

Syllabus of M.Sc. Physics

Proposed by the Board of Studies on 7th March 2022

Dr. Louie Frobel P. G.
Chairman Board of Studies

Approved by the Academic Council on 17th March 2022

Dr. M. A. Solomon, Principal
Chairman, Academic Council.

Adopted by the Governing Council on 29th March 2022

Rev. Fr. Dr. Antony Thoppil

Chairman, Governing Council



Board of Studies

Sl.No	Name	Designation	Qualification
Chairman: <i>(Head of the Department concerned)</i>			
1	Dr. Louie Frobel P. G.	HoD	MSc, M.Phil. PhD
Teachers: <i>(The entire faculty of each specialization)</i>			
1	Dr Nandakumar Kalarikkal	Hon. Director of International and Interuniversity Centre for Nanoscience & Nanotechnology, and Associate Professor, School of pure and Applied Physics, Mahatma Gandhi University, Kottayam - 686560 , Kerala , India.	MSc, PhD.
2	Dr. Pramod Gopinath	Professor, International School of Photonics, CUSAT, Kalamassery	MSc, Ph.D
3	Dr. James Kurian	Professor, Department of Electronics, CUSAT, Kalamassery	M.Tech , Ph.D
4	Dr. Sajeeesh T H	Asst. Professor, Department of Physics, St. Albert's College Ernakulam	M.Sc, Ph.D
5	Mr. Augustine Sumesh C J	Asst. Professor, Department of Physics, St. Albert's College Ernakulam	M.Sc, B.Ed
6	Dr. Arun Babu K. P.	Asst. Professor, Department of Physics, St. Albert's College Ernakulam	M.Sc, Ph.D
7	Dr. Lijo Thomas George	Asst. Professor, Department of Physics, St. Albert's College Ernakulam	M.Sc, Ph.D
8	Dr. Anjana R.	Asst. Professor, Department of Physics, St. Albert's College Ernakulam	M.Sc, Ph.D
9	Dr. Vimala George	Asst. Professor, Department of Physics St. Xavier's College for women Aluva	M.Sc, Ph.D
10	Dr. Ninan Sajith Philip	Associate Professor, Department of Physics, St. Thomas College, Kozhencherri-689641..	MSc, PhD.
11	Dr. Tripti S. Warriar	Assistant Professor, Department of Electronics, CUSAT, Kalamassery.	B Tech, M Tech, PhD.

Two Subject Experts: <i>(From outside the Parent University to be nominated by the Academic Council)</i>			
1	Dr. Anand Narayanan	Associate Professor , Department of Earth and Space Science , Indian Institute of Space Science and Technology, TVM	M.Sc., Ph.D
2	Dr. M. K. Jayaraj	Syndicate member, and Professor Department of Physics, CUSAT , Kalamassery	M.Sc , Ph.D
Nominee of Vice Chancellor: <i>(one expert to be nominated by the Vice-Chancellor from a panel of six experts recommended by the Principal)</i>			
1	Dr. Issac Paul	Associate Professor, Department of Physics , S.B. College Changanassery	M.Sc , Ph.D
Placement Representative: <i>(One representative from industry/corporate sector/allied area relating to placement)</i>			
1	Mr G. Sivaramakrishnan	Consultant, Konark Systems Pvt Ltd, Kaloor, Ernakulam, Kerala	
2	Rev.Dr.George Peter Pittappillil	Director, Mithradham	
Meritorious alumnus: <i>(One postgraduate meritorious alumnus to be nominated by the Principal)</i>			
1	Dr. Sasikumar	Principal (retired), Govt.College Thalasseri	M.Sc , Ph.D
The Chairman, Board of Studies, may with the approval of the Principal of the college, co-opt:			
Co-opted Special Experts from outside <i>(Experts from outside the college whenever special courses of studies are to be formulated):</i>			
1	Dr. Joe Jacob	Associate Professor and HoD Department of Physics, SB College Changanserri	M.Sc , Ph.D
2	Dr. L. Godfrey	Emeritus professor, Dept. of Physics, CUSAT	M.Sc , Ph.D
Other members of staff of the same faculty:			
1	Dr. Paxy George	Assistant Professor, Department of Physics	M.Sc. Ph.D
2	Dr. Anu Varghese	Assistant Professor,	M.Sc. Ph.D

		Department of Physics	
3	Dr. Jerin Mohan N D	Assistant Professor Department of Renewable Energy.	M.Sc, Ph.D
4	Ms. Vijayalakshmi C. G.	Assistant Professor Department of Renewable Energy.	M.Sc
5	Mr. Abinash John Peter	Assistant Professor Department of Space Science	M.Sc.
6	Ms. Subitha Sudheer M		M.Sc,



Acknowledgement

There are many profound personalities whose relentless support and guidance made this syllabus restructuring 2022 a success. We take this opportunity to express our sincere appreciation to all those who were part of this endeavour for restructuring the syllabus of PG programme in Physics under St. Albert's College (Autonomous) Ernakulam.

We express profound gratitude to the Chairman, Principal, Members of the Governing Council and Academic Council for their sincere co-operation and guidance for completion of this work. We place on record my wholehearted gratitude to the members of Board of Studies for their untiring efforts.

Special thanks are due to the external members of BOS, who have actively participated and contributed to the revision of syllabus through group chats and e-mail conversations. The enthusiasm and sincerity shown by the teachers from various departments of the college in the context of syllabus restructuring is highly appreciated.

Prepared by BOS

Ernakulam

07-03-2022

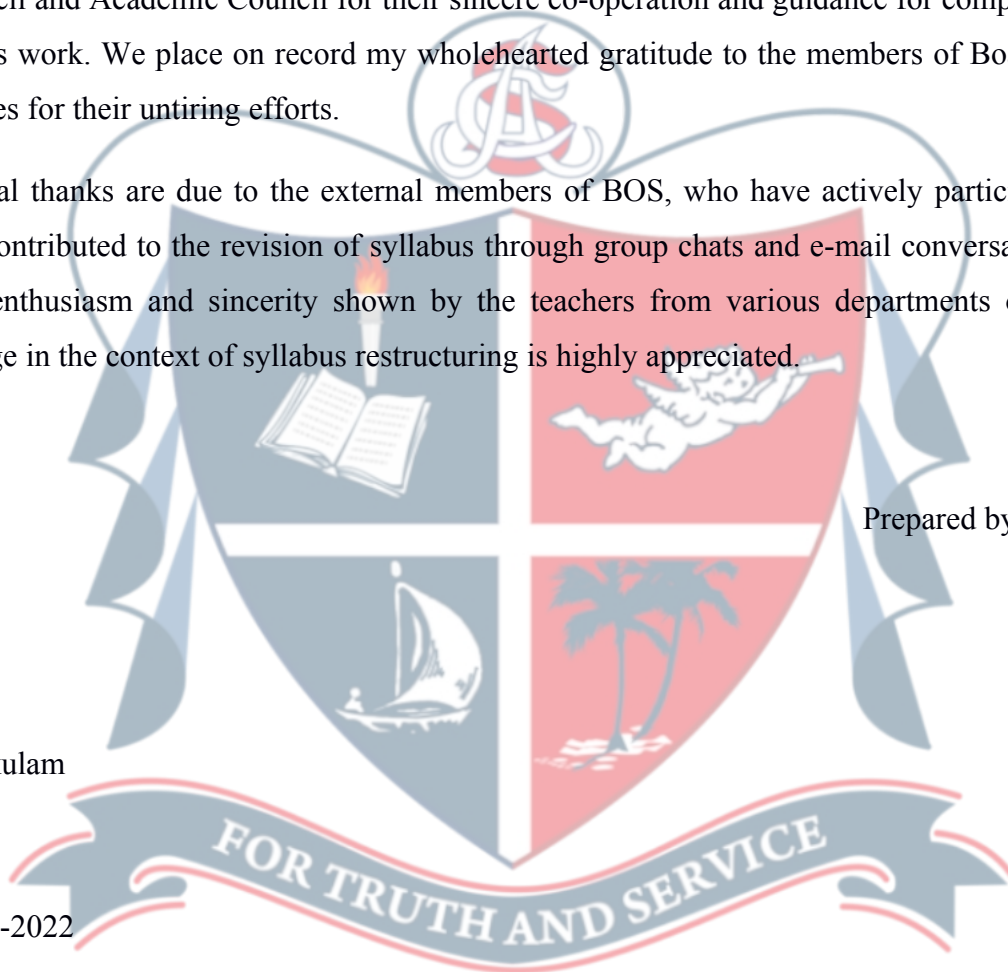


Table of Contents

Board of Studies.....	3
Acknowledgement.....	6
Preface.....	9
Programme Outcomes.....	10
Programme Specific Outcomes.....	11
Regulation.....	12
Programme Design.....	33
Detailed Syllabus: Semester I.....	39
Mathematical Methods in Physics - I (PPH1CRT0122).....	40
Classical Mechanics (PPH1CRT0222).....	43
Electrodynamics (PPH1CRT0322).....	46
Electronics (PPH1CRT0422).....	48
General Physics Practicals (PPH1CRP0122).....	50
Detailed Syllabus: Semester II.....	52
Mathematical Methods In Physics - II (PPH2CRT0122).....	53
Quantum Mechanics-I (PPH2CRT0222).....	56
Statistical Mechanics (PPH2CRT0322).....	58
Condensed Matter Physics (PPH2CRT0422).....	60
Electronics Practical (PPH2CRP0222).....	63
Detailed syllabus: Semester III.....	65
QUANTUM MECHANICS-II (PPH3CRT0122).....	66
Computational Physics (PPH3CRT0222).....	68
Atomic and Molecular Physics (PH3CRT0322).....	70
Digital Signal Processing (PPH3CRT0422).....	73
Computational Physics Practicals (PPH3CRP0122).....	75
Detailed Syllabus: Semester IV.....	78

Nuclear and Particle Physics (PPH4CRT0122).....	79
Introduction to Embedded Systems (PPH4CRT0222).....	81
Semiconductor Devices (PPH4CRT0322).....	83
Communication Systems (PPH4CRT0322).....	85
Advanced Practicals in Electronics (PPH4CRP0222).....	87
GIST OF CHANGES.....	89



Preface

As envisaged in the recent regulations of Autonomous colleges in India by University Grants Commission, autonomous colleges enjoy the academic freedom to enrich the curriculum by incorporating recent trends and needs. Curriculum and syllabus of each academic program has to be revised periodically to impart major objectives like global competency, skill component, values and regional relevance. Academicians and scholars in the respective area of knowledge have to express a missionary zeal for this great purpose.

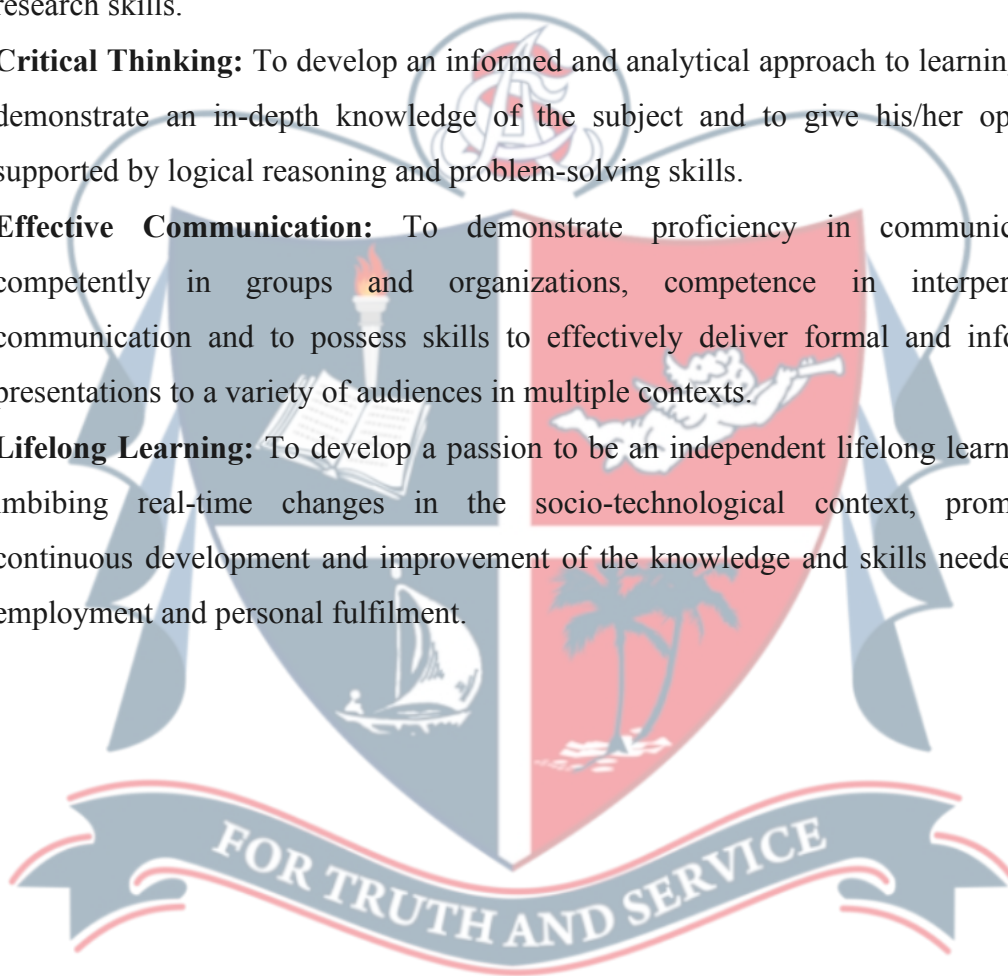
In 2016, when St. Albert's College was granted autonomy, we adopted the curriculum and syllabus followed by the Mahatma Gandhi University, Kottayam for the year 2016. Further in the year 2019, when the M.G. university revised the syllabus and curriculum, we have adopted the same. However, the Syllabus revision committee of the department studied the present curriculum in detail and proposed some reasonable changes for further enrichment which may be implemented from 2022 admission onwards.

The present M.Sc. Degree programme in Physics follows the Credit and Semester System consisting of four semesters. The present curriculum offers a wide exposure to various conventional, advanced and applied fields in Physical Science which will facilitate them for pursuing higher studies in Physics. It is intended that students will acquire due knowledge and skill which will enable them to go for higher studies in Physics and employed in research institutes, and in related industries and departments. Attempts were also made to integrate the essential components to generate interest for self-employment or start-ups among the pupils. All possible attempts have been made to enrich the syllabus by incorporating current and most recent developments in various branches of Physics.

