58%	0.31%	
11	676GS2061	1,91,910	1			2,190.0				
12	716GS2050	218	2							
13	762GS2039	10,158	1							
14	772GS2055	44,440	4							
15	795GS2032	110	1							
16	A2ZINFRA	28,48,616	2							
17	AAATECH	1,89,000	1							
18	AAKASH	3,18,06,428	3							
19	AAREYDRUGS	14,22,431	1							
20	AARON	16,72,841	1							
21	AARTIDRUGS	56,89,59,966	5							
22	AARTIIND	1,15,71,37,035	1							
23	AARTISURF	1,24,06,141	1							
24	AARVEEDEN	4,51,112	4							

Inference

The difference is matching (not even 0.5%). When the difference is more than 1% or 2%. It doesn't mean a fraud, it could alarm the auditor.

Spreadsheet functions

- Extract the 1st digit out of the database [=LEFT(J2)] click enter
- Column for digits 1 to 9
- Actual frequency column (how many times the digit appearing in the beginning) [COUNTIF] Actual percentage (Actual/Total) \times 100 [Q2/Q11(F4)]
- Benford's percentage [=log10(1/P2+1)]
- Difference (Actual - Benford)

4.2.1 OTHER APPLICATIONS

- Accounting Fraud detection
- Use in Criminal Trails.
- Election Data
- Genome Data
- Scientific Fraud Detection economic Data Digit Analysis

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Project Report

On

QUEUING THEORY

Submitted

in partial fulfilment of the requirements for the degree of

BACHELOR OF SCIENCE

in

MATHEMATICS

by

JEAS MARIA C J

(Register No. AB19BMAT035)

Under the Supervision of

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APRIL 2022

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM



CERTIFICATE

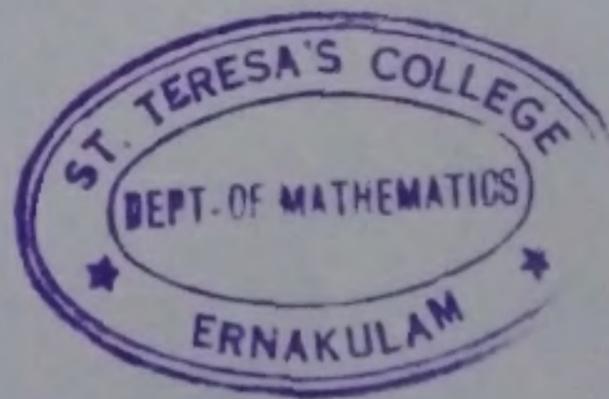
This is to certify that the dissertation entitled, **QUEUING THEORY** is a bonafide record of the work done by Ms. **JEAS MARIA C J** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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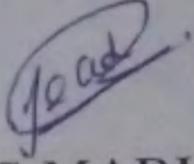
2:

DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of Smt. Betty Jospheh, Associate Professor, Department of Mathematics and Statistics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.

Date: 08.03.2022


JEAS MARIA C J

AB19BMAT035

ACKNOWLEDGEMENT

Firstly I thank God Almighty for giving me his grace to execute the project work successfully. I express my sincere gratitude to our guide Smt. Betty Joseph, Associate Professor of Department of Mathematics and Statistics, St. Teresa's College (Autonomous), Ernakulam, for her valuable guidance throughout the project. I would also like to mention Smt. Neenu Susan Paul, Department of Mathematics and Statistics, St. Teresa's College (Autonomous), Ernakulam, for her help and support.

I do express my gratitude to Dr. Ursula Paul, HOD of Department of Mathematics and Statistics, St. Teresa's College (Autonomous) Ernakulam .

My gratitude to all the other teachers and all those for their valuable support throughout the work.

Ernakulam.

Date: 08.03.2022

JEAS MARIA C J

AB19BMAT035

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INTRODUCTION

Queuing theory is the mathematical study of formation, congestion and purpose of waiting lines .It is observed as a branch of Operations Research because the outcomes are often used for making business decisions about the measures needed to provide a service.

Queuing theory has its origin in 1909 when Professor A K Erlang Danish Mathematician and engineer published his fundamental paper in telephone traffic. He sought to determine how many circuits were needed to provide an acceptable level of telephone service for people not to be " on hold " for too long.



A queue is formed at a queuing system when either customers (human beings or physical entities) requiring service wait due to the number of customers exceeding the number of service facilities or service facilities do not work efficiently and take more time than prescribed to serve a customer.

Queuing theory can be applied to a variety of situations where it is not possible to predict accurately the arrival rate (or time) of customers and service rate (or time) of service facility or facilities. In particular, it can be used to determine the level of service (either the service

rate or the number of service facilities) that balances the following two conflicting costs.

(i) cost of offering the service

(ii) cost incurred due to delay in offering service

Chapter 1

BASICS OF QUEUING THEORY

1.1 Basic Definitions

1.1.1 Queue

A line or sequence of people or items awaiting their turn to be attended or for a service is called a queue.

1.1.2 Customer

A list of items or people that waits for a service is called customer.

1.1.3 Queue Length

Number of customers waiting in a system for service.

1.1.4 Server

Server provides service in the system.

1.2 The Basic Components of a Queue

1.2.1 Arrival process

Arrival defines the way customers enter the system , mostly the customers arrive randomly in between two adjacent arrivals.

1.2.2 Service and Departure process

It defines how long service will take, how many no. of servers are accessible, whether it is in series or parallel. Departure process is a Poisson process with rate that is statistically identical to the arrival process.

1.2.3 The number of servers

The number of servers available to serve the customers in the system. It may be single server or multi-server

1.2.4 The queuing discipline

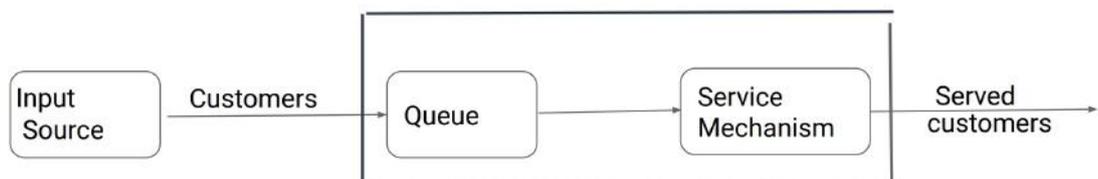
It represents the order in which the customers are selected from the queue for service.

1.2.5 The queue capacity

The number of customers/items the queue can hold

1.2.6 The size of the client population

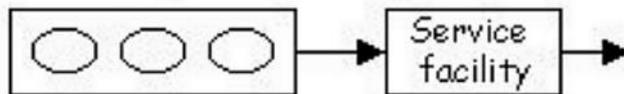
Also known as population size. The size of calling population can be finite or infinite. In case of large population, it is assumed as infinite



1.3 Types of Queues

1.3.1 Single server Single-phase

A waiting line in which single line of customers go through a single waiting line or phase and they are served by a single server. Queues in ATM is an example.



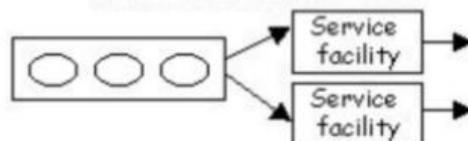
1.3.2 Single server Multi-phase

The system in Which there are multiple number of waiting lines or phase but only one server to serve. Queues in buffet restaurants is an example.



1.3.3 Multi server Single-phase

In this system there will be only one waiting line or phase and they are served by more than one servers. Queues in bank are commonly seen example.

