ST. TERESA'S COLLEGE, ERNAKULAM

(AUTONOMOUS)

Affiliated to Mahatma Gandhi University, Kottayam

CURRICULUM FOR

M.Sc. PHYSICS

Under Credit & Semester System

(2020 Admissions Onwards)

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

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17. Smt. Sunsu Kurian Thottil, Guest Lecturer, Department of Physics, St. Teresa's College, Ernakulam

FACULTY OF THE DEPARTMENT WHO HAVE CONTRIBUTED TOWARDS CURRICULUM AND SYLLABUS IN PHYSICS

1. Dr. Sajimol Augustine M., Principal, St. Teresa's College, Ernakulam
2. Smt. Tessy Joseph, Associate Professor, Department of Physics, St. Teresa's College, Ernakulam
3. Dr. Kala M. S. (Chairperson), Associate Professor &HoD, Department of Physics, St. Teresa's College, Ernakulam
4. Smt. Priya Parvathi Ameena Jose, Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
5. Smt. Mary Vinaya, Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
6. Dr. Santhi A., Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
7. Smt. Minu Pius, Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
8. Smt. Susan Mathew, Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
9. Dr.Mariyam Thomas, Assistant Professor, Department of Physics, St. Teresa's College, Ernakulam
10. Ms. Farzana M. U., Guest Lecturer, Department of Physics, St. Teresa's College, Ernakulam
11. Ms. Riny Maria James, Guest Lecturer, Department of Physics, St. Teresa's College, Ernakulam
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ACKNOWLEDGEMENTS

The prime objective of restructuring the M. Sc. Physics syllabus is to accommodate the fast paced developments in the different areas of Physics. In this journey, many profound personalities have rendered their relentless support and guidance which made this task successful. I take this opportunity to express our sincere appreciation to all those who were part of this endeavour for restructuring the syllabus of PG course in Physics

Our Director Dr. Sr. Vinitha and Principal Dr. Sajimol Augustine have rendered motivation and support and stood as the driving force behind this new curriculum. On behalf of the Department of Physics, I would like to record our deep sense of gratitude to them.

In the preparation of this syllabus, the support offered by the Members of the Board of Studies has been invaluable. They have gone through the syllabus thoroughly, suggested modifications and comments to update the syllabus to high standards. It is an honour to thank them for their cooperation which has been of great benefit to us in shaping the syllabus.

I am also grateful to all the members of the Curriculum Committee of the college for their guidance during the syllabus restructuring process.

I would like to express my special appreciation and thanks to all the faculty members of the Department of Physics whose collective efforts and fruitful discussions enabled us to structure the syllabus into its final version.

I wish to record my gratitude to our students for their active participation in the discussions we had on various aspects of curricula.

Dr Kala M. S.

Chairperson, Board of Studies in Physics

St. Teresa's College (Autonomous), Ernakulam

PREFACE

As an autonomous college under Mahatma Gandhi University, St. Teresa's College has taken conscientious efforts to strengthen the curriculum by retaining all the fundamental stipulations of the University/Higher Education Council, to ensure a well-balanced Curriculum. Within the constraints of a prescribed syllabus, we have resolved to take a collective effort to create an inspiring academic culture in the institution, essential for teachers and students to access deeper knowledge and participate in its expansion and transmission. It is also to re-articulate almost lost or forgotten fact that production and transmission of Quality Knowledge, essential for the development of students in particular and society in general, are the primary functions of any Educational Institution.

The restructured syllabi of the programmes aim to provide students many opportunities to engage with authentic, real world learning which will foster their reasoning, imagination, intelligence and problem solving skills, thereby enabling them to acquire true knowledge of universal validity and relevance which will lead to individual development, civil efficiency, economic competency and welfare of the whole of humanity.

I acknowledge the efforts taken by the teachers in restructuring the syllabi and course outcomes of the programmes that focus on the cognitive and intellectual skills of the learners, confidence to carry out independent and scholarly research in the area of professional interest to them and to position themselves as globally effective cross- cultural educators.

I congratulate the efforts taken by the Principal Dr. Sajimol Augustine M. and Smt. Shanty B.P. who coordinated the syllabus restructuring of all the programmes in an effective manner. Transformation is what makes St. Teresa's distinctive; transforming lives in order to make a real impact on the local and international stage through the creation, sharing and application of knowledge. We look forward to sharing with you the outcomes of our curriculum restructuring and I hope that these resources will enable you to reflect on the learning gain in our institution.

Dr. Sr. Vinitha (Celine E)

Director, St. Teresa's College, Ernakulam

FOREWORD

Autonomy in the field of higher education implies responsibility and accountability and this in turn leads to excellence in academics and pro-active governance. St Teresa's College was given autonomous status in the year 2014 and we have made a concerted attempt to maintain a high level of quality in the standard of education that we impart. In 2019 the college has been re-accredited with A++ grade (CGPA 3.57).

Academic autonomy has granted us the freedom to fine tune the syllabus keeping in mind the changing needs of the new generation of students. Education in the current scenario throws up a multitude of challenges and the curricula and syllabi ought to reflect the paradigm shift that has occurred in the various disciplines. Structured feedback was taken from the Students, Alumni and the experts from the industry and the changes suggested by them were duly incorporated in the restructured syllabi.

The Board of Studies constituted for each department meet regularly in the stipulated time frame and in depth discussions are conducted about the different dimensions of the curricula and syllabi. The IQAC team has felicitated the conduct of a number of workshops and conferences to equip the faculty with the necessary skill set to restructure the syllabi, set question papers for internal tests that evaluate whether the learning outcomes enlisted in the syllabus have been achieved and to ensure the fair and transparent conduct of examinations.

The responsibility that autonomy has placed on us is indeed onerous but we have strived together to meet all the challenges that were placed in our way. We have worked towards moulding young women as responsible citizens who will carry forward the task of nation building in an exemplary manner. All effort has been made to nurture their academic ambitions as well as their skills in co-curricular activities. To keep in pace with the need of the new generation students, we have decided to restructure postgraduate programmes in the next academic year.

With sincere gratitude I acknowledge the instinct support and constant guidance extended by Rev. Sr. Dr.Vinitha, the Director of the College.

I specially thank the team headed by Smt. Shanty B. P. for coordinating the syllabus restructuring of the programmes, the Heads of the Departments and all the faculty members for their diligence, commitment and exceptional contribution towards this endeavour.

Dr. Sajimol Augustine M.
Principal

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PREAMBLE

The aim of the Postgraduate education is to provide high quality education as well as a supportive learning environment for the students to reach their full academic potential. The higher education has to inculcate in students the spirit of hard work and research aptitude to pursue further studies in the nationally/internationally reputed institutions as well as prepare them for a wider range of career opportunities in industry and commerce.

Board of Studies in Physics has designed the curriculum for M.Sc. Physics so as to monitor, review and enhance educational provision which ensures the Post Graduate Education remains intellectually demanding and relevant to current needs of physics graduates. The thrust is given in fostering a friendly and stimulating learning environment which will motivate the students to reach high standards, enable them to acquire real insight into physics and become self-confident, committed and adaptable graduates. With this in mind, we aim to provide a firm foundation in every aspect of Physics and to explain a broad spectrum of modern trends in Physics and to develop analytical, experimental, computational and mathematical skills of students.

The Board of Studies acknowledges and appreciates the good effort put in by the faculty members of Physics Department to frame the syllabus for M.Sc. Programme in Physics in the institution which will be implemented for the admissions from 2020 onwards.

PROGRAMME OUTCOME

The Department of Physics is committed to provide an enriched educational experience to develop the knowledge, skills and attributes of students to equip them for life in a complex and rapidly changing world.

On completion of the M.Sc. Programme in Physics our students should be able to demonstrate the programme outcomes listed below:

PO 1. *Disciplinary knowledge*

- Demonstrate a mastery of the fundamental knowledge and skills required in the discipline to function effectively as an entry-level professional in the field.

PO 2. *Scientific Temper*

- Experiment with new approaches, challenge existing knowledge boundaries and take informed action to solve problems related to society.
- Identify, define, and deal with problems through logical, analytical and critical thinking acquired from different domains of knowledge

PO 3. *Research and Digital Competence*

- Develop a research culture for lifelong learning and demonstrate competency in creating new knowledge.
- Analyze and choose from available data and information sources to communicate, collaborate and network through a range of digital media.

PO 4. *Communication Skills*

- Develop language proficiency through interactions embedded in meaningful contexts.
- Demonstrate communicative competence particularly using technology in social and global environments.

PO 5. *Leadership, Teamwork and Interpersonal Skills*

- Function effectively both as leader and/or member of a team.
- Collaborate and interact effectively with others.

PO 6. *Moral & Ethical Awareness and Social Responsibility*

- Demonstrate social and national responsibility.
- Engage in activities that contribute to the betterment of society, with a preferential option for the economically challenged and the marginalized.

PROGRAMME SPECIFIC OUTCOME

The syllabus is framed in such a way that it provides a complete and logic framework in almost all areas of Physics. On completion of the M. Sc. Physics programme, the student should

PSO1: Acquire knowledge and general competence of core physical concepts, principles and theories along with their applications in Mathematical Methods, Classical, Quantum and Statistical Mechanics, Condensed Matter Physics, Electronics, Electrodynamics, Atomic and Molecular Physics and Nuclear and Particle Physics

PSO 2: Imbibe an interest in one of the frontier areas of Physics-Electronics/ Material Science/ Informatics/ Theoretical Physics as elective bunch

PSO3: Develop proficiency in the analysis of complex physical problems and adopt mathematical, computational or other appropriate techniques to solve them.

PSO4: Design and carry out experiments in the above mentioned areas as well as certain advanced areas of Physics

PSO 5: Identify, plan, investigate and report an original project work and develop a flair for scientific research with moral and ethical values

PSO6: Develop communication skills, both written and oral, for specialized and non-specialized audiences.

ELIGIBILITY FOR ADMISSION

Graduation in Physics with

(i) CGPA for Core, Open and Complementary courses-not less than 5.00 out of 10.00 - CBCSS (New Pattern)

OR

(ii) CGPA for Core, Open and Complementary courses-not less than 2.00 out of 4.00- CBCSS (Old Pattern)

OR

(iii) Not less than 50% marks in Part III subjects (Main/Core+ subsidiaries/ Complementaries)- Pre-CBCSS

DURATION OF THE PROGRAMME

Four Semesters

EXAMINATION

Credit and Semester system (CSS)

Direct Grading system with 7 point scale

MEDIUM OF INSTRUCTION AND ASSESSMENT

English

FACULTY UNDER WHICH THE DEGREE IS AWARDED

Science

STRUCTURE OF M.Sc. PHYSICS

M. Sc. Physics is a two year program with four semesters in which credit and semester system is followed. There are 18 weeks in a semester and in each week there are15 lecture hours and 10 laboratory hours. In each semester there are 270 lecture hours and 180 practical hours. Thus the total calendar hours in each semester are 450 which is in compliance with the minimum 390 hours stipulated by the UGC.

The programme shall include two types of courses, Core courses and Elective courses. There shall also be a project and comprehensive viva-voce as core courses. The programme also includes assignment/seminar/practical etc. The total credit for the programme is fixed at 80.

Theory Courses

There are **fifteen** theory courses spread in all the four semesters of the M.Sc. Program. Distribution of theory courses is as follows. There are twelve core courses common to all students. Semester I and Semester II will have **four** core courses each and Semester III will have **three** core courses and Semester IV will have **one** core course. **One** elective course is in semester III and **two** elective courses are in semester IV. The **three** elective courses can be chosen as per the interest of the students, availability of faculty and academic infrastructure.

Practical

All four semesters will have a course on laboratory practical. The practical examinations will be conducted at the respective examination centres by two external and one internal examiner appointed by the controller of examinations at the end of even semesters only. The first and second semester examinations of laboratory practical courses will be conducted at the end of Semester II while the third and fourth semester practical examinations will be conducted at the end of Semester IV.

Project

An M.Sc. student should be capable of doing research at least in the preliminary way. To accomplish this, a research oriented project is made part of this curriculum. The project of the programme should be relevant and innovative in nature. The type of project can be decided by the student and the guide (a faculty of the department or other department/ college/ university /institution). The project work should be taken up seriously by the student and the guide. The project should be aimed to motivate the inquisitive and research aptitude of the students. The students may be encouraged to present the results of the project in seminars/symposia. The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV along with the practical examination. The project is evaluated by two external and one internal examiner.

Viva Voce:

A viva voce examination will be conducted by a team of two external and one internal examiner at the time of evaluation of the project. The components of viva consist of subject of special interest, fundamental Physics, topics covering all semesters and awareness of current and advanced topics.

Course Code:

The courses in the programme are coded according to the following criteria. The first two letters of the code indicates the name of the programme, ie. PH stands for Physics. Next digit is to indicate the semester. i.e., PH1 (Physics, 1st semester) followed by the letter C or E indicating whether the course is a Core course or Elective course as the case may be. However in the case of Project/Comprehensive viva voce this letter is omitted. Next two digits indicate the course number (avoided in the case of Project/Comprehensive viva voce). The letter/letters T/P/ PR/V follow it and is used to indicate theory/practical/project/viva. The next letter will be M which indicates that the programme is for masters. The last two digits is 20 representing the year in which restructuring is done.

DISTRIBUTION OF COURSES AND CREDITS

Semester	Course Code	Course Title	Teaching hours per week	Credit	Total credits
I	PH1C01TM20	Mathematical Methods in Physics -I	3	4	16
	PH1C02TM20	Classical Mechanics	4	4	
	PH1C03TM20	Electrodynamics	4	4	
	PH1C04TM20	Electronics	4	4	
	PH2C01PM20	General Physics Practicals	5	*	
	PH2C02PM20	Electronics Practicals	5	*	
II	PH2C05TM20	Mathematical Methods in Physics- II	4	4	24
	PH2C06TM20	Quantum Mechanics – I	3	4	
	PH2C07TM20	Thermodynamics and Statistical Mechanics	4	4	
	PH2C08TM20	Condensed Matter Physics	4	4	
	PH2C01PM20	General Physics Practicals	5	4	
	PH2C02PM20	Electronics Practicals	5	4	
III	PH3C09TM20	Quantum Mechanics – II	4	4	16
	PH3C10TM20	Computational Physics	4	4	
	PH3C11TM20	Atomic and Molecular Physics	4	4	
	PH3E0*TM20	Elective – 1	3	4	
	PH4E0*PM20	Advanced Elective Practicals	5	*	
	PH4C03PM20	Computational Physics Practicals	5	*	
IV	PH4C12TM20	Nuclear and Particle Physics	5	4	24
	PH4E0*TM20	Elective – 2	5	3	
	PH4E0*TM20	Elective – 3	5	3	
	PH4E0*PM20	Advanced Elective Practicals	5	4	
	PH4C03PM20	Computational Physics Practicals	5	4	
	PH4PRM20	Project/Dissertation	-	4	
	PH4VM20	Comprehensive Viva-voce	-	2	
	Total Credits				**80**

ELECTIVE COURSES

There are three Electives Bunches offered in this PGCSS Programme. Each consists of a bunch of **three** theory courses and **one** laboratory course. The first theory course of a bunch is placed in the Semester III, while the second and third theory courses and the laboratory course will be done in Semester IV. The student can opt for any one Elective Bunch in an academic year. The course structure of the Electives Bunches is given below.

The Electives Bunches are

(i) Bunch A : Material Science

(ii) Bunch B : Electronics

(iii) Bunch C : Theoretical Physics

Bunch A: Materials Science

Course code	Course Title	Teaching hours per week	Credit
PH3E01TM20	Solid State Physics for Materials	3	4
PH4E02TM20	Science of Advanced Materials	5	3
PH4E03TM20	Nanostructures and Materials characterisation	5	3
PH4E01PM20	Advanced Practicals in Materials Science	10	4

Bunch B: Electronics

Course code	Course Title	Teaching hours per week	Credit
PH3E04TM20	Digital Signal Processing	3	4
PH4E05TM20	Micro Electronics and Semiconductor Devices	5	3
PH4E06TM20	Communication Systems	5	3
PH4E02PM20	Advanced Practicals in Electronics	10	4

Bunch C: Theoretical Physics

Course code	Course Title	Teaching hours per week	Credit
PH3E07TM20	General Relativity and Applications	3	4
PH4E08TM20	Nonlinear Dynamics	5	3
PH4E09TM20	Quantum Field Theory	5	3
PH4E03PM20	Special Computational Practicals	10	4

DISTRIBUTION OF CREDITS:

The total credit for the programme is fixed at 80.The distribution of credit points in each semester and allocation of the number of credit for theory courses, practical, project and viva is as follows. The credit of theory courses is 4 per course in the first, second and third semesters. The core courses in the fourth semester will have 4 credits and elective courses will have 3 credits. All the three core practical and elective practical have 4 credits. The project and viva voce will have a credit of 4 and 2 respectively. The distribution of credits is shown below.

Semester	Courses	Credit	Total Credit
I	4 Theory Core Courses	4	4 x 4 = 16
II	4 Theory Core Courses	4	4 x 4 = 16
	2 Practical Core courses	4	2 x 4 = 8
III	3 Theory Core Courses	4	3 x 4 = 12
	1 Theory Elective Course	4	1 x 4 = 4
IV	1 Theory Core Course	4	1 x 4 = 4
	2 Theory Elective Courses	3	2 x 3 = 6
	1 Practical Core Course	4	1 x 4 = 4
	1 Practical Elective Course	4	1 x 4 = 4
	1 Project / Dissertation	4	1 x 4 = 4
	1 Viva Voce	2	1 x 2 = 2
GRAND TOTAL			**80**

EVALUATION AND GRADING

The evaluation for each course shall contain two parts - In-Semester Assessment (ISA) and End Semester Assessment (ESA). The ratio between ISA and ESA shall be 1:3. Both ISA and ESA shall be carried out using direct grading system.

Evaluation (Both ISA and ESA) to be done by the teacher is based on a six point scale shown in the table below:

GRADE	GRADE POINT	RANGE
A^+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

Direct Grading System based on a 7 – point scale is used to evaluate the performance of students in both ISA and ESA.

For all courses (theory & practical) / semester / overall program letter grades and GPA/SGPA/CGPA are given in the following table

RANGE	GRADE	INDICATOR
4.50 to 5.00	A^+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B^+	Very good
3.00 to 3.49	B	Good(Average)
2.50 to 2.99	C^+	Fair
2.00 to 2.49	C	Marginal
0.00 to 1.99	D	Deficient(Fail)

IN SEMESTER ASSESSMENT (ISA)

No separate minimum is required for internal evaluation (ISA) for a pass for each course but a minimum C grade is required for a pass in ESA. The sessional evaluation is to be done by continuous assessments of the components given below.