Programme Outcomes

Within a few years of earning a M.Sc degree in Physics, graduates are expected to achieve one or more of the following program educational outcomes:

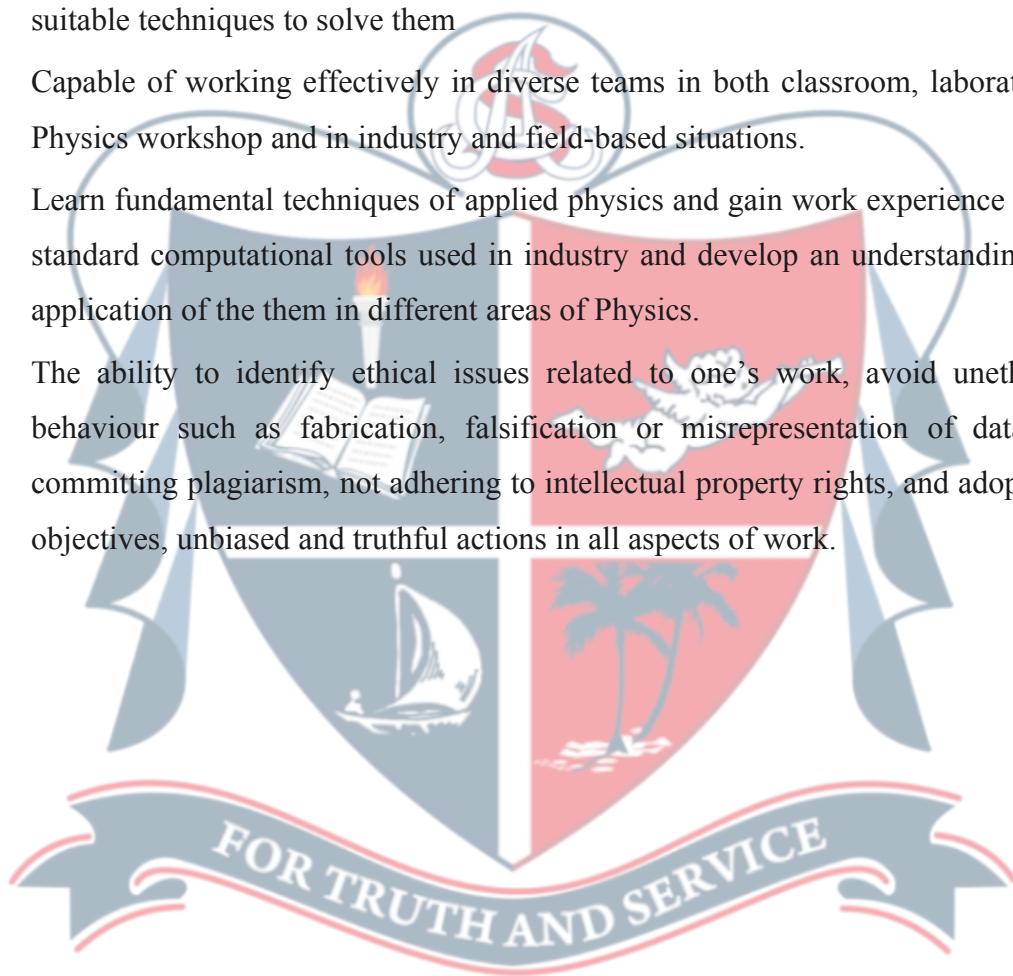
- **Deep Knowledge in the Discipline:** Acquire in-depth knowledge and understanding of physics with higher order critical, analytical, mathematical and research skills.
- **Critical Thinking:** To develop an informed and analytical approach to learning and demonstrate an in-depth knowledge of the subject and to give his/her opinion supported by logical reasoning and problem-solving skills.
- **Effective Communication:** To demonstrate proficiency in communicating competently in groups and organizations, competence in interpersonal communication and to possess skills to effectively deliver formal and informal presentations to a variety of audiences in multiple contexts.
- **Lifelong Learning:** To develop a passion to be an independent lifelong learner by imbibing real-time changes in the socio-technological context, promoting continuous development and improvement of the knowledge and skills needed for employment and personal fulfilment.



Programme Specific Outcomes

Within a few years of earning an undergraduate degree in Physics, graduates are expected to achieve one or more of the following Program Specific Outcomes:

- Understanding the basic concepts of physics, and apply these theoretical knowledge to analyze complex physical problems and use mathematical or other suitable techniques to solve them
- Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in industry and field-based situations.
- Learn fundamental techniques of applied physics and gain work experience with standard computational tools used in industry and develop an understanding of application of the them in different areas of Physics.
- The ability to identify ethical issues related to one's work, avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.



Regulation

1. SHORT TITLE

- 1.1. These regulations shall be called SACA Regulations (2022) governing Post Graduate Programmes under Credit Semester System (SACA-PG-CSS 2022).
- 1.2. These Regulations shall come into force from the Academic Year 2022-2023 onwards.

2. Scope

- 2.1. The regulations provided herein shall apply to all Regular Post-graduate programmes (except M.B.A and M.Sc. Space Science and Technology) conducted in the Institution, with effect from the academic year 2022-2021.
- 2.2. The provisions herein supersede all the existing regulations for the regular post-graduate programmes conducted in the Institution (except M.B.A and M.Sc. Space Science and Technology).

3. DEFINITIONS

- 3.1. 'Academic Council' means the Committee constituted by the Governing body under this regulation to monitor the running of the post-graduate programmes under the Credit Semester System (SACA-PG-CSS 2022).
- 3.2. 'Academic Week' is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of minimum of 18 such academic weeks constitutes a semester.
- 3.3. 'Audit Course' is a course for which no credits are awarded.
- 3.4. 'CE' means Continuous Evaluation (Internal Evaluation)
- 3.5. 'Comprehensive viva-voice' means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.
- 3.6. 'Core Course' means a course which cannot be substituted by any other course.
- 3.7. 'Course' means a course segment of subject matter to be covered in a semester. Each course is to be designed variously under lectures/ tutorials/ laboratory or fieldwork/ seminar/ project/ practical training/ assignments/ viva-voice etc., to meet effective teaching and learning needs.
- 3.8. 'Course Code' means a unique alphanumeric code assigned to each course of a programme.
- 3.9. 'Course Credit' on credit of a course is defined as a minimum of 1 hour lecture /minimum of two hours lab field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination.
- 3.10. 'Course Teacher' means the teacher of the institution in charge of the course offered in

the programme.

- 3.11. 'Credit (Cr)' of a course is a numerical value which depicts the measure of the weekly unit of work assigned for that course in a semester
- 3.12. 'Credit point (CP)' of a course is the value obtained by multiplying the Grade Point (GP) by the credit (Cr) of the course $CP = GP \times Cr$.
- 3.13. 'Cumulative Grade point average (CGPA)' is the value obtained by dividing the sum of credit points of all the courses taken by the students for the entire programme by the total number of credits and shall be rounded off to two decimal places. CGPA determines the overall performance of a student at the end of the programme. (CGPA = total CP obtained / Total credits of the programme)
- 3.14. 'Department' means any teaching Department in the Institution offering a programme of study approved as per the Act/ statutes of the University.
- 3.15. 'Department Council' means the body of all teachers of a Department in a college.
- 3.16. 'Dissertation' means a long document on a particular subject in connection with the project/ research/ field work etc.
- 3.17. 'Duration of a Programme' means the period of time required for the conduct of the programme. The duration of the post-graduate programme shall be 4 semesters spread over two academic years.
- 3.18. 'Elective course' means a course, which can be substituted, by an equivalent course from the same subject.
- 3.19. 'Elective Group' means a group consisting of elective courses for the programme.
- 3.20. 'ESE' means End Semester Evaluation (External Evaluation).
- 3.21. 'Evaluation' is the process by which the knowledge acquired by the student is quantified as per the criteria detail in these regulations.
- 3.22. 'External Examiner' is the teacher appointed from other colleges for the valuation of courses of study undergone by the students in a college. The external examiner shall be appointed by the College.
- 3.23. 'Exam Coordinator' is a teacher nominated by the Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department of the college.
- 3.24. 'Grace Grade Points' means grade points awarded to course(s), in recognition of the students' meritorious achievement in NSS/Sports/ Arts and cultural activities etc.
- 3.25. 'Grade point (GP) letter grade is assigned a 'Grade point' (GP) which is an integer indicating the numerical equivalent of the board level of performance of a student in a course.
- 3.26. 'Grade Point Average (GP)' is an index of the performance of student in a course. It is

obtained by dividing the sum of the weighted grade points obtained in the course by the sum of the weights of the course. ($GPA = \frac{\sum WGP}{\sum W}$).

- 3.27. 'Improvement course' is a course registered by a student for improving his/ her performance in that particular course.
- 3.28. 'Internal Examiner' is a teacher nominated by the department concerned to conduct internal evaluation.
- 3.29. 'Letter Grade' or 'Grade' for a course is a letter symbol (A⁺, A, B⁺, B, C, C⁺, D) which indicates the broad level of performance of a student for a course.
- 3.30. 'SACA-PG-CSS 2022' means St. Albert's College Autonomous Regulations Governing Post Graduate Programmes under Credit Semester System, 2022.
- 3.31. 'Parent Department' means the Department which offers a particular post graduate programme.
- 3.32. 'Plagiarism' is the unreferenced use of other authors' material in dissertations and assignments and is a serious academic offence.
- 3.33. 'Programme' means the entire course of study and examinations.
- 3.34. 'Project' is a core course in a programme. It means a regular project work with stated credits on which the student undergoes a project under the supervision of a teacher in the parent department/ any appropriate research center in order to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their own learning and culminate in a realistic, student-generated product for findings.
- 3.35. 'Repeat course' is a course that is repeated by the student for having failed in that course in an earlier registration.
- 3.36. 'Semester' means a term consisting of a minimum of 90 working days, inclusive of examinations, distributed over a minimum of 18 weeks of 5 working days each.
- 3.37. 'Seminar' means a lecture given by the student on a selected topic and is expected to train the student in self-study, collection of relevant matter from various resources, editing, document writing and presentation.
- 3.38. 'Semester Grade Point Average'(SGPA) is the value of trained by dividing the sum of credit points CP obtained by a student in the various courses taken in a semester by the total number of credits for the course in that semester. The SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of the semester ($SGPA = \frac{\text{Total CP obtained in the semester}}{\text{Total Credits for the semester}}$).
- 3.39. 'Tutorial' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.
- 3.40. 'University' means Mahatma Gandhi University, Kottayam, Kerala.
- 3.41. 'College' means St. Albert's College (Autonomous), Ernakulam, Kerala.

- 3.42. 'Weight' is a numeric measure assigned to the assessment units of various components of a course of study.
- 3.43. 'Weighted Grade Point'(WGP) is the grade point multiplied by weight. ($WPG = GP \times W$).
- 3.44. 'Weighted Grade Point Average (WGPA)' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points by the sum of the weights. WGPA shall be obtained for CE (Continuous Evaluation) and ESE (End Semester Evaluation) separately and then the combined WGPA shall be obtained for each course.
- 3.45. Words and expressions used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes that you shall have the meaning assigned to them in the Act and Statute.

4. ACADEMIC COUNCIL: COMPOSITION OF ACADEMIC COUNCIL

- 4.1. The Principal (Chairman)
- 4.2. All Heads of the Departments
- 4.3. Four teachers of the college representing different categories of teaching staff by rotation on the basis of seniority of service in the college.
- 4.4. Not less than four experts/academicians from outside the college representing areas such as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc., to be nominated by the Governing Body.
- 4.5. Three nominees of the university not less than Professors.
- 4.6. A faculty member nominated by the Principal (Member Secretary).

5. PROGRAMME STRUCTURE

- 5.1. The medium of instruction shall be English except for programmes under Faculty of Language and Literature.
- 5.2. Student shall be admitted to post graduate programmes under various faculties. The programme shall include three types of courses, Core courses, Elective courses and Common core courses. There shall be a project with the dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments/ seminars/practicals project field study etc.
- 5.3. Elective course and Groups
- 5.3.1. There shall be at least two and not more than four elective groups (Group A, Group B, Group C, etc.) comprising of three courses each for a programme and these elective courses shall be included either in the fourth semester or be distributed among third and fourth semesters. This clause is not applicable to MSW, MBA and M. Voc.
- 5.3.2. The number of elective courses assigned for study in a particular semester shall be the same across all elective groups for the programme concerned.

- 5.3.3. The colleges shall select any one of the elective groups for each programme as per the interest of the students, availability of faculty and academic infrastructure in the Institution.
- 5.3.4. The selection of courses from different elective groups is not permitted.
- 5.3.5. The elective group selected by the college shall be intimated to the Controller of Examinations without within two weeks of commencement of the semester in which the elective courses are offered. The elective group selected by the college for the students who are admitted in a particular academic year shall not be changed.
- 5.4. Project work
- 5.5. Project work shall be completed in accordance with the guidelines given in the curriculum and shall be carried out under the supervision of a teacher of the department concerned. A candidate may, however, in certain cases be permitted to work on the project in an Industrial/ Research Organization on the recommendation of the supervising teacher.
- 5.6. There shall be internal assessment and external assessment for the project work.
- 5.7. The project work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the Viva-voce on the project.
- 5.8. The external evaluation of the project work shall be conducted by an external examiner from different college and an internal examiner from the college concerned.
- 5.9. The final Grade of the project (External) shall be calculated by taking the average of the Weighted Grade Points given by the two external examiners and the internal examiner.
- 5.10. **Assignments:** Every student should submit at least one assignment as an internal component for each course.
- 5.11. **Seminar Lecture:** Each student shall deliver one seminar lecture as an internal component for every course with a weightage of two. The seminar lecture is expected to train the student is self-study, collection of relevant matter from the various resources, editing, document writing, and presentation.
- 5.12. **Test Papers (Internal):** Student shall undergo at least two class tests as an internal component for each course with a weightage of one each. The best two shall be taken for awarding the grade for class tests.
- 5.13. No course shall have more than 5 credits unless otherwise specified.
- 5.14. **Comprehensive Viva-Voce:** Comprehensive Viva-voce conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the examiners of the project evaluation.
- 5.14.1. Comprehensive Viva-Voce cover questions from all courses in the programme.
- 5.14.2. There shall be an internal assessment and an external assessment for the comprehensive Viva-voce.

6. Attendance

- 6.1. The minimum requirement of aggregate attendance during a semester for operating at the end-semester examination shall be 75%. Condonation of shortage of attendance for students having a minimum of 65% attendance, (up to a maximum of 10 days) in a semester subject to a maximum of two times during the whole Period of the programme may be granted by the College.
- 6.2. If a student represents his/her institution, University, State or Nation in Sports or Cultural or any other officially sponsored activities such as College Union/ University Union etc. he/ she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a semester based on the specific recommendations of the teacher concerned, class tutor, Head of the Department forwarded through the Dean Students Affairs subjected to the approval of the Principal. For exceptional achievements/situations, the Principal may recommend for the award of additional attendance to the Governing Body.
- 6.3. Those who could not register for the examination of a particular semester due to shortage of attendance will not be able to repeat the semester and will be removed from the rolls.