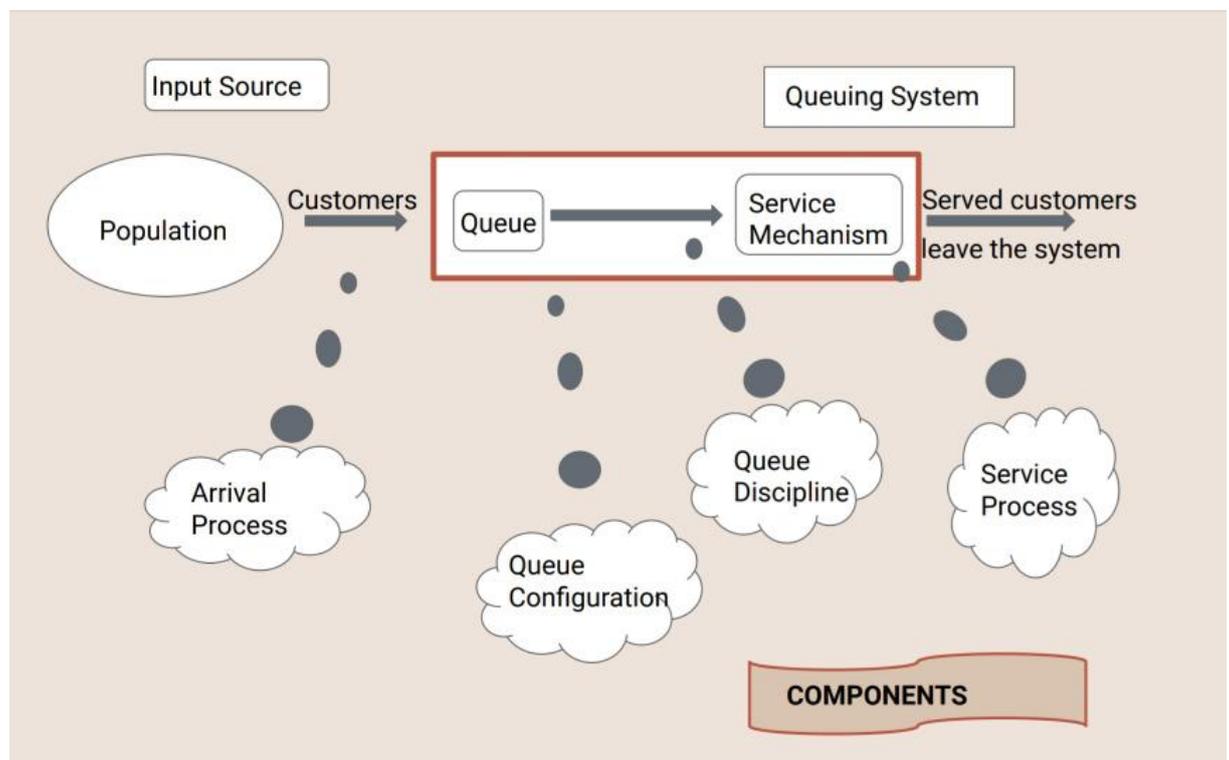


Multi server Multi-phase

Here we have two or more servers for serving multiple number of waiting lines. Supermarket queues are examples.



1.4 Queuing system



1.4.1 Queuing structure

It is the crucial element of queuing system, as it shows the queue discipline, which means the order in which the customers are picked from the queue for service.

1.4.2 Queuing system

Queuing systems are simplified mathematical models to explain congestion.

1.4.3 Components of Queuing systems

- **Input source** - The input source generates customers for the service mechanism. The most important characteristic of the input source is its size. It may be either finite or infinite.
- **Queue** - Queue represents a certain no. of customers waiting for a service.
- **Arrival process** - Arrival defines the way customers enter the system, mostly the arrivals are random intervals between two adjacent arrivals.
- **Queue configuration** - It refers to the queue in the system, their relationship to the servers. A queue may be a single queue or a multiple queue.
- **Queue discipline** - It indicates the order in which members of the queue are selected.

There are mainly three ways for queue discipline

(i) FIFO (First In First Out)

The first customer is served first or first item added will be the first one to be removed.

eg: Ticket supply in theaters

(ii) LIFO (Last In First Out)

The last customer is first or last item added will be the first one to be removed.

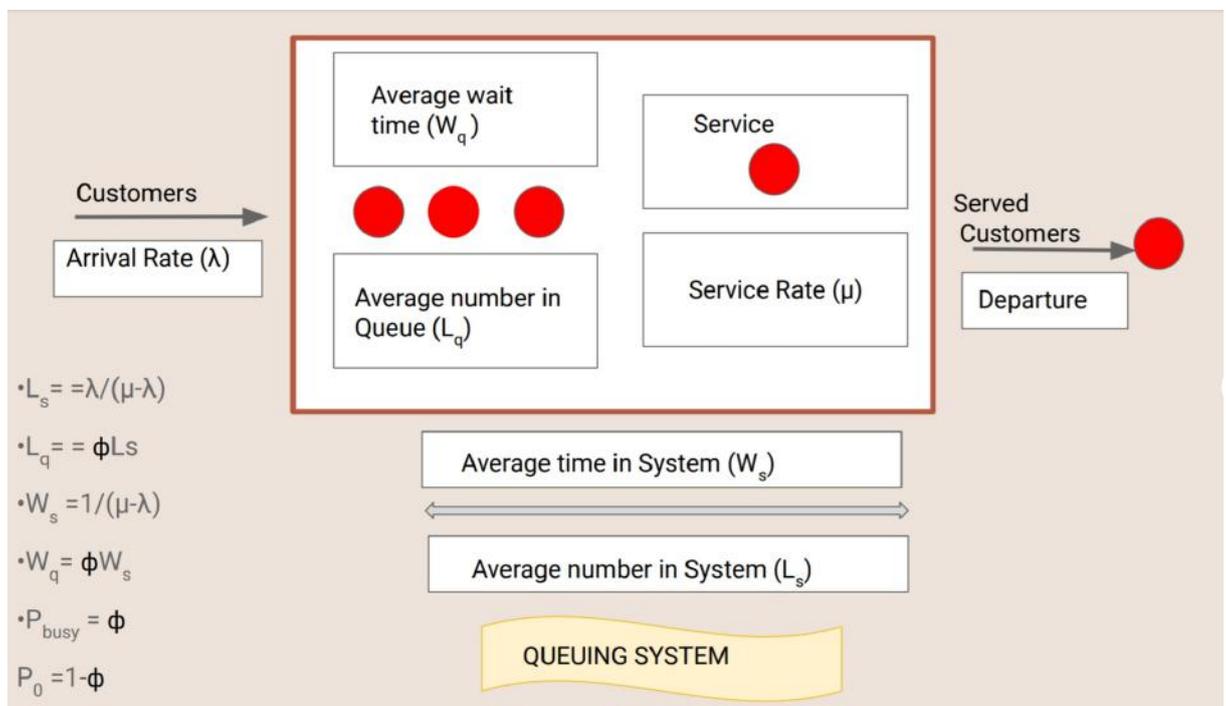
eg: A stack of plates that arrange in a pile

(iii) SIRO (Serve In Random Order)

In this system server selects one of the customers and service is provided randomly.

eg: Entering business

- Service process - It defines how long service will take, how many no. of servers available, whether the servers are in series or parallel.
- Service mechanism - Service represents some activity that takes time and that the customers are waiting for. it may be a real service carried on persons or machines. Typically a service takes random time.



1.5 Basic Terminologies

- Arrival rate (λ): Number of arrivals per unit time.
- Service rate (μ): Rate at which customers are served in the system.

- Utilisation factor (ϕ) : Average time the customers spends in the queue.

$$\phi = \frac{\lambda}{\mu}$$

- L_s = average no. of customers in the system
- P_0 = ideal probability = $1 - \phi$
- L_q = average no. of customers in the queue = ϕL_s
- W_s = average time in the system = $\frac{1}{\mu - \lambda}$
- W_q = average time in the queue = ϕW_s
- P_{busy} = standard busy probability = ϕ



Chapter 2

LAW AND NOTATION

2.1 Kendall's Notation

David George Kendall (15 January 1918 - 23 October 2007), well known English Statistician and Mathematician, known for his work on probability, statistical shape analysis, ley lines and queuing theory.



The standard system that describes and classifies a queuing node. D.G. Kendall proposed this in 1953. A general queuing system is denoted by

$$(P/Q/R) : (X/Y/Z)$$

The parameters of this notation are :

P - Arrival Rate distribution.

Arrival distribution can mainly be of Poisson distribution, Exponential distribution or Markov distribution.

Q - Service Rate distribution.

R - Number of servers.

X - Service discipline.

Y - Minimum number of customers permitted in the system.

Z - Size of the calling source of the customers.

2.1.1 Poisson Distribution

A discrete random variable **X** is said to be follow a Poisson distribution with the parameter λ if it's p.d.f is given by

$$f(x) = \frac{e^{-\lambda} \lambda^x}{x!}, \text{ when } x = 0, 1, 2, \dots (\lambda \text{ greater than } 0)$$

$$f(x) = 0, \text{ elsewhere}$$

x-number of occurrences

x = 0, 1, 2...

e-Euler's number (e=2.71828...)

Mean = λ

Variance = λ

Skewness = $\frac{1}{\sqrt{\lambda}}$

Kurtosis = λ^{-1}

MGF = $\exp[\lambda(e^t - 1)]$

$\lambda = E(X) = Var(X)$

2.1.2 Exponential Distribution

A continuous random variable X is said to follow exponential distribution with parameter λ (λ greater than 0) if it's p.d.f is given by

$$f(x) = \lambda e^{-\lambda x}, \text{ when } x \text{ greater than or equal to } 0$$

$$f(x) = 0, \text{ elsewhere}$$

x - No. of occurrences, $x = 0, 1, 2, \dots$

e - Euler's number, $e = 2.71828\dots$

Mean = λ^{-1}

Variance = λ^{-2}

Skewness = 2

Kurtosis = 6

MGF = $(1 - \frac{t}{\lambda})^{-1}$

2.1.3 Markovian Distribution

A mathematical model for the time between job arrivals to a system. Markov process is a stochastic process which is used to analyse decision problems in which the occurrence of a specific event depends on the occurrence of the event immediately prior to the current event. Basically Markov process help us to identify

- (i) A specific state of the system being studied, and
- (ii) The state - transition relationship.