The components of the **In Semester Assessment for theory and practical** and their weightages are as in the following table.

THEORY		PRACTICALS	
COMPONENTS	**WEIGHTAGE**	**COMPONENTS**	**WEIGHTAGE**
Assignment	1	Written / Lab test	3
Seminar	2	Lab involvement and record	1
Test Papers (*Total of 2)	2	Viva	1
TOTAL	**5**	**TOTAL**	**5**

The two test papers should be in the same model as the End Semester Examination question paper. For test papers questions shall be set in such a way that the answers can be awarded A^+, A, B, C, D, E grades. Students with attendance less than 75% in a course are not eligible to attend End Semester examination of that course. The performance of students in the seminar and assignment should also be documented in terms of grades.

The components for assignments and seminars and their weights are as in the following table:

ASSIGNMENTS		SEMINAR	
COMPONENTS	**WEIGHTAGE**	**COMPONENTS**	**WEIGHTAGE**
Punctuality	40 %	Content	40%
Content	60 %	Presentation	60%

The components of the **In Semester Assessment for Project** and their weights are as in the following table.

PROJECT	
COMPONENTS	**WEIGHTAGE**
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
TOTAL	**5**

The In Semester evaluation of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the beginning of the Semester III. The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in student(s), the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of two students may be allowed to perform one project work if the volume of the work demands it. Project evaluation begins with (i) the selection of problem, (ii) literature survey, (iii) work plan, (iv) experimental / theoretical setup/data collection, (v) characterization techniques/computation/analysis (vi) use of modern software for data analysis/experiments (Origin, LABView, MATLAB etc) and (vi) preparation of dissertation. The project internal grades are to be submitted at the end of Semester IV.

The components of the In-Semester Assessment for comprehensive **Viva- Voce** and their weightage are as in the following table.

VIVA-VOCE	
COMPONENTS	**WEIGHTAGE**
Fundamental concepts	3
Awareness of current topic/advanced topic	2
TOTAL	**5**

General Instructions for In-Semester assessment:

- The In Semester assessment should be fair and transparent. The responsibility of evaluating the ISA is vested on the teacher(s) who teach the course. The components of the evaluation should be published and acknowledged by students. All documents of In Semester assessments are to be kept in the institution for 2 years.
- The assignments/ seminars / test papers are to be conducted at regular intervals. These should be marked and promptly returned to the students.
- One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheet for In-Semester assessment in the department in the format supplied by the Controller of the examinations. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for Final Assessment.

The grade sheet should be signed by the coordinator and counter signed by the Head of the Department and the college Principal.

- The consolidated grades in specific format are to be kept in the college for future references. The consolidated grades in each course should be uploaded to the Institution Portal at the end of each semester as directed by the Controller of the Examinations.
- A candidate who fails to register for the examination in a particular semester is not eligible to continue in the subsequent semester.
- There shall not be any chance for the improvement of ISA grade point.
- Grievance Redressal Mechanism for ISA

There will be provision for grievance redress at three levels, viz,

1. At the level of teacher concerned
2. At the level of departmental committee consisting of Head of the Department, Coordinator and teacher concerned
3. At the level of college committee consisting of the Principal, Controller of Examinations and Head of the Department

College level complaints should be filed within one week of the publication of results and decisions taken within the next two weeks.

END SEMESTER ASSESSMENT (ESA)

The End Semester Assessment of all semesters shall be conducted by the institution on the close of each semester. The End Semester Assessment will be of 3 hours duration for each lecture based courses and 5 hours for practical courses. There is no minimum grade for a pass in ISA but a minimum C grade is required for a pass in ESA. Also a minimum C grade is required for a pass in a course.

Students with less than 75% aggregate attendance during a semester are not eligible to attend ESA of any course.

If a student represents her Institution/ University / State/ Nation in Sports /NCC/NSS or Cultural or any other officially sponsored activities such as college union/university union etc she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 15 days in a semester based on the specific recommendations of the Head of the Department or teacher concerned.

For reappearance/ improvement, students may appear along with the next batch.

QUESTION PAPER PATTERN FOR THEORY COURSES

All the theory question papers are of three hour duration. The question shall be prepared in such a way that the answers can be awarded the grades A+,A, B, C, D, E. All question papers will have three parts; A, B and C

Part A: Questions from this part are very short answer type. Eight questions have to be answered from among ten questions. Each question will have weightage one and the Part A will have a total weightage of eight.

Part B: Part B consists of problem solving and short essay type questions from the course concerned. Six questions out of eight given have to be answered. Each question has a weightage two making the Part B to have total weightage twelve.

Part C: Part C will have four questions. Two questions have to be answered out of four questions. Each question will have a weightage five making the total weight ten in Part C.

Maximum weightage for external evaluation is 30. Therefore Maximum Weighted Grade Point (WGP) is 150.

DIRECTIONS FOR QUESTION SETTERS:

1) Questions shall be set to assess knowledge acquired, standard and application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge.
2) Due weightage shall be given to each module on content/teaching hours allotted to each module.
3) The question setter shall ensure that questions are set as per the course outcomes.
4) A question paper shall be a judicious mix of short answer type, short essay type/problem solving type and long essay type questions.
5) The questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grade.
6) Different types of questions shall be given different weights to quantify their range as shown below:

	Type of Questions	Weight	Number of questions to be answered
Part A	Short Answer type questions	1	8 out of 10
Part B	Short essay/ problem solving type questions	2	6 out of 8
Part C	Long Essay type questions	5	2 out of 4

PRACTICAL, PROJECT AND VIVA VOCE EXAMINATIONS

Practical Examination:

First and second semester practical examinations are conducted at the end of Semester II and third and fourth semester practical examinations are conducted at the end of Semester IV. The practical examinations are conducted immediately after the second and fourth semester theory examinations respectively. There will be separate practical examination boards to conduct these practical exams. All practical examinations will be of five hours duration.

The external examiners will be selected from the panel of examiners and one internal examiner will be selected by the department.

Evaluation of Practical Examinations:

The scheme of Evaluation of the practical examination will be decided by the Board of Examiners. The weightage for assessment of different components is shown in the following table.

COMPONENTS	WEIGHTAGE
Written/Lab test	10
Lab involvement and Record	3
Viva	2
TOTAL	**15**

Project Evaluation:

The project is evaluated by two external examiners deputed from the board of examination. The dissertation of the project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the head of the department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project. The different weights for assessment of different components are shown in the following table.

COMPONENTS	WEIGHTAGE
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
TOTAL	**15**

Comprehensive Viva- Voce Examination:

Viva voce examination is conducted only by the external examiners of the board of examinations. The viva voce examination for M.Sc. Physics programme is given a credit two. The components of the Final Assessment for comprehensive viva- voce and their weights are as in the following table.

COMPONENTS	WEIGHTAGE
Fundamental concepts	9
Awareness of current topic/advanced topic	6
TOTAL	**15**

Both project evaluation and viva voce examination are to be conducted in batches of students formed for the practical examinations.

REAPPEARANCE / IMPROVEMENT

- A student who fails to secure a minimum grade (Grade C) for a pass in a course will be permitted to write the examination along with the next batch.
- The candidates who wish to improve the grade/grade point of the End-Semester Assessment of a course / courses she has passed can do the same by appearing in the End-Semester Assessment of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semesters of the programme.
- There shall be supplementary examinations (no improvement) for third semester.
- One Time Betterment Programme: A candidate will be permitted to improve the CGPA of the programme within a continuous period of four semesters immediately following the completion of the programme allowing only once for a particular semester. The CGPA for the betterment appearance will be computed based on the SGPA secured in the original or betterment appearance of each semester whichever is higher.

If a candidate opts for the betterment of CGPA of a programme, she has to appear for the external examination of the entire semesters excluding practicals/ project/ comprehensive viva voce. One time betterment programme is restricted to students who have passed in all courses of the programme at the regular (first) appearance.

PROMOTION

- A student who registers for a particular semester examination shall be promoted to the next semester.
- A student having 75% attendance and fails to register for examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided application for notional registration shall be submitted within 15 days of the commencement of the next semester.

COMPUTATION OF GPA/SGPA/CGPA

Grade Point Average (GPA): ISA and ESA are separately graded using a six point scale and the combined grade point with weightage 1 for ISA and 3 for ESA shall be applied to calculate the grade point average (GPA) of each course.

The Semester Grade Point Average (SGPA): After the successful completion of a semester SGPA of a student in that semester is calculated using the formula given below

Semester Grade Point Average (SGPA) = $\frac{\sum(C_i \; X \; GPA_i)}{\sum C_i}$ where C_i and GPA_i are the credit point and GPA of each course respectively.

Cumulative Grade Point Average (CGPA) for the programme is calculated as follows:

CGPA = $\frac{\sum(C_i \; X \; SGPA_i)}{\sum C_i}$ where C_i and $SGPA_i$ are the total credit point and SGPA of each semester respectively.

Note: A separate minimum of **C** Grade each for ISA and ESA (for both theory and practical) is required for pass for a course. For a pass in a programme, a separate minimum of Grade **C** is required for all the individual courses. If a candidate secures **D** Grade for any one of the courses offered in a Semester/Programme, only **D** grade will be awarded for that Semester/Programme until she improves this to **C** grade or above within the permitted period.

Note on compliance with the UGC minimum standards for the conduct and award of postgraduate degrees:

Credit and semester system is followed in this program. The program has 4 semesters with eighteen weeks in each semester. In each semester there are 450 hours including both lecture and practical hours which is in compliance with the minimum 390 hours stipulated by the UGC.

All Rules and regulations are subject to change as and when modified by MG University to which St Teresa's College [Autonomous] is affiliated.

SYLLABUS

M.Sc. PHYSICS

Semester I

PH1C01TM20 - MATHEMATICAL METHODS IN PHYSICS–I

Total Credits: 4

Total Lecture hours: 54

Course Outcomes:

CO1: Discuss linear vector spaces and express various operators in general curvilinear coordinate system

CO2: Discuss the properties of different distributions in statistics

CO3: Discuss about special types of matrices and tensors that are relevant in physics

CO4: Apply the concept of metric tensor to different coordinate systems and evaluate the transformation of Christoffel symbols

Module I

Vectors analysis and Vector Spaces (8 Hrs)

Integral forms of gradient, divergence and curl - Equation of continuity , Line, surface and volume integrals – Stoke's, Gauss's and Green's theorems - Potential theory - scalar, gravitational and centrifugal potentials.

Linear Vector Spaces (8 Hrs)

Linear vector spaces - Hermitian, unitary and projection operators with their properties- inner product space – Schmidt orthogonalization - Hilbert space - Schwartz inequality.

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken& H.J. Weber 4th Edition, Academic Press***
2. ***Mathematical Physics – B.S Rajput, Yog Prakash, Publications: PragatiPrakashan, P. B. No:62, Meerut, India.***

Module II

Curvilinear coordinates (8 hrs)

Transformation of coordinates- Orthogonal Curvilinear coordinates - Unit Vectors in curvilinear systems - Arc Length and Volume Elements - Gradient, Divergence and Curl in orthogonal curvilinear coordinates - Special Orthogonal coordinates system, Rectangular Cartesian Coordinates, Cylindrical Coordinates, Spherical Polar Coordinates

Probability theory and distributions (6 Hrs)

Elementary probability theory, Random variables, Binomial, Poisson and Gaussian distributions-central limit theorem.

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken& H.J. Weber 4th Edition, Academic Press.***
2. ***Theory and problems of vector analysis, Murray R. Spiegel (Schaum's outline series).***
3. ***Vector Analysis & Tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill.***

Module III

Matrices (12 Hrs)

Direct sum and direct product of matrices - diagonal matrices, Orthogonal, unitary and Hermitian matrices, normal matrices, Pauli spin matrices- Characteristic equation - Cayley-Hamilton theorem - Eigenvalues and eigenvectors – Diagonalisation - Solution of simultaneous linear equation-Gauss elimination method – Matrix inversion by Gauss-Jordan inversion method – Application – Normal modes of vibrations.

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4th Edition, Academic Press***
2. ***Mathematical Physics, P.K Chattopadhyay, New Age International***
3. ***Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi***

Module IV

Differential Geometry (12 hrs)

Definition of tensors – Basic properties of tensors - Contravariant, Covariant and mixed tensors – Kronecker delta - Levi-Civita tensor- Metric tensor and its properties – Tensor algebra-Associated tensors – Christoffel symbols & their transformation laws- Covariant differentiation of a tensor – Geodesics

Text Books:

1. ***Matrices and Tensors in Physics – A.W. Joshi, Publications: Wiley Eastern Limited, New Delhi.***
2. ***Mathematical Physics – B.S Rajput, Yog Prakash, Publications: PragatiPrakashan, P. B. No:62, Meerut, India.***
3. ***Vector Analysis & Tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill.***

References:

1. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press
2. Advanced Engineering Mathematics, E. Kreyszig, 7th Ed., John Wiley
3. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
4. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
5. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R. Harvill, Tata McGraw Hill
6. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.
7. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

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PH1C01TM20- MATHEMATICAL METHODS IN PHYSICS – I

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 16 hrs	4	2	1	13
Module II- 14 hrs	3	2	1	12
Module III-12 hrs	2/1	2	1	11/10
Module IV- 12 hrs	1/2	2	1	10/11

MODEL QUESTION PAPER

PH1C01TM20- MATHEMATICAL METHODS IN PHYSICS – I

Time: 3 hrs **Total Weights: 30**

Part A

I. Answer any 8 questions, each question carries weight 1

1. State Green's theorem.
2. Define Unitary operator with an example.
3. Define projection operator and mention its two properties
4. Discuss the properties of Pauli spin matrices?
5. Explain Poisson distribution with one example.
6. Express laplacian in curvilinear coordinate system.
7. Write notes on the cylindrical and spherical coordinate system.
8. Define Dirac delta function. State one situation where it finds application.
9. Define outer product of tensors.
10. Prove that $\delta^i_j = N$

(8 x 1 = 8 weights)

Part B

II. Answer any 6 questions, each question carries weight 2

11. State and prove Gauss's and Stokes theorem.
12. Show that the spherical polar coordinate system is orthogonal.
13. Find arc length and volume elements in all three coordinate systems.
14. Explain elementary probability theory. In a box, there are 8 red, 7 blue and 6 green balls. One ball is picked up randomly. What is the probability that it is neither red nor green?
15. Define Hermitian and skew – Hermitian matrices. Show that eigen vectors of Hermitian matrix are orthogonal and eigen values are real.
16. Diagonalise the matrix A = $\begin{bmatrix} 3 & 1 & 1 \\ 1 & 3 & 2 \\ 2 & 2 & 3 \end{bmatrix}$
17. Prove that single contraction of the tensor A^{ijk}_{lm} results a tensor of rank 3.
18. Set up Geodesic equation on Reimannian space.

(6 x 2 = 12 weights)

Part C

III. Answer any 2 questions, each question carries weight 5.

19. Define line, surface and volume integrals. Explain the theorems connecting these integrals.
20. Express the gradient, divergence and curl operators in Cartesian, spherical and cylindrical coordinates.
21. Illustrate the application of the matrix technique in finding the normal modes of vibration of a CO_2 molecule.
22. Write Christoffel symbols of I^{st} and II^{nd} kind and derive their transformation equations.

(2 x 5 = 10 weights)

Semester I

PH1C02TM20 - CLASSICAL MECHANICS

Total Credits: 4

Total Lecture hours: 72

Course Outcomes:

CO1: Apply Lagrange's and Hamilton's formulations for any given physical system.

CO2: Evaluate the normal modes of a N-coupled oscillator

CO3: Generate canonical transformations and express in Poisson Bracket formalism

CO4: Elaborate the kinematics and dynamics of rigid body and central force problem

CO5: Solve 1D and 2-D mechanical problems using Hamilton Jacobi theory and Action Angle variables

CO6: Develop the Lagrangian formulation of relativistic mechanics

Module I

Lagrangian formulation (14 hrs)

Review of Newtonian Mechanics: Mechanics of a Particle, Mechanics of aSystem of Particles, Constraints - D' Alembert's principle and Lagrange's equations , velocity-Dependent potentials and the Dissipation Function, Lagrangian for a charged particle in electromagnetic field- Application of Lagrange's equation to motion of a single particle in Cartesian coordinate system and plane polar coordinate system, bead sliding on a rotating wire- Hamilton's Principle, Technique of Calculus of variations , The Brachistochrone problem - Derivation of Lagrange's equations from Hamilton's Principle - Canonical momentum, cyclic coordinates, Conservation laws and Symmetry properties- homogeneity of space and conservation of linear momentum; isotropy of space and conservation of angular momentum, homogeneity of time and conservation of energy, Noether's theorem(statement only; no proof is expected)

Hamiltonian formulation: (4hrs)

Legendre Transformations, Hamilton's canonical equations of motion, Hamiltonian for a charged particle in electromagnetic field - Cyclic coordinates and conservation theorems, Hamilton's equations of motion from modified Hamilton's principle

Module II

Small oscillations (8hrs)

Stable equilibrium, unstable equilibrium and neutral equilibrium - motion of a system near stable equilibrium - Lagrangian of the system and equations of motion - Small oscillations- frequencies of free vibrations, normal coordinates and normal modes- System of two coupled pendula - resonant frequencies, normal modes and normal coordinates, free vibrations of CO_2 molecule- resonant frequencies, normal modes and normal coordinates.

Canonical transformations and Poisson brackets (10 hrs)

Equations of canonical transformations, Four basic types of generating functions and the corresponding basic canonical transformations - Examples of canonical transformations - identity transformation and point transformation - Solution of harmonic oscillator using canonical transformations.

Poisson Brackets - Fundamental Poisson Brackets, Properties of Poisson Brackets , Equations of motion in Poisson Bracket form - Poisson Bracket and integrals of motion, Poisson's theorem; Canonical invariance of the Poisson bracket

Module III

Central force problem (9hours)

Reduction of two-body problem to one-body problem, Equation of motion for conservative central forces - angular momentum and energy as first integrals, law of equal areas - Equivalent one-dimensional problem –centrifugal potential, classification of orbits - Differential Equations for the orbit, equation of the orbit using the energy method, The Kepler Problem of the inverse square law force, Scattering in a central force field - Scattering in a Coulomb field and Rutherford scattering cross section

Rigid body dynamics (9hrs)

Independent coordinates of a rigid body; Orthogonal transformations, Euler Angles. Infinitesimal rotations: polar and axial vectors, rate of change of vectors in space and body frames, Covioliseffect. Angular momentum and kinetic energy of motion about a point, Inertia tensor and the Moment of Inertia, Eigenvalues of the inertia tensor and the Principal axis transformation - Euler equations of motion, force free motion of a symmetrical top.