7. Registration/Duration

- 7.1. A student shall be permitted to register for the programme at the time of admission.
- 7.2. A student who has registered for the programme shall complete the programme within a period of four years from the date of commencement of the programme.

8. Admission

- 8.1 The admission to all regular PG programme shall be through the Centralised Allotment Process of the College.
- 8.2 If there is an entrance examination specified for the admission for a particular programme, it will be as per the directions of the office of the CoE of the college.
- 8.3 The eligibility criteria for admission to PG programmes shall be published by the College in the prospectus.

9 Admission Requirements

- 9.1 Candidates for admission to the first semester of the PG programme through CSS shall be required to have passed an appropriate Degree Examination of any recognized university/institutions. Other eligibility requirements for specific programmes will be published in the prospectus.
- 9.2 Students admitted under this programme are governed by the Regulations of the College.

10 Promotion

- 10.1 A student who registers for a particular semester examination shall be promoted to the

next semester.

11 Examinations

- 11.1 There shall be an examination conducted by St. Albert's College, (Autonomous) at the end of each semester.
- 11.2 Practical Examination shall be conducted by the College at the end of semester or at the end of even semester as prescribed in the syllabus of the particular programme. The number of examiners for the Practical Examination shall be prescribed by the Board of Studies of the program.
- 11.3 End Semester Examinations: The examinations shall normally be conducted at the end of each semester.
- 11.4 There shall be one End-semester examination of 3 hours duration for each lecture based courses.
- 11.5 A question paper may contain short answer type/annotation, short essay type questions problem and long essay type questions. Different types of questions shall have different weightages.

12 Evaluation And Grading

- 12.1 **Evaluation:** The evaluation scheme for each course shall contain two parts; (a) End Semester Evaluation (ESE) (External Evaluation) and (b) Continuous Evaluation (CE) (Internal Evaluation). The ratio of weightage between internal and external is 1:3 (unless for the courses, it is otherwise specified by the BoS). Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using direct grading system.
- 12.2 Direct grading: The direct grading for CE (Internal) and ESE (External Evaluation) shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively.
- 12.3 Grade Point Average GPA: internal and external components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided.
- 12.4 Internal evaluation for regular programme: The internal evaluation shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars, lab skills, records, Viva-voce etc.
- 12.5 Components of internal (CE) and external evaluation (ESE): Grades shall be given to the evaluation of theory/ practical/ project/ comprehensive Viva-voce and all internal evaluations based on the Direct Grading System.
- 12.6 Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and the comprehensive viva-voce within the framework of the

regulation.

12.7 There shall be no separate minimum grade point for internal evaluation.

12.8 The model of the components and its weightages of continuous evaluation (CE) and End Semester Evaluation (ESE) are Shown in below:

a) For theory (CE)(Internal)

	Components	Weightage
i.	Assignment	2
ii.	Seminar	4
iii.	Best Two Test papers	4 (2 each)
Total		10

(Grades of best two test papers shall be considered. For test papers all questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grade.)

a) For the theory (ESE) (External)

Evaluation is based on the pattern of questions specified 12.16.5

b) For Practical (CE) (Internal)

Components	Weightage
Written/Lab test	2
Lab involvement and Record	1
Viva	2
Total	5

(The components and the weightage of the components of the practical (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

a) For Practical (ESE) (External)

Components	Weightage
Written / Lab test	7
Lab involvement and Record	3
Viva	5
Total	15

[The components and the weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15.]

b) For Project (CE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
Total	5

(The Components and the weightage of the components of the project (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

a) For Project (ESE) (External)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	15

(The Components and the weightage of the components of the project (External) can be modified by the concerned BOS without changing the total weightage 15.)

a) Comprehensive viva-voce (CE)(internal)

Components	Weightage
Comprehensive viva-voce (all courses from first semester to fourth semester)	5
Total	5

(Weightage of the components of the comprehensive viva-voce(internal) shall not be modified.)

a) Comprehensive viva-voce (CE)(External)

Components	Weightage
Comprehensive viva- voce (all courses from first semester to fourth semester)	15
Total	15

(Weightage of the components of the comprehensive viva-voce(external) shall not be modified unless specified by the respective BoS for a particular course.)

12.9 All grade point averages shall be rounded to two decimal points.

- 12.10 To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of the external examination.
- 12.11 There shall not be any chance for improvement for internal grade.
- 12.12 The course teacher and the Exam coordinator shall maintain the academic details of each student registered for the course and a copy should be kept in the department for verification for at least five years after the student completes the programme.
- 12.13 **External evaluation:** The external examination in theory courses is to be conducted by the College at the end of the semester. The answers should be in English except those for the Faculty of Languages. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination.
- 12.14 Photocopies of the answer scripts of the external examination shall be made available to the students on request as per the rules prevailing in the College.
- 12.15 The question paper should be strictly on the basis of model question papers set and the directions prescribed by the BOS/Governing Body of the college for each programme.

13 Pattern of questions

- 13.1 Questions shall be set to assess the knowledge acquired, standard application of Knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightages shall be given to each module based on content/ teaching hours allotted to each module.
- 13.2 The question setter shall ensure that questions covering all outcomes are met.
- 13.3 A question paper shall be a judicious mix of short answer type, short essay type/ problem solving type and long essay type questions.
- 13.4 The questions shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, E grades.
- 13.5 Weight: Different types of questions shall be given different weights to quantify their range as follows:

Sl.No.	Type of Questions	Weight	Number of questions to be answered
1	Short Answer type questions	1	8 out of 10
2	Short essay/ problem solving type questions	2	6 out of 8
3	Long Essay type questions	5	2 out of 4

- 13.6 **Pattern of questions for practical:** the pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

13.7 **Direct grading System:** Direct Grading System based on a 6-point scale is used to evaluate the Internal and External examinations taken by the students for various courses of study.

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

a) Performance Grading

Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7-point scale as detailed below. *(7-point scale needed clarification)*

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(pass)
up to 1.99	D	Deficient (Fail)

No separate minimum is required for internal evaluation for a pass, but a minimum C grade is required for a pass in an external evaluation. However, a minimum C grade is required for pass in a course.

A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

Improvement of course: The candidates who wish to improve the grade/ grade point of the external examination of a course/ courses he/she has passed can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semesters of the program.

Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) calculations. The **SGPA** is the ratio of the sum of the credit points of all courses taken by a student in the semester to the total credit for that semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below.

$$\text{Semester Grade Point Average (SGPA)} (S_j) = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

(SGPA = Total credit Points awarded in all semesters / Total credits of the semester)

Where 'S_j' is the jth semester, 'G_i' is the grade point scored by the student in the ith course 'C_i' is the credit of ith course.

a) Cumulative Grade Point Average (CGPA) of a programme is calculated using the formula:-

$$\text{Cumulative Grade Point Average (CGPA)} = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

(CGPA = Total credit Points awarded in a semester / Total credits of the programme)

Where 'C_i' is the credits for the ith semester 'S_i' is the **SGPA** for the ith semester. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points.

For the successful completion of semester, a student shall pass all courses and score a minimum SGPA of 2.0 . However, a student is permitted to move to the next semester irrespective of her/ his **SGPA**.

3. Grade Card

- A. The College under its seal shall issue to the students, a consolidated grade card on completion of the programme, which shall contain the following information.
- Name of College
 - Name of the University
 - Title of the PG Program
 - Name of the Semesters
 - Name and Register Number of the student
 - Code, Title, Credits and Max GPA (Internal, External & Total) of each course (theory & Practical), project, viva etc., in each semester.
 - Internal, external and total grade, Grade Point (G), Letter Grade and Credit point (P) in each course opted in the semester.
 - The total credits and total credit points in each semester
 - Semester Grade Point Average (SGPA) and corresponding Grade in each semester
 - Cumulative Grade Point Average (CGPA), Grade for the entire Program.
 - Separate Grade card will be issued at the request of candidates and based on College

Guidelines issued from time to time.

1. Details of description of evaluation process-Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

4. **Award Of Degree**

The successful completion of all the courses with 'C' grade within the stipulated period shall be the minimum requirement for the award of the degree.

5. **Monitoring Committee**

There shall be a Monitoring Committee constructed by the Principal to monitor the internal evaluation conducted by departments.

6. **Position Certificate**

The College shall publish the list of top 3 candidates for each programme after the publication of the programme results. Position certificate shall be issued to candidates on their request.

Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing that rank/position. Position certificates shall be signed by the Controller of Examinations.

7. **Grievance Redressal Committee**

In order to address the grievance of students a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

- a. **Class Level:** The cell is chaired by the class tutor and the course teacher or a teacher nominated by the Head of the Department.
- b. **Department level:** The College shall form a Grievance Redressal Committee in each department comprising of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The committee shall address all grievances relating to the internal assessment grade of the students.
- c. **College level:** A committee with the Principal as Chairman, Dept. Coordinator, HOD of concerned Department and a senior teacher nominated by the Executive Committee as members.

8. **Transitory Provision**

Notwithstanding anything contained in these regulations, the Governing Body shall, for a period of two years from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

Credits allotted for programme and Courses

- a. Total credit for each programme shall be 80 except MSW , M.Voc. and MBA programs.
 - b. Semester-wise total credit can vary from 16 to 25.
 - c. The minimum credit of a course is 2 and maximum credit is 5 except for M. Voc, MBA and MSW.
9. **Course code:** The course codes assigned for all courses (core courses, elective courses, common courses etc.) shall be unique.
10. **Models of distribution of courses, course codes, type of the course, credits, teaching hours for a program are given in the following table.**



Example **Programmes with the practical-Total Credits 80-** scheme of the syllabus

Semester	Course Code	Course name	Type of the course	Teaching Hours/Week	Credit	Total Credits
I	Course.code1	Name1	Core	4	4	19
	Course.code2	Name2	Core	4	4	
	Course.code3	Name3	Core	4	4	
	Course.code4	Name4	Core	3	3	
	Practical Course.code5	Name5	Core	10	4	
II	Course.code6	Name6	Core	4	4	20
	Course.code7	Name7	Core	4	4	
	Course.code8	Name8	Core	4	4	
	Course.code9	Name9	Core	3	4	
	Practical- Course.code10	Name10	Core	10	4	
III	Course.code11	Name11	Core	4	4	20
	Course.code12	Name12	Core	4	4	
	Course.code13	Name13	Core	4	4	
	Course.code14	Name14	Core	3	4	
	Practical Course.code15	Name15	Core	10	4	
IV	Course.code16	Name16	Elective	5	3	21
	Course.code17	Name17	Elective	5	3	
	Course.code18	Name18	Elective	5	3	
	Practical- Course.code19	Name19	Core	10	5	
	Project- Course.code20	Name20	Core		5	
	Comprehensive viva-voce - Course.code 21	Name 21	Core		2	
	Total					80

Appendix

1. Evaluation first stage-Both internal and external (to be done by the teacher)

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

The final Grade range for courses SGPA and CGPA

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
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
Up to 1.99	D	Deficient (Fail)

Theory -External – ESE

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

Type of Question	Qn. No's	Grade Awarded	Grade point	Weights	Weighted Grade Point
Short Answer	1	A+	5	1	5
	2	-	-	-	-
	3	A	4	1	4
	4	C	2	1	2
	5	A	4	1	4
	6	A	4	1	4
	7	B	3	1	3
	8	A	4	1	4
	9	B	3	1	3
	10	-	-	-	-
Short Essay	11	B	3	2	6
	12	A+	5	2	10
	13	A	4	2	8
	14	A+	5	2	10
	15	-	-	-	-
	16	-	-	-	-
	17	A	4	2	8
	18	B	3	2	6
Long Essay	20	A+	5	5	25
	21	-	-	-	-
	22	-	-	-	-
	23	B	3	5	15
			TOTAL	30	117
Calculation: Overall Grade of the theory paper = Sum of Weighted Grade Points / Total weight $117/30 = 3.90 = \text{Grade B}$					

Theory- Internal-CE

Maximum weight for internal evaluation is 10. Therefore, Maximum weight Grade Point (WGP) is 50.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Assignment	2	A	4	8	WGP/Total weight = 48/10 =4.8
Seminar	4	A+	5	20	
Test paper 1	2	A+	5	10	
Test paper 2	2	A+	5	10	
Total	10			48	A+

Practical-External-ESE

Maximum weight for external evaluation is 5. Therefore Maximum Weighted Grade Point (WPG) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Written/Lab	7	A	4	28	WGP/Total weight = 58 / 15 = 3.86
Test					
Lab					
Involvement & Record	3	A+	5	15	
Viva	5	B	3	15	
Total	15			58	B

Practical-Internal-CE

Maximum weight for internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Written/ Lab test	2	A	4	8	WGP/Total

Lab involvement & record	1	A+	5	5	weight = $17/5=3.40$
Viva	2	C	2	4	
Total	5			17	B

Project-External-ESE

Maximum weight for external evaluation is 15. Therefore, Maximum weighted Grade Point (WGP) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Relevance of the topic & Analysis	2	C	2	4	WGP/Total weight = $59/15=3.93$
Project content & presentation	8	A+	5	40	
Project viva- voce	5	B	3	15	
Total	15			59	B

Project-Internal-CE

Maximum weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Relevance of the topic & Analysis	2	B	3	6	WGP/Total weight = $21/5=4.2$
Project content & presentation	2	A+	5	10	
Project viva- voce	1	A+	5	5	
Total	5			21	A

Comprehensive viva-voce-External-ESE

Maximum weight for External evaluation is 15. Therefore, maximum Weighted Grade Point (WGP) 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Comprehensive viva-voce	15	A	4	60	WGP/Total weight = 60/15 = 4
Total	15			60	A

Comprehensive viva-Internal-CE

Maximum Weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Comprehensive viva-voce	5	A+	5	25	WGP/Total weight = 25/ 5 = 5
Total	5			25	A+

Evaluation- Second stage (to be done by the **College**)

Consolidation of the Grade (GPA) of a Course PC-1

The End Semester Evaluation valuation (ESE) (External evaluation) grade awarded for the course PC -1 is A and its Continuous Evaluation (CE) (Internal Evaluation) grade is A. The consolidated grade for the course PC -1 is as follows:

Evaluation	Weight	Grade awarded	Grade Points awarded	Weighted Grade Point
External	3	A	4.20	12.6
Internal	1	A	4.40	4.40
Total	4			17
Grade of a course.	GPA of the course =Total weighted Grade Points/Total weight $17/4 = 4.25 = \text{Grade A}$			

Evaluation- Third stage (to be done by the College)**Semester Grade Point Average (SGPA)**