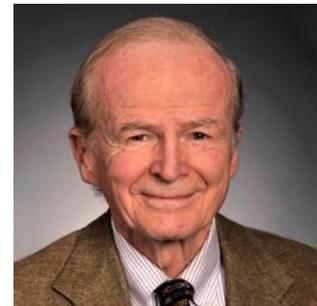
The occurrence of an event at a specified point in time (say, period n) put the system in a given state, say E_n . If, after the passage of one time unit, another event occurs (during time period $n+1$), the system has moved from state E_n to state E_{n+1} .

$$f(x) = \lambda e^{-\lambda x}, x \geq 0$$

2.2 Little's Law

Queuing Theory is a daily life applicable study that helps to work more easier in the queues. Waiting in line is a common process in daily life. Some theorems and laws were introduced to ensure the queues more effective. One of the theorem is Little Law.

John Little introduced Little Law in 1964. Initially, Little had not published the proof of the theorem. However in 1961, he published the proof.



Little law is a theorem that determines the average number of items in a stationary queuing system, based on the average waiting time of an item within a system and the average number of items arriving at the system per unit of time.

Little law states that the average number of customers in a queuing system is equal to their product of average arrival rate and average amount of time they spent in the system.

In other words, we can say that

Number of items in the queue = Arrival rate x Average time spent in the queue

$$L = \lambda W$$

L - stands for the number of items inside the queuing system. It is

also known as WIP which means work in progress.

λ - Arrival rate and departure rate of items in and out of the system.

W - Average amount of time an item spends in the system.

Chapter 3

QUEUING MODELS

3.1 Model 1 - $(M/M/1) : (GD/\infty/\infty)$

The parameters of the model :

- M - Arrival rate follows Poisson distribution.
- M - Service rate follows Poisson distribution.
- 1- Number of servers is one.
- GD - Service discipline is general.
- ∞ - Maximum number of customers permitted in the system is infinite.
- ∞ - Size of the calling source Infinite.

The steady-state formula to obtain the probability of having n customers in the system P_n are

$$P_n = (1 - \phi) \phi^n$$

$$L_s = \frac{\phi}{1-\phi}$$

$$L_q = L_s - \left(\frac{\lambda}{\mu}\right) = \frac{\phi^2}{(1-\phi)}$$

$$W_s = \frac{L_s}{\lambda} = \frac{\phi}{(1-\phi)\mu} = \frac{1}{\mu-\lambda}$$

$$W_q = \frac{L_q}{\lambda} = \frac{\phi}{\mu - \lambda}$$

Using the notation of the general model, we have

$$\lambda_0 = \lambda$$

$$\mu_0 = \mu$$

Also $\lambda_{eff} = \lambda$ and $\lambda_{lost} = 0$, because all arriving customers can join the system.

Letting $\rho = \frac{\lambda}{\mu}$, the expression for p_n in the generalised model reduces to

$$p_n = \rho^n p_0, n = 0, 1, 2, \dots$$

To determine the value of p_0 , we use the identity

$$p_0 (1 + \rho + \rho^2 + \dots) = 1$$

The sum of the geometric series is $\left(\frac{1}{1-\rho}\right)$, provided $\rho < 1$. Thus

$$\rho = 1 - \rho, \rho < 1$$

The general formula for p_n is thus given by the following geometric distribution

$$p_n = (1 - \rho) \rho^n, n = 1, 2, \dots (\rho < 1)$$

The mathematical derivation of p_n imposes the condition $\rho < 1$, or $\lambda < \mu$. If $\lambda \geq \mu$, the geometric series diverges, and the steady-state probabilities p_n do not exist. This result makes the intuitive sense, because unless the service rate is larger than the arrival rate, queue length will continually increase and no steady state can be reached.

The measure of performance L_q can be derived in the following manner :

$$\begin{aligned} L_s &= \sum_{n=0}^{\infty} np_n = \sum_{n=0}^{\infty} n(1-\rho)\rho^n \\ &= (1-\rho)\rho \frac{d}{d\rho} \sum_{n=0}^{\infty} \rho^n \\ &= (1-\rho)\rho \frac{d}{d\rho} \left(\frac{1}{1-\rho} \right) \\ &= \frac{\rho}{1-\rho} \end{aligned}$$

Because $\lambda_{eff} = \lambda$ for the present situation, the remaining measures of performances are computed using the relationships. Thus,

$$\begin{aligned} W_s &= \frac{L_s}{\lambda} = \frac{1}{\mu(1-\rho)} = \frac{1}{\mu-\lambda} \\ W_q &= W_s - \frac{1}{\mu} = \frac{\rho}{\mu(1-\rho)} \\ L_q &= \lambda W_q = \frac{\rho^2}{1-\rho} \\ \bar{c} &= L_s - L_q = \rho \end{aligned}$$

Example : The arrival rate of customers at a banking counter follows Poisson distribution with a mean of 45 per hour. The service rate of the counter clerk also follows Poisson distribution with a mean of 60 per hour.

1. What is the probability of having 0 customers in the system?
2. What is the probability of having 5 customers in the system?
3. What is the probability of having 10 customers in the system?
4. Find L_s, L_q, W_s, W_q ?

Solution : We have

$$\begin{aligned} \text{Arrival rate, } \lambda &= 45 \text{ per hour} \\ \text{Service rate, } \mu &= 60 \text{ per hour} \\ \text{Utilisation factor, } \phi &= \frac{\lambda}{\mu} = \frac{45}{60} = 0.75 \end{aligned}$$

1. $P_0 = 1 - \phi = 1 - 0.75 = 0.25$
2. $P_5 = (1 - \phi) \phi^5 = (1 - 0.75)0.75^5 = 0.593$
3. $P_{10} = (1 - \phi) \phi^{10} = (1 - 0.75)0.75^{10} = 0.0141$
4. $L_s = \frac{\phi}{1-\phi} = \frac{0.75}{1-0.75} = 3$ customers
- $L_q = \frac{\phi^2}{(1-\phi)} = \frac{0.75^2}{1-0.75} = 2.25$ customers
- $W_s = \frac{1}{\mu-\lambda} = \frac{1}{60-45} = 0.067$ hours
- $W_q = \frac{\phi}{\mu-\lambda} = \frac{0.75}{60-45} = 0.05$ hours

3.2 Model 2 - (M/M/C) : (GD/∞/∞)

The parameters of this model are given below :

- M - Arrival rate follows Poisson distribution.
- M - Service rate follows Poisson distribution.
- C- Number of servers is C.
- GD - Service discipline is general discipline.
- ∞ - Maximum number of customers permitted in the system is infinite.
- ∞ - Size of the calling source is infinite.

The steady-state formula to obtain the probability of having n customers in the system P_n and the formula for P_0, L_s, L_q, W_q, W_s are presented below:

$$\begin{aligned}
 P_n &= \phi^n n! P_0, \text{ where } 0 \leq n \leq C \\
 &= \phi^n \frac{1}{C^{n-C} C!} P_0, n > C \text{ where } \frac{\phi}{C} < 1 \text{ or } \frac{\lambda}{\mu C} < 1 \\
 P_0 &= \sum_{c+1}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^C}{C!} \left[1 - \left(\frac{\phi}{C} \right) \right]^{-1}
 \end{aligned}$$

$$P_0 = \left[\sum_{n=0}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^c}{C! \left[1 - \frac{\phi}{c}\right]} \right]^{-1}$$

The expression for L_q can be determined as follows:

$$\begin{aligned} L_q &= \sum_{n=c}^{\infty} (n - c) P_n \\ &= \sum_{k=0}^{\infty} K P_{k+c} \\ &= \sum_{k=0}^{\infty} K \frac{\phi^{k+1}}{c^k c!} P_0 \\ &= \frac{\phi^{c+1}}{c! c} P_0 \sum_{k=0}^{\infty} K \left(\frac{\phi}{c}\right)^{k-1} \\ &= \frac{\phi^{c+1}}{c! c} P_0 \frac{d}{d\left(\frac{\phi}{c}\right)} \sum_{k=0}^{\infty} \left(\frac{\phi}{c}\right)^k \\ &= \frac{\phi^{c+1}}{(c-1)!(c-\phi)^2} P_0 \end{aligned}$$

$$L_s = L_q + \phi$$

$$\begin{aligned} W_q &= \frac{L_q}{\lambda} \\ &= \frac{L_q + \phi}{\lambda} \\ &= \frac{L_q}{\lambda} + \frac{\phi}{\lambda} \\ &= W_q + \frac{1}{\mu} \end{aligned}$$

$$W_q = \frac{L_q}{\lambda}$$

Example: At a central ware-house, vehicles arrive at the rate of 18 per hour and the arrival rate follows Poisson distribution. the unloading time of the vehicles follows exponential distribution and the unloading rate is 6 vehicles per hour. There are 4 unloading crews. Find the following:

a) P_0 and P_3

b) L_q, L_s, W_q and W_s

Solution: we have,

Arrival rate, $\lambda = 18$ per hour

Unloading rate, $\mu = 6$ per hour

No. of unloading crews, $C = 4$

$$\phi = \frac{\lambda}{\mu}$$

$$= \frac{18}{6} = 3$$

a) Therefore P_0 is computed as :

$$\begin{aligned} P_0 &= \left[\sum_{n=0}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^c}{C! [1 - \frac{\phi}{c}]} \right]^{-1} \\ &= \left[\sum_{n=0}^3 \frac{3^n}{n!} + \frac{3^4}{4! [1 - \frac{3}{4}]} \right]^{-1} \\ &= \left[\frac{3^0}{3!} + \frac{3^1}{1!} + \frac{3^2}{2!} + \frac{3^3}{3!} + \frac{3^4}{4!(1 - (\frac{3}{4}))} \right]^{-1} \\ &= 0.0377 \end{aligned}$$