Module IV

Hamilton-Jacobi theory and action-angle variables (12 hrs)

Hamilton-Jacobi Equation for Hamilton's Principal Function, physical significance of the principal function - Harmonic oscillator problem using the Hamilton-Jacobi method - Hamilton-Jacobi Equation for Hamilton's characteristic function - Separation of variables in the Hamilton-Jacobi Equation, Separability of a cyclic coordinate in Hamilton-Jacobi equation, Hamilton-Jacobi equation for a particle moving in a central force field (plane polar coordinates) - Action-Angle variables, harmonic oscillator problem in action-angle variables.

Classical mechanics of relativity (6 hrs)

Lorentz transformation in matrix form, velocity addition, Thomas precession - Lagrangian formulation of relativistic mechanics, Application of relativistic Lagrangian to (i)motion under a constant force (ii) harmonic oscillator and (iii) charged particle under constant magnetic field.

Text Books:

1. Classical Mechanics: Herbert Goldstein, Charles Poole and John Safko, (3/e); Pearson Education.
2. Classical Mechanics: J.C. Upadhyaya, Himalaya Publications, 2010.
3. Classical Mechanics: G. Aruldhas, Prentice Hall 2009.

References:

1. Theory and Problems of Theoretical Mechanics (Schaum Outline Series): Murray R. Spiegel, Tata McGraw-Hill 2006.
2. Classical Mechanics: An Undergraduate Text: Douglas Gregory, Cambridge University Press.
3. Classical Mechanics: Tom Kibble and Frank Berkshire, Imperial College Press.
4. Classical Mechanics (Course of Theoretical Physics Volume 1): L.D. Landau and E.M. Lifshitz, Pergamon Press.
5. Analytical Mechanics: Louis Hand and Janet Finch, Cambridge University Press.
6. Classical Mechanics: N.C.Rana and P. S. Joag, Tata McGraw Hill.
7. www.nptelvideos.in/2012/11/classicalphysics.html.

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PH1C02TM20 - CLASSICAL MECHANICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	2/2/3/3	2	1	11/11/12/12
Module II- 18 hrs	2/3/3/2	2	1	11/12/12/11
Module III-18 hrs	3/2/2/3	2	1	12/11/11/12
Module IV- 18 hrs	3/3/2/2	2	1	12/12/11/11

MODEL QUESTION PAPER

PH1C02TM20– CLASSICAL MECHANICS

Time: Three hours **Maximum Weight: 30**

Part A

I. Answer any eight questions. Each question carries a weight of 1

1. State the weak law of action and reaction.
2. Define constraints. How do they simplify the equations of motion?
3. Explain cyclic coordinates? Give an example.
4. Distinguish between stable and unstable equilibrium.
5. Define Poisson Brackets. Discuss its properties.
6. Relate the various generating functions using Legendre transformation.
7. Briefly discuss the effect of Coriolis force on projective shot in the northern and southern hemisphere of earth.
8. Illustrate the idea of fictitious potential energy with an example.
9. Bring out the significance of action angle variables
10. Explain Thomas precession.

(8 x 1=8 weights)

Part B

II. Answer any six questions. Each question carries a weight of 2

11. Outline the principle of least action. Show that the shortest distance between two points in a plane is a straight line
12. A particle moves in the xy plane under the constraint that its velocity vector is always directed towards a point on the x axis whose abscissa is some given function of time f(t). Show that for f(t) differentiable but otherwise arbitrary the constraint is nonholonomic.
13. Show that the transformation, $P=\frac{1}{2}(p^2+q^2)$ $Q=\tan^{-1}(q/p)$ is canonical.
14. Establish the canonical invariance of Poisson Bracket.
15. A particle falls freely from a height h at a place with latitude λ. Find the deflection due to Coriolis force.
16. Work out the Torque for free motion of a symmetric top molecule using Euler's Equation.
17. Obtain the frequency of harmonic oscillator problem using action angle variables.
18. Formulate relativistic Lagrangian of a motion under a constant force

(6 x 2 = 12 weights)

Part C

III. Answer two questions. Each question carries a weight of 5.

19. Derive Lagrange's equation from D'Alembert's principle. How will the equations get modified in the presence of velocity dependent potentials?
20. Obtain Lagrange's Equation of motion for small oscillation in terms of normal coordinates.
21. Derive the elliptical orbit equation for a particle moving in a central force which obeys inverse square law.
22. Formulate and solve equations of motion for a particle moving in a central force field using Hamilton-Jacobi Theory.

(2x 5 = 10 weights)

Semester I

PH1C03TM20- ELECTRODYNAMICS

Total Credits: 4

Total Lecture Hours: 72

Course Outcomes:

CO1: Understand the basic concepts of electricity, magnetism and electrodynamics.

CO2: Discuss propagation of electromagnetic waves and boundary conditions in various conditions.

CO3: Investigate the power radiated from different radiating systems.

CO4: Relate electromagnetic field tensor with Maxwell's equations.

CO5: Deduce the different field configurations of a rectangular waveguide.

Module I

Electrostatics, Magnetostatics and basics of Electrodynamics (18 hrs)

Electrostatics: Electric field of a polarized object - Electric field in a - conductor, dielectric - electric displacement - Gauss's law in dielectric medium - linear dielectric medium -Boundary condition across dielectric (ε_{r1}) - dielectric (ε_{r2}), conductor-dielectric (ε_r), conductor-free space (ε_r=1) interface - Uniqueness theorem and electrostatic potential. Potential at large distance - multipole expansion due to a localized charge distribution - Electric field of a dipole.

Magnetostatics: Biot-Savart law - divergence and curl of B - Ampere's law- Magnetic vector potential - multipole expansion of vector potential - boundary conditions. Magnetic field inside matter - Magnetization (M) -Magnetic flux density (B) - Auxiliary field (H)

Electrodynamics: Electromotive force - motional emf, Faraday's law, electrodynamic equations, displacement current - Uniform sinusoidal time varying fields E and B and Maxwell's equations in free space and matter -Boundary conditions of electric and magnetic fields - Conservation laws - continuity equation - Poynting's theorem - Maxwell's stress tensor - momentum conservation.

Module II

Electromagnetic waves (18 hrs)

Electromagnetic waves in vacuum -Wave equation for E and B, monochromatic plane waves, energy- momentum in electromagnetic waves - Propagation of em waves through linear media, Reflection and transmission of plane wave at normal and oblique incidence - Electromagnetic waves in a conducting medium , Reflection at conducting surface, frequency dependence of permittivity - Dispersion of electromagnetic waves in non-conductors, conductors and plasma medium.

Module III

Electromagnetic radiation (18 hrs)

Potential formulation of electrodynamics - Gauge transformations, Coulomb and Lorentz gauge - Continuous distributions - Retarded potential, Jefimenko's equations - Point charges- Lienard- Wiechert potentials, Field of a point charge in motion, Power radiated by a point charge - Dipole Radiation- Electric dipole radiation, Magnetic dipole radiation; Radiation reaction-Abraham-Lorentz formula.

Module IV

Relativistic electrodynamics and Waveguides (18 Hrs)

Structure of space time - Four vectors, Relativistic mechanics - Proper time and proper velocity, Relativistic energy and momentum, Relativistic dynamics, Minkowski force; Relativistic electrodynamics - Magnetism as a relativistic phenomenon - Lorentz transformation of em field, field tensor, electrodynamics in tensor notation - Potential formulation of relativistic electrodynamics, relativistic potentials - Rectangular waveguide - TE-TM waves, impossibility of TEM waves.

Text books:

1. ***Introduction to Electrodynamics, David J. Griffiths, PHI.***
2. ***Electromagnetics, John D. Kraus, McGraw-Hill International.***
3. ***Classical Electrodynamics, J.D Jackson, John Wiley & Sons Inc.***

References:

1. Electromagnetic waves and radiating systems: Edward C Jordan, Keith G Balamin, Prentice Hall India Pvt.Ltd
2. Elements of Electromagnetics: Mathew N. O. Sadiku, Oxford University Press
3. Antenna and wave propagation: K.D Prasad, Satyaprakashan, New Delhi
4. Electromagnetism problems with solutions:AshutoshPramanik, PHI

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PH1C03TM20 - ELECTRODYNAMICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	2/2/3/3	2	1	11/11/12/12
Module II- 18 hrs	2/3/3/2	2	1	11/12/12/11
Module III-18 hrs	3/2/2/3	2	1	12/11/11/12
Module IV- 18 hrs	3/3/2/2	2	1	12/12/11/11

MODEL QUESTION PAPER

PH1C03TM20- ELECTRODYNAMICS

Time: 3 hrs **Total weightage: 30**

Part A

I. Answer any eight questions, each question carries weight 1.

1. Discuss the function of an electromotive force.
2. Illustrate the concept of displacement current.
3. Derive the boundary conditions for electric field and magnetic field.
4. Discuss the frequency dependence of permittivity of a medium.
5. Define radiation reaction.
6. Write a note on retarded potential.
7. Explain the need for Gauge transformations.
8. Show that current density 4-vector is divergenceless.
9. Write down Minkowski metric and Einstein summation convention.
10. Define Minkowski force.

(8 x 1 = 8 weights)

Part B

II. Answer any six questions, each question carries weight 2.

11. Derive an expression for Maxwell's stress tensor.
12. Discuss the continuity equation in electrodynamics.
13. Derive the laws of Optics from the boundary conditions of electromagnetic waves in matter.
14. Explain the dispersion of electromagnetic waves in conductors.
15. Show that power radiated by a point charge is proportional to the square of its acceleration.
16. Deduce Lienard-Wiechert potentials.
17. Describe (a) energy – momentum 4 – vector (b) proper time and proper velocity.
18. A standard air filled rectangular waveguide with dimensions a = 8.636 cm, b = 4.318 cm is fed by a 4 GHz carrier from a coaxial cable. Determine if a TE10 mode will be propagated. If so, calculate the phase velocity and the group velocity.

(6x 2 = 12 weights)

Part C

III. Answer two questions, each question carries weight 5

19. State and prove Poynting's theorem.
20. Discuss the reflection and transmission of electromagnetic waves at a dielectric surface at oblique incidence. Show that R + T = 1.
21. Discuss the radiation from an oscillating magnetic dipole.
22. Derive the relativistic transformation rules for electric and magnetic fields.

(2×5 =10 weights)

Semester I

PH1C04TM20- ELECTRONICS

Total Credits: 4

Total Lecture hours: 72

Course Outcomes:

CO1: Discuss the working and characteristics of JFET and MOSFET

CO2: Discuss various offsets and linear applications of op amp and effect of different feedbacks on parameters of op-amp

CO3: Recognize current to voltage converter and inverter

CO4: Exemplify instrumentation amplifier.

CO5: Discuss the frequency response of compensated and non-compensated op-amps and working of oscillators, comparators, converters, voltage regulators, superheterodyne AM and FM radio receivers, generators.

CO6: Distinguish various active filters, integrator and differentiator.

Module I

Field Effect Transistors (5 Hrs)

Types of FET- junction FET-formation of depletion region in JFET-characteristics of JFET-JFET parameters-comparison between FET and bipolar transistor- types of MOSFET-depletion type MOSFET- working and characteristics-Enhancement type MOSFET- characteristics.

Op-amp with Negative Feedback (13 Hrs)

Differential amplifier – Inverting amplifier – Non-inverting amplifier –Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain – Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offset voltage with feedback – Voltage follower. Voltage shunt feedback amplifier: Closed loop voltage gain – inverting input terminal and virtual ground - input and output resistance with feedback – Bandwidth with feedback - Total output offset voltage with feedback – Current to voltage converter- Inverter - Differential amplifier with one op-amp and two op-amps.

Module II

The Practical Op-amp (6 Hrs)

Input offset voltage –Input bias current – input offset current – Total output offset voltage-Thermal drift – Effect of variation in power supply voltage on offset voltage – Change in input offset voltage and input offset current with time - Noise – Common mode configuration and CMRR.

General Linear Applications (with design) (12 Hrs)

DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Low voltage DC and AC voltmeter - Voltage to current converter with grounded load – Current to voltage converter– Very high input impedance circuit – integrator and differentiator**.**

Module III

Frequency Response of an Op-amp (6 Hrs)

Frequency response –Compensating networks – Frequency response of internally compensated and non compensated op-amps – High frequency opamp equivalent circuit – Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate

Active Filters and Oscillators (with design) (12 Hrs)

Active filters – First order and second order low pass Butterworth filter – First order and second order high pass Butterworth filter- wide and narrow band pass filter - wide and narrow band reject filter- All pass filter – Oscillators: Phase shift and Wien-bridgeoscillators – square, triangular and sawtooth wave generators- Voltage controlled oscillator.

Module IV

Comparators and Converters (8 Hrs)

Basic comparator- Zero crossing detector- Schmitt Trigger – Comparator characteristics- Limitations of op-amp as comparators- Voltage to frequency and frequency to voltage converters - D/A and A/D converters- Peak detector – Sample and Hold circuit.

Voltage Regulators (3Hrs)

Voltage Regulators-fixed regulators-adjustable voltage regulators -switching regulators

Analog Communication (7 Hrs)

Review of analog modulation – Radio receivers – AM receivers – superhetrodyne receiver – detection and automatic gain control – communication receiver – FM receiver – phase discriminators – ratio detector – stereo FM reception.

Text Books:

1. ***Op-amps and linear integrated circuits, R.A. Gayakwad, PHI, 4th Ed.***
2. ***Electronic Communication Systems, Kennedy & Davis 4th Ed., TMH.***

References:

1. Applied Electronics, R. S Sedha, S Chand publications.

2. Electronic Devices (Electron Flow Version), 9/E TThomas L. Floyd, Pearson.
3. Fundamentals of Electronic Devices and Circuits 5Pth P Ed. David A. Bell, Cambridge.
4. Electronic Communications Dennis Roddy and John Coolen, 4th Ed. Pearson.
5. Modern digital and analog communication systems, B.P. Lathi&Zhi Ding, Oxford University Press.
6. Linear Integrated Circuits and Op Amps, T. S Bali, TMH

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PH1C04TM20- ELECTRONICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**2/2/3/3**	**2**	**1**	**11/11/12/12**
Module II- 18 hrs	**2/3/3/2**	**2**	**1**	**11/12/12/11**
Module III-18 hrs	**3/2/2/3**	**2**	**1**	**12/11/11/12**
Module IV- 18 hrs	**3/3/2/2**	**2**	**1**	**12/12/11/11**

MODEL QUESTION PAPER

PH1C04TM20 - ELECTRONICS

Time: 3 hrs **Total weight: 30**

Part A

I. Answer any eight questions, each question carries weight 1

1. Explain the operation of zero crossing detectors?
2. Distinguish between triangular and sawtooth waves?
3. Distinguish betweenA/D and D/A converters.
4. Define active filters.
5. Compare break frequency and bandwidth.
6. Define input offset voltage in an op amp.
7. Draw the circuit diagram of a subtractor in differential configuration.
8. List characteristics of an ideal op amp.
9. Differentiate voltage series and voltage shunt feedback?
10. Discuss the effect of negative feedback in non inverting amplifiers.

(8 x 1 = 8 weights)

Part B

II. Answer any six questions, each question carries weight 2

11. (i) Draw the schematic diagram of a phase shift oscillator. (ii) A phase shift oscillator with C= 0.1μF, R = 3.9kΩ, R_F=29R_1, What is the frequency of oscillation?
12. In the Schmidtt trigger R_1= 150Ω, R_2 = 68kΩ, R_L = 10 kΩ, V_{in} = 50mV_{pp}, sine wave and saturation voltage = ±14V. (a) Determine the threshold voltages V_{ut} and V_{lt}.(b) What is the value of hysteresis voltage V_{hy}.
13. Discuss the frequency response of internally compensated and non compensated op amps.
14. What is thermal drift?. Give the graphical variation of input bias current, input offset current and input offset voltage with the temperature.
15. Compute the maximum possible total output offset voltage in an op amp circuit with following specifications: V_{io} = 7.5mV maximum, I_{io} = 50 nA maximum, I_B = 250 nA maximum at T_A = 25˚C , R_F =10kΩ and R_1= 1 kΩ.

16. An inverting amplifier with R_1 =470 Ω and R_F= 2R1assume that the opamp IC 741 has A =200,000, R_i = 2 MΩ, R_o = 75 Ω, F_o = 5Hz, Supply voltage= ±15V, output voltage swing = ±13V. Compute the values of A_F, R_{iF}, R_{oF} and f_F.
17. In the triangular wave generator R2 = 1.2kΩ, R3 = 6.8kΩ, R1 = 120kΩ and C1= 0.01μF. Determine (a) the peak to peak output amplitude of the triangular wave and (b) the frequency of the wave.
18. Discuss the effect of negative feedback on voltage gain and bandwidth?

(6 x 2 = 12 weights)

Part C

III. Answer any two questions, each question carries weight 4

19. Explain the working of a voltage to frequency converter.
20. Describe the working of a comparator and a square wave generator using op amp.
21. Discuss the working of an instrumentation amplifier using a transducer bridge and give its application as a temperature indicator.
22. What are two differential amplifier configurations? Briefly compare and contrast these two configurations.

(2×5 =10)

Semester II

PH2C05TM20 - MATHEMATICAL METHODS IN PHYSICS – II

Total Credits: 4

Total Lecture Hours: 72

Course Outcomes:

CO1: Expand the functions in Taylor and Laurent series

CO2: Evaluate integrals using complex analysis

CO3: Apply Fourier series, Fourier transform and Laplace transform to problems in Physics.

CO4: Discuss special functions and differential equations as the basis for further application in theoretical physics.

CO5: Apply method of separation of variables to Heat and Laplace's differential equations in different coordinate systems.

CO6: Design Green's function for Poisson equation, Helmholtz equation and scattering problem

Module I

Complex analysis (18 hrs)

Functions of a complex variable - Analytic functions - Cauchy-Riemann equation - Integration in a complex plane - Cauchy Theorem - Cauchy's integral formulas - Taylor expansion & Laurent expansion - Residue, poles - Cauchy residue theorem - Cauchy's principal value theorem - Evaluation of integrals.