Course code	Title of the course	Credits (C)	Grade Awarded	Grade Points (G)	Credit Points (CP=C X G)
01	PC-1	5	A	4.25	21.25
02	----	5	A	4.00	20.00
03	----	5	B+	3.80	19.00
04	----	2	A	4.40	8.80
05	----	3	A	4.00	12.00
TOTAL		20			81.05
SGPA = Total credit points / Total credits = 81.05/20 = 4.05 = Grade- A					

Evaluation- Fourth Stage (to be done by the College)**Cumulative Grade Point Average (CGPA)**

If a candidate is awarded three A+ grades in semester 1 (SGPA of semester 1), semester 2 (SGPA of semester 2) and semester 4 (SGPA of semester 4) and a B grade in semester 3 (SGPA of semester 3). Then the CGPA is calculated as follows:

Semester	Credit of the Semesters	Grade Awarded	Grade point (SGPA)	Credit points
I	20	A+	4.50	90
II	20	A+	4.60	92
III	20	B	3.00	60
IV	20	A+	4.50	90
TOTAL	80			332
CGPA = Total credit points awarded / Total credit of all semesters = 332 / 80 = 4.15 (Which is in between 4.00 and 4.49 in 7-point scale). Therefore, the overall Grade awarded in the program is A				

Programme Design

CHAPTER-I

1. GENERAL SCHEME OF THE SYLLABI

- 1.1 Theory Courses: There are fifteen theory courses in all four semesters in 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. There are four Elective Bunch offered in this syllabus. An Elective Bunch has three theory courses. A college can choose one Elective Bunch in one academic year.
- 1.2 Practicals: All four semesters will have a course on laboratory practicals. The laboratory practicals of Semesters I, II and III are common courses. The Semester IV laboratory practical course will change, subject to the Elective Bunch opted by the college. A minimum of 12 experiments should be done and recorded in each semester. The practical examinations will be conducted at the respective examination centers by two external examiners appointed by the university 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.
- 1.3 Project: The project of the PG program 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 as being practiced in the present syllabus. The project is evaluated by the external examiners. The project guide or a faculty member deputed by the head of the department may be present at the time of project evaluation. This is to facilitate the proper assessment of the project.
- 1.4 Viva Voce: A viva voce examination will be conducted by the two external examiners at the time of evaluation of the project. The components of viva consists of subject of special interest, fundamental physics, topics covering all semesters and awareness of current and advanced topics.
- 1.5 Course Code: The 12 core courses in the program are coded according to the following criteria. The first three letters of the code indicates the name of program, ie. PPH stands for MSc Physics. The next digit indicate the semester. The next three letters indicate the course type and the next two digits run for the paper number. The last two digits indicate the syllabus revision year.

1.6 Course Structure of M.Sc. Physics Program:

The detailed structure of the Core courses common to all students of the program is given in Table 1.1

Semester I

SL No.	Course Code	Course Title	Course Category	Hours per Week	Credits
1	PPH1CRT0122	Mathematical methods in Physics – I	Core	3	3
2	PPH1CRT0222	Classical Mechanics	Core	4	4
3	PPH1CRT0322	Electrodynamics	Core	4	4
4	PPH1CRT0422	Electronics	Core	4	4
5	PPH1CRP0122	General Physics Practicals	Core(P)	5	Evaluation at the end of II semester
6	PPH2CRP0222	Electronics Practicals	Core(P)	5	
Total for Semester 1				25	16

Semester II

Sl No.	Course Code	Course Title	Course Category	Hours per week	Credits
1	PPH2CRT0122	Mathematical methods in Physics – II	Core	4	4
2	PPH2CRT0222	Quantum Mechanics – I	Core	3	4
3	PPH2CRT0322	Statistical Mechanics	Core	4	4
4	PPH2CRT0422	Condensed Matter Physics	Core	4	4
5	PPH2CRP0122	General Physics Practicals	Core	5	4
6	PPH2CRP0222	Electronics Practicals	Core	5	4
Total for Semester 2				25	24

Semester III

Sl No.	Course Code	Course Title	Course Category	Hours per week	Credits
1	PPH3CRT0122	Quantum Mechanics – II	Core	4	4
2	PPH3CRT0222	Computational Physics	Core	4	4
3	PPH3CRT0322	Atomic and Molecular Physics	Core	4	4
4	PPH3CRT0422	Elective – 1	Elective	3	4
5	PPH3CRP0122	Computational Physics Practicals	Core(P)	5	Evaluation at the end of IV semester
6	PPH3CRP0222	Advanced Elective Practicals	Elective(P)	5	
Total for Semester 3				25	16

Semester IV

Sl No.	Course Code	Course Title	Course Category	Hours per week	Credits
1	PPH4CRT0122	Nuclear and Particle Physics	Core	5	4
2	PPH4CRT0222	Elective – 2	Elective	5	3
3	PPH4CRT0322	Elective – 3	Elective	5	3
4	PPH4CRP0122	Computational Physics Practicals	Core(P)	5	4
5	PPH4CRP0222	Advanced Elective Practicals	Elective(P)	5	4
6	PPH4CPR0122	Project	Core	-	4
7	PPH4CRV0122	Comprehensive viva voce	Core	-	2
Total for Semester 4				25	24
Grand Total					80

1.7 The Elective Bunches

There are four Electives Bunches offered in this PGCSS Program. Each elective consists of a bunch of three theory courses and one laboratory course. The first theory course and the laboratory course of a bunch are placed in the Semester III, while the second and third are in Semester IV. An institution can select only one Elective Bunch in an academic year. The course structure of the Electives Bunches is given in Table 1.2

The Electives Bunches are named,

- (i) Bunch A : Electronics
- (ii) Bunch B : Material Science
- (iii) Bunch C : Informatics
- (iv) Bunch D : Theoretical Physics.

Table 1.2: The Elective Bunch

Bunch A: Electronics Specialization :

Semester	Course Title	Hours per week	Credits
3	Digital Signal Processing	3	3
4	Introduction to Embedded Systems	5	3
4	Semiconductor Devices	5	3
	OR		
	Communication Systems		
4	Advanced Practicals in Electronics	10	5

Bunch B: Materials Science Specialization :

Semester	Course Title	Hours per week	Credits
3	Solid State Physics for Materials	3	3
4	Science of Advanced Materials	5	3
4	Nanostructures and Materials Characterisation	5	3
4	Advanced Practicals in Materials Science	10	5

Bunch C: Informatics Specialization:

Semester	Course Title	Hours per week	Credits
3	Programming in JAVA and HTML	3	3
4	Data Communication and Computer Networks	5	3
4	Computer applications in Physics	5	3
4	Practicals in Informatics	10	5

Bunch D: Theoretical Physics:

Semester	Course Title	Hours per week	Credits
3	General Relativity and Applications	3	3
4	Nonlinear Dynamics	5	3
4	Quantum Field Theory	5	3
4	Special Computational Practicals	10	5

- 1.8 **Distribution of Credit:** The total credit for the program is fixed at 80. The distribution of credit points in each semester and allocation of the number of credit for theory courses, practicals, project and viva is shown in Table 1.1 and Table 1.2.

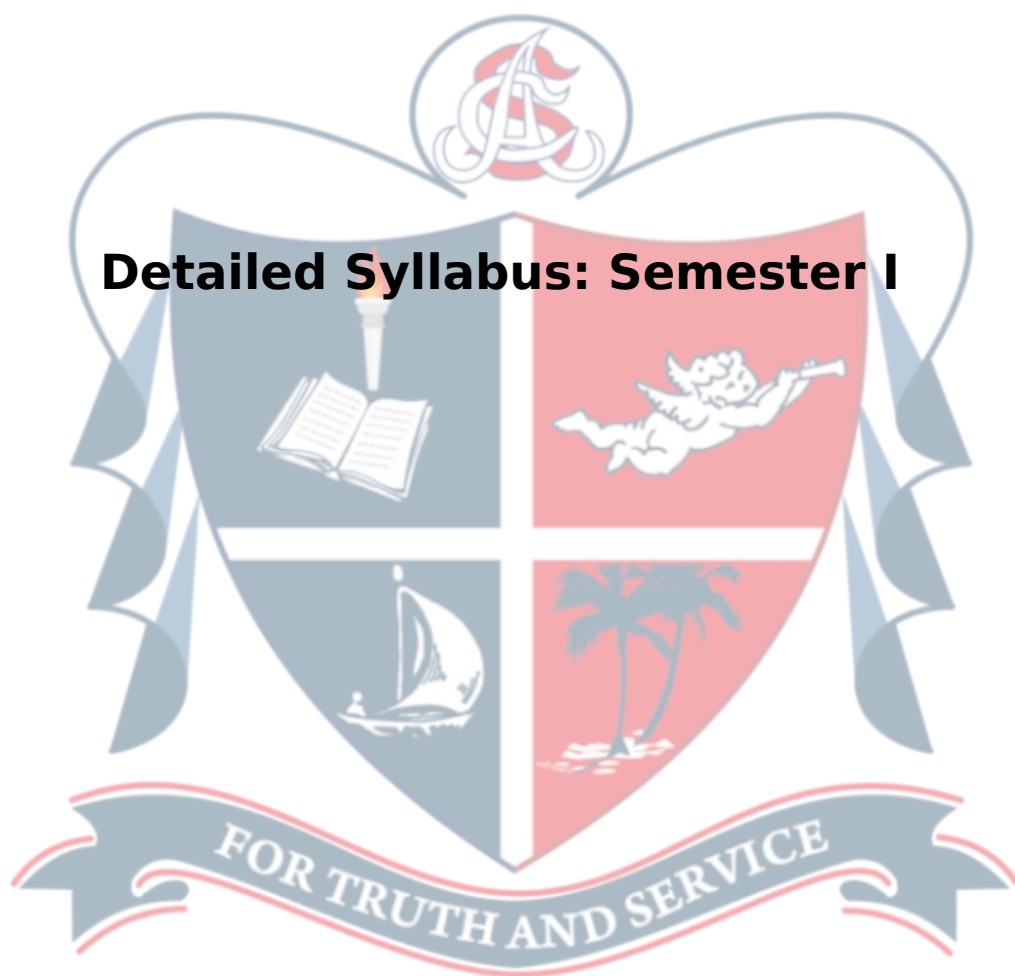
M.Sc. Physics Syllabus

Introduction

This chapter deals with the syllabi of all core courses, Elective courses of the MSc. Physics program. The semester wise distribution of the courses is given.

In the semester III and semester IV, the courses from bunch A: Electronics Specialization will come as opted by the department.





Mathematical Methods in Physics - I (PPH1CRT0122)

54 Hours

3 Credits

Course Outcomes

At the end of this course, students will be able to:

- Explain linear dependence and linear combination of vectors as quantities in physics.
- Perform the differentiation and integration of vector fields through vector calculus and apply them to solve problems in Physics
- Summarize the distributions including binomial, Poisson and Normal distribution.
- Discuss about special types of matrices and their applications in Physics including solution of equations.
- Summarize the introductory concepts in tensors

Module I: Vector analysis

(8 Hours)

- 1.1 Line, Surface and Volume integrals
- 1.2 Gradient, divergence and curl of vector Functions
- 1.3 Gauss Divergence Theorem
- 1.4 Stoke's Theorem
- 1.5 Green's Theorem
- 1.6 Potential Theory
 - 1.6.1 Scalar Potential-Gravitational Potential, Centrifugal Potential

Curvilinear co-ordinates

(8 Hours)

- 1.7 Transformation of co-ordinates
- 1.8 Orthogonal Curvilinear co-ordinates
- 1.9 Unit Vectors in curvilinear systems
- 1.10 Arc Length and Volume Elements
- 1.11 Gradient, Divergence and Curl in orthogonal curvilinear co-ordinates
- 1.12 Special Orthogonal co-ordinates system
 - 1.12.1 Rectangular Cartesian Co-ordinates
 - 1.12.2 Cylindrical Co-ordinates
 - 1.12.3 Spherical Polar Co-ordinates

Module II: Linear vector space

(14 Hours)

- 1.1 Definition of linear vector space

- 2.2 Inner product of vectors
- 2.3 basis sets
- 2.4 Gram schmidt ortho normalization
- 2.5 Expansion of an arbitrary vector
- 2.6 Schwarz inequality Probability theory and distribution
- 2.7 Elementary Probability Theory
- 2.8 Binomial Distribution
- 2.9 Poisson Distribution
- 2.10 Gaussian Distribution
- 2.11 Central Limit Theorem

Module III: Matrices**(12 Hours)**

- 3.1 Direct Sum and Direct Product of Matrices
- 3.2 Diagonal matrices
- 3.3 Matrices inversion (Gauss Jordan Inversion Methods)
- 3.4 Orthogonal, unitary and Hermitian Matrices
- 3.5 Pauli spin matrices, Dirac matrices, Normal matrices 3.6 Cayley Hamilton Theorem
- 3.6 Similarity transformation
- 3.7 Orthogonal & Unitary Transformations
- 3.8 Eigen values & Eigen Vectors 3
- 3.9 Diagonalization using normalized Eigen vectors
- 3.10 Solution of linear equation Gauss Elimination method

Module IV: Tensors**(12 Hours)**

- 4.1 Definition of Tensors
- 4.2 Basic Properties of Tensors
- 4.3 Covariant, Contra variant & Mixed Tensors
- 4.4 Kronecker delta, Levi-Civita Tensor
- 4.5 Metric Tensor and its properties
- 4.6 Tensor algebra
- 4.7 Associated Tensors
- 4.8 Christoffel Symbols & their transformation laws

4.9 Covariant Differentiation

4.10 Geodesics

Text Books

- Mathematical methods for Physicists, G.B. Arfken & H.J. Weber 5th edition, Academic Press.
- Mathematical Physics, V. Balakrishnan, Ane Books Pvt Limited
- Introduction to Mathematical Physics – Charles Harper, PHI
- Vector Analysis & Tensor Analysis – Schaum's Outline Series, M.R. Spiegel, Mc Graw Hill
- Mathematical methods for physics and engineering, K F Riley, M P Hobson, S J Bence, Cambridge university press.

References

- An Introduction to Relativity, Jayant V. Narlikar, Cambridge University Press.
- Advanced Engineering Mathematics E. Kreyszig 7th edition John Wiley
- Mathematical Physics, B.S. Rajput, Y. Prakash 9th edition Pragati Prakashan
- Mathematical Physics, B.D. Gupta, Vikas Publishing House
- Matrices and tensors in Physics, A.W. Joshi
- Mathematical Physics, P.K. Chatopadhyay, New Age International Publishers
- Mathematical Physics, Sathyaprakash, Sultan Chand & Sons



Classical Mechanics (PPH1CRT0222)

72 Hours

4 Credits

Course Outcome

At the end of this course, students will be able to:

- Interpret the Lagrangian and Hamiltonian dynamics and apply these formulations to any given physical system including relativistic mechanics.
- Analyse Canonical transformations and explain Hamilton-Jacobi theory.
- Analyze the theory of small oscillations and evaluate the normal modes of N-Coupled oscillator.
- Summarize the dynamics of a rigid body and discuss the central force problem.
- Solve 1D and 2-D mechanical problems using Hamilton Jacobi theory and Action Angle variables.