Now we have to compute P_3 , we have

$$P_n = \frac{\phi^n}{n!} P_0, 0 \leq n \leq C$$

Therefore,

$$\begin{aligned} P_3 &= \frac{3^3}{6} * 0.0377 \\ &= 0.1697 \end{aligned}$$

b) L_q, L_S, W_q and W_s are computed as under:

$$L_q = \frac{\phi^{c+1}}{(c-1)!(c-\phi)^2} P_0$$

$$\begin{aligned}
&= \frac{3^5}{31 * 1} * 0.0377 \\
&= 1.53 = 2 \text{ vehicles} \\
L_s &= L_q + \phi \\
&= 1.53 + 3 \\
&= 4.53 = 5 \text{ vehicles} \\
W_q &= \frac{L_q}{\lambda} \\
&= \frac{1.53}{18} \\
&= 0.252 \text{ hour} = 5.1 \text{ minutes} \\
W_s &= W_q + \frac{1}{\mu} \\
&= 0.085 + \frac{1}{6} \\
&= 0.252 \text{ hours} = 15.12 \text{ minutes}
\end{aligned}$$

3.3 Model 3 - (M/M/1) : (GD/N/∞)

The parameters of this model are given below:

- M - Arrival rate follows Poisson's distribution.
- M - Service rate follows Poisson's distribution.
- 1 - Number of servers is one.
- GD - Service discipline is general discipline.
- N - Maximum number of customers permitted in the system is N.
- ∞ Size of calling source is infinite.

This model differ from (M/M/1):(GD/∞/∞) in that there is a limit N on the number in the system (maximum queue length=N-1) .Examples include manufacturing situations in which a machine may have a limited buffer space and a one-lane drive-in window in a fast-food restaurant .New arrivals are not allowed when the number of customers in the

system reaches N . Thus,

$$\lambda_n = \begin{cases} \lambda, n = 0, 1, \dots, N - 1 \\ 0, n = N, N + 1 \end{cases}$$

$$\mu_n = \mu, n = 0, 1, \dots$$

the value of P_0 is determined from the equation

$\sum_{n=0}^{\infty} P_n = 1$, which yields

$$P_0(1 + p + p^2 + \dots + p^N) = 1$$

or

$$p_0 = \begin{cases} \frac{1-\phi}{1-\phi^{N+1}}, \phi \neq 1 \\ \frac{1-\phi}{1-\phi^{N+1}}, \phi = 1 \end{cases}$$

The steady-state formula to obtain the probability of having n customers in the system P_n and the formula for P_0, L_s, L_q, W_s and W_q are represented below.

$$\begin{aligned} P_N &= \frac{1-\phi}{1-\phi^{N+1}} \phi^N, \phi \neq 1 \text{ and } N = 0, 1, 2, \dots, n \\ &= \frac{1}{N+1}, \phi = 1 \end{aligned}$$

The expected number of customers in the system is computed as

$$\begin{aligned}
 L_s &= \sum_{n=1}^N nP_n \\
 &= \frac{1-\phi}{1-\phi^{N+1}} \sum_{n=0}^N n\phi^n \\
 &= \left(\frac{1-\phi}{1-\phi^{N+1}}\right)\phi \frac{d}{d\phi} \sum_{n=0}^N \phi^n \\
 &= \left(\frac{1-\phi}{1-\phi^{N+1}}\phi\right) \frac{d}{d\phi} \left(\frac{1-\phi^{N+1}}{1-\phi}\right) \\
 &= \frac{\phi[1-(N+1)\phi^N + N\phi^{N+1}]}{(1-\phi)(1-\phi^{N+1})}, \phi \neq 1 \\
 &= \frac{N}{2}, \phi \neq 1 \\
 \lambda_{eff} &= \lambda(1-P_N) \\
 L_q &= L_s - \frac{\lambda_{eff}}{\mu} \\
 &= L_s - \frac{\lambda(1-P_N)}{\mu} \\
 W_q &= \frac{L_q}{\lambda_{eff}} \\
 &= \frac{L_q}{\lambda(1-P_N)} \\
 W_s &= W_s + \frac{1}{\mu} \\
 &= \frac{L_q}{\lambda_{eff}} \\
 &= \frac{L_q}{\lambda(1-P_N)}
 \end{aligned}$$

Example: Cars arrive at a drive-in restaurant with a mean arrival rate of 24 cars per hour and the service rate of the cars is 20 cars per hour. The arrival rate and the service rate follows Poisson distribution. The number of parking spaces for cars is only 4. Find the standard results of this system.

Solution:

Here ,Arrival rate, $\lambda = 24$ cars per hour

Service rate, $\mu = 20$ cars per hour

$N = 4$

$$\begin{aligned}\phi &= \frac{\lambda}{\mu} \\ &= \frac{24}{20} = \mathbf{1.2}\end{aligned}$$

Therefore we get,

$$L_s = \frac{\phi[1-(N+1)\phi^N + N\phi^{N+1}]}{(1-\phi)(1-\phi^{N+1})} = \frac{1.2[1-(4+1)1.2^4 + 4*1.2^5]}{(1-1.2)(1-1.2^5)} = 2.3 \text{ cars}$$

and

$$\begin{aligned}P_N &= \frac{1-\phi}{1-\phi^{N+1}}\phi^N \\ &= \left(\frac{1-1.2}{1-1.2^5}\right) * 1.2^4 = 0.2787 \text{ cars}\end{aligned}$$

the other results are:

$$\begin{aligned}\lambda_{eff} &= \lambda(1 - P_N) \\ &= 24(1-0.2787) \\ &= \mathbf{17.3112 \text{ per hour}}\end{aligned}$$

$$\begin{aligned}L_q &= L_s - \frac{eff}{\mu} \\ &= 2.36 - \left(\frac{17.3112}{20}\right) \\ &= \mathbf{1.494 \text{ cars}}\end{aligned}$$

$$\begin{aligned}W_q &= \frac{L_q}{\lambda_{eff}} \\ &= \frac{1.494}{17.3112} \\ &= \mathbf{0.0863 \text{ hours}} \\ &= \mathbf{5.2 \text{ min}}\end{aligned}$$

$$\begin{aligned}W_s &= \frac{L_s}{\lambda_{eff}} \\ &= \frac{2.36}{17.3112} \\ &= 0.1363 \text{ hours} \\ &= 8.2 \text{ min}\end{aligned}$$

Chapter 4

APPLICATIONS

4.1 Daily Life Applications

SITUATION	CUSTOMERS	SERVICE
Clinic	Patients	Doctors
Job interviews	Applicants	Experts
Railway station	Travelers	Ticket window
Bank counter	Account holders	Counter clerk
Airport runways	Planes	Runway
Telephone booth	Customers	Telephone
Ration shop	Ration card holders	Shop clerk
ATM counters	Customers	ATM machine
Toll plaza	Vehicles	Toll collectors
Emigration department	Travelers	Emigration officers
Traffic system	Vehicles	Signal point
Supermarkets	Customers	Workers
Computer center	Programs	Computer
Library	Students	Counter clerk
Maintenance shop	Breakdown machines	Machines
Photostat shop	Papers	Photostat machine

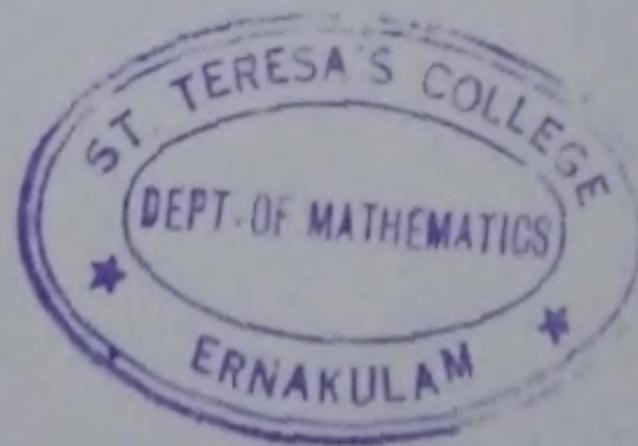
- Queuing theory has a important role in casualties of hospital
- It is useful in evaluating the impact of breakdown down of disasters
- It is really helpful in making business decisions
- If we consider the rain in monsoon season in India then the waiting days for getting the rain is a queue, here days are the customers and the sky is the server.
- As Covid-19 cases increasing day by day, vaccination centres need to provide more number of servers to avoid congestion of people.