Text Books:

1. ***Introduction to Mathematical physics, Charlie Harper, PHI.***
2. ***Mathematical Physics, B.D. Gupta, Vikas Pub. House, New Delhi.***

Module II

Integral transforms (18 hrs)

Fourier Series -Application of Fourier series - Square Wave - Full Wave Rectifier - Fourier Integral - Fourier Transform - Finite Wave Train - Convolution Theorem of parseval's relation - Momentum representation - Hydrogen atom – Harmonic oscillator - Laplace Transform, Inverse Laplace transform - Earth Mutation - Damped Oscillator -Driven Oscillator -LCR circuit.

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken& H.J. Weber 4th Edition, Academic Press.***
2. ***Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi.***

Module III

Special functions and differential equations (18 hrs)

Gamma Function - Beta Function - Symmetry Property of Functions - Evaluation of Beta functions - Other forms of Beta Functions --Transformation of Beta Functions - Evaluation of Gamma Functions - Other forms of Gamma Functions- Transformation of Gamma Functions - Relation between Beta and Gamma Functions -Evaluation of Integrals - Bessel's Differential Equation-Legendre Differential Equation - Associated Legendre Differential Equations -Hermite Differential Equations - Laguerre Differential Equations (Generating function, recurrence relation, orthogonality condition, Rodrigues formulae for all functions.)

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press.***
2. ***Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi.***

Module IV

Partial differential equations (18 hrs)

Characteristics of boundary conditions for partial differential equation -Solution of partial differential equations by the method of separation of variables in Cartesian, cylindrical and spherical polar coordinates - Solution of Laplace equation in cartesian, cylindrical and spherical polar coordinates - Heat equation in Cartesian coordinates - Non-Homogeneous equation - Green's function -Symmetry of Green's Function-Green's Function for Poisson equation and Helmholtz equation -Application of Green's equation in scattering problem.

Text Books:

1. ***Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press.***
2. ***Mathematical Physics, B.S Rajput, Yog Prakash, Publications: PragatiPrakashan.***
3. ***Mathematical Physics, P.K Chattopadhyay, New Age International.***

References:

1. Advanced Engineering Mathematics, E. Kreyszig, 7th P Ed., John Wiley
2. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
3. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
4. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R. Harvill, TataMcGraw Hill
5. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.
6. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

7. Essential Mathematical Methods for the Physical Sciences, K. F. Riley and M. P. Hobson.
8. Mathematical Physics, H.K Dass&Dr. Rama Verma, S. Chand & Co.

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PH2C05TM20- MATHEMATICAL METHODS IN PHYSICS – II

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**2/3/2/3**	**2**	**1**	**11/12/11/12**
Module II- 18 hrs	**2/3/3/2**	**2**	**1**	**11/12/12/11**
Module III-18 hrs	**3/2/2/3**	**2**	**1**	**12/11/11/12**
Module IV- 18 hrs	**3/2/3/2**	**2**	**1**	**12/11/12/11**

Semester II

PH2C06TM20 - QUANTUM MECHANICS-I

Total Credits: 4

Total Lecture Hours: 54

Course Outcomes:

CO1: Develop basic ideas of complex abstract space in Quantum Mechanics.

CO2: Compute the eigen values and eigenkets of a simple harmonic oscillator.

CO3: Analyse spin ½ systems and finite rotations.

CO4: Derive the fundamental commutation relations, eigen values and eigen states of angular momentum operator.

CO5: Discuss the theory of addition of angular momenta.

CO6: Understand the quantum dynamics of Hydrogen atom.

Module I

Basics Formulation of Quantum Mechanics (20 hours)

Development of the idea of state vectors from sequential Stern-Gerlach experiments -Dirac notation for state vectors: ket space, bra space and inner products - Operators - Associative axiom - outer product–Hermitian adjoint - Hermitian operator -Eigenkets and eigenvalues of Hermitian operators, Eigenkets of observables as base kets - concept of complete set, Projection operators - Matrix representations of operators, kets and bras - Measurements in quantum mechanics - expectation value - Compatible observables and existence of simultaneous eigenkets - General Uncertainty Relation - Unitary operator - change of basis and transformation matrix - unitary equivalent observables - Position eigenkets - infinitesimal translation operator and its properties - linear momentum as generator of translation - canonical commutation relations, Wave function as an expansion coefficient - momentum eigen function -Momentum space wavefunctions and the relation between wavefunctions in position space and momentum space- Gaussian wave packet- computation of dispersions in position and momentum.

Text Book:

1. ***Modern Quantum Mechanic : J. J. Sakurai, Pearson Education.***

Module II

Quantum Dynamics (16 hours)

Time evolution operator and its properties- Schrodinger equation for the time evolution operator, solution of the Schrodinger equation for different time dependences of the Hamiltonian- Energy eigenkets - time dependence of expectation values- Time evolution of a spin half system and spin precession - Correlation amplitude - time-energy uncertainty relation and its interpretation. Schrodinger picture and Heisenberg picture -behavior of state kets and observables in Schrodinger and Heisenberg pictures - Heisenberg's equation of motion. Ehrenfest's theorem- time evolution of base kets - transition amplitudes - Simple Harmonic Oscillator - Energy eigenvalues and energy eigenkets

Text Book:

1. ***Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.***

Module III

Theory of Angular Momentum (14 hours)

Non-commutativity of rotations around different axes - the rotation operator, fundamental commutation relations for angular momentum operators - Rotation operators for spin half systems, spin precession in a magnetic field - Pauli's two component formalism - 2X2 matrix representation of the rotation operator- Ladder operators - eigenvalue problem for angular momentum operators - Matrix representation of angular momentum operators- Orbital angular momentum - orbital angular momentum as a generator of rotation- Addition of orbital angular momentum and spin angular momentum, addition of angular momenta of two spin-½ particles - General theory of Angular Momentum addition - Computation of Clebsch - Gordon coefficients.

Text Book:

1. ***Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.***

Module IV

The Hydrogen Atom (4 hours)

Behaviour of the radial wavefunction near the origin - the Coulomb potential and the hydrogen atom–hydrogenic wavefunctions - degeneracy in hydrogen atom

Text Book:

1. ***A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books.***

Recommended References:

1. Quantum Mechanics (Schaum's Outline): Yoav Peleg *et al*. Tata McGraw Hill PrivateLimited,2/e.
2. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
3. Quantum Mechanics Demystified: David McMohan, McGrawHill 2006.
4. Introductory Quantum Mechanics: Richard L Liboff, Pearson Education .
5. Introduction to Quantum Mechanics: D.J. Grifith, Pearson Education.
6. Quantum Mechanics: V. K. Thankappan, New Age International.
7. Quantum Mechanics: An Introduction: Walter Greiner and Allan Bromley, Springer.
8. Quantum Mechanics: Non-Relativistic Theory (Course of Theoretical Physics Vol3): L.D. Landau and E. M. Lifshitz, Pergamon Press.
9. The Feynman Lectures on Physics Vol3, Narosa.
10. www.nptel/videos.in/2012/11/quantum-physics.html
11. https://nptel.ac.in/courses/115106066/

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PH2C06TM20 - QUANTUM MECHANICS-I

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 20 hrs	**3**	**2**	**2**	**17**
Module II - 16 hrs	**3**	**3**	**1**	**14**
Module III-14 hrs	**3**	**2**	**1**	**12**
Module IV - 4 hrs	**1**	**1**	**0**	**3**

Semester II

PH2C07TM20 – THERMODYNAMICS AND STATISTICAL MECHANICS

Credits: 4

Total Lecture Hours: 72

Course Outcomes:

CO1: Discuss laws of thermodynamics.

CO2: Apply probability theory and quantum mechanics to determine the relevant partition function and various thermodynamic quantities for a given system.

CO3: Explain the statistical treatment for blackbody radiation, Einstein's & Debye's model of vibrations in solids.

CO4: Formulate the thermodynamics of Fermi Gas and non-interacting Bose Gas system.

CO5: Distinguish between first order and continuous phase transitions.

Module I

Fundamental of Thermodynamics (10 Hrs)

First law of Thermodynamics - Fundamental definitions – different aspects of equilibrium – functions of state – internal energy – reversible changes – enthalpy – heat capacities – reversible adiabatic changes in an ideal gas. Second law of thermodynamics– the Carnot cycle - equivalence of the absolute and the perfect gas scale of temperature – definition of entropy- measuring the entropy – law of increase of entropy – calculations of the increase in the entropy in irreversible processes – the approach to equilibrium.

Foundations of Statistical Mechanics (8 Hrs)

Ideas about probability – classical probability – statistical probability – the axioms of probability theory – independent events – counting the number of events – statistics and distributions - Basic ideas of statistical mechanics - definition of the quantum state of the system – simple model of spins on lattice sites – equations of state – the second law of thermodynamics

Module II

The Canonical Ensemble (12 Hrs)

A system in contact with a heat bath – the partition function – definition of the entropy in the canonical ensemble – the bridge to thermodynamics through partition function – condition for thermal equilibrium – thermodynamic quantities from partition function – case of a two level system – single particle in a one dimensional box – single particle in a three dimensional box –expression for heat and work – rotational energy levels for diatomic molecules – vibrational energy levels for diatomic molecules – factorizing the partition function – equipartition theorem – minimizing the free energy.

Statistics of Identical Particles (4 Hrs)

Identical particles – symmetric and antisymmetric wave functions - bosons – fermions calculating the partition function for identical particles – spin – identical particles localized on lattice sites.

Module III

Maxwell Distribution and Planck's Distribution (12 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory -Planck's distribution – derivation of the Planck distribution – the free energy – Einstein's model vibrations in a solid – Debye's model of vibrations in a solid.

Grand Canonical Ensemble (8 Hrs)

Systems with variable number of particles – the condition for chemical equilibrium – the approach to chemical equilibrium – chemical potential –reactions – external chemical potential – grand canonical ensemble –partition function – adsorption of atoms on surface sites – grand potential.

Module IV

Fermi and Bose Particles (6 Hrs)

Statistical mechanics of identical particles – thermodynamic properties of a Fermi gas – examples of Fermi systems – non-interacting Bose gas.

Phase Transitions (12 Hrs)

Phases – thermodynamic potential – approximation – first order phase transition - Clapeyron equation – phase separation – phase separation in mixtures. Ising model – order parameter – Landau theory- symmetry breaking field – critical exponents

Text Book:

1. ***Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn., 2007, Oxford University Press.***

References:

1. Statistical Mechanics, R.K. Pathria & P.D. Beale, 2ndEdn, B-H (Elsevier) (2004).
2. Introductory Statistical Physics, S.R.A. Salinas, Springer (2000).
3. Fundamentals of Statistical and Thermal Physics, F. Rief, McGraw Hill (1986).
4. Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).
5. Statistical Mechanics, Satyaprakash& Agarwal, KedarNath Ram Nath Pub. (2004).
6. Problems and solutions on Thermodynamics and Statistical mechanics, Yung Kuo Lim, World Scientific Pub. (1990)
7. Fundamentals of Statistical Mechanics, A.K. Dasgupta, New Central Book Agency Pub. (2005)
8. Statistical Mechanics: a survival guide, A.M. Glazer and J.S. Wark, Oxford University Press. (2001).

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PH2C07TM20 - THERMODYNAMICS AND STATISTICAL MECHANICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**2/3/2/3**	**2**	**1**	**11/12/11/12**
Module II- 18 hrs	**2/3/3/2**	**2**	**1**	**11/12/12/11**
Module III-18 hrs	**3/2/2/3**	**2**	**1**	**12/11/11/12**
Module IV- 18 hrs	**3/2/3/2**	**2**	**1**	**12/11/12/11**

Semester II

PH2C08TM20 - CONDENSED MATTER PHYSICS

Total Credits: 4

Total Lecture Hours: 72

Course Outcomes:

CO1 Apply the concept of Bragg diffraction to analyse the structure of a crystal and correlate the outcome to the 2D/3D Ewald construction

CO2 Develop a concept of the crystal classes , symmetries and the relationship between real and reciprocal space

CO3 Interpret the electrical and thermal properties of metals and semiconductors on the basis of the free electron model.

CO4 Discuss the formation of energy bands in solids and represent them in different zone schemes

CO5 Formulate models for vibrational motion of crystals and explain thermal properties of crystalline solids based on this.

CO6 Compare the different types of magnetism – Para, ferro and antiferro magnetism and discuss the different models which explains their behaviour

Module I

Wave Diffraction and the Reciprocal Lattice (5Hrs)

Diffraction of waves by crystals-Bragg's Law- Scattered wave amplitude, reciprocal lattice vectors, diffraction condition, Laue equations, Ewald construction- Brillouin zones- reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice- Diffraction intensity - structure factor and atomic form factor- physical significance.

Crystal Symmetry (7Hrs)

Crystal symmetry-symmetry elements in crystals-point groups, space groups - Ordered phases of matter-translational and orientational order- kinds of liquid crystalline order-Elements of Quasi crystals

Free Electron Fermi Gas (12 Hrs)

Energy levels in one dimension - quantum states and degeneracy- density of states-Fermi-Dirac statistics - Effect of temperature on Fermi-Dirac distribution –Free electron gas in three dimensions- Heat capacity of the electron gas- relaxation time and mean free path - Electrical conductivity and Ohm's law - Wiedmann-Franz-Lorentz law - electrical resistivity of metals.

Module II

Energy Bands (8 Hrs)

Nearly free electron model- Origin of energy gap-Magnitude of the Energy Gap-Bloch functions –Kronig-Penney model –Wave equation of election in a periodic potential-Restatement of Bloch theorem-Crystal momentum of an Electron-Solution of the central equations-Brillouin zone-construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - Effective mass of electron –Distinction between conductors, semiconductors and insulators.

Semiconductor Crystals (10 Hrs)

Band Gap-Equations of motion-Effective mass-Physical interpretation of effective mass - Effective mass in semiconductors-Silicon and Germanium-Intrinsic carrier concentration-Impurity conductivity - Thermal ionization of Donors and Acceptors - Thermoelectric effects-semimetals-super lattices - Bloch Oscillator - Zener tunnelling.

Module III

Crystal Vibrations and Thermal Properties (16 Hrs)

Vibrations of crystals with monatomic basis –First Brillouin zone-Group Velocity-Two atoms per Primitive Basis – Quantization of elastic waves – Phonon momentum- Inelastic scattering of phonons - Phonon Heat Capacity- Plank distribution- Einstein Model -Density of States in one and three dimensions - Debye model for density of states- Debye T^3 Law- Anharmonic Crystal interactions - Thermal Expansion- Thermal Conductivity-thermal resistivity of phonon gas-Umklapp Processes- Imperfections

Module IV

Magnetic Properties of Solids (14 hrs)

Quantum theory of paramagnetism – Hund's rules-crystal field splitting-spectroscopic splitting factor-Cooling by adiabatic demagnetization – Nuclear Demagnetization- Ferromagnetic order-Curie point and the exchange integral-Temperature dependence of the saturation Magnetization-Saturation Magnetization at absolute Zero-Magnons- Quantization of spin waves-Thermal excitation of Magnons- Neutron Magnetic Scattering-Ferrimagnetic order-curie temperature and

Susceptibility-Antiferromagnetic order-susceptibility below Neel Temperature-Ferromagnetic domains-Anisotropic Energy- transition region between Domains- origin of domains - Coercivity and Hysteresis- Single Domain Particles- Geomagnetism and Biomagnetism

Textbooks:

1. ***Introduction to Solid State Physics, Charles Kittel, Wiely, Indian reprint (2015)***

2. ***Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)***

3. ***Introduction to Solids, L V Azaroff, Mcgraw-Hill Book Company, Inc.New York (1960)***

Reference Books:

1. Solid State Physics: Structure and properties of materials, M.A.Wahab, Narosa 2nd Edn. (2010)
2. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th Indian Reprint (2011).
3. Solid State Physics, R.L. Singhal, KedarNath Ram Nath& Co (1981)
4. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
5. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
6. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
7. Solid State Physics, Dan Wei, Cengage Learning (2008)
8. Solid State Physics, S.O. Pillai, New Age International 6th Edn. (2010)

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PH2C08TM20 - CONDENSED MATTER PHYSICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 24 hrs	4	3	1	15
Module II - 18 hrs	3	2	1	12
Module III-16 hrs	1	2	1	10
Module IV-14hrs	2	1	1	9

PH2C01PM20 - GENERAL PHYSICS PRACTICALS

Total credits: 4

Total hours: 180

Course Outcomes:

CO1: Develop the skills to carry out experiments in Optics, Electricity Magnetism and Mechanism and to acquire data accurately and keep systematic record of laboratory activities

CO2: Interpret findings using the correct physical scientific framework and tools

CO3: Evaluate possible causes of error in experimental observations and results

Minimum of 12 Experiments may be chosen from the list. Error analysis of the experiments is to be done.

1. Y, n, σ Cornu's method (a) Elliptical fringes and (b) Hyperbolic fringes.
2. Absorption spectrum –KMnO4 solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method
3. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.
4. Resistivity of semiconductor specimen–Four Probe Method
5. Band gap energy measurement of silicon.
6. Acousto-optic technique-elastic property of a liquid
7. B - H Curve-Hysteresis.
9. Magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
10. Curie temperature of a magnetic material.
11. Dielectric Constant and Curie temperature of ferroelectric Ceramics.
12. Oscillating Disc-Viscosity of a liquid
13. e/m of the electron-Thomson's method
14. Characteristic of a thermistor - Determination of the relevant parameters.
15. Dielectric constant of a non-polar liquid.
16. Dipole moment of an organic molecule (acetone).
17. Young's modulus of steel using the flexural vibrations of a bar.
18. Verification of Stefan's law and determination of Stefan's constant of radiation
19. Photoelectric effect – determination of Plank's constant.
20. Calibration of Silicon diode as a temperature sensor.