Module I: Lagrangian formulation**(14 Hours)**

- 1.1 Review of Newtonian Mechanics: Mechanics of a Particle; Mechanics of a System of Particles; Constraints;
- 1.2 D' Alembert's principle and Lagrange's equations; velocity-Dependent potentials and the Dissipation Function; Lagrangian for a charged particle in electromagnetic field;
- 1.3 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.
- 1.4 Hamilton's Principle; Technique of Calculus of variations; The Brachistochrone problem.
- 1.5 Derivation of Lagrange's equations from Hamilton's Principle.
- 1.6 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**(4 Hours)**

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

Module II: Small oscillations**(8 Hours)**

- 2.1 Stable equilibrium unstable equilibrium and neutral equilibrium; motion of a system near stable equilibrium-Lagrangian of the system and equations of motion.

- 2.2 Small oscillations- frequencies of free vibrations; normal coordinates and normal modes
- 2.3 System of two coupled pendula-resonant frequencies normal modes and normal coordinates ;free vibrations of CO₂ molecule- resonant frequencies normal modes and normal coordinates.

Canonical transformations and poisson brackets**(10 Hours)**

- 2.4 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.
- 2.5 Solution of harmonic oscillator using canonical transformations.
- 2.6 Poisson Brackets ; Fundamental Poisson Brackets; Properties of Poisson Brackets
- 2.7 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**(9 hours)**

- 3.1 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
- 3.2 Equivalent one-dimensional problem –centrifugal potential; classification of orbits.
- 3.3 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**(9 Hours)**

- 3.4 Independent coordinates of a rigid body; Orthogonal transformations ; Euler Angles.
- 3.5 Infinitesimal rotations: polar and axial vectors; rate of change of vectors in space and body frames; Coriolis effect.
- 3.6 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.
- 3.7 Euler equations of motion; force free motion of a symmetrical top.

Module IV: Hamilton-Jacobi theory and action-angle variables**(12 Hours)**

- 4.1 Hamilton-Jacobi Equation for Hamilton's Principal Function; physical significance of the principal function.
- 4.2 Harmonic oscillator problem using the Hamilton-Jacobi method. Hamilton-Jacobi Equation for Hamilton's characteristic function
- 4.3 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) .

4.4 Action-Angle variables; harmonic oscillator problem in action-angle variables.

Classical mechanics of relativity

(6 Hours)

4.5 Lorentz transformation in matrix form; velocity addition; Thomas precession.

4.6 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

- Classical Mechanics: Herbert Goldstein, Charles Poole and John Safko, (3/e); Pearson Education.
- Classical Mechanics: G. Aruldas, Prentice Hall 2009.

References

- Theory and Problems of Theoretical Mechanics (Schaum Outline Series): Murray R. Spiegel, Tata McGraw-Hill 2006.
- Classical Mechanics : An Undergraduate Text: Douglas Gregory, Cambridge University Press.
- Classical Mechanics: Tom Kibble and Frank Berkshire, Imperial College Press.
- Classical Mechanics (Course of Theoretical Physics Volume 1): L.D. Landau and E.M. Lifshitz, Pergamon Press.
- Analytical Mechanics: Louis Hand and Janet Finch, Cambridge University Press.
- Classical Mechanics: N.C.Rana and P. S. Joag, Tata Mc Graw Hill.
- Classical Mechanics: J.C. Upadhyaya, Himalaya Publications, 2010.
- www.nptelvideos.in/2012/11/classicalphysics.html.

Electrodynamics (PPH1CRT0322)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Explain the basic theories of electrostatics and magneto-statics and solve the problems related to these numerically.
- Discuss propagation of electromagnetic waves through different medium and categorize the conservation laws.
- Investigate the power radiated from different radiating systems.
- Analyze the applications of electromagnetic radiation and wave guides.
- Discuss the relativistic aspects of electrodynamics.

Module I: Electrostatics, Magnetostatics and basics of Electrodynamics (18 Hours)

- 1.1 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 ($\epsilon_r=1$) interface.
- 1.2 Uniqueness theorem and electrostatic potential-Solving Poisson's and Laplace equations for boundary value problems
- 1.3 Method of images- point charge -line charge above a grounded conducting plane.
- 1.4 Potential at large distance-multipole expansion due to a localized charge distribution- Electric field of a dipole.
- 1.5 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).
- 1.6 Electrodynamics: Electromotive force - motional emf - Faraday's law-, electrodynamic equations - displacement current.
- 1.7 Uniform sinusoidal time varying fields E and B and Maxwell's equations in free space and matter. Boundary conditions of electric and magnetic field
- 1.8 Conservation laws- continuity equation- Poynting's theorem-Maxwell's stress tensor- momentum conservation.

Module II: Electromagnetic waves (18 Hours)

- 1.1 Wave equation for E and B- monochromatic plane waves- energy- momentum
- 1.2 Propagation of em waves through linear media- Reflection and transmission of a plane wave at normal - oblique incidence.

1.3 Electromagnetic waves in a conducting medium. Reflection at conducting surface- frequency dependence of permittivity

1.4 Dispersion of electromagnetic waves in non-conductors, conductors and plasma medium

Module III: Electromagnetic radiation (18 Hours)

3.1 Potential formulation of electrodynamics- Gauge transformations-Coulomb and Lorentz gauge

3.2 Continuous charge distribution-Retarded potential-Jefmenko's equation.

3.3 Point charges- Lienard-Wiechert potentials-Field of a point charge in motion- Power radiated by a point charge

3.4 Electric dipole radiation-magnetic dipole radiation-radiation from arbitrary distribution of charges

3.5 Radiation reaction-Abraham-Lorentz formula.

Module IV: Relativistic electrodynamics and Waveguides (18 Hours)

4.1 Relativistic electrodynamics

4.1.1 Structure of spacetime- Four vectors-Proper time and proper velocity- Relativistic energy and momentum-Relativistic dynamics- Minkowski force.

4.1.2 Magnetism as a relativistic phenomenon.

4.1.3 Lorentz transformation of em field- field tensor-electrodynamics in tensor notation.

4.1.4 Potential formulation of relativistic electrodynamics.

4.2 Waveguides

4.2.1 Waves between parallel planes-TE-TM-TEM waves

4.2.2 Rectangular waveguide- TE-TM waves -impossibility of TEM wave.

4.2.3 Cylindrical waveguide- TE-TM waves

Text Books

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

References

- Electromagnetic waves and radiating systems Edward C Jordan, Keith G Balamin, Printice Hall India Pvt.Ltd
- Elements of Electromagnetic, Mathew N. O Sadiku, Oxford University Press
- Antenna and wave propagation, K.D Prasad, Satyaprakashan, New Delhi
- Electromagnetism problems with solutions, Ashutosh Pramanik, PHI.

Electronics (PPH1CRT0422)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Apply the knowledge of op amp circuits to construct and analyze various practical op amp circuits.
- Study the application of Op Amp as a current to voltage converter and inverter.
- 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.
- Describe the working of an instrumentation amplifier and its applications.
- Distinguish various active filters, integrator and differentiator.

Module I: Op-amp with Negative Feedback (16 Hours)

- 1.1 Differential amplifier – Inverting amplifier – Non-inverting amplifier -Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain
- 1.2 Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offset voltage with feedback–Voltage follower.
- 1.3 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.
- 1.4 Current to voltage converter- Inverter. Differential amplifier with one op-amp and two op-amps.

Module II

The Practical Op-amp (6 Hours)

- 2.1 Input offset voltage –Input bias current – input offset current – Total output offset voltage- Thermal drift
- 2.2 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) (14 Hours)

- 2.3 DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers.
- 2.4 Instrumentation amplifier using transducer bridge. Differential input and differential output amplifier – Low voltage DC and AC voltmeter.

2.5 Voltage to current converter with grounded load – Current to voltage converter.

2.6 Very high input impedance circuit – integrator and differentiator.

Module III: Frequency Response of an Op-amp (6 Hours)

3.1 Frequency response –Compensating networks – Frequency response of internally compensated and non-compensated op-amps – High frequency op- amp equivalent circuit.

3.2 Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate.

Active Filters and Oscillators. (with design) (12 Hours)

3.3 Active filters – First order and second order low pass Butterworth filter

3.4 First order and second order high pass Butterworth filter.

3.5 Wide and narrow band pass filter - wide and narrow band reject filter. All pass filter – Oscillators: Phase shift and Wien-bridge oscillators.

3.6 Square, triangular and saw tooth wave generators- Voltage controlled oscillator.

Module IV: Comparators and Converters (8 Hours)

4.1 Basic comparator- Zero crossing detector.

4.2 Schmitt Trigger – Comparator characteristics- Limitations of op-amp as comparators.

4.3 Voltage to frequency and frequency to voltage converters.

4.4 D/A and A/D converters- Peak detector – Sample and Hold circuit.

IC555 Timer (3 Hours)

4.5 IC555 Internal architecture, Applications IC565-PLL, Voltage regulator ICs 78XX and 79XX

Analog Communication (7 Hours)

4.6 Review of analog modulation – Radio receivers – AM receivers – superhetrodyne receiver.

4.7 Detection and automatic gain control – communication receiver.

4.8 FM receiver – phase discriminators – ratio detector – stereo FM reception

Text Books

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

References

- Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
- Fundamentals of Electronic Devices and Circuits 5th Ed. David A. Bell, Cambridge.

General Physics Practicals (PPH1CRP0122)

180 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Learn to carry out experiments in basic as well as certain advanced areas of physics such as condensed matter physics, nanoscience, lasers and electronics.
- Capability for planning, executing the experiment and to Interpret findings using the correct physical scientific framework and tools.
- Ability to present the results of a theoretical or experimental investigation in a systematic way.
- Evaluate possible causes of error in experimental observations and results
- To demonstrate proficiency in communicating competently in groups.

* Minimum number of experiments to be done 12

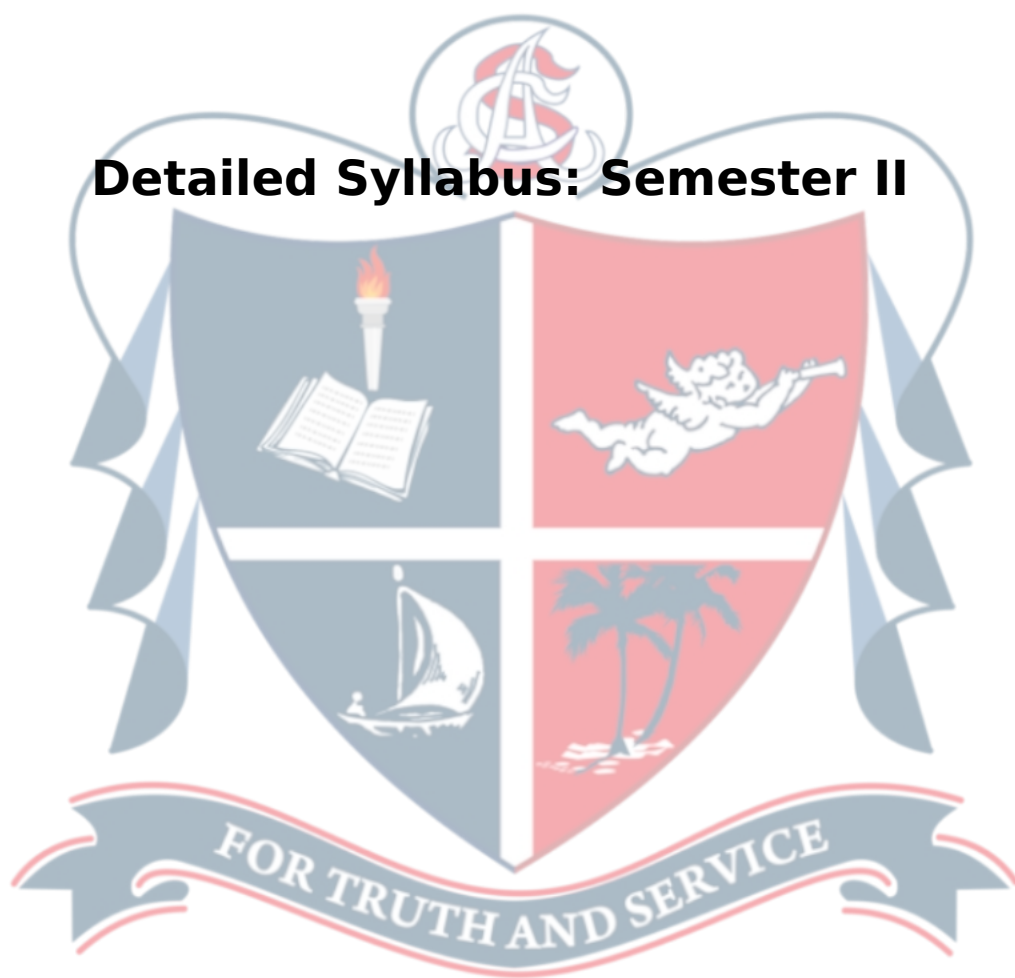
**Error analysis of the result is a compulsory part of experimental work

1. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility.
2. Ultrasonic- acoustic optic technique-elastic property of a liquid.
3. Magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
4. Curie temperature of a magnetic material.
5. Dielectric Constant and Curie temperature of ferroelectric Ceramics.
6. Draw the hysteresis curve (B – H Curve) of a ferromagnetic material and determination of retentivity and coercivity.
7. Cornu's method- Determination of elastic constant of a transparent material
8. Determination of e/m by Thomson's method.
9. Determination of e/k of Silicon.
10. Determination of Planck's constant (Photoelectric effect).
11. Measurement of resistivity of a semiconductor by four-probe method at different temperature and determination of band gap.
12. Determination of magnetic susceptibility of a solid by Guoy's method.
13. Measurement of wavelength of laser using reflection grating.
14. Fraunhofer diffraction pattern of a single slit, determination of wavelength/slit width.
15. Fraunhofer diffraction pattern of wire mesh, determination of wavelength/slit width.
16. Fraunhofer diffraction pattern of double slit, determination of wavelength/slit width.
17. Diffraction pattern of light with circular aperture using Diode/He-Ne laser.