CONCLUSION

Queues are very common in our society. Every person has to stand in a queue atleast once. Queuing theory helps in enhancing business strategies. From this project, we can conclude that, when the Average Service Rate μ is greater than Average Arrival rate λ , the customers are served at a faster rate than they arrive and the service will be fast. This theory gives a basic information for successfully designing queuing systems that acheives a healthy balance between arrival rate and service rate.

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and P Umarani
- Operations Research - R.Panneerselvam



Project Report

On

QUEUING THEORY

Submitted

in partial fulfilment of the requirements for the degree of

BACHELOR OF SCIENCE

in

MATHEMATICS

by

JEAS MARIA C J

(Register No. AB19BMAT035)

Under the Supervision of

SMT. BETTY JOSEPH



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APRIL 2022

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM



CERTIFICATE

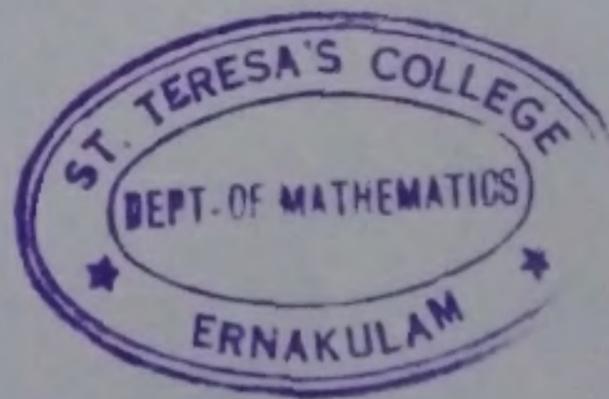
This is to certify that the dissertation entitled, **QUEUING THEORY** is a bonafide record of the work done by Ms. **JEAS MARIA C J** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

Date: 08.03.2022

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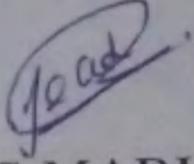
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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of Smt. Betty Joseph, Associate Professor, Department of Mathematics and Statistics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Ernakulam.

Date: 08.03.2022


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ACKNOWLEDGEMENT

Firstly I thank God Almighty for giving me his grace to execute the project work successfully. I express my sincere gratitude to our guide Smt. Betty Joseph, Associate Professor of Department of Mathematics and Statistics, St. Teresa's College (Autonomous), Ernakulam, for her valuable guidance throughout the project. I would also like to mention Smt. Neenu Susan Paul, Department of Mathematics and Statistics, St. Teresa's College (Autonomous), Ernakulam, for her help and support.

I do express my gratitude to Dr. Ursula Paul, HOD of Department of Mathematics and Statistics, St. Teresa's College (Autonomous) Ernakulam .

My gratitude to all the other teachers and all those for their valuable support throughout the work.

Ernakulam.

Date: 08.03.2022

JEAS MARIA C J

AB19BMAT035

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INTRODUCTION

Queuing theory is the mathematical study of formation, congestion and purpose of waiting lines .It is observed as a branch of Operations Research because the outcomes are often used for making business decisions about the measures needed to provide a service.

Queuing theory has its origin in 1909 when Professor A K Erlang Danish Mathematician and engineer published his fundamental paper in telephone traffic. He sought to determine how many circuits were needed to provide an acceptable level of telephone service for people not to be " on hold " for too long.



A queue is formed at a queuing system when either customers (human beings or physical entities) requiring service wait due to the number of customers exceeding the number of service facilities or service facilities do not work efficiently and take more time than prescribed to serve a customer.

Queuing theory can be applied to a variety of situations where it is not possible to predict accurately the arrival rate (or time) of customers and service rate (or time) of service facility or facilities. In particular, it can be used to determine the level of service (either the service

rate or the number of service facilities) that balances the following two conflicting costs.

(i) cost of offering the service

(ii) cost incurred due to delay in offering service

Chapter 1

BASICS OF QUEUING THEORY

1.1 Basic Definitions

1.1.1 Queue

A line or sequence of people or items awaiting their turn to be attended or for a service is called a queue.

1.1.2 Customer

A list of items or people that waits for a service is called customer.

1.1.3 Queue Length

Number of customers waiting in a system for service.

1.1.4 Server

Server provides service in the system.

1.2 The Basic Components of a Queue

1.2.1 Arrival process

Arrival defines the way customers enter the system , mostly the customers arrive randomly in between two adjacent arrivals.

1.2.2 Service and Departure process

It defines how long service will take, how many no. of servers are accessible, whether it is in series or parallel. Departure process is a Poisson process with rate that is statistically identical to the arrival process.

1.2.3 The number of servers

The number of servers available to serve the customers in the system. It may be single server or multi-server

1.2.4 The queuing discipline

It represents the order in which the customers are selected from the queue for service.

1.2.5 The queue capacity

The number of customers/items the queue can hold

1.2.6 The size of the client population

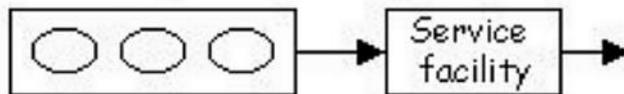
Also known as population size. The size of calling population can be finite or infinite. In case of large population, it is assumed as infinite



1.3 Types of Queues

1.3.1 Single server Single-phase

A waiting line in which single line of customers go through a single waiting line or phase and they are served by a single server. Queues in ATM is an example.



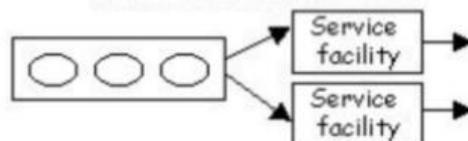
1.3.2 Single server Multi-phase

The system in Which there are multiple number of waiting lines or phase but only one server to serve. Queues in buffet restaurants is an example.



1.3.3 Multi server Single-phase

In this system there will be only one waiting line or phase and they are served by more than one servers. Queues in bank are commonly seen example.

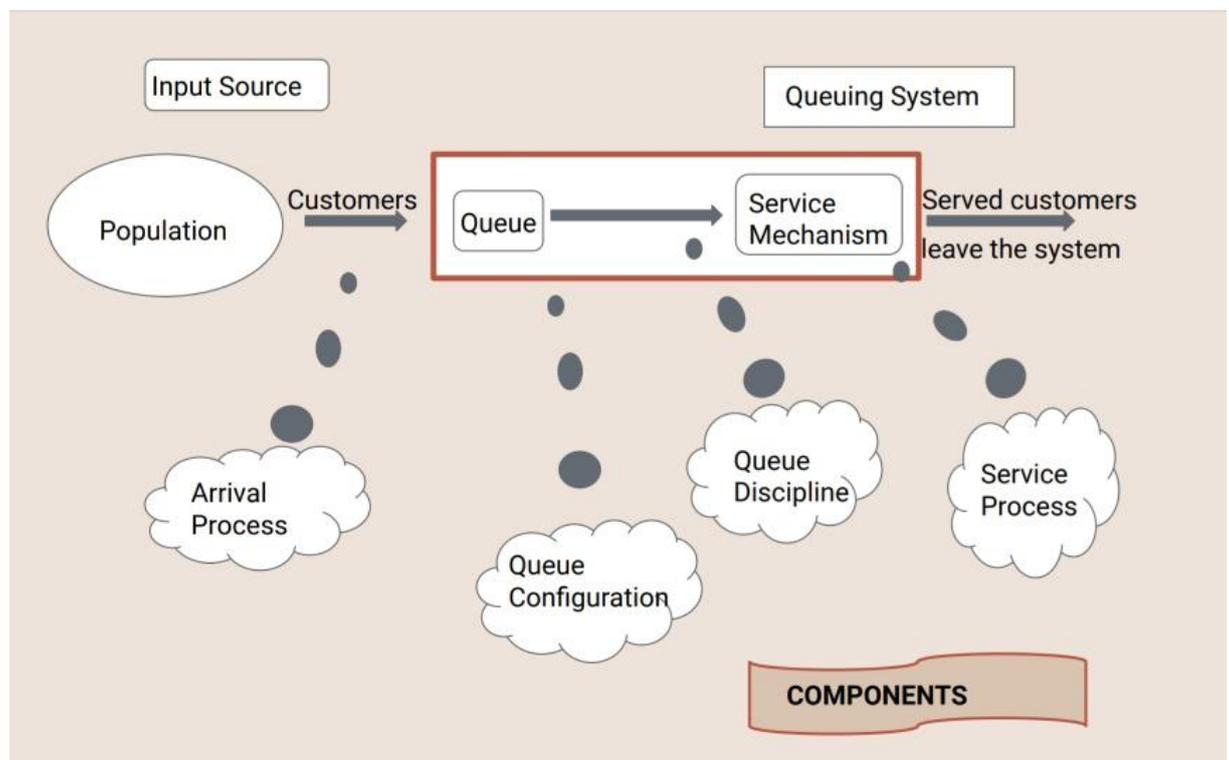


Multi server Multi-phase

Here we have two or more servers for serving multiple number of waiting lines. Supermarket queues are examples.