21. Elementary experiments using Laser: (a) Study of Gaussian nature of laser beam(b) Evaluation of beam spot size (c) Measurement of divergence
22. Determination of magnetic susceptibility of a solid by Guoy's method.
23. Measurement of wavelength of laser using reflection grating.
24. Fraunhoffer diffraction pattern of a single slit, determination of wavelength/slit width.
25. Fraunhoffer diffraction pattern of wire mesh, determination of wavelength/slit width.
26. Fraunhoffer diffraction pattern of double slit, determination of wavelength/slit width.
27. Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
28. Fresnel diffraction pattern of a single slit.
29. Determine the numerical aperture of optical fibre and propagation of light through it.
30. Determine the refractive index of the material using Brewster angle setup.
31. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law
32. Photograph/Record the absorption spectrum of iodine vapour and a standard spectrum. Analyze the given absorption spectrum of iodine vapour and determine the convergence limit. Also estimate the dissociation energy of iodine (wave number corresponding to the electronic energy gap = 759800 m^{-1})
33. Determine the charge of an electron using Millikan oil drop experiment.
34. Linear electro optic effect (Pockel effect), Frank Hertz experiment.
35. Frank Hertz experiment determination of ionization potential.
36. Koening's method, Poisson's ratio of the given material of bar.
37. Constants of a thermocouple and temperature of inversion.

Reference Books

1. Advanced Practical Physics for students - B.L. Worsnop and H.T. Flint – Methusen & Co (1950)
2. Manual of experiments in applied Physics - E.V. Smith - Butterworth (1970)
3. Experimental Physics - Modern methods - R.A. Dunlap - Oxford University Press
4. Methods of experimental Physics - series of volumes D. Malacara (ed) - Academic Press Inc (1988)
5. A course on experiment with He-Ne Laser, R.SSirohi, John Wiley & Sons (Asia) Pvt.ltd
6. Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan, K.R Priolkar, Indian Academy of Sciences.
7. Advanced Practical Physics, S.P Singh, Pragati Prakasan,
8. Practical Physics, Gupta, Kumar, Pragati Prakasan.
9. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd: **for error analysis only.

PH2C02PM20 - ELECTRONICS PRACTICAL

Total credit: 4

Total hours: 180

Course Outcomes:

CO1: Use Op-Amp as differentiator, integrator and for solving differential equations.

CO2: Design and test the operation of the Schmitt Trigger circuit, first and second order low pass, high pass and band pass active filters using Op-Amp,with given specifications.

CO3: Design and analyse various waveform generation circuits using Op-Amps and IC packages.

CO4: Investigate the operation of VCO and A/D and D/A converters.

*** Minimum number of experiments to be done 12**

*** PC interfacing facilities such as ExpEYES can be used for the experiments**

1. Op-Amp parameters (i) Open loop gain (ii) input offset voltage (iii) input bias current (iv) CMRR (v) slew rate (vi) Band width
2. Design and construct an integrator using Op-Amp (μA741), draw the input output curve and study the frequency response.
3. Design and construct a differentiator using Op-Amp (μA741) for sin wave and square wave input and study the output wave for different frequencies.
4. Design and construct a logarithmic amplifier using Op-Amp (μA741) and study the output wave form.
5. Design and construct a square wave generator using Op-Amp (μA741) for a frequency f_0.
6. Design and construct a triangular wave generator using (μA741) for a frequency f_0.
7. Design and construct a saw tooth wave generator using Op-Amp (μA741) generator.
8. Design and construct an Op-Amp Wien bridge oscillator with amplitude stabilization and study the output wave form.
9. Design and construct a Schmidt trigger using Op-Amp μA741, plot of the hysteresis curve.
10. Design and construct an astablemultivibrator using μA741 with duty cycle other than 50%
11. Design and construct a RC phase shift oscillator using μA741for a frequency f_0.
12. Design and construct a first and second order low pass Butterworth filter using μA741 and plot the frequency response curve.
13. Design and construct a first and second order high pass Butterworth filter using μA741 and study the frequency response.

14. Design and construct a first order narrow band pass Butterworth filter using μA741.
15. Solving differential equation using μA741
16. Design and construct current to voltage and voltage to current converter (μA741).
17. Design and construct the differential amplifier using transistors and constant current source-frequency response and CMRR
18. Astable multivibrator using 555 timer, study the positive and negative pulse width and free running frequency.
19. Monostable multivibrator using 555 timers and study the input output waveform.
20. Voltage controlled Oscillator using 555 timer
21. Design and construct a Schmitt Trigger circuit using IC 555.
22. Design and test a two stage RC coupled common emitter transistor amplifier and find the bandwidth, mid-frequency gain, input and output impedance.
23. Design and test a RC phase shift oscillator using transistor for a given operating frequency.
24. Voltage controlled Oscillator using transistor
25. Study the function of (i) analog to digital converter using IC 0800 (ii) digital to analog converter DAC 0808
26. Study the application of op-Amp (μA741) as a differential amplifier.
27. Solving simultaneous equation using op-Amp (μA741).

References:

1. Op-Amp and linear integrated circuit Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7
2. Electronic Laboratory Primer a design approach S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi
3. Electronic lab manual Vol I, K ANavas, Rajath Publishing
4. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd: **For error analysis only.

Semester III

PH3C09TM20 - QUANTUM MECHANICS-II

Total Credits: 4

Total Lecture Hours: 72

Course Outcomes:

CO1: Discuss the degenerate and non-degenerate perturbation theory for stationary states.

CO2: Derive the time dependent perturbation theory and apply it to selected examples of quantum systems.

CO3: Distinguish between bosons and fermions and develop the Pauli's exclusion principle.

CO4: Solve the dynamics of He atom using the idea of identical particles.

CO5: Understand the basic concepts of scattering and solve scattering problems

CO6: Discuss the relativistic quantum mechanics: Klein-Gordan and Dirac equations.

Module I

Approximation Methods for Stationary States (18 Hours)

Non-degenerate Perturbation Theory: First order energy shift - first order correction to the energy eigenstate - second order energy shift, Harmonic oscillator subjected to a constant electric field - Degenerate Perturbation theory - First order Stark effect in hydrogen - Zeeman effect in hydrogen and the Lande g-factor - The variational Method - Estimation of ground state energies of harmonic oscillator and delta function potential - Hydrogen Molecule ion. -The WKB method and its validity - The WKB wave function in the classical region - non-classical region - connection formulas(derivation not required) - Potential well and quantization condition - the harmonic oscillator.

Text Book:

1. ***Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.***

Module II

Time-Dependent Perturbation Theory (18 Hours)

Time dependent potentials - interaction picture - time evolution operator in interaction picture - Spin Magnetic Resonance in spin half systems - Time dependent perturbation theory - Dyson series - transition probability - constant perturbation - Fermi's Golden Rule - Harmonic perturbation - interaction of atom with classical radiation field - absorption and stimulated emission - electric dipole approximation - photoelectric effect - Energy shift and decay width.

Text Book:

1. ***Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.***

Module III

Identical Particles and Scattering Theory (18 Hours)

Bosons and fermions - anti-symmetric wave functions and Pauli's exclusion principle - The Helium Atom.- The Asymptotic wave function - differential scattering cross section and scattering amplitude - The Born approximation - scattering amplitude in Born approximation - validity of the Born approximation - Yukawa potential - Coulomb potential and the Rutherford formula- Partial wave analysis - hard sphere scattering - S-wave scattering for finite potential well - Resonances and Ramsauer-Townsend effect.

Text Book:

1. ***A modern Approach to Quantum Mechanics: John Townsend, Viva Books, New Delhi.***
2. ***Introduction to Quantum Mechanics: D.J. Griffith, Pearson Education.***

Module IV

Relativistic Quantum Mechanics (18 Hours)

Klein-Gordon Equation - continuity equation and probability density in Klein-Gordon theory - Non-relativistic limit of the Klein-Gordon equation - Solutions of the Klein –Gordon equation for positive, negative and neutral spin0 particles - Klein-Gordon equation in the Schrodinger form - Dirac Equation in the Schrodinger form - Dirac's matrices and their properties - Solutions of the free particle Dirac equation - single particle interpretation of the plane waves - velocity operator - zitterbewegung - Non-relativistic limit of the Dirac equation - spin of Dirac particles -Total angular momentum as a constant of motion

Text Book:

1. ***Relativistic Quantum Mechanics: Walter Greiner, Springer-Verlag.***

References:

1. Quantum Mechanics (Schaum's Outline Series): YoavPelegetal., Tata McGraw Hill Education Private Limited, 2/e.
2. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
3. Problems and Solutions in Quantum Mechanics: KyriakosTamvakis, Cambridge University Press.
4. Introductory Quantum Mechanics: Richard L Liboff, Pearson Education.

5. Quantum Mechanics: V. K. Thankappan, New Age International.
6. A Textbook of Quantum Mechanics: P M Mathews and R Venkatesan, Tata McGraw Hill.
7. Quantum Mechanics: Non Relativistic Theory (Course of Theoretical Physics Course Vol3) L. D. Landau and E. M. Lifshitz, Pergamon Press.
8. Relativistic Quantum Mechanics: James D Bjorken and Sidney D Drell, Tata McGraw Hill 2013
9. www.ntpel/videos.in/2012/11/quantum-physics.html
10. https://nptel.ac.in/courses/115106066

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PH3C09TM20 - QUANTUM MECHANICS-II

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	2/2/3/3	2	1	11/11/12/12
Module II- 18 hrs	2/3/3/2	2	1	11/12/12/11
Module III-18 hrs	3/2/2/3	2	1	12/11/11/12
Module IV- 18 hrs	3/3/2/2	2	1	12/12/11/11

Semester III

PH3C10TM20 - COMPUTATIONAL PHYSICS

Total Credits: 4

Total lecture hours: 72

Course Outcomes:

CO1: Explain various interpolation and finite difference concepts.

CO2: Solve numerical differentiation and integration whenever and wherever routine methods are not applicable.

CO3: Work numerically on the ordinary differential equations using different methods through the theory of finite differences.

CO4: Apply different methods to find numerical solution of ordinary, partial differential equations and system of equations.

Module I

Curve Fitting and Interpolation (20Hrs)

The least squares method for fitting a straight line, parabola, power and exponential curves with the help of principle of least square fit - Interpolation - Introduction to finite difference operators- Newton's forward and backward difference interpolation formulae- Lagrange's interpolation formula- Newton's divided difference formula with error term- interpolation in two dimensions- Cubic spline interpolation- end conditions-Statistical Ψ^2 test

Module II

Numerical Differentiation and Integration (16 Hrs)

Numerical differentiation, errors in numerical differentiation- cubic spline method - finding maxima and minima of a tabulated function - Integration of a function with Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule and error associated with each - Romberg's integration-Gaussian integration method- numerical double integration

Module III

Numerical Solution of Ordinary Differential Equations (20Hrs)

Euler method - modified Euler method and Runge - Kutta 4^{th} order methods - predictor - corrector methods - Milne's method and Adam-Mouton method.

Numerical Solution of System of Equations

Elimination methods – Gauss elimination with pivoting and Gauss-Jordan elimination Method – Iteration methods – Jacobi's method and Gauss-Seidel iteration method – Gauss elimination method and Gauss-Jordan method to find inverse of a matrix - Power method and Jacobi's method to solve eigen value problems

Module IV

Numerical solutions of partial differential equations (16Hrs)

Classification of second order partial differential equations - finite difference approximations to derivatives - Laplace's equation- Jacobi's method, Gauss-Seidel method, successive over relaxation method - Parabolic equations- Schmidt Method, Crank - Nicholson method.Iterative methods for the solution of equations- Hyperbolic equations

Text Books:

1. ***Numerical methods for Scientists and Engineers - K Sankara Rao, Prentice Hall of India***
2. ***Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.***
3. ***Numerical Methods, E.Balaguruswamy, Tata McGraw Hill,2009***

Reference Books

1. Numerical methods for Scientists and Engineers - K Sankara Rao, Prentice Hall of India
2. An Introduction to Computational Physics-Tao Pang, Cambridge University Press
3. Numerical methods for scientific and Engineering computation -M.K S.R.K Iyengar, R.K. Jain, New Age International Publishers
4. Computer Oriented Numerical Methods- V. Rajaraman, PHI,2004
5. Numerical Methods -E. Balagurusami, Tata McGraw Hill ,2009
6. Numerical Mathematical Analysis, J.B. Scarborough, 4th Edn, 1958

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PH3C10TM20- COMPUTATIONAL PHYSICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 20 hrs	**4/3**	**2**	**1**	**13/12**
Module II- 16 hrs	**1/2**	**2**	**1**	**10/11**
Module III-20 hrs	**4/3**	**2**	**1**	**13/12**
Module IV- 16 hrs	**1/2**	**2**	**1**	**10/11**

Semester III

PH3C11TM20- ATOMIC AND MOLECULAR PHYSICS

Total Credits: 4

Total Lecture hours: 72

Course Outcomes:

CO1: Apply vector atom model to explain spectroscopic behaviour of atoms in electric and magnetic field

CO2: Analyse the rotational spectrum of rigid and non-rigid diatomic rotator

CO3: Illustrate the effects of rotation on vibrational spectra of polyatomic molecules

CO4: Describe different magneto- optical and electro-optical phenomena, various nonlinear and stimulated Raman effects.

CO5: Describe the theory of electronic spectrum of diatomic molecules.

CO6: Outline theory and experimental techniques of NMR, ESR , Raman spectroscopy and Mossbauer spectroscopy

Module I

Atomic Spectra (18 Hrs)

Vector atom model and quantum numbers - spectroscopic terms - Spin-orbit interaction- derivation of spin-orbit interaction energy, extension to penetrating orbits; fine structure in sodium atom, selection rules. Lande g factor - Normal and anomalous Zeeman effects, Paschen–Back effect and Stark effect in one electron system, quadratic Stark effect in potassium doublet - Coupling schemes - L S and j j coupling- spectroscopic terms arising from two valence electrons; terms arising from two equivalent s-electrons, vector diagram, examples- sp and pd electrons, derivation of interaction energy, Hund's rule &Lande interval rule. Hyperfine structure and width of spectral lines (Qualitative ideas only)

Text Book:

1. ***Introduction of Atomic Spectra, H.E. White, McGraw Hill***

Module II

Microwave and Infrared Spectroscopy (18 Hrs)

Microwave Spectroscopy: Width of spectral lines-natural width, collision broadening, Doppler broadening- Classification of molecules- linear, symmetric top, asymmetric top and spherical top molecules - Rotational spectra of rigid diatomic molecules; effect of isotopic substitution; intensity of spectral lines; energy levels and spectrum of non–rigid rotor .-

Information derived from rotational spectra(molecular structure, dipole moment , atomic mass and nuclear quadrupole moment)

Infrared Spectroscopy : Vibrational energy of a diatomic molecule- simple harmonic oscillator –energy levels; diatomic molecule as anharmonic oscillator- energy levels; infrared selection rules; spectrum of a vibrating diatomic molecule - Diatomic vibrating rotator –P and R branches; break down of Born-Oppenheimer approximation - Vibrations of polyatomic molecules – fundamental vibrations and their symmetry; overtone and combination frequencies; Analysis by IR techniques- skeletal vibrations and group frequencies

Text Book:

1. ***Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw Hill***

Module III

Raman Spectroscopy and Electronic Spectroscopy (18 Hrs)

Raman Spectroscopy: Quantum theory of Raman effect**;** classical theory-molecular polarizability; Pure rotational Raman spectra of linear molecules - Raman activity of vibrations; rule of mutual exclusion; vibrational Raman spectra;rotational fine structure - Structure determination from Raman and IR spectroscopy. -Non- linear Raman effects - hyper Raman effect - classical treatment; stimulated Raman effect - CARS, PARS - inverse Raman effect.

Electronic Spectroscopy : Electronic spectra of diatomic molecules –Born-Oppenheimer approximation, vibrational coarse structure-progressions and sequences intensity of spectral lines- Franck – Condon principle -Dissociation energy and dissociation products; Rotational fine structure of electronic-vibrational transition; Fortrat parabola; Predissociation.

Text Book:

1. ***Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw Hill***
2. ***Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.***

Module IV

Spin Resonance Spectroscopy (18 Hrs)

Nuclear Magnetic Resonance (NMR): Nuclear Magnetic Resonance (NMR)-resonance condition; relaxation processes - Bloch equations - Chemical shift; indirect spin–spin interaction - CW NMR spectrometer; Magnetic Resonance Imaging.-

Electron Spin Resonance(ESR) : Electron Spin Resonance(ESR)-Principle of ESR; thermal equilibrium and relaxation; ESR spectrometer; characteristics of the g-factor -Total Hamiltonian for an electron; Hyperfine Structure- ESR spectrum of hydrogen atom.

Mossbauer Spectroscopy: Mossbauer effect - recoilless emission and absorption; Experimental techniques in Mossbauer spectroscopy -Isomer shift; quadrupoleinteraction; magnetic hyperfine interaction.

Text Book:

1. ***Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw Hill***
2. ***Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.***

References:

1. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons.
2. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern
3. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons

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PH3C11TM20- ATOMIC AND MOLECULAR PHYSICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	2/3/2/3	2	1	11/12/11/12
Module II- 18 hrs	2/3/3/2	2	1	11/12/12/11
Module III-18 hrs	3/2/2/3	2	1	12/11/11/12
Module IV- 18 hrs	3/2/3/2	2	1	12/11/12/11

Semester IV

PH4C12TM20 - NUCLEAR AND PARTICLE PHYSICS

Total Credits: 4

Total Lecture hours : 90

Course outcomes:

CO1 Acquire basic knowledge about fundamental nuclear properties and nuclear forces

CO2 Discuss about the different nuclear decay processes, interactions, their characteristics and analyse beta decay in detail.

CO3 Apply the different models of nuclei to explain the properties exhibited by them.

CO4 Compare nuclear fission and fusion reactions and their characteristics.