18. Fresnel diffraction pattern of a single slit.
19. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
20. Determine the numerical aperture of optical fibre and propagation of light through it.
21. Determine the refractive index of the material using Brewster angle setup.
22. Absorption bands of KMnO_4 using incandescent lamp. Determine the wave lengths of the absorption bands. Determine the wave lengths of the absorption bands by evaluating Hartman's constants.
23. Determine the co-efficient of viscosity of the given liquid by oscillating disc method.
24. Measure the thermoemf of a thermocouple as function of temperature. Also prove that Seebeck effect is reversible.
25. Determine the Young's modulus of the material of a bar by flexural vibrations.
26. Using Michelson interferometer determine the wavelength of light.
27. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law
28. Study the dipole moment of an organic molecule (acetone).
29. Determine the dielectric constant of a non-polar liquid.
30. 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})
31. Determine the dielectric constant of a non-polar liquid.
32. Determine the charge of an electron using Millikan oil drop experiment.
33. Linear electro optic effect(Pockel effect), Frank Hertz experiment.
34. Frank Hertz experiment determination of ionization potential.
35. Koenig's method, Poisson's ratio of the given material of bar.
36. Determination of Stefan's constant of radiation from a hot body.

References

- R1.** Advanced practical physics for students, B.L Worsnop and H.T Flint, University of California.
- R2.** A course on experiment with He-Ne Laser, R.S Sirohi, John Wiley & Sons (Asia) Pvt.ltd
- R3.** Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan ,K.R Priolkar, Indian Academy of Sciences.
- R4.** Advanced Practical Physics, S.P singh, PragatiPrakasan,
- R5.** Practical Physics, Gupta, Kumar, PragatiPrakasan.
- R6.** An advanced course in Practical Physics, D.Chattopadhyay, C.R Rakshit, New Central Book Agency Pvt. Ltd: ****for error analysis only.**



Mathematical Methods In Physics - II (PPH2CRT0122)

72 Hours

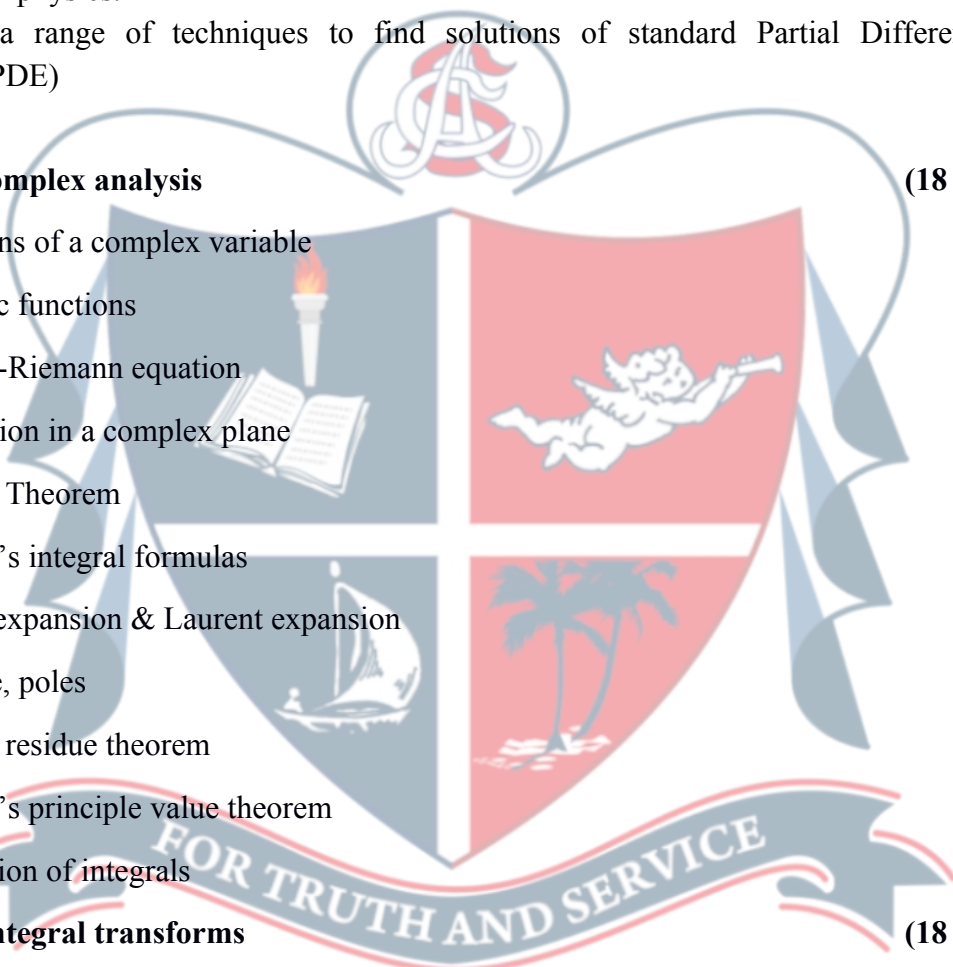
4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Learn the basic elements of complex analysis, including the integral theorems and obtain the residues of a complex function.
- Apply the residue theorem to evaluate definite integrals for solving physical problems.
- Apply Fourier series, Fourier transform and Laplace transform to problems in Physics.
- Discuss special functions and differential equations as the basis for further application in theoretical physics.
- Apply a range of techniques to find solutions of standard Partial Differential Equations (PDE)

Module I: Complex analysis**(18 Hours)**

- 
- 1.1 Functions of a complex variable
 - 1.2 Analytic functions
 - 1.3 Cauchy-Riemann equation
 - 1.4 Integration in a complex plane
 - 1.5 Cauchy Theorem
 - 1.6 Cauchy's integral formulas
 - 1.7 Taylor expansion & Laurent expansion
 - 1.8 Residue, poles
 - 1.9 Cauchy residue theorem
 - 1.10 Cauchy's principle value theorem
 - 1.11 Evaluation of integrals

Module II: Integral transforms**(18 Hours)**

- 2.1 Fourier Series
- 2.2 Application of Fourier series
 - 2.2.1 Square Wave
 - 2.2.2 Full Wave Rectifier
- 2.3 Fourier Integral
- 2.4 Fourier Transform
 - 2.4.1 Finite Wave Train

- 2.5 Convolution Theorem of parseval's relation
- 2.6 Momentum representation
 - 2.6.1 Hydrogen atom
 - 2.6.2 Harmonicoscillator
- 2.7 Laplace Transform, Inverse Laplace transform
- 2.8 Earth Mutation
- 2.9 Damped Oscillator
- 2.10 LCR circuit

Module III: Special functions and differential equations**(18 Hours)**

- 3.1 Gamma Function
- 3.2 Beta Function
- 3.3 Symmetry Property of Functions
- 3.4 Evaluation of Beta functions
- 3.5 Other forms of Beta Functions --Transformation of Beta Functions
- 3.6 Evaluation of Gamma Functions
- 3.7 Other forms of Gamma Functions- Transformation of Gamma Functions
- 3.8 Relation between Beta and Gamma Functions
- 3.9 Evaluation of Integrals
- 3.10 Bessel's Differential Equation,
- 3.11 Legendre Differential Equation
- 3.12 Associated Legendre Differential Equations
- 3.13 Hermite Differential Equations
- 3.14 Laguerre Differential Equations (Generating function, recurrence relation, orthogonality condition, Rodrigues formulae for all functions)

Module IV: Partial differential equations**(18 Hours)**

- 4.1 Characteristics of boundary conditions for partial differential equation
- 4.2 Solution of partial differential equations by the method of separation of variables in Cartesian, cylindrical and spherical polar co-ordinates
- 4.3 Solution of Laplace equation in cartesian, cylindrical and spherical polar co-ordinates
- 4.4 Heat equation in Cartesian co-ordinates
- 4.5 Non-Homogeneous equation

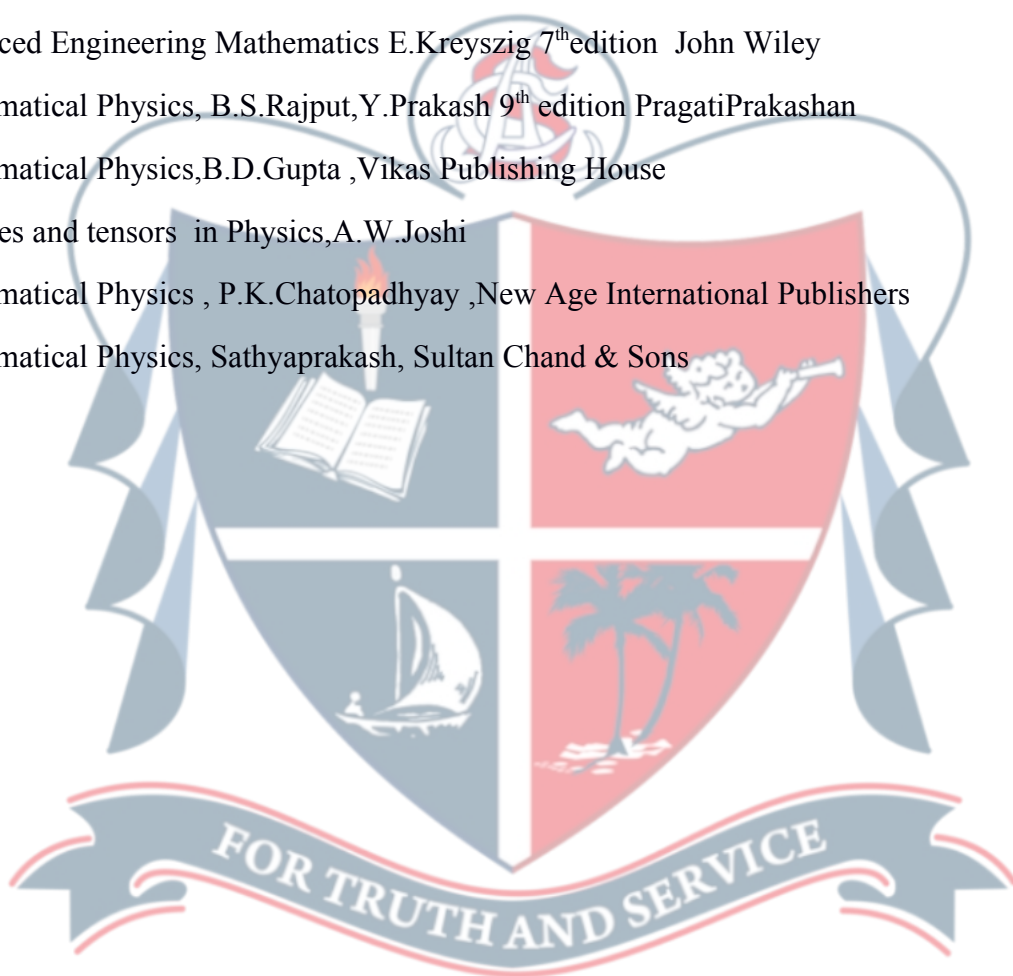
- 4.6 Green's function
- 4.7 Symmetry of Green's Function
- 4.8 Green's Function for Poisson Equation, Laplace equation, Helmholtz equation
- 4.9 Application of Greens equation in scattering problem

Text Books

- Mathematical methods for Physicists, G.B. Arfken & H.J. Weber 5th edition, Academic Press.
- Mathematical Physics, V. Balakrishnan, Ane Books Pvt Limited

Reference

- Advanced Engineering Mathematics E. Kreyszig 7th edition John Wiley
- Mathematical Physics, B.S. Rajput, Y. Prakash 9th edition Pragati Prakashan
- Mathematical Physics, B.D. Gupta, Vikas Publishing House
- Matrices and tensors in Physics, A.W. Joshi
- Mathematical Physics, P.K. Chatopadhyay, New Age International Publishers
- Mathematical Physics, Sathyaprakash, Sultan Chand & Sons



Quantum Mechanics-I (PPH2CRT0222)

54 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- To familiarize the student with Dirac notations, use them to analyze eigen states.
- Analyze spin $\frac{1}{2}$ systems and finite rotations.
- Define time evolution operator, Heisenberg and Schrodinger picture.
- Derive the fundamental commutation relations, eigen values and eigen states of angular momentum operator.
- Explain the Hydrogen atom using the quantum theory.

Module I: Basics Formulation of Quantum Mechanics

(20 hours)

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

Module II: Quantum Dynamics

(16 hours)

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

Module III: Theory of Angular Momentum**(14 hours)**

- 3.1 Non-commutativity of rotations around different axes; the rotation operator; fundamental commutation relations for angular momentum operators
- 3.2 rotation operators for spin half systems; spin precession in a magnetic field
- 3.3 Pauli's two component formalism; 2X2 matrix representation of the rotation operator
- 3.4 ladder operators; eigenvalue problem for angular momentum operators
- 3.5 matrix representation of angular momentum operators.
- 3.6 Orbital angular momentum ; orbital angular momentum as a generator of rotation
- 3.7 Addition of orbital angular momentum and spin angular momentum; addition of angular momenta of two spin-1/2 particles. General theory of Angular Momentum addition- Computation of Clebsch - Gordon coefficients.

Module IV: The Hydrogen Atom**(4 hours)**

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

Text Books

- Modern Quantum Mechanics : J. J. Sakurai, Pearson Education.
- A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books.

References

- Quantum Mechanics (Schaum's Outline) : Yoav Peleg *et al.* Tata Mc Graw Hill Private Limited, 2/e.
- Quantum Mechanics: 500 Problems with Solutions: G Aruldas, Prentice Hall of India.
- Quantum Mechanics Demystified: David McMohan, McGrawHill 2006.
- Introductory Quantum Mechanics: Richard L Liboff, Pearson Education .
- Introduction to Quantum Mechanics: D.J. Griffith, Pearson Education.
- Quantum Mechanics : V. K. Thankappan, New Age International.
- Quantum Mechanics: An Introduction: Walter Greiner and Allan Bromley, Springer.
- Quantum Mechanics : Non-Relativistic Theory(Course of Theoretical Physics Vol3): L. D. Landau and E. M. Lifshitz, Pregamon Press.
- The Feynman Lectures on Physics Vol3, Narosa.
- www.nptel/videos.in/2012/11/quantum-physics.html
- <https://nptel.ac.in/courses/115106066/>

Statistical Mechanics (PPH2CRT0322)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Apply probability theory and quantum mechanics to determine the relevant partition function and various thermodynamic quantities for a given system.
- Summarize the concept of ensembles and apply the ensemble theory to solve different physical systems.
- Explain and compare the principles of classical and quantum statistical physics. Apply them to analyze the real-world problems.
- Have a basic idea of phase transitions.
- Develop analytical ability to solve problems relevant to statistical mechanics.

Module I**(22 Hours)**

1.1. The Statistical Basis of Thermodynamics

- 1.1.1. Macroscopic and microscopic states.
- 1.1.2. Connection between thermodynamics and statistics.
- 1.1.3. Classical ideal gas.
- 1.1.4. Entropy of mixing and Gibbs paradox.
- 1.1.5. Correct enumeration of micro states.

1.2. Elements of Ensemble Theory

- 1.2.1. Phase space of a classical system.
- 1.2.2. Liouville's theorem.
- 1.2.3. Micro-canonical ensemble.
- 1.2.4. Quantum states and phase space.