1.4 Queuing system



1.4.1 Queuing structure

It is the crucial element of queuing system, as it shows the queue discipline, which means the order in which the customers are picked from the queue for service.

1.4.2 Queuing system

Queuing systems are simplified mathematical models to explain congestion.

1.4.3 Components of Queuing systems

- **Input source** - The input source generates customers for the service mechanism. The most important characteristic of the input source is its size. It may be either finite or infinite.
- **Queue** - Queue represents a certain no. of customers waiting for a service.
- **Arrival process** - Arrival defines the way customers enter the system, mostly the arrivals are random intervals between two adjacent arrivals.
- **Queue configuration** - It refers to the queue in the system, their relationship to the servers. A queue may be a single queue or a multiple queue.
- **Queue discipline** - It indicates the order in which members of the queue are selected.

There are mainly three ways for queue discipline

(i) FIFO (First In First Out)

The first customer is served first or first item added will be the first one to be removed.

eg: Ticket supply in theaters

(ii) LIFO (Last In First Out)

The last customer is first or last item added will be the first one to be removed.

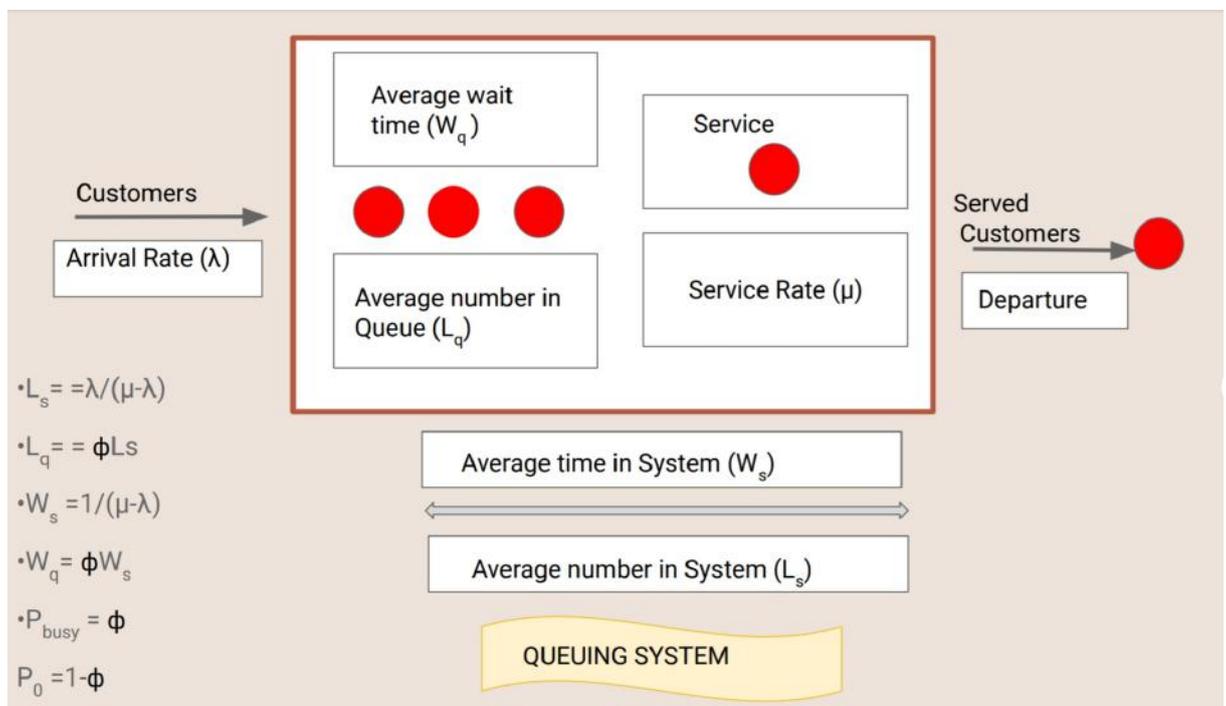
eg: A stack of plates that arrange in a pile

(iii) SIRO (Serve In Random Order)

In this system server selects one of the customers and service is provided randomly.

eg: Entering business

- Service process - It defines how long service will take, how many no. of servers available, whether the servers are in series or parallel.
- Service mechanism - Service represents some activity that takes time and that the customers are waiting for. it may be a real service carried on persons or machines. Typically a service takes random time.



1.5 Basic Terminologies

- Arrival rate (λ): Number of arrivals per unit time.
- Service rate (μ): Rate at which customers are served in the system.

- Utilisation factor (ϕ) : Average time the customers spends in the queue.

$$\phi = \frac{\lambda}{\mu}$$

- L_s = average no. of customers in the system
- P_0 = ideal probability = $1 - \phi$
- L_q = average no. of customers in the queue = ϕL_s
- W_s = average time in the system = $\frac{1}{\mu - \lambda}$
- W_q = average time in the queue = ϕW_s
- P_{busy} = standard busy probability = ϕ



Chapter 2

LAW AND NOTATION

2.1 Kendall's Notation

David George Kendall (15 January 1918 - 23 October 2007), well known English Statistician and Mathematician, known for his work on probability, statistical shape analysis, ley lines and queuing theory.



The standard system that describes and classifies a queuing node. D.G. Kendall proposed this in 1953. A general queuing system is denoted by

$$(P/Q/R) : (X/Y/Z)$$

The parameters of this notation are :

P - Arrival Rate distribution.

Arrival distribution can mainly be of Poisson distribution, Exponential distribution or Markov distribution.

Q - Service Rate distribution.

R - Number of servers.

X - Service discipline.

Y - Minimum number of customers permitted in the system.

Z - Size of the calling source of the customers.

2.1.1 Poisson Distribution

A discrete random variable **X** is said to be follow a Poisson distribution with the parameter λ if it's p.d.f is given by

$$f(x) = \frac{e^{-\lambda} \lambda^x}{x!}, \text{ when } x = 0, 1, 2, \dots (\lambda \text{ greater than } 0)$$

$$f(x) = 0, \text{ elsewhere}$$

x-number of occurrences

x = 0, 1, 2...

e-Euler's number (e=2.71828...)

Mean = λ

Variance = λ

Skewness = $\frac{1}{\sqrt{\lambda}}$

Kurtosis = λ^{-1}

MGF = $\exp[\lambda(e^t - 1)]$

$\lambda = E(X) = Var(X)$

2.1.2 Exponential Distribution

A continuous random variable X is said to follow exponential distribution with parameter λ (λ greater than 0) if it's p.d.f is given by

$$f(x) = \lambda e^{-\lambda x}, \text{ when } x \text{ greater than or equal to } 0$$

$$f(x) = 0, \text{ elsewhere}$$

x - No. of occurrences, $x = 0, 1, 2, \dots$

e - Euler's number, $e = 2.71828\dots$

Mean = λ^{-1}

Variance = λ^{-2}

Skewness = 2

Kurtosis = 6

MGF = $(1 - \frac{t}{\lambda})^{-1}$

2.1.3 Markovian Distribution

A mathematical model for the time between job arrivals to a system. Markov process is a stochastic process which is used to analyse decision problems in which the occurrence of a specific event depends on the occurrence of the event immediately prior to the current event. Basically Markov process help us to identify

- (i) A specific state of the system being studied, and
- (ii) The state - transition relationship.

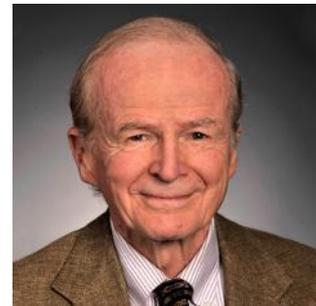
The occurrence of an event at a specified point in time (say, period n) put the system in a given state, say E_n . If, after the passage of one time unit, another event occurs (during time period $n+1$), the system has moved from state E_n to state E_{n+1} .

$$f(x) = \lambda e^{-\lambda x}, x \geq 0$$

2.2 Little's Law

Queuing Theory is a daily life applicable study that helps to work more easier in the queues. Waiting in line is a common process in daily life. Some theorems and laws were introduced to ensure the queues more effective. One of the theorem is Little Law.

John Little introduced Little Law in 1964. Initially, Little had not published the proof of the theorem. However in 1961, he published the proof.



Little law is a theorem that determines the average number of items in a stationary queuing system, based on the average waiting time of an item within a system and the average number of items arriving at the system per unit of time.

Little law states that the average number of customers in a queuing system is equal to their product of average arrival rate and average amount of time they spent in the system.

In other words, we can say that

Number of items in the queue = Arrival rate x Average time spent in the queue

$$L = \lambda W$$

L - stands for the number of items inside the queuing system. It is

also known as WIP which means work in progress.

λ - Arrival rate and departure rate of items in and out of the system.

W - Average amount of time an item spends in the system.