CO5 Classify the elementary particles,nuclear interactions, symmetries and their conservation laws

CO6 Explain primordial and stellar nucleosynthesis and discuss some applications of nuclear physics

Module I

Nuclear properties and Force between nucleons (18 hrs)

The nuclear radius- distribution of nuclear charge (isotope shift, muonic shift, mirror nuclei), distribution of nuclear matter - Mass and abundance of nuclides -Nuclear binding energy- Nuclear angular momentum and parity - Nuclear electromagnetic moments - The deuteron- binding energy, spin, parity, magnetic dipole moment and electric quadrupole moment. Nucleon-nucleon scattering - Properties of nuclear forces - Exchange force model

Module II

Nuclear Decay and Nuclear Reactions (18 Hrs)

Elementary ideas of α, β, γ decay - Beta decay- energy release- Fermi theory- angular momentum and parity selection rules, Comparative half lives and forbidden decays-neutrino physics- non conservation of parity - Types of reactions and conservation laws-energetics of nuclear reactions - isospin. Reaction cross sections- Coulomb scattering, nuclear scattering - scattering and reaction cross sections- compound-nucleus reactions, direct Reactions

Module III

Nuclear Models, Fission and Fusion (18 Hrs)

Shell model - Spin-orbit potential - Magnetic dipole moments, Electric quadrupole moments - Valence Nucleons - Collective structure - Nuclear vibrations, Nuclear rotations

Liquid drop Model, Bethe – Weizsacker formula - Application of semi empirical formula - Alpha decay

Nuclear fission – characteristics - energy in fission - Controlled fission reactions - Fission reactors

Nuclear Fusion - Characteristics - Controlled fusion reactors

Module IV

Particle Physics (18 Hrs)

Classification of elementary particles - Types of interactions - The four basic forces – symmetries and conservation laws - Conservation of energy, mass, linear and angular momentum, electric charge, Baryon and lepton numbers, strangeness, isospin and parity - C, P, T theorem - Gell-Mann-Nishijima formula - applications of symmetry arguments to particle reactions - Quark model, confined quarks, coloured quarks, experimental evidences for quark model – Gluons - quark-gluon interaction - Grand unified theories- standard model of particle physics

Module V

Nuclear Astrophysics and Practical Applications of Nuclear Physics (18 Hrs)

Particle and nuclear interactions in the early universe, primordial nucleosynthesis –Stellar nucleosynthesis (for both A<60 and A>60) - Higg's boson and the LHC experiments; detection of gravitational waves and LIGO (qualitative ideas only)

Rutherford Backscattering spectroscopy and applications -Computerized Axial Tomography (CAT) - Positron Emission Tomography (PET)

Text Books:

1. ***Introductory Nuclear Physics, K. S. Krane, Wiley India Pvt. Ltd.(Chapter 3&4)***
2. ***Nuclear Physics- D.C. Tayal, Himalaya Publishing House***
3. ***Nuclear Physics, S. N. Ghoshal, S.Chand Ltd.***

References:

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY
2. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, NewDelhi

3. The particle Hunters - Yuval Ne'eman&Yoramkirsh CUP
4. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi
5. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai
6. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
7. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi
8. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London
9. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi
10. Atomic and Nuclear Physics, Ghoshal, Vol. 2, S. Chand & Company
11. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York
12. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison-Wesley, Tokyo
13. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.
14. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer
15. Elementary Particles and Symmetries, L.H. Ryder, Gordon and Breach, SciencePublishers, NY
16. https://nptel.ac.in/ course/115104043
17. https://www.ias.ac.in/article/fulltext/reso/022/03/0245-0255
18. https://www.ias.ac.in/article/fulltext/reso/017/10/0956-0973
19. https://atlas.cern/updates/atlas-feature/higgs-boson

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PH4C12TM20 - NUCLEAR AND PARTICLE PHYSICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**2**	**1/1/1/1/4**	**1/1/1/1/0**	**9/9/9/9/10**
Module II- 18 hrs	**2**	**1/1/1/4/1**	**1/1/1/0/1**	**9/9/9/10/9**
Module III-18 hrs	**2**	**1/1/4/1/1**	**1/1/0/1/1**	**9/9/10/9/9**
Module IV- 18 hrs	**2**	**1/4/1//1/1**	**1/0/1/1/1**	**9/10/9/9/9**
Module IV- 18 hrs	**2**	**4/1/1/1/1**	**0/1/1/1/1**	**10/9/9/9/9**

PH4C03PM20 - COMPUTATIONAL PHYSICS PRACTICALS

Total Credits: 4

Total Hours: 180

Course Outcomes:

CO1: Develop programming concepts in solving problems in Physics

CO2: Develop basic skills to use numerical methods for modeling physical systems

CO3: Critically examine and evaluate a model of a physical system

Introduction to computational facility in the Centre

Introduction to the IDE used in the centre and commands for execution of a program. Inputting data and variables, outputting results on a console.

- Achieving arithmetic operations and use of data and variables in the software used at the College
- Usage of decisions and loops.
- Creating an array and using array operations.
- Method of declaring functions and function calling.
- Writing data to a file and reading data from a file.
- Getting a graph from a data available using plotting software available with the College.

(*Minimum number of experiments to be done is 12)

1. Find the root of the given non-linear equations by the bisection method.
2. Find the root of the given non-linear equations by the Newton-Raphson method.
3. A thermistor gives following set of values. Calculate the temperature corresponding to the given resistance using Lagrange interpolation.

Temperature	1101.0 K	911.3 K	36.0 K	636.0K	51.1 K	273 K
Resistance	25.113 Ω	30.131 Ω	0.120 Ω	40.120	0.128 Ω	?

This is only a sample data. Students should be capable to interpolate any set of data)

4. Newton's forward interpolation / backward interpolation.

5. Using appropriate technique and the given "Table", Calculate the pressure at the temperature asked.

   Steam Table

Temperature in C	140	150	160	170	180
Pressure kgf/cc	3.685	4.854	6.302	8.076	10.22

   Temperature: 175^0C (This is only a sample data. Students should be capable to handle another set of data from any other physical phenomena)

6. Value of some trigonometric function [say f(θ) = tan (θ)] for θ=15,30,45,60,75 are given to you. Using appropriate interpolation technique calculate value of f(θ) for a given value.
7. Numerical integration by the trapezoidal rule.
8. Using the trapezoidal rule, calculate the inner surface area of a parabolic reflecting mirror. (length of semi major axis , semi minor axis and height are to be given)
9. Numerical integration by the Simpson rule (both 1/3 and 3/8 rule).
10. Fit a straight line using method of least square to a set of given data without using any built in function of curve fitting. Compare your result with any built in curve fitting technique.
11. Find out the normal equations and hence fit a parabola using method of least square to a set of given data without using any built in function of curve fitting. Compare your result with any built in curve fitting technique.
12. Fit a exponential curve to the given set of data using method of least square with out using any built in curve fitting technique. Compare your result with any built in curve fitting technique.
13. Study the given function as a sum of infinite series. Compare your value with the available standard value.
14. Numerical solution of ordinary first-order differential equations using the Euler methods or the fourth order Runge-Kutta method.
15. Using technique of Monte Carlo method obtain the value of π correct to two decimal places .
16. Using Monte Carlo technique calculate the value of the given integral. Compare your result with result obtained by analytical method.

17. Write a program to solve the given system of linear equations by the Gauss elimination method.
18. Find out inverse of a given matrix by using Gauss-Jordan method.
19. Numerical solution of second-order differential equations using the fourth order Runge-Kutta method.
20. Fast Fourier Transform of a given signal.
21. Solution of Heat equation / Diffusion equation using Finite Difference Method.
22. A Duffing oscillator is given by $\ddot{x} + \delta \dot{x} + \beta x + \alpha^{3} = \gamma \cos \omega t$ where δ is damping constant>0. Write a program to study periodic and aperiodic behavior
23. Study of path of a Projectile in motion with and without air drag and compare the values
24. A study of Variation of magnetic field B(T) with critical temperature in superconductivity
25. Generation of output waveform of a Half wave / full wave rectifier.
26. Charging /discharging of a capacitor through an inductor and resistor
27. Variation in phase relation between applied voltage and current of a series L.C.R circuit
28. Phase plot of a pendulum (driven and damped pendulum)
29. Study variation of intensity along a screen due to the interference from Young's double slit experiment. Also study the variation of intensity with variation of distance of the screen from the slit.
30. Study variation of intensity along a screen due to the diffraction due to a grating. Also study the variation of intensity with variation of distance of the screen from the grating.
31. A particle obeying F-D statistics is constrained to be in 0 to 2eV at 300K. Calculate Fermi energy of this particle assuming kT =0.025eV at 300K
32. Solve the following differential equation and study periodic and aperiodic behavior.

$$dy/dx = \sigma(y - x), \quad dy/dx = x(\rho - x) - y, \quad dy/dx = xy - \beta z$$

33. Study the difference equation $X_{n+1} = mX_n(1 - X_n)$ and obtain periodic and aperiodic behavior.
34. Generate a standing wave pattern and study change in pattern by changing its various parameters.

35. Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.
36. Numerical integration by Rectangle rule.
37. Analyse the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference.

Note:

- Develop algorithm / Flowchart for all experiments
- Codes can be developed in any package / programming language. Candidates should be trained to explain parts of the codes used.
- Plotting can be done in any plotting package and can be separate from the programming package / environment.
- Verify numerical results with analytical results wherever possible.
- Repeat experiments for various initial values / functions / step-sizes.
- Training may be given to use methods discussed below to solve real physics problems.

Reference books

1. Computational Physics: An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt.Ltd,2014.
2. An Introduction To Computational Physics, 2nd Edn,Tao Pang Cambridge University Press, 2010
3. Numerical Recipes: The Art of Scientific Computing 3rd Edn, William H. Press Cambridge University Press, 2007.

Electives Bunch A: Material Science

Semester III

PH3E01TM20 - SOLID STATE PHYSICS FOR MATERIALS

Total Credits: 4

Total Lecture Hours: 54

Course Outcomes:

CO1: Identify all possible defect states in a given crystal system and predict its impact on crystal properties.

CO2: Apply Pauli's rule in the context of polymorphism in crystals.

CO3: Apply the laws of diffusion to a given system of atoms.

CO4: Predict the formation of stable states and their compositions using phase diagrams.

CO5: Analyse the features of different types of quanta of energy states.

CO6: Evaluate the excited state energy features of quantum confined structures using the weak and tight binding models.

Module I

Crystal defects (18hrs)

Crystal Imperfection - point imperfections, vacancy, Frenkel and Schottky imperfections - Dislocations - Edge, screw, Burger's vector critical resolved shear stress - Dislocation motion - dislocation reaction, dislocation energy, slip - Surface and volume imperfections, stacking faults, fracture, twinning (Ref 5)-Voids in close packing - size, coordination and significance -Pauling's rule and applications - allotropy, polymorphism (Ref 4),polytypism

Module II

Atomic Diffusion (6hrs)

Fick's laws - solution and applications - Kirkendall effect - atomic model of diffusion and other diffusion processes and mechanisms

Crystal binding (12hrs)

Crystals of inert gas, Van der Waals -London interaction, repulsive interaction, equilibrium lattice constants, cohesive energy - Ionic crystals - Madelung energy, Madelung constant - Covalent crystals - metals, hydrogen bond, Born-Haber cycle

Module III

Phase diagrams (6h)

Phase diagram rules - unary and binary phase diagrams -Microstructural changes during cooling - applications

Excitations in solids (12h)

Plasma optics, plasmons –Polaritons- LST relations - Electron-phonon interaction-polarons – KramersKronig Relations -excitons, Frenkel and Wannier excitons, electron hole drops Magnons - spin wave quantization and thermal excitation of magnons

Textbooks:

1. Materials Science and Engineering- V Raghavan-PHI.

2. Introduction to solid state physics- C Kittel- Wiley India.

3. Solid State Physics- Wahab- Narosa

References:

1. Lectures on Solid State Physics- Georg Busch & Horst Schade; Pergamon Press.
2. Callister's Materials Science and Engineering- Wiley India.
4. Elementary Solid State Physics: M Ali Omar- Pearson.
5. Solid State Physics- S O Pillai- New Age.
6. Introduction to solids- Azaroff-TMH.
7. Solid State Physics- Adrianus J Dekker- Macmillan.

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PH3E01TM20 - SOLID STATE PHYSICS FOR MATERIALS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**5/4**	**2/3**	**1/1**	**14/15**
Module II- 18 hrs	**2/3**	**3/4**	**2/1**	**18/16**
Module III-18 hrs	**3/3**	**3/1**	**1/2**	**14/15**

MODEL QUESTION PAPER

PH3E01TM20 - SOLID STATE PHYSICS FOR MATERIALS

Time: 3 hrs **Total weight: 30**

Part A

I. Answer any 8 questions, each question carries weight 1

1. What is polytypism?
2. Explain edge dislocation.
3. Discuss the formation of stacking faults in fcc crystals.
4. What is polymorphism?
5. State Pauling's rules.
6. What is Kirkendall effect?
8. How does Van der Waals- London interaction evolve?
9. Distinguish between Frenkel and Wannier excitons?
10. Write a note on plasmons.

(8 x 1 = 8 weights)

Part B

II. Answer any 6 questions, each question carries weight 2

11. Determine the fraction of atoms in a given solid with energy equal to or greater than 1.4eV at room temperature and 5 times room temperature.
12. Find the radius of the largest sphere that will fit into the void produced by the bcc packing of atoms of radius R.
13. Explain the importance of Born-Haber cycle.
14. What are the different types of diffusion mechanisms? Explain.
15. Assume that the potential energy of two particles in the field of each other is given by where A and B are constants. Show that the particles form a stable compound for. Prove that for stable configuration, the energy of attraction is 9 times the energy of repulsion. Also find the potential energy under stable configuration.
16. Briefly discuss the phase diagram rules.
17. Discuss the role of phase diagram in zone refining of materials.
18. What is LST relation? Explain its importance.

(6 x 2 = 12 weights)

Part C

III. Answer any 2 questions, each question carries weight 5.

19. What is dislocation and obtain the expression for the energy of dislocation.
20. Explain Madelung energy and evaluate the Madelung constant for a one dimensional chain.
21. What are Fick's laws? Obtain the solution for second Fick's law for the diffusion througha plane surface.
22. Discuss the origin of the quantization of spin waves.

(2 x 5 = 10 weights)

Semester IV

PH4E02TM20 - SCIENCE OF ADVANCED MATERIALS

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes

CO1: Evaluate the performance of batteries and fuel cells.

CO2: Analyse the propagation features of Gaussian beams.

CO3: Apply the theory for pulse modulation and pulse compression and evaluate the number of possible laser modes in a given system.

CO4: Analyse the design features of LEDs and solar cells.

CO5: Compare the features of type I and II superconductors.

CO6: Judge the suitability of a particular crystal growth method for a given crystal system.

Module I

Materials for Energy Applications (25hrs)

Batteries and Super capacitors (10hrs)

Batteries and Super capacitors for electrochemical energy storage - Batteries, primary and secondary batteries, Lithium, Solid-state and molten solvent batteries, Lead acid batteries, Nickel Cadmium Batteries - Super capacitors for energy storage- Role of carbon nanomaterials as electrodes in batteries and super capacitors.

Materials for energy storage: (5hrs)

Carbon Nano-Tubes (CNT), Carbon Nano-Fibres (CNF), graphene - Fabrication of CNTs and CNFs, CNTs and CNFs for hydrogen storage

Fuel Cells and its applications (10hrs)

Fuel Cells, components of fuel cells, Types of fuel cells, Acid/alkaline fuel cells, polymer electrolyte fuel cell, molten carbonate fuel cell, solid oxide fuel cell, Types of solid oxide fuel cells- High temperature, intermediate temperature Single chamber solid oxide fuel cells, Problems with fuel cells, applications of fuel cells, difference between batteries and fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack.

Module II

Optical properties of materials (10hrs)

Absorption processes, photoconductivity, photovoltaic effect, colour centers - types and generation -Luminescence – photoluminescence, cathodoluminescence, electroluminescence, injection luminescence, radiative recombination - Gaussian Beam - Amplitude, properties, quality - Optical coherence- temporal, spatial

Lasers (10hrs)

Absorption of radiation, threshold conditions, line shape function, population inversion and pumping threshold conditions -laser modes, Semiconductor lasers, hetero junction lasers - Methods of pulsing lasers – Q switching and mode locking

Module III

Photonic materials and Applied Photonics (20hrs)

LEDs (5hrs)

Principles, structure, materials and characteristics, heterojunction LED, SLED and ELED

Solar cells (5 hrs)

Principles, characteristics, PERL, heterojunction, cascaded, and schottky barrier cells, material and design considerations

Photonic Materials and Display Devices (10hrs)

Basic concepts and features of Photonic crystals, Liquid crystals, optics of metamaterials, Amorphous semiconductors - detector arrays-CCDs-Electro-optic effect, magneto-optic effect, acousto-optic effect

Module IV

Superconductors, Thin films and crystal growth (25 hrs)

Superconductors (12 hrs)

Thermodynamics and electrodynamics, BCS theory, flux quantization, type I &II superconductors, single particle tunnelling, Josephson tunnelling, high temperature superconductors

Thin films (7hrs)

Nature- deposition technology-Resistance heating, Cathodic sputtering, interferometric film thickness measurement, Applications: Antireflection coating, solar cells and sensors

Crystal growth (6hrs)

Mechanism of crystal growth, nucleation, classification of crystal growth methods, growth from melt-Czochralski, Bridgeman, Floatzone techniques, growth from solution - gel growth

Text Books:

1. ***Modern Batteries, Collin A Vincent***
2. ***Fuel cell fundamentals-Ryan O'Hayre***
3. ***Modern batteries - Collin A Vincent***
4. ***Fuel cells for advanced applications- S Srinivasan***
5. ***Solid State Physics- Wahab- Narosa***
6. ***Optoelectronics- Wilson & Hawkes- Pearson 2018***
7. ***Optoelectronics and Photonics: Principles and Practices- S O Kasap- Pearson***
8. ***Introduction to solid state physics- C. Kittel- Wiley India***
9. ***Thin film fundamentals: A Goswami- New Age***
10. ***Semiconductor Physics and devices, S.S. Islam, Oxford University press***

References:

1. Fundamentals of Photonics- Saleh and Teich- Wiley India
2. Lasers and Nonlinear Optics: B B Laud; NewAge
3. Solid State Physics- S O Pillai- NewAge
4. Solid State Physics- Wahab- Narosa
5. Semiconductor Optoelectronic Devices: Pallab Bhattacharya-Pearson
6. Introduction to nanotechnology: Charles P Poole, Frank J Owens-Wiley India
7. Elementary Solid State Physics: M Ali Omar-Pearson
8. Crystal growth: processes and methods- P.S. Raghavan and P. Ramasamy, KRU publications
9. Materials Science and Engineering- V. Raghavan -PHI.
10. Essentials of Crystallography- M A Wahab-Narosa
11. Semiconductor Devices: Physics and Technology- S M Sze- Wiley India
12. Fiber optics and Optolelectronics- R P Khare-Oxford

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PH4E02TM20 - SCIENCE OF ADVANCED MATERIALS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Unit I - 25 hrs	3	2	1	12
Unit II- 20 hrs	2	2	1	11
Unit III-20 hrs	2	2	1	11
Unit IV-25 hrs	3	2	1	12

MODEL QUESTION PAPER

PH4E02TM20 - SCIENCE OF ADVANCED MATERIALS

Time: 3 hours **Total Weight:30**

Part A

I Answer any *eight* questions. Each question carries a weight of 1

1. What are super capacitors?
2. How can CNF be used for hydrogen storage?
3. What are the differences between batteries and fuel cells?
4. Mention the properties of Gaussian beams.
5. Distinguish between temporal and spatial coherence.
6. List the features of photonic crystals.
7. Compare SLED and ELED.
8. What is nucleation?
9. What the natures of thin films?
10. Write a note on cathodic sputtering.