1.3. Canonical ensemble.

- 1.3.1. Equilibrium between a system and a heat reservoir.
- 1.3.2. System in canonical ensemble.
- 1.3.3. Physical significance of statistical quantities in canonical ensemble.
- 1.3.4. Classical systems.
- 1.3.5. Energy fluctuations in canonical ensemble.
- 1.3.6. Equipartition theorem.

Module II**(18 Hours)**

2.1 Grand canonical Ensemble

- 2.1.1 Equilibrium between system and energy-particle reservoir.
- 2.1.2 A system in grand canonical ensemble.
- 2.1.3 Physical significance of various statistical quantities.
- 2.1.4 Examples.

2.1.5 Fluctuations in grand canonical ensemble.

2.2 Formulation of Quantum Statistics

2.2.1 Quantum mechanical ensemble theory.

2.2.2 Density matrix. 2.2.3. Statistics of various ensembles.

2.2.3 Examples (an electron in magnetic fields, free particle in a box).

2.2.4 A system composed of indistinguishable particles.

Module III

(22 Hours)

3.1 Quantum Theory of Simple Gases

3.1.1 Ideal gas in quantum-micro canonical ensemble.

3.1.2 Ideal gas in other quantum mechanical ensembles.

3.1.3 Statistics of the occupation numbers

3.2 Ideal Bose Systems

3.2.1 Thermodynamic behaviour of ideal Bose gas.

3.2.2 Thermodynamics of black body radiation. The field of sound waves .

3.3 Ideal Fermi Systems

3.3.1 Thermodynamics of ideal Fermi gas.

3.3.2 Magnetic behaviour of ideal fermi gas.

3.3.3 Electron gas in metals. 4.

Module IV

(10 Hours)

4.1. Phase Transitions

4.1.1. Phases.

4.1.2. Thermodynamic potentials,

4.1.3. Approximation.

4.1.4. First order phase transition.

4.1.5. Clapeyron equation.

Text books

- Text book- R.K. Pathria, Statistical Mechanics, second edition (1996), Butterworth, Heinemann. (For Modules I, II and III.)
- R Bowley and M. Sanchez, Introductory Statistical Mechanics, second edition, Oxford University Press. (For Module IV)

Reference Books

- Kerson Huang, Statistical Mechanics, John Wiley and Sons (2003).
- F. Rief, Fundamentals of Statistical and Thermal Physics, McGraw Hill (1986).
- D. Chandler, Introduction to Statistical Mechanics, Oxford University Press (1987)
- L.D Landau and E.M Lifshitz, Statistical Physics (Vol-1), 3rd Edition. Pergamon Press (1989)
- Yung-Kuo Lim, Problems and Solutions in Thermodynamics and Statistical Mechanics, World Scientific (1990).

Condensed Matter Physics (PPH2CRT0422)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Explain the concept of reciprocal lattice and its physical significance.
- Explain the electrical and thermal properties of metals and semiconductors adopting the free electron model
- Apply the band theory to explain the properties of semiconductor crystals.
- Formulate models for vibrational motion of crystals and explain thermal properties of crystalline solids based on this.
- Compare the different types of magnetism – Para, ferro and antiferro magnetism and discuss the different models which explains their behavior.

Module I: Wave Diffraction and the Reciprocal Lattice (5 Hours)

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

Crystal Symmetry (7 Hours)

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

Free Electron Fermi Gas (12 Hours)

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

Module II: Energy Bands (8 Hours)

- 2.1 Nearly free electron model- Origin of energy gap-Magnitude of the Energy Gap-
- 2.2 Bloch functions –

- 2.3 Kronig-Penney model –
- 2.4 Wave equation of electron in a periodic potential-Restatement of Bloch theorem-Crystal momentum of an Electron-Solution of the central equations-
- 2.5 Brillouin zone- construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) –
- 2.6 Effective mass of electron –
- 2.7 Distinction between conductors, semiconductors and insulators.

Semiconductor Crystals**(10 Hours)**

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

Module III: Phonons Crystal Vibrations and Thermal Properties**(16 Hours)**

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

Module IV: Magnetic Properties of Solids**(14 Hours)**

- 4.1 Quantum theory of paramagnetism–Hunds rules-crystal field splitting-spectroscopic splitting factor-
- 4.2 Cooling by adiabatic demagnetization – Nuclear Demagnetization-
- 4.3 Ferromagnetic order-Curie point and the exchange integral-Temperature dependence of the saturation-Magnetization-Saturation Magnetization at absolute Zero-
- 4.4 Magnons- Quantization of spin waves-Thermal excitation of Manganons-
- 4.5 Neutron Magnetic Scattering-

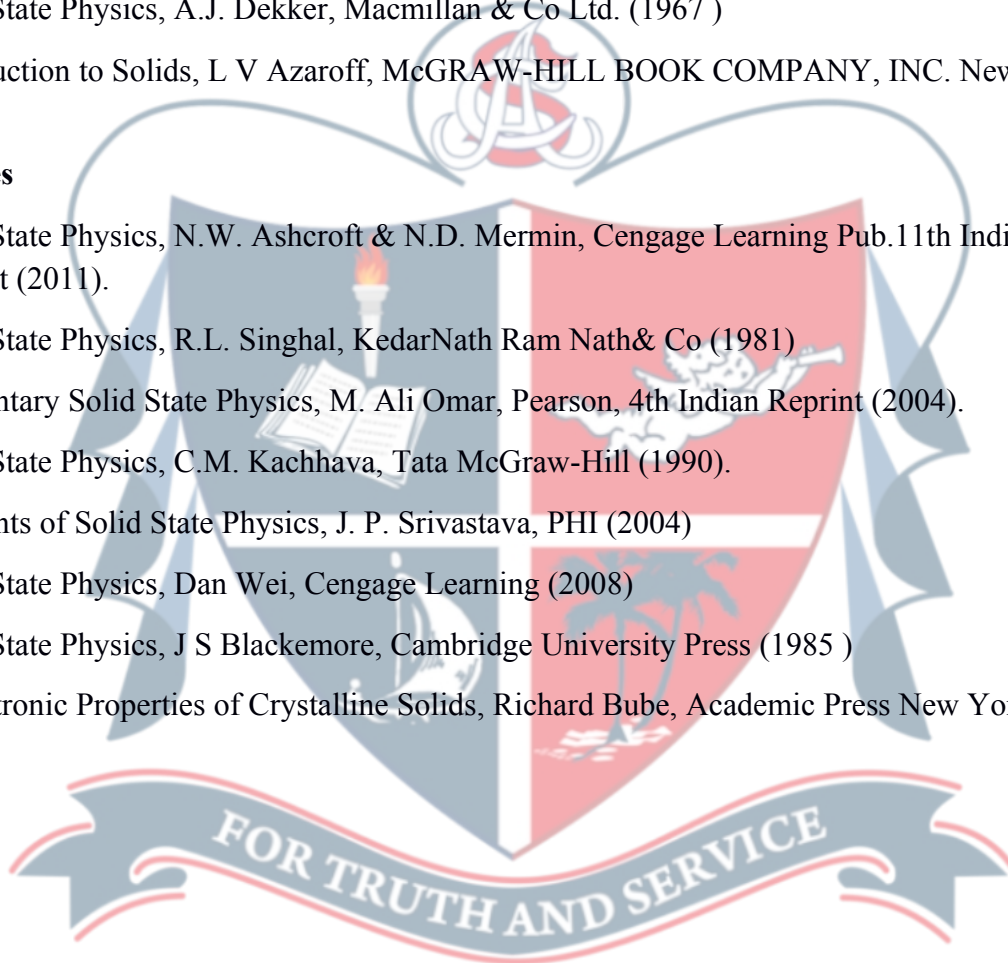
- 4.6 Ferromagnetic order-curie temperature and Susceptibility-
- 4.7 Antiferromagnetic order-susceptibility below Neel-Temperature-
- 4.8 Ferromagnetic domains-Anisotropic Energy-transition region between Domains-origin of domains - Corecivity and Hysteresis-
- 4.9 Single Domain Particles-Geomagnetism and Biomagnetism-Magnetic scope microscopy
- 4.10 Elements of superfluidity

Textbooks

- Introduction to Solid State Physics, Charles Kittel, Wiley, Indian reprint (2015).
- Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)
- Introduction to Solids, L V Azaroff, McGRAW-HILL BOOK COMPANY, INC. New York (1960)

References

- Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th Indian Reprint (2011).
- Solid State Physics, R.L. Singhal, KedarNath Ram Nath& Co (1981)
- Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
- Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
- Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
- Solid State Physics, Dan Wei, Cengage Learning (2008)
- Solid State Physics, J S Blackemore, Cambridge University Press (1985)
- 8.Electronic Properties of Crystalline Solids, Richard Bube, Academic Press New York (1974)



Electronics Practical (PPH2CRP0222)

180 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Learn to carry out experiments in basic as well as certain advanced areas of physics such as condensed matter physics, Electronics.
- Capability for planning, executing the experiment and to Interpret findings using the correct physical scientific framework and tools.
- Ability to present the results of a theoretical or experimental investigation in a systematic way.
- Evaluate possible causes of error in experimental observations and results.
- To demonstrate proficiency in communicating competently in groups.

* *Minimum number of experiments to be done 12*

***Error analysis of the result is a compulsory part of experimental work*

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

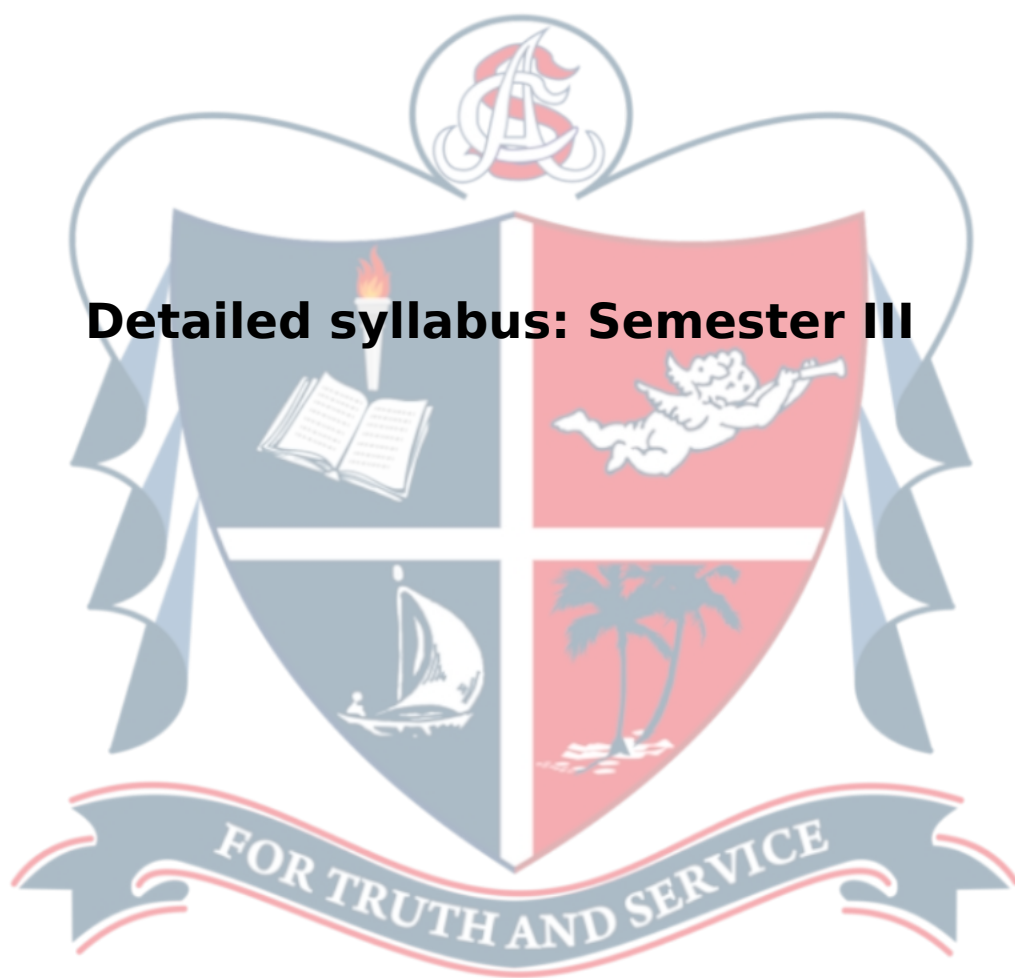
Op-Amp parameters

- (i) Open loop gain
 - (ii) input offset voltage
 - (iii) input bias current
 - (iv) CMRR
 - (v) slew rate
 - (vi) Band width
1. Design and construct an integrator using Op-Amp ($\mu A741$), draw the input output curve and study the frequency response.
 2. Design and construct a differentiator using Op-Amp ($\mu A741$) for *sin wave and square wave input* and study the output wave for different frequencies.
 3. Design and construct a logarithmic amplifier using Op-Amp ($\mu A741$) and study the output wave form.
 4. Design and construct a square wave generator using Op-Amp ($\mu A741$) for a frequency f_0 .
 5. Design and construct a triangular wave generator using ($\mu A741$) for a frequency f_0 .
 6. Design and construct a saw tooth wave generator using Op-Amp ($\mu A741$) generator.
 7. Design and construct an Op-Amp Wien bridge oscillator with amplitude stabilization and study the output wave form.
 8. Design and construct a Schmidt trigger using Op-Amp $\mu A741$, plot of the hysteresis curve.
 9. Design and construct an astable multivibrator using $\mu A741$ with duty cycle other than 50%

10. Design and construct a RC phase shift oscillator using $\mu A741$ for a frequency f_0 .
11. Design and construct a first and second order low pass Butterworth filter using $\mu A741$ and plot the frequency response curve.
12. Design and construct a first and second order high pass Butterworth filter using $\mu A741$ and study the frequency response.
13. Design and construct a first order narrow band pass Butterworth filter using $\mu A741$.
14. Solving differential equation using $\mu A741$
15. Design and construct current to voltage and voltage to current converter ($\mu A741$)
16. Astable multivibrator using 555 timer, study the positive and negative pulse width and free running frequency.
17. Monostable multivibrator using 555 timers and study the input output waveform.
18. Voltage controlled Oscillator using 555 timer
19. Design and construct a Schmitt Trigger circuit using IC 555.
20. Design and test a two stage RC coupled common emitter transistor amplifier and find the bandwidth, mid-frequency gain, input and output impedance.
21. Design and test a RC phase shift oscillator using transistor for a given operating frequency.
22. Voltage controlled Oscillator using transistor
23. Study the function of (i) analog to digital converter using IC 0800 (ii) digital to analog converter DAC 0808
24. Study the application of op-Amp ($\mu A741$) as a differential amplifier.
25. Solving simultaneous equation using op-Amp ($\mu A741$).