Chapter 3

QUEUING MODELS

3.1 Model 1 - $(M/M/1) : (GD/\infty/\infty)$

The parameters of the model :

- M - Arrival rate follows Poisson distribution.
- M - Service rate follows Poisson distribution.
- 1- Number of servers is one.
- GD - Service discipline is general.
- ∞ - Maximum number of customers permitted in the system is infinite.
- ∞ - Size of the calling source Infinite.

The steady-state formula to obtain the probability of having n customers in the system P_n are

$$P_n = (1 - \phi) \phi^n$$

$$L_s = \frac{\phi}{1-\phi}$$

$$L_q = L_s - \left(\frac{\lambda}{\mu}\right) = \frac{\phi^2}{(1-\phi)}$$

$$W_s = \frac{L_s}{\lambda} = \frac{\phi}{(1-\phi)\mu} = \frac{1}{\mu-\lambda}$$

$$W_q = \frac{L_q}{\lambda} = \frac{\phi}{\mu - \lambda}$$

Using the notation of the general model, we have

$$\lambda_0 = \lambda$$

$$\mu_0 = \mu$$

Also $\lambda_{eff} = \lambda$ and $\lambda_{lost} = 0$, because all arriving customers can join the system.

Letting $\rho = \frac{\lambda}{\mu}$, the expression for p_n in the generalised model reduces to

$$p_n = \rho^n p_0, n = 0, 1, 2, \dots$$

To determine the value of p_0 , we use the identity

$$p_0 (1 + \rho + \rho^2 + \dots) = 1$$

The sum of the geometric series is $\left(\frac{1}{1-\rho}\right)$, provided $\rho < 1$. Thus

$$\rho = 1 - \rho, \rho < 1$$

The general formula for p_n is thus given by the following geometric distribution

$$p_n = (1 - \rho) \rho^n, n = 1, 2, \dots (\rho < 1)$$

The mathematical derivation of p_n imposes the condition $\rho < 1$, or $\lambda < \mu$. If $\lambda \geq \mu$, the geometric series diverges, and the steady-state probabilities p_n do not exist. This result makes the intuitive sense, because unless the service rate is larger than the arrival rate, queue length will continually increase and no steady state can be reached.

The measure of performance L_q can be derived in the following manner :

$$\begin{aligned} L_s &= \sum_{n=0}^{\infty} np_n = \sum_{n=0}^{\infty} n(1-\rho)\rho^n \\ &= (1-\rho)\rho \frac{d}{d\rho} \sum_{n=0}^{\infty} \rho^n \\ &= (1-\rho)\rho \frac{d}{d\rho} \left(\frac{1}{1-\rho} \right) \\ &= \frac{\rho}{1-\rho} \end{aligned}$$

Because $\lambda_{eff} = \lambda$ for the present situation, the remaining measures of performances are computed using the relationships. Thus,

$$\begin{aligned} W_s &= \frac{L_s}{\lambda} = \frac{1}{\mu(1-\rho)} = \frac{1}{\mu-\lambda} \\ W_q &= W_s - \frac{1}{\mu} = \frac{\rho}{\mu(1-\rho)} \\ L_q &= \lambda W_q = \frac{\rho^2}{1-\rho} \\ \bar{c} &= L_s - L_q = \rho \end{aligned}$$

Example : The arrival rate of customers at a banking counter follows Poisson distribution with a mean of 45 per hour. The service rate of the counter clerk also follows Poisson distribution with a mean of 60 per hour.

1. What is the probability of having 0 customers in the system?
2. What is the probability of having 5 customers in the system?
3. What is the probability of having 10 customers in the system?
4. Find L_s, L_q, W_s, W_q ?

Solution : We have

$$\begin{aligned} \text{Arrival rate, } \lambda &= 45 \text{ per hour} \\ \text{Service rate, } \mu &= 60 \text{ per hour} \\ \text{Utilisation factor, } \phi &= \frac{\lambda}{\mu} = \frac{45}{60} = 0.75 \end{aligned}$$

1. $P_0 = 1 - \phi = 1 - 0.75 = 0.25$
2. $P_5 = (1 - \phi) \phi^5 = (1 - 0.75)0.75^5 = 0.593$
3. $P_{10} = (1 - \phi) \phi^{10} = (1 - 0.75)0.75^{10} = 0.0141$
4. $L_s = \frac{\phi}{1-\phi} = \frac{0.75}{1-0.75} = 3$ customers
- $L_q = \frac{\phi^2}{(1-\phi)} = \frac{0.75^2}{1-0.75} = 2.25$ customers
- $W_s = \frac{1}{\mu-\lambda} = \frac{1}{60-45} = 0.067$ hours
- $W_q = \frac{\phi}{\mu-\lambda} = \frac{0.75}{60-45} = 0.05$ hours

3.2 Model 2 - (M/M/C) : (GD/∞/∞)

The parameters of this model are given below :

- M - Arrival rate follows Poisson distribution.
- M - Service rate follows Poisson distribution.
- C- Number of servers is C.
- GD - Service discipline is general discipline.
- ∞ - Maximum number of customers permitted in the system is infinite.
- ∞ - Size of the calling source is infinite.

The steady-state formula to obtain the probability of having n customers in the system P_n and the formula for P_0, L_s, L_q, W_q, W_s are presented below:

$$\begin{aligned}
 P_n &= \phi^n n! P_0, \text{ where } 0 \leq n \leq C \\
 &= \phi^n \frac{1}{C^{n-C} C!} P_0, n > C \text{ where } \frac{\phi}{C} < 1 \text{ or } \frac{\lambda}{\mu C} < 1 \\
 P_0 &= \sum_{c+1}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^C}{C!} \left[1 - \left(\frac{\phi}{C} \right) \right]^{-1}
 \end{aligned}$$

$$P_0 = \left[\sum_{n=0}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^c}{C! \left[1 - \frac{\phi}{c}\right]} \right]^{-1}$$

The expression for L_q can be determined as follows:

$$\begin{aligned} L_q &= \sum_{n=c}^{\infty} (n - c) P_n \\ &= \sum_{k=0}^{\infty} K P_{k+c} \\ &= \sum_{k=0}^{\infty} K \frac{\phi^{k+1}}{c^k c!} P_0 \\ &= \frac{\phi^{c+1}}{c! c} P_0 \sum_{k=0}^{\infty} K \left(\frac{\phi}{c}\right)^{k-1} \\ &= \frac{\phi^{c+1}}{c! c} P_0 \frac{d}{d\left(\frac{\phi}{c}\right)} \sum_{k=0}^{\infty} \left(\frac{\phi}{c}\right)^k \\ &= \frac{\phi^{c+1}}{(c-1)!(c-\phi)^2} P_0 \end{aligned}$$

$$L_s = L_q + \phi$$

$$\begin{aligned} W_q &= \frac{L_q}{\lambda} \\ &= \frac{L_q + \phi}{\lambda} \\ &= \frac{L_q}{\lambda} + \frac{\phi}{\lambda} \\ &= W_q + \frac{1}{\mu} \end{aligned}$$

$$W_q = \frac{L_q}{\lambda}$$

Example: At a central ware-house, vehicles arrive at the rate of 18 per hour and the arrival rate follows Poisson distribution. the unloading time of the vehicles follows exponential distribution and the unloading rate is 6 vehicles per hour. There are 4 unloading crews. Find the following:

a) P_0 and P_3

b) L_q, L_s, W_q and W_s

Solution: we have,

Arrival rate, $\lambda = 18$ per hour

Unloading rate, $\mu = 6$ per hour

No. of unloading crews, $C = 4$

$$\phi = \frac{\lambda}{\mu}$$

$$= \frac{18}{6} = 3$$

a) Therefore P_0 is computed as :

$$\begin{aligned} P_0 &= \left[\sum_{n=0}^{c-1} \frac{\phi^n}{n!} + \frac{\phi^c}{C! [1 - \frac{\phi}{c}]} \right]^{-1} \\ &= \left[\sum_{n=0}^3 \frac{3^n}{n!} + \frac{3^4}{4! [1 - \frac{3}{4}]} \right]^{-1} \\ &= \left[\frac{3^0}{3!} + \frac{3^1}{1!} + \frac{3^2}{2!} + \frac{3^3}{3!} + \frac{3^4}{4!(1 - (\frac{3}{4}))} \right]^{-1} \\ &= 0.0377 \end{aligned}$$

Now we have to compute P_3 , we have

$$P_n = \frac{\phi^n}{n!} P_0, 0 \leq n \leq C$$

Therefore,

$$\begin{aligned} P_3 &= \frac{3^3}{6} * 0.0377 \\ &= 0.1697 \end{aligned}$$

b) L_q, L_S, W_q and W_s are computed as under:

$$L_q = \frac{\phi^{c+1}}{(c-1)!(c-\phi)^2} P_0$$

$$\begin{aligned}
&= \frac{3^5}{31 * 1} * 0.0377 \\
&= 1.53 = 2 \text{ vehicles} \\
L_s &= L_q + \phi \\
&= 1.53 + 3 \\
&= 4.53 = 5 \text{ vehicles} \\
W_q &= \frac{L_q}{\lambda} \\
&= \frac{1.53}{18} \\
&= 0.252 \text{ hour} = 5.1 \text{ minutes} \\
W_s &= W_q + \frac{1}{\mu} \\
&= 0.085 + \frac{1}{6} \\
&= 0.252 \text{ hours} = 15.12 \text{ minutes}
\end{aligned}$$

3.3 Model 3 - (M/M/1) : (GD/N/∞)

The parameters of this model are given below:

- M - Arrival rate follows Poisson's distribution.
- M - Service rate follows Poisson's distribution.
- 1 - Number of servers is one.
- GD - Service discipline is general discipline.
- N - Maximum number of customers permitted in the system is N.
- ∞ Size of calling source is infinite.