(8x1=8 weights)

Part B

II Answer any *six* questions. Each question carries a weight of 2

11. Distinguish between lead acid batteries and lithium ion batteries.
12. Give a detailed account of the classification and fabrication of CNT
13. Show that the photovoltage varies logarithmically with photocurrent.
14. Find the ratio of populations of the two states in a laser that produces a wavelength of 590nm at room temperature.
15. An acousto-optic cell of Raman Nath modulator contains water. A piezoelectric crystal generates an acoustic wave of frequency 5MHz in water. The velocity of the acoustic wave in water is 1500m/s and the thickness of the cell is 1cm. If a laser beam of 632nm is incident on the cell, calculate the angle between the first order diffracted beam and the direct beam.
16. Discuss the classification of liquid crystals.
17. Differentiate between type I and type II superconductors.
18. Explain Josephson tunnelling.

(6x2=12 weights)

Part C

III Answer any *two* questions. Each question carries a weight of 5

19. Describe the structure and working of typical fuel cells. Give a detailed account of the classification of fuel cells.
20. How does mode locking be different from Q-switching? How are they achieved?
21. Explain the solar cell principles and characteristics.
22. Analyse the electrodynamics of superconductors.

(2x5=10 weights)

Semester IV

PH4E03TM20 - NANOSTRUCTURES AND MATERIALS CHARACTERISATION

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes

CO1: Categorise various methods for nanoparticle synthesis.

CO2: Illustrate the modifications in optical, magnetic and mechanical features of materials in nano regime.

CO3: Apply the principles of thermal lens and photoacoustic spectroscopy to evaluate the optothermal properties of materials.

CO4: Apply the rules of thermal gravimetry to predict the stability of a material.

CO5: Apply various methods for particle size measurements and judge their accuracy

Module I

Nanostructures: Synthesis and properties (25 hrs)

Applications of Schrodinger equation in nanoworld- particle confined in one dimension, quantum leak, penetration of barrier - Nanostructures for electronics- quantum dots, nanowires, superlattices and heterostructures - Preparation of quantum nanostructures, size and dimensionality effects, single electron tunnelling - Metal nanoclusters, semiconducting nanoparticles, rare gas and molecular clusters - Self assembly and catalysis. Synthesis routes- bottom up approaches- PVD, CVD, MBE, PLD, wet chemical -Top down synthesis routes- mechanical alloying, nanolithography

Module II

Nanomaterials and applications (20 hrs)

Carbon nanostructures: carbon clusters, fullerenes, CNT-structure of CNT, functionalization of CNT, electronic, vibrational, mechanical and optical properties of CNT, 2D structures and graphene, synthesis of graphene -Nanostructured materials-superparamagnetic nanoparticles, GMR, ferrofluids, colossal magnetoresistance, nanostructured thermal devices, superhydrophobic nanostructured surfaces, biomimetics- nanomachines and nanodevices - MEMs, NEMs, nanosensors, Molecular and supramolecular switches, nanocatalysts, properties and applications of nano ZnO and TiO_2, dendrimers, micelles

Module III

Optical Absorption and Emission spectroscopy (20 hrs)

Instruments for absorption photometry – radiation sources, wavelength selection, cells and sampling devices, detectors; Fundamental laws of photometry (Beer Lambert's law), spectrophotometric accuracy, precision, absorptivity, bathochromic and hypsochromic shift, Jablonski diagram - Principles of Fourier transform optical measurements- advantages of Fourier transform spectrometry, time domain spectrometry, fourier transform of interferograms - Optical atomic spectra- atomic line widths, effect of temperature -Principles and applications of Differential, difference and derivative spectroscopy, photoacoustic and thermal lens spectroscopy. General applications of uv absorption spectroscopy. Theory of fluorescence and phosphorescence spectrophotometry, PL power, total luminescence spectroscopy, fluorescence lifetime measurements, quenching and applications, principle and applications of chemiluminescence, Qualitative ideas of resonance raman spectroscopy, surface enhanced raman spectroscopy

Module IV

Chemical, thermal and X-ray diffraction methods (25 h)

X ray diffraction- production and detection of X-rays and X-ray spectra, Moseley's law, Geometry of an X-ray diffractometer, (Ref 3) X-ray photoelectron spectroscopy, X-ray fluorescence, Particle size determination, Debye Scherrer formula, stress measurementAuger recombination, Auger Emission Spectroscopy. Working of SEM, TEM, AFM and STM with instrumentation - **Mass spectrometry**: ionization methods, mass spectrometers and analyzers, correlation of mass spectra with molecular structure - **Thermal methods**: thermogravimetry, DTA, DTG, DSC, microthermal analysis; Principles of pH measurement, potentiometry, voltammetry and electrogravimetry

Text Books:

(Unit 1 & 2)

1. Introduction to nanotechnology: Charles P Poole, Frank J Owens-Wiley india

2. Textbook of nanoscience and nanotechnology- B S Murty, P Shankar, Baldev Raj, B B Rath, James Muday- Springer Univ. Press

3. Introduction to Nanoscience and Nanotechnology- K K Chattopadhyay A N Banerjee-PHI

4. Introduction to Nanoscience- S M Lindsay, Oxford University Press.

(Unit 3&4)

1. Instrumental methods of analysis- Williard, Merritt, Dean, Settle- CBS

2. Introduction to nanoscience and nanotechnology- KK Chattopadhyay and A N Banerjee-PHI

3. Introduction to Nanoscience- S M Lindsay, Oxford University Press.

4. *Principles of Instrumental analysis- Holler, Skoog, Crouch-Cenage*

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PH4E03TM20 - NANOSTRUCTURES AND MATERIALS CHARACTERISATION

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 25 hrs	3	2	1	12
Module II- 20 hrs	2	2	1	11
Module III-20 hrs	2	2	1	11
Module IV-25 hrs	3	2	1	12

MODEL QUESTION PAPER

PH4E03TM20 - NANOSTRUCTURES AND MATERIALS CHARACTERISATION

Time: 3 hours **Max. Weight:30**

Part A

I. Answer any *eight* questions. Each question carries a weight of 1

1. Write a note on quantum dots.
2. What are super lattices?
3. Explain self-assembly.
4. What are the advantages of nanosensors?
5. Why does graphene be important in nanoworld?
6. Distinguish between bathochromic and hypsochromic shifts.
7. What are the features of thermal lens spectroscopy?
8. State and explain Moseley's law.

9. Define amu and daltons.
10. Why are the applications of TGA more limited than those for DSC?

(8x1=8 weights)

Part B

II. Answer any *six* questions. Each question carries a weight of 2

11. Discuss the various steps involve d in a CVD process.
12. Briefly explain the nanolithographic techniques.
13. Describe the features of giant and colossal magnetoresistance.
14. Discuss the size effects in nanostructures.
15. If the molar absorptivity of a complex is 12000 $lmol^{-1}cm^{-1}$ and the minimum detectable absorbance is 0.001, find the minimum molar concentration that can be detected for 1cm path length.
16. What are the advantages of Fourier transform spectrometry?
17. What is the short wavelength limit of the continuum produced by an X-ray tube having silver target and operated at 90kV?
18. An AFM cantilever has a spring constant 0.1N/m. Find its mass if oscillating frequency is 40kHz.

(6x2=12 weights)

Part C

III. Answer any *two* questions. Each question carries a weight of 5

19. Discuss the theory of quantum leak.
20. Explain the properties and applications of nanoZnO and TiO_2.
21. (a) Explain how the photoluminescence power is related to concentration. (b) How does the fluorescence lifetime be calculated?
22. Analyse the functioning of TEM. How can you use TEM for quantitative analysis.

(2x5=10 weights)

PH4E01PM20 - ADVANCED PRACTICALS IN MATERIAL SCIENCE

Total credit: 4

Total hours: 180

Course Outcomes

CO1: Acquire skills in characterisation techniques

CO2: Develop skills in setting up experiments

CO3: Analyse the experimental data

(Minimum number of experiments to be done is 12. Error analysis of the result is a compulsory part of experimental work)

1. Malus' law- verification
2. Optical activity- specific rotation measurement
3. Stefan's constant- torch bulb filament resistance measurement
4. Absorption coefficient of solution- path length and concentration dependence
5. XRD- Crystal Structure Determination Cubic/Hexagonal
6. XRD-Lattice Parameter Measurements
7. XRD- Phase Diagram Determination
8. XRD-Determination of Crystallite Size and Lattice Strain
9. Zeeman effect- shift of atomic energy levels
10. Laser- measurement of thread angle, pitch and the diameter of a micrometre screw
11. Thin film thickness- Newton's rings/ Michelson interferometer
12. Magneto-optic effect - Determination of Verdet constant
13. Michelson interferometer /Edser Butler method/ Fresnel's biprism- mica sheet thickness
14. Bandgap- semiconductor diode
15. Laser –Young's double slit - interference
16. Refractive index of liquid- Newton's ring /Laser/ Fresnel's biprism
17. Resolving power- lens- Laser
18. Rydberg constant- Hydrogen discharge tube
19. Particle size – corona plate
20. Comparison of thickness of thin sheets by air wedge
21. Band gap and type of optical transition (direct or Indirect using Tauc relation) from absorption spectra
22. Synthesis of metallic (Ag or Au) nanoparticles in aqueous medium and estimation particle size using absorption spectrum
23. Thermal analysis of materials from experimental data
24. Analysis of FTIR spectrum
25. Solar cell- efficiency & Fill factor

26. Laser diffraction- comparison of thickness of wires of different gauges
27. Thermistor –parameters (energy band gap)
28. Temperature sensor- silicon diode and thermocouple
29. Optical fiber- bending loss.
30. Fermi energy of copper.
31. ESR spectrometer- g factor.
32. Verification of laws of geometrical optics- reflection and transmission coefficients, critical angle, refractive index of glass slab/ prism.
33. Study of Bravais lattices with the help of models.
34. Verification of Fresnel's equations.
35. Spring constant-static and dynamic method
36. Coherence length of LED.
37. Comparison of resistance variation of a carbon film resistor, metal wire, semiconductor and thermistor with temperature.
38. Thermal diffusivity of brass.
39. Young's modulus- strain gauge.
40. Young's modulus measurement by Digital Holography.
41. Michelson interferometer- Sodium D lines separation/ Measurement of Coherence length of a diode laser.
42. Fresnel's biprism- wavelength of monochromatic light.
43. Beam Profile measurement of a laser beam and calculation of the beam divergence.
44. Spatial filtering and calculation of the laser wavelength.
45. Michelson interferometer- Sodium D lines separation.
46. Fresnel's biprism- wavelength of monochromatic light.

References:

1. A course of experiments with He-Ne laser- R S Sirohi, Wiley
2. Practical Physics- C L Arora, S Chand
3. X ray diffraction a practical approach :C Suryanarayana, M Grant Norton; Springer
4. Practical Physics: D Chattopadhyay, P C Rakshit; New Central Book Agency
5. Advanced practical physics: Chauhan, Singh; Pragati Prakashan

Electives Bunch B: Electronics

Semester III

PH3E04TM20 - DIGITAL SIGNAL PROCESSING

Total Credits: **4**

Total Lecture Hours: 54

Course Outcomes

CO1: Analyse continuous time and discrete time signals.

CO2: Illustrate digital signal processing techniques for frequency analysis.

CO3: Represent discrete time signals in complex domain.

CO4: Design IIR and FIR filters.

Module I

Discrete time signals and Linear systems (16 Hours)

Examples of Signals -Classification of signals -System-Examples of discrete time System models -Signal processing-Advantages ,Limitations and applications of DSP- Elementary continuous time signals-Representation of discrete time signals- Elementary discrete time signals-Classification of discrete time signals- Operation on signals- Sampling and Aliasing - Discrete time system-Classifications- Representation of an arbitrary sequence- Impulse response and convolution sum-properties-Causality- FIR,IIR, stable and unstable systems-Correlation of two sequences.

Module II

DSP Techniques (10 Hrs)

Frequency analysis of Discrete Time signals –Discrete frequency spectrum and frequency range -Development of DFT from DTFT –Definition of Discrete Fourier transform- Frequency spectrum using DFT- Properties of Discrete Fourier transform-Relationship of the DFT to other transforms-Properties- Fast Fourier Transform (FFT) – Decimation in time algorithm –Radix-FFT - 8 point DFT using Radix -2 DIT FFT

Module III

Z Transform (12 Hrs)

Z-Transform & ROC -properties - Z transform of finite duration ,infinite duration and two sided sequence – System function – Poles and Zeros-Stability criterion (Problems based on determination of Z transform, ROC and Properties are expected)

Module IV

Digital Filters (16 Hrs)IIR filters-frequency selective filters- Design of digital filters from Analog filters- Analog low pass filter design-Design of IIR filters from Analog filters- Approximation of derivatives - Design of IIR filter using impulse invariance Technique- Bilinear transformation- Direct form I structure of IIR systems-Cascade form realization of IIR systems- Realization of digital filters- Direct form I realization-4.12 Direct form II realization- FIR filters- Linear phase FIR filters- Design of FIR filter using rectangular window- The Fourier series method of designing FIR filters

Text Books:

1. Digital Signal Processing, Fourth edition P. Ramesh Babu, Scitech
2. Digital signal Processing – A NagoorKani, Tata Mc Grow Hill
3. Digital Signal Processing: Theory, Analysis and Digital-Filter Design, B. Somanathan Nair, PHI (2004)
4. Digital Signal Processing, Alan V. Oppenheim & R.W. Schafer, PHI
5. Digital Signal Processing -A practical Guide for scientists and Engineers- Steven W Smith
6. Digital signal processing -Hand book – Vijay K Madisetty& Douglas B Williams

Recommended References:

1. Computer applications in physics, Suresh Chandra, Alpha Science International (2006)
2. Digital Signal Processing, S. Salivahanan, A. Vallavaraj, C.Gnanapriya, TMH
3. Signals and Systems, Allan V. Oppenheim, Alan S. Willsky, S.H.Nawab, PHI
4. Digital Signal Processing, John G. Proakis, Dimitris G. Manolakis, PHI
5. Digital signal processing, Sanjay Sharma, S.K. Kataria & Sons, 2010
6. Mathematical Methods for Physicists, G.B.Arfken & H.J.Weber. Elsavier, Academic Press
7. Digital signal; processing – V K Khanna S.Chand
8. Digital Signal Processing and Applications - Dag Stranneby &William Walker

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PH3E04TM20 - DIGITAL SIGNAL PROCESSING

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 16 hrs	3/2	3	1	14/13
Module II- 10 hrs	2	1	1	9
Module III-12 hrs	3	1	1	10
Module IV-16 hrs	2/3	3	1	13/14

Semester IV

PH4E05TM20 -MICROELECTRONICS AND SEMICONDUCTOR DEVICES

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Distinguish between the architecture and memory management of 8085 and 8086 microprocessors

CO2: Develop the assembly language program for 8085 and 8086 microprocessors

CO3: Elucidate the architecture of 8081 microcontroller

CO4: Explain the concepts of metal-semiconductor and semiconductor heterojunctions.

CO5: Understand various fabrication process for Integrated Circuits

Module I

Introduction to microprocessors (20Hrs)

Microprocessor organization- General organization of a microprocessor based microcomputer system Memory organization – main memory array –memory management, cache memory, virtual memory-Input/output operation – StandardI/O – memory mapped I/O- interrupt driven I/O –DMA 8085 Microprocessor – Architecture 8085 addressing modes, instruction set, Pin out diagram, Simple programming concepts.

Module II

8086 Microprocessor (16Hrs)

The Intel 8086- Architecture - MN/MX modes –Pin diagram -8086 addressing modes 8086 instruction set- instruction format- assembler directives and operators.Programming with 8086-Familiarisation with Debug utility- Interfacing memory and I/O ports.

Module III

Microcontrollers (19 Hrs)

Introduction to microcontrollers and embedded systems -Comparison of microprocessors and microcontrollers -- The 8051 architecture - Register set of 8051- important operational features I/O pins of 8051, ports and circuits - external memory - counters and timers – interrupts - Instruction set of 8051 - Basic programming concepts- Applications of microcontrollers - (basic ideas) – Embedded systems(basic ideas)

Module IV

Metal-semiconductor and semiconductor hetero-junctions(17Hrs)

Metal-semiconductor - Schottky barrier diode - qualitative characteristics – ideal junction properties- Current voltage relationship, Comparison with junction diode Metal semiconductor ohmic contact Ideal non-rectifying barriers – tunneling barrier – specific contact resistances Semiconductor hetero-junctions – hetero-junction materials – energy band diagram –Two dimensional electron gas equilibrium electrostatics – current voltage characteristics.

Module V

Integrated Circuit Fabrication and Characteristics (18 Hrs)

Integrated circuit technology – basic monolithic IC – epitaxial growth –marking and etching - diffusion of impurities – transistor for monolithic circuit -Monolithic diodes – integrated resisters, capacitors and inductors- monolithic circuit layout - additional isolation methods -MSI, LSI, VLSI– the metal semiconductor contact.

Text books:

1. ***Microprocessor Architecture Programming and Applications with 8085, R.S. Gaonkar – Penram int. Pub. Mumbai***
2. ***Fundamentals of Microprocessors and microcomputers- B. Ram (DhanpatRaiPub.)***
3. ***Microprocessors and Microcomputer based system design, H. Rafiquizzaman, Universal Book stall, New Delhi***
4. ***The 8051 microcontroller, Architecture Programming and Applications, Kenneth J Ayala- Penram Int. Pub. Mumbai***
5. ***Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill***
6. ***Integrated Electronics-Analogue and Digital Circuits and Systems, J Millmann and C CHalkias, TMGH***

References:

1. 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
2. Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi – TMHMicroprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
3. Microprocessor and Peripherals, S.P. Chowdhury& S. Chowdhury- SCITECH Publications.

4. Operating system Principles, Abraham Silberschatz& Peter Baer Galvin & Greg Gagne, John Wiley
5. Solid state electronic devices, Streetman and Banerjee, PHI (2010).
6. Physics of Semiconductor Devices, Michael Shur, PHI (2002).
7. Introduction to Semiconductor materials and Devices, M.S. Tyagi, John Wiley and Sons (2000)

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PH4E05TM20 -MICROELECTRONICS AND SEMICONDUCTOR DEVICES

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 20 hrs	3	2	1	12
Module II- 16 hrs	1/2	1/2	1/0	8/6
Module III-19 hrs	3	2	1	12
Module IV-17 hrs	2/1	2/1	0/1	6/8
Module IV-18 hrs	1	1	1	8

Semester IV

PH4E06TM20 -COMMUNICATION SYSTEMS

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Understand the basic concepts of digital communication

CO2: Discuss the underlying concepts in mobile communication

CO3: Distinguish the satellite communication from other modes of communication

CO4: Elucidate the prospects of Fibre optic communication.

CO5: Discuss the features of Radar systems

Module I

Digital Communication (18 hrs)

Pulse Communication -Introduction - Pulse modulation:– PAM - PWM – PPM-PCM PCM:– Sampling theorem- Quantisation -Noise Generation and demodulation of PCM- Companding - DPCM- ADPCM-Delta modulation. Information theory-Coding-Noise-Data Communication – Digital codes – Error detection and correction. Data sets and interconnection requirements-Modem classification and interfacings- Multiplexing techniques -Frequency division multiplex -Time division multiplex - Digital transmission techniques:-ASK- FSK-PSK-QPSK.

Module II

Mobile Communication (20 hrs)

Introduction to Wireless Communication Systems-Mobile Radio System Around the World-Examples of wireless communication systems: - Paging system-Cordless Telephone System-Cellular Telephone System—How a Cellular Telephone Call is Made- Comparison of Common Mobile Radio Systems- Trends in Cellular and Personal Communications. Wireless communication systems—2G-3G - 4G

The Cellular Concept-Frequency Reuse-Channel Assignment Strategies-Handoff Strategies:—Prioritizing handoffs and practical handoff consideration-Interference and System Capacity-Improving Coverage and Capacity in Cellular Systems:—Cell splitting- Sectoring-Microcell zone concept. Basic idea of Path Loss and Multipath Fading- Multiple Access Techniques –

Introduction-FDMA-TDMA-SSMA:- FHMA-CDMA-Hybrid Spread Spectrum Techniques-SDMA GSM.

Module III

Satellite Communication (16 hrs)

Satellite Communication Fundamentals-Satellite Orbits-Satellite Positioning-Frequency Allocations-Polarization-Antennas—gain-beam width - Multiple Access Techniques. Geostationary Satellite communication-Satellite parameters - VSAT (Basic Idea) Geostationary Satellite Path/Link Budget - Satellite TV Systems-Satellite TV broadcasting- GPS

Module IV

Fiber Optics Communication(20 hrs)

Introduction - Ray theory transmission-Total Internal Reflection-Acceptance Angle-Numerical aperture-Skew rays. Electromagnetic mode theory for optical propagation-Electromagnetic waves-Modes in a planar guide-Phase and group velocity - Fiber Classification-cylindrical fiber-Step Index- Graded Index-Single mode fiber- Cut off wave length-Group delay -Photonic crystal fibers:-Index guided micro structures-Photonic band gap fibers. Dispersion:- chromatic-intermodal-Non-linear effects. Optical fiber connection-Fiber Splices:-Fusion splices- Mechanical splices-Multiple splices-Fiber connectors - Cylindrical ferrule connectors, Duplex and multiple-fiber connectors-Fiber couplers (basic idea).

Module V

Radar Systems (16 hrs)

Basic Principles –Fundamentals:- Basic radar Systems-Development of Radar-Radar Performance Factors:—Radar range equation-factors influencing maximum range-Effects of noise- Target properties -Pulsed Systems-Block diagram and description-Antennas and Scanning:-Antennas Scanning- Antenna tracking-Display Methods - Pulsed radar systems-Moving Target Indication:-Doppler Effect-Fundamentals of MTI-Delay Line- Blind speeds-Radar Beacons - Other radar systems-CW Doppler Radar-Frequency Modulated CW Radar-Phased ArrayRadars-Planar Array Radars.

Text Books:

1. ***Electronic Communication Systems by Kennedy/Davis, McGraw Hill Publication, 4th edition, (Module-1 and 5)***

2. ***Wireless Communication Principles and Practice by Theodore S Rappaport, Person Publication, 2nd Edition, (Module-2)***
3. ***Telecommunication Transmission Systems by Robert G Winch, McGrawHill Publication,2nd edition,(Module-3).***
4. ***Optical fiber communications-Principles and Practice John M Senior, Pearson publications, 3rdedition, (Module-4).***

References:

1. Optical Fiber Communications by GerdKeiser(Module-2).
2. Satellite Communications by Dennis Roddy, McGraw Hill Publication,3rd edition.
3. Introductions to RADAR Systems by Skolnik, McGraw Hill, 3rd edition
4. Satellite communication by Dr.D.C Agarwal.
5. Electronics Communication Systems by Wayne Thomas, Pearson Publication, 5 th Edition.

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PH4E06TM20 -COMMUNICATION SYSTEMS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	2	1	1	9
Module II- 20 hrs	3	2	1	12
Module III-16 hrs	0/2	1/2	1/0	7/6
Module IV-20 hrs	3	2	1	12
Module IV-16 hrs	2/0	2/1	0/1	6/7

PH4E02PM20-ADVANCED PRACTICALS IN ELECTRONICS

Total credit: **4**

Total hours: 180

Course Outcomes:

CO1: Develop skills in designing and implementing electronic circuits

CO2: Design, construct, test, and debug moderate-scale digital and optoelectronic circuits

CO3: Analyze the operation of medium complexity standard combinational circuits

CO4: Set up programming strategies for solving a given problem and run the programmes on the Microprocessors and Microcontrollers

(Minimum of 12 Experiments should be done choosing at least 2 experiments from each group)

[A] Microprocessors and Micro Controllers (use a PC or 8086-µp kit)

- Sorting of numbers in ascending/descending order.
- Find the largest and smallest of numbers in array of memory
- Conversion of Hexadecimal number to ASCII and ASCII to Hexadecimal number.
- Multi channelanalog voltage measurements using AC card.
- Generation of square wave of different periods using a microcontroller.
- Measurement of frequency, current and voltage using microprocessors.

[B] Communication Electronics

- Generation PAM and PWM
- Frequency modulation and demodulation using IC –CD4046.
- Multiplexer and demultiplexer using digital IC 7432.
- Radiation characteristics of a horn antenna.
- Measurement of characteristic impedance and transmission line parameters of a coaxial cable.

[C] Electronic Instrumentation

- DC and AC milli-voltmeter construction and calibration.
- Amplified DC voltmeter using FET.
- Instrumentation amplifier using a transducer.
- Generation of BH curve and diode characteristics on CRO.

- Voltage to frequency and frequency to voltage conversion.
- Construction of digital frequency meter.
- Characterization of PLL and frequency multiplier and FM detector.

[D] Optoelectronics

- Characteristic of a photo diode - Determination of the relevant parameters.
- Beam Profile of laser, spot size and divergence.
- Temperature co-efficient of resistance of copper.
- Data transmission and reception through optical fiber link.

References

1. Sedra, Adel S., Smith, Kenneth C., "Microelectronics Circuits", 5^{th} Edition, Oxford University Press,NewYork.
2. Smith, Kenneth C., "Laboratory Explorations for Microelectronic Circuits", 4^{th} Edition, Oxford University Press,New York
3. Mims, Forrest, M., "Engineer's Mini-Notebook, Op-Amp Circuits", 2^{nd} Edition, Siliconcepts
4. Microelectronics Circuit Analysis and Design, D. A. Neamen, McGraw Hill, 4th Edition
5. Electronics Lab Manual Volume 1,2,3 K. A. Navas, Rajath Publishers, Kochi Electronics lab Manuel, T D Kuryachan, S. Shyam Mohan, Ayodhya Publication.
6. Basic Electronics: A text. Zbar, Paul.B Lab Manual M C Graw Hill Tata
7. Edminister, Joseph, Electric Design, M C Graw Hill Tata

Electives Bunch C: Theoretical Physics

Semester III

PH3E07TM20: GENERAL RELATIVITY AND APPLICATIONS

Total Credits: 4

Total Hours: 54

Course Outcomes:

CO1: Demonstrate a detailed physical and mathematical framework for understanding the systems and processes in general theory of relativity

CO2: Develop conceptual skills necessary for astrophysical and cosmological applications of the general theory of relativity

CO3: Examine the effect of relativity on selected examples of physical systems

CO4: Familiarize with the fundamental models and equations in cosmology

Module I

Basics of relativity, Tensor analysis(18 hours)

Overview of special relativity-Principles of special relativity, Line interval - Proper time, Lorentz transformation, Minkowski spacetime Lightcones, Relativistic momentum 4-vectors, Lorentz transformation of electromagnetic field, Energy Momentum tensor for a fluid, perfect fluid, Conceptual foundations of GR and curved spacetime - Principle of equivalence, Connection between gravity and geometry, Metric tensor and its properties, metric in Newtonian limit Concept of curved spaces and spacetimes, Tangent space and four vectors, Tensor algebra, Tensor calculus, Covariant differentiation.

Module II

Einstein's field equations(18 Hours)

Parallel transport, Riemann curvature tensor, Geodesics - Particle trajectories in gravitational field, Einstein's field equations- Definition of the stress tensor, Bianchi identities and conservation of the stress tensor, Einstein's equations for weak gravitational fields, Newtonian limit. Derivation of Schwarzschild metric, Basic properties of Schwarzschild metric coordinate- systems and nature of R=2M surface, Effective potential for particle orbits in Schwarzschild metric, Deflection of ultra relativistic particles, Gravitational red-shift.

Module III

Applications of General Relativity (9 Hours)

Gravitational waves - Wave equation in linearised theory, Plane waves, Transverse traceless gauge, Effect on test particles, Principles of detection and generation of gravitational waves, Types of detectors(qualitative), Hulse Taylor binary pulsar.

Module IV

Cosmology (9 Hours)

Models of the universe, Einstein universe, Expanding universe, Simplifying assumptions, Hubble's law, Friedmann models: Einstein equations, Energy tensors - Solutions to Friedman equations.

Text Books:

1. ***First course in general relativity, B. F. Schutz; Cambridge University Press (Units I, II, III)***
2. ***Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press (Unit IV)***

Reference:

1. Gravitation and Cosmology: Principles and Applications of General Theory of Relativity, Steven Weinberg; John Wiley & Sons.
2. Classical Theory of Fields, Vol. 2: L. D. Landau and E. M. Lifshitz, Oxford :Pergamon Press.
3. General Relativity and Cosmology, J. V. Narlikar Delhi: Macmillan Company of India Ltd.
4. Gravitation, Charles W. Misner, Kip S. Thorne, John A. Wheeler; W. H. Freeman and Company.

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PH3E07TM20: GENERAL RELATIVITY AND APPLICATIONS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 18 hrs	**3/4**	**3/2**	**1**	**14/13**
Module II- 18 hrs	**4/3**	**2/3**	**1**	**13/14**
Module III-9 hrs	**2/1**	**1/2**	**1**	**9/10**
Module IV-9 hrs	**1/2**	**2/1**	**1**	**10/9**

Semester IV

PH4E08TM20: NONLINEAR DYNAMICS

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Identify the characteristics of nonlinear dynamical systems.

CO2: Discuss various types of bifurcations in phase space.

CO3: Analyse numerical and graphical methods to describe chaotic dynamics.

CO4: Calculate Lyapunov exponents and fractal dimensions in chaotic systems**.**

CO5: Discuss the reconstruction of Phase space.

Module I (33 hrs)

A brief history of Nonlinear dynamics - Importance of Nonlinear dynamics - World as a dynamical system. One dimensional flows. fixed points- Linear stability analysis. Bifurcations- saddle-Node bifurcation - Transcritical bifurcation. Pitchfork bifurcation - Potentials - Uniform and non uniform oscillators. Two dimensional flows. Phase portraits - existence and uniqueness. Fixed points and linearization linearization (of one dimensional flows) - Limit cycles. Poincare Bendixon theorem

Module II (12 hrs)

Phase portraits. Numerical computation of phase portraits - Fixed points and linearization (of two dimensional flows)- Lorenz equations. simple properties of Lorenz equations. Chaos on a strange attractor - Defining Attractor and Strange attractor - Lorenz map-ruling out stable limit cycles - exploring parameter space

Module III (30 hrs)

One dimensional maps - Fixed points and linear stability - Logistic map: numerics. Logistic map: analysis. Lyapunov exponent – Fractals - countable and uncountable sets. Cantor set. Dimension of self similar fractals. Box dimension Pointwise correlation dimensions. Baker's map, Henonmap - Elementary properties of Henon map - Rossler system- Forced double well oscillator - Magneto-Elastic mechanical system

Module IV (15 hrs)

Chatter in Machine Tools -Correlations among data points. Prediction of the displacement - Reconstruction of Phase space - Observed Chaos - Embedding: Phase space reconstruction. Geometry of Phase space reconstruction

Text Book

1. ***Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014.***
2. ***Analysis of Observed Chaotic Data, Abarbanel, Henry D.I., Springer, 1995.***

Reference Books:

1. Deterministic Chaos, N. Kumar, Universities Press.
2. Chaos and Nonlinear Dynamics, RC. Hilborn, Oxford University Press.
3. Chaotic Dynamics: An Introduction, G.L. Baker, and J.P. Gollub, CUP, 1993.
4. Chaos in Dynamical System, E. Ott, Cambridge University Press.
5. S. Neil Rasband, Chaotic Dynamics of Nonlinear Systems, Courier Dover Publications

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PH4E08TM20: NONLINEAR DYNAMICS

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 33 hrs	5	4	1	18
Module II- 12hrs	1	0	1	6
Module III-30 hrs	3	3	1	14
Module IV-15 hrs	1	1	1	8

Semester IV

PH4E09TM20 - QUANTUM FIELD THEORY

Total Credits: 3

Total Lecture Hours: 90

Course Outcomes:

CO1: Describe field theory and the canonical quantization procedure.

CO2: Illustrate the Feynman diagrams to describe interacting fields for different interactions.

CO3: Discuss the path integral formalism to quantize an arbitrary field theory.

CO4: Discuss the interacting field theory through S-matrix, reduction formulas, phi-4 theory and Fadeev-popov quantization.

Module I

Classical fields (27 Hours)

Lagrangian, symmetries, gauge fields, Real scalar – variation lprinciple, Noether theorem, Complex scalar field, Electromagnetic field, Yang-Mills field, Maxwell and Proca equations, Canonical quantization: Klein-Gordon field as Harmonic Oscillators, Klein-Gordon field in space-time, Lorentz invariance in wave equations, Dirac equation, Free particle solutions, Dirac Matrices, Dirac Field Bilinears, Quantization of Dirac field, Discrete Symmetries of Dirac Theory

Module II

Interactions (20 Hours)

Perturbation theory, Perturbation Expansion of Correlation Functions, Wick's Theorem, Feynman diagrams, Feynman rules for Fermions.

Module III

Path integral formulation of perturbation theory(20 hours)

Path integral formulation, Perturbation theory and S-matrix, Coulomb scattering, Functional calculus and properties of path integrals,Generating functional for scalar fields - functional integration, Free particle Green's functions, Generating functional for interacting fields.

Module IV

S-matrix, Renormalization, Faddeev-Popov method (23 hours)

Phi-4 Theory, Generating functional for connected diagrams, Fermions using functional methods, S-matrix and reduction formula, Divergences in Phi-4 theory, Dimensional regularization of Phi-4 theory, Renormalization of Phi-4 theory, Faddeev-Popov quantization, Feynman rules for QED, Ward-Takahashi identity.

Textbooks

1. ***Quantum Field Theory, Lewis H Ryder, 2nd Edn, Cambridge University***
2. ***An Introduction to Quantum Field Theory, Michael E Peskin, Daniel V Schroeder, Westview (1995). (1.6 – 1.13 of Unit I, Unit II)***

Reference:

1. The Quantum Theory of Fields, Steven Weinberg, Cambridge University Press.
2. Quantum Field Theory, M Srednicki, Cambridge University Press (1996).
3. Critical Properties of Phi-4 Theories, Hagen Kleinert, Verena Schulte-Frohlinde, World Scientific (2001)
4. Relativistic Quantum Fields, J D Bjorken and S D Drell, McGraw Hill Company
5. Quantum Field Theory, C Itzykson, J-B Zuber, McGraw Hill Inc (1980).
6. Field theory: A Modern Primer, P Ramond, Benjamin-Cummins Publishing Co (1981)
7. Introduction to the Theory of Quantized Fields, N NBogoliubov, D V Shirkov New York, (1959)

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PH4EB3TM20 - QUANTUM FIELD THEORY

Module	Part A (8 out of 10) Weight 1	Part B (6 out of 8) Weight 2	Part C (2 out of 4) Weight 5	Total Weights (30 out of 46)
Module I - 27 hrs	**4**	**3**	**1**	**15**
Module II- 20 hrs	**2/1**	**2**	**1**	**11/8**
Module III-20 hrs	**1/2**	**2**	**1**	**8/11**
Module IV-23 hrs	**3**	**2**	**1**	**12**

PH4E03PM20: SPECIAL COMPUTATIONAL PRACTICALS

Total credit: 4

Total hours: 180

Course Outcomes

CO1: Develop algorithms and programs for numerical experiments

CO2: Analyse the data using numerical and graphical methods.

Students may use any programming language and/or packages of their choice.

1. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance.
2. Phase space of the harmonic oscillator with and without damping.
3. Phase space of a pendulum with and without damping.
4. Phase space of a driven damped pendulum.
5. Lyapunov exponents of the Logistic map with varying parameters.
6. Self similar structure of the Henon Map.
7. Phase space of chaotic Duffing Oscillator.
8. Bifurcation diagram of the Duffing Oscillator..
9. Poincaré section of chaotic Duffing Oscillator.
10. Bifurcation diagram of the Lorenz system.
11. Bifurcation diagram of the Roessler system system
12. Poincaré section of the Lorenz system.
13. Poincaré section of the Roessler system.
14. Lyapunov exponents of the Lorenz system.
15. Plotting of Julia set.
16. Plotting of Mandelbrot set.