This model differ from (M/M/1):(GD/∞/∞) in that there is a limit N on the number in the system (maximum queue length=N-1) .Examples include manufacturing situations in which a machine may have a limited buffer space and a one-lane drive-in window in a fast-food restaurant .New arrivals are not allowed when the number of customers in the

system reaches N . Thus,

$$\lambda_n = \begin{cases} \lambda, n = 0, 1, \dots, N - 1 \\ 0, n = N, N + 1 \end{cases}$$

$$\mu_n = \mu, n = 0, 1, \dots$$

the value of P_0 is determined from the equation

$\sum_{n=0}^{\infty} P_n = 1$, which yields

$$P_0(1 + p + p^2 + \dots + p^N) = 1$$

or

$$p_0 = \begin{cases} \frac{1-\phi}{1-\phi^{N+1}}, \phi \neq 1 \\ \frac{1-\phi}{1-\phi^{N+1}}, \phi = 1 \end{cases}$$

The steady-state formula to obtain the probability of having n customers in the system P_n and the formula for P_0, L_s, L_q, W_s and W_q are represented below.

$$\begin{aligned} P_N &= \frac{1-\phi}{1-\phi^{N+1}} \phi^N, \phi \neq 1 \text{ and } N = 0, 1, 2, \dots, n \\ &= \frac{1}{N+1}, \phi = 1 \end{aligned}$$

The expected number of customers in the system is computed as

$$\begin{aligned}
 L_s &= \sum_{n=1}^N nP_n \\
 &= \frac{1-\phi}{1-\phi^{N+1}} \sum_{n=0}^N n\phi^n \\
 &= \left(\frac{1-\phi}{1-\phi^{N+1}}\right)\phi \frac{d}{d\phi} \sum_{n=0}^N \phi^n \\
 &= \left(\frac{1-\phi}{1-\phi^{N+1}}\phi\right) \frac{d}{d\phi} \left(\frac{1-\phi^{N+1}}{1-\phi}\right) \\
 &= \frac{\phi[1-(N+1)\phi^N + N\phi^{N+1}]}{(1-\phi)(1-\phi^{N+1})}, \phi \neq 1 \\
 &= \frac{N}{2}, \phi \neq 1 \\
 \lambda_{eff} &= \lambda(1 - P_N) \\
 L_q &= L_s - \frac{\lambda_{eff}}{\mu} \\
 &= L_s - \frac{\lambda(1 - P_N)}{\mu} \\
 W_q &= \frac{L_q}{\lambda_{eff}} \\
 &= \frac{L_q}{\lambda(1 - P_N)} \\
 W_s &= W_s + \frac{1}{\mu} \\
 &= \frac{L_q}{\lambda_{eff}} \\
 &= \frac{L_q}{\lambda(1 - P_N)}
 \end{aligned}$$

Example: Cars arrive at a drive-in restaurant with a mean arrival rate of 24 cars per hour and the service rate of the cars is 20 cars per hour. The arrival rate and the service rate follows Poisson distribution. The number of parking spaces for cars is only 4. Find the standard results of this system.

Solution:

Here ,Arrival rate, $\lambda = 24$ cars per hour

Service rate, $\mu = 20$ cars per hour

$N = 4$

$$\begin{aligned}\phi &= \frac{\lambda}{\mu} \\ &= \frac{24}{20} = \mathbf{1.2}\end{aligned}$$

Therefore we get,

$$L_s = \frac{\phi[1-(N+1)\phi^N + N\phi^{N+1}]}{(1-\phi)(1-\phi^{N+1})} = \frac{1.2[1-(4+1)1.2^4 + 4*1.2^5]}{(1-1.2)(1-1.2^5)} = 2.3 \text{ cars}$$

and

$$\begin{aligned}P_N &= \frac{1-\phi}{1-\phi^{N+1}}\phi^N \\ &= \left(\frac{1-1.2}{1-1.2^5}\right) * 1.2^4 = 0.2787 \text{ cars}\end{aligned}$$

the other results are:

$$\begin{aligned}\lambda_{eff} &= \lambda(1 - P_N) \\ &= 24(1-0.2787) \\ &= \mathbf{17.3112 \text{ per hour}}\end{aligned}$$

$$\begin{aligned}L_q &= L_s - \frac{eff}{\mu} \\ &= 2.36 - \left(\frac{17.3112}{20}\right) \\ &= \mathbf{1.494 \text{ cars}}\end{aligned}$$

$$\begin{aligned}W_q &= \frac{L_q}{\lambda_{eff}} \\ &= \frac{1.494}{17.3112} \\ &= \mathbf{0.0863 \text{ hours}} \\ &= \mathbf{5.2 \text{ min}}\end{aligned}$$

$$\begin{aligned}W_s &= \frac{L_s}{\lambda_{eff}} \\ &= \frac{2.36}{17.3112} \\ &= 0.1363 \text{ hours} \\ &= 8.2 \text{ min}\end{aligned}$$

Chapter 4

APPLICATIONS

4.1 Daily Life Applications

SITUATION	CUSTOMERS	SERVICE
Clinic	Patients	Doctors
Job interviews	Applicants	Experts
Railway station	Travelers	Ticket window
Bank counter	Account holders	Counter clerk
Airport runways	Planes	Runway
Telephone booth	Customers	Telephone
Ration shop	Ration card holders	Shop clerk
ATM counters	Customers	ATM machine
Toll plaza	Vehicles	Toll collectors
Emigration department	Travelers	Emigration officers
Traffic system	Vehicles	Signal point
Supermarkets	Customers	Workers
Computer center	Programs	Computer
Library	Students	Counter clerk
Maintenance shop	Breakdown machines	Machines
Photostat shop	Papers	Photostat machine

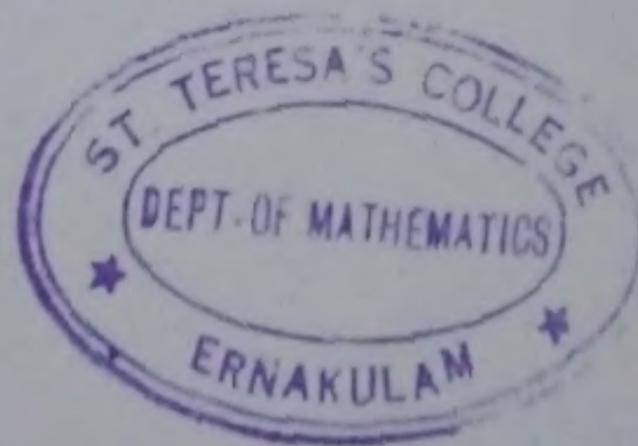
- Queuing theory has a important role in casualties of hospital
- It is useful in evaluating the impact of breakdown down of disasters
- It is really helpful in making business decisions
- If we consider the rain in monsoon season in India then the waiting days for getting the rain is a queue, here days are the customers and the sky is the server.
- As Covid-19 cases increasing day by day, vaccination centres need to provide more number of servers to avoid congestion of people.

CONCLUSION

Queues are very common in our society. Every person has to stand in a queue atleast once. Queuing theory helps in enhancing business strategies. From this project, we can conclude that, when the Average Service Rate μ is greater than Average Arrival rate λ , the customers are served at a faster rate than they arrive and the service will be fast. This theory gives a basic information for successfully designing queuing systems that acheives a healthy balance between arrival rate and service rate.

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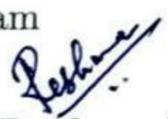
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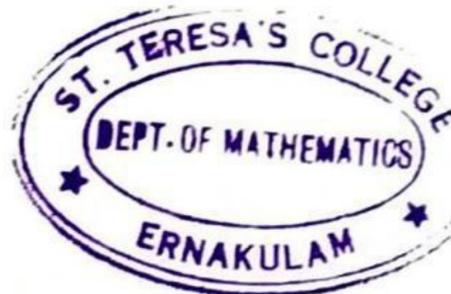


CERTIFICATE

This is to certify that the dissertation entitled, **STATISTICAL STUDY ON YOUTUBE USAGE DURING COVID-19** is a bonafide record of the work done by Ms. **MEERA JOSEPH** under my guidance as partial fulfillment of the award of the degree of **Bachelor of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

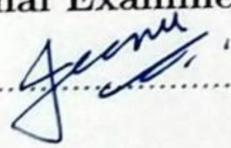
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