References

- R1.** Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7
- R2.** Electronic Laboratory Primer a design approach, S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi
- R3.** Electronic lab manual Vol I, K ANavas, Rajath Publishing
- R4.** Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
- R5.** Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
- R6.** An advanced course in Practical Physics, D.Chattopadhyay, C.R Rakshit, New Central Book Agency Pvt. Ltd: ****For error analysis only.**



QUANTUM MECHANICS-II (PPH3CRT0122)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Apply fundamental time independent approximation methods for various problems in quantum mechanics.
- Apply the variational method and WKB approximation to solve problems in quantum mechanics.
- Derive the time dependent perturbation theory and apply it to selected examples of quantum systems.
- Explain the basic concepts of scattering and solve scattering problems.
- Describe the relativistic quantum mechanics; Klein-Gordan and Dirac equations.

Module I: Approximation Methods for Stationary States (18 Hours)

- 1.1 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.
- 1.2 Degenerate Perturbation theory First order Stark effect in hydrogen; Zeeman effect in hydrogen and the Lande g-factor.
- 1.3 The variational Method; Estimation of ground state energies of harmonic oscillator and delta function potential
- 1.4 Ground State of Helium atom ; Hydrogen Molecule ion.
- 1.5 The WKB method and its validity; The WKB wavefunction in the classical region; non-classical region ; connection formulas(derivation not required)
- 1.6 Potential well and quantization condition; the harmonic oscillator.
- 1.7 Tunneling; application to alpha decay.

Module II: Time-Dependent Perturbation Theory (18 Hours)

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

Module III: Identical Particles and Scattering Theory (18 Hours)

- 3.1 Bosons and fermions; anti-symmetric wave functions and Pauli's exclusion principle.
- 3.2 The Helium Atom.
- 3.3 The Asymptotic wave function - differential scattering cross section and scattering amplitude

3.4 The Born approximation- scattering amplitude in Born approximation; validity of the Born approximation; Yukawa potential ; Coulomb potential and the Rutherford formula.

3.5 Partial wave analysis- hard sphere scattering; S-wave scattering for finite potential well; Resonances and Ramsauer-Townsend effect .

Module IV: Relativistic Quantum Mechanics

(18 Hours)

4.1 Klein-Gordon Equation; continuity equation and probability density in Klein-Gordon theory.

4.2 Non-relativistic limit of the Klein-Gordon equation

4.3 Solutions of the Klein –Gordon equation for positive, negative and neutral spin0 particles; Klein-Gordon equation in the Schrodinger form.

4.4 Dirac Equation in the Scrodinger form; Dirac's matrices and their properties

4.5 Solutions of the free particle Dirac equation; single particle interpretation of the plane waves; velocity operator; *zitterbewegung*

4.6 Non-relativistic limit of the Dirac equation; spin of Dirac particles; Total angular momentum as a constant of motion.

4.7 Negative energy states and Dirac's hole theory.

Text Books

- Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.
- A modern Approach to Quantum Mechanics: John Townsend, Viva Books New Delhi
- Introduction to Quantum Mechanics: D.J. Griffith, Pearson Education
- Relativistic Quantum Mechanics: Walter Greiner, Springer-Verlag

References

- Quantum Mechanics (Schaum's Outline Series): Yoav Peleg etal., Tata McGraw Hill .Education Private Limited, 2/e.
- Quantum Mechanics: 500 Problems with Solutions: G Aruldas, Prentice Hall of India.
- Problems and Solutions in Quantum Mechanics: Kyriakos Tamvakis, Cambridge University Press.
- Introductory Quantum Mechanics: Richard L Liboff, Pearson Education.
- Quantum Mechanics: V. K. Thankappan, New Age International.
- A Textbook of Quantum Mechanics: P M Mathews and R Venkatesan, Tata McGraw Hill.
- Quantum Mechanics: Non Relativistic Theory (Course of Theoretical Physics Course Vol3) : L. D. Landau and E. M. Lifshitz, Pregamon Press.
- Relativistic Quantum Mechanics: James D Bjorken and Sidney D Drell, Tata McGraw Hill 2013
- www.ntpel/videos.in/2012/11/quantum-physics.html
- <https://nptel.ac.in/courses/115106066/>

Computational Physics (PPH3CRT0222)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Explain the methods for curve –fitting and ordinary differential equations.
- Solve numerical problems of curve fitting and ordinary differential equations.
- Discuss the various methods to solve algebraic, transcendental equations and linear equations.
- Solve algebraic and transcendental equations using these equations.
- Apply different methods to find numerical solution of ordinary, partial differential equations and system of equations.

Module I: Curve Fitting and Interpolation (20 Hours)

- 1.1 The least squares method for fitting a straight line,
- 1.2 The least squares method for fitting a parabola,
- 1.3 The least squares method for fitting a power curves,
- 1.4 The least squares method for fitting an exponential curves.
- 1.5 Interpolation - Introduction to finite difference operators,
- 1.6 Newton's forward and backward difference interpolation formula,
- 1.7 Newton's divided difference formula,
- 1.8 Cubic spline interpolation.

Module II: Numerical Differentiation and Integration (16 Hours)

- 2.1 Numerical differentiation,
- 2.2 cubic spline method,
- 2.3 errors in numerical differentiation,
- 2.4 Integration of a function with Trapezoidal Rule,
- 2.5 Simpson's 1/3
- 2.6 Integration of a function with Simpson's 3/8 Rule and error associated with each.
- 2.7 Relevant Algorithms for each.

Module III: Numerical Solution of Ordinary Differential Equations (20 Hours)

- 3.1 Euler method,
- 3.2 modified Euler method
- 3.3 Runge - Kutta 4th order methods –
- 3.4 adaptive step size R-K method,
- 3.5 Higher order equations.
- 3.6 Concepts of stability.

Numerical Solution of System of Equations

- 3.7 Gauss-Jordan elimination Method,

- 3.8 Gauss-Seidel iteration method,
- 3.9 Gauss elimination method
- 3.10 Gauss-Jordan method to find inverse of a matrix.
- 3.11 Power method
- 3.12 Jacobi's method to solve eigenvalue problems.

Module IV: Numerical solutions of partial differential equations**(16 Hours)**

- 4.1 Elementary ideas and basic concepts in finite difference method,
- 4.2 Schmidt Method,
- 4.3 Crank - Nicholson method,
- 4.4 Weighted average implicit method.
- 4.5 Monte Carlo evaluation of integrals,
- 4.6 Buffon's needle problem,
- 4.7 requirement for random number generation.

Text Books

- Numerical Methods for Scientists and Engineers , K SankaraRao, PHI Pvt. Ltd .
- Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.
- Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

Reference

- An Introduction to Computational Physics, Tao Pang, Cambridge University Press
- Numerical methods for scientific and Engineering computation M.K Jain, S.R. Kiyengar, R.K. Jain, New Age International Publishers
- Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
- Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
- Numerical Mathematical Analysis, J.B. Scarborough, 4th Edn, 1958
- Explorations in Monte Carlo Methods Ronald W Shonkwiler and Franklin Mendivil , Springer

Atomic and Molecular Physics (PH3CRT0322)

72 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Apply vector atom model to explain spectroscopic behaviour of atoms in electric and magnetic field.
- Solve problems related to Zeeman effect and Stark effect.
- Analyze the rotational spectrum of rigid and non-rigid diatomic rotator.
- Illustrate the effects of rotation on vibrational spectra of polyatomic molecules.
- Outline theory and experimental techniques of NMR, ESR, Raman spectroscopy and Mossbauer spectroscopy.

Module I: Atomic Spectra

(18 Hours)

- 1.1 The quantum mechanical treatment of hydrogen atom- quantum numbers n , l and m_l ; spectra of alkali metal vapours
- 1.2 Derivation of spin-orbit interaction energy in hydrogen-like atoms; extension to penetrating orbits; fine structure in sodium atom
- 1.3 Normal Zeeman effect; Anomalous Zeeman effect- magnetic moment of the atom and g factor; spectral frequencies; Lande g -formula.
- 1.4 Paschen-Back effect – splitting of sodium D-lines; Stark effect – quadratic Stark effect in potassium doublet.
- 1.5 L S coupling scheme -spectroscopic terms arising from two valence electrons; terms arising from two equivalent s-electrons; derivation of interaction energy - combination of s and p electrons; Hund's rule, Lande interval rule.
- 1.6 The jj coupling scheme in two electron systems -derivation of interaction energy-combination of s and p electrons; Hyperfine structure (qualitative ideas only).

Module II: Microwave and Infrared Spectroscopy

(18 Hours)

- 2.1 Width of spectral lines-natural width, collision broadening, Doppler broadening. Classification of molecules- linear, symmetric top, asymmetric top and spherical top molecules.
- 2.2 Rotational spectra of rigid diatomic molecules; effect of isotopic substitution; intensity of spectral lines; energy levels and spectrum of non-rigid rotor
- 2.3 Information derived from rotational spectra(molecular structure, dipole moment, atomic mass and nuclear quadrupole moment).
- 2.4 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.

- 2.5 Diatomic vibrating rotator –P and R branches; break down of Born-Oppenheimer approximation.
- 2.6 Vibrations of polyatomic molecules –fundamental vibrations and their symmetry; overtone and combination frequencies; Analysis by IR techniques- skeletal vibrations and group frequencies.

Module III: Raman Spectroscopy and Electronic Spectroscopy. (18 Hours)

- 3.1 Quantum theory of Raman effect; classical theory-molecular polarizability ;Pure rotational Raman spectra of linear molecules
- 3.2 Raman activity of vibrations; rule of mutual exclusion; vibrational Raman spectra ;rotational fine structure
- 3.3 Structure determination from Raman and IR spectroscopy.
- 3.4 Non- linear Raman effects - hyper Raman effect - classical treatment; stimulated Raman effect - CARS, PARS - inverse Raman effect.
- 3.5 Electronic spectra of diatomic molecules –Born-Oppenheimer approximation, vibrational coarse structure-progressions and sequences ; intensity of spectral lines- Franck – Condon principle
- 3.6 Dissociation energy and dissociation products; Rotational fine structure of electronic-vibrational transition ; Fortrat parabola; Predissociation.

Module IV: Spin Resonance Spectroscopy (18 Hours)

- 4.1 Nuclear Magnetic Resonance (NMR)-resonance condition ; relaxation processes - Bloch equations
- 4.2 Chemical shift ; indirect spin–spin interaction
- 4.3 CW NMR spectrometer; Magnetic Resonance Imaging.
- 4.4 Electron Spin Resonance(ESR)-Principle of ESR; thermal equilibrium and relaxation; ESR spectrometer; characteristics of the g-factor.
- 4.5 Total Hamiltonian for an electron; Hyperfine Structure- ESR spectrum of hydrogen atom.
- 4.6 Mossbauer effect - recoilless emission and absorption; Experimental techniques in Mossbauer spectroscopy
- 4.7 Isomer shift; quadrupole interaction ; magnetic hyperfine interaction.

Text Books

- Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons
- Introduction of Atomic Spectra, H.E. White, Mc Graw Hill.
- Fundamentals of molecular spectroscopy, C.N. Banwell and E M McCash, TataMcGraw

Hill Education Private Limited.

- Molecular structure and spectroscopy, G. Aruldas, PHI Learning Pvt. Ltd.

References

- Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Science
- paperbacks 1976
- Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
- Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
- Introduction to Spectroscopy, D L Pavia, G M Lampman and G S Kriz, Thomson Learning Inc.
- Modern Spectroscopy, J M Hollas, John Wiley .
- Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan.
- <https://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/nmr1.htm>
- <https://ntpel.ac.in/courses/15101003/downloads/modu21/lecture23.pdf>
- <https://www.ias.ac.in/article/fulltext/reso/009/0034-0049>
- <https://ntpel.ac.in/courses/122101001/downloads/modu21/lec-15.pdf>
- <https://www.youtube.com/watch?v=Q2Fo5BAREGo>



Digital Signal Processing (PPH3CRT0422)

54 Hours

3 Credits

Course Outcomes

At the end of this course, students will be able to:

- Analyze continuous time and discrete time signals.
- Illustrate digital signal processing techniques for frequency analysis.
- Represent discrete time signals in complex domain.
- Explain the theory of digital filters and Design IIR and FIR filters.

Module I: Discrete time signals and Linear systems

(16 Hours)

- 1.1 Examples of Signals –
- 1.2 Classification of signals system-
- 1.3 Examples of discrete time System models
- 1.4 Signal processing Advantages ,Limitations and applications of DSP-
- 1.5 Elementary continuous time signals-
- 1.6 Representation of discrete time signals-
- 1.7 Elementary discrete time signals-
- 1.8 Classification of discrete time signals-
- 1.9 Operation on signals-
- 1.10 Sampling and Aliasing –
- 1.11 Discrete time system-Classifications-
- 1.12 Representation of an arbitrary sequence-
- 1.13 Impulse response and convolution sum-properties-Causality-
- 1.14 FIR,IIR, stable and unstable systems-
- 1.15 Correlation of two sequences.

Module II: DSP Techniques

(10 Hours)

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

Module III: Z Transform

(12 Hours)

- 3.1 Z-Transform & ROC -properties –

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

Module IV: Digital Filters**(16 Hours)**

- 4.1 IIR filters-frequency selective filters-
- 4.2 Design of digital filters from Analog filters-
- 4.3 Analog low pass filter design-
- 4.4 Design of IIR filters from Analog filters-
- 4.5 Approximation of derivatives –
- 4.6 Design of IIR filter using impulse invariance Technique-
- 4.7 Bilinear transformation-
- 4.8 Direct form I structure of IIR systems-
- 4.9 Cascade form realization of IIR systems-
- 4.10 Realization of digital filters-
- 4.11 Direct form I realization-4.12 Direct form II realization-
- 4.12 FIR filters-4.14 Linear phase FIR filters-4.15 Design of FIR filter using rectangular window-
- 4.13 The Fourier series method of designing FIR filters

Text Books

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

References

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

Computational Physics Practicals (PPH3CRP0122)

180 Hours

5 Credits

Course Outcomes

At the end of this course, students will be able to:

- Summarize the basic concepts of digital communication.
- Describe the underlying concepts in mobile communication.
- Explain different modes of communication and satellite communication in detail.
- Elucidate the merits of Fiber optic communication.
- Discuss the features of Radar systems

Develop algorithm / Flowchart for all experiments

Codes can be developed in any package / programming language. Candidate 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.

Introduction to computational facility in the Centre

Introduction to the IDE used in the center 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 Centre. 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 Centre.

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	636.0 K	451.1 K	273 K
Resistance	25.113 Ω	30.131 Ω	40.120 Ω	50.128 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: 1750 C (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 $f(\theta) = \tan(\theta)$] for $\theta=15,30,45,60,75$ are given to you. Using appropriate interpolation technique calculate value of $f(\theta)$ 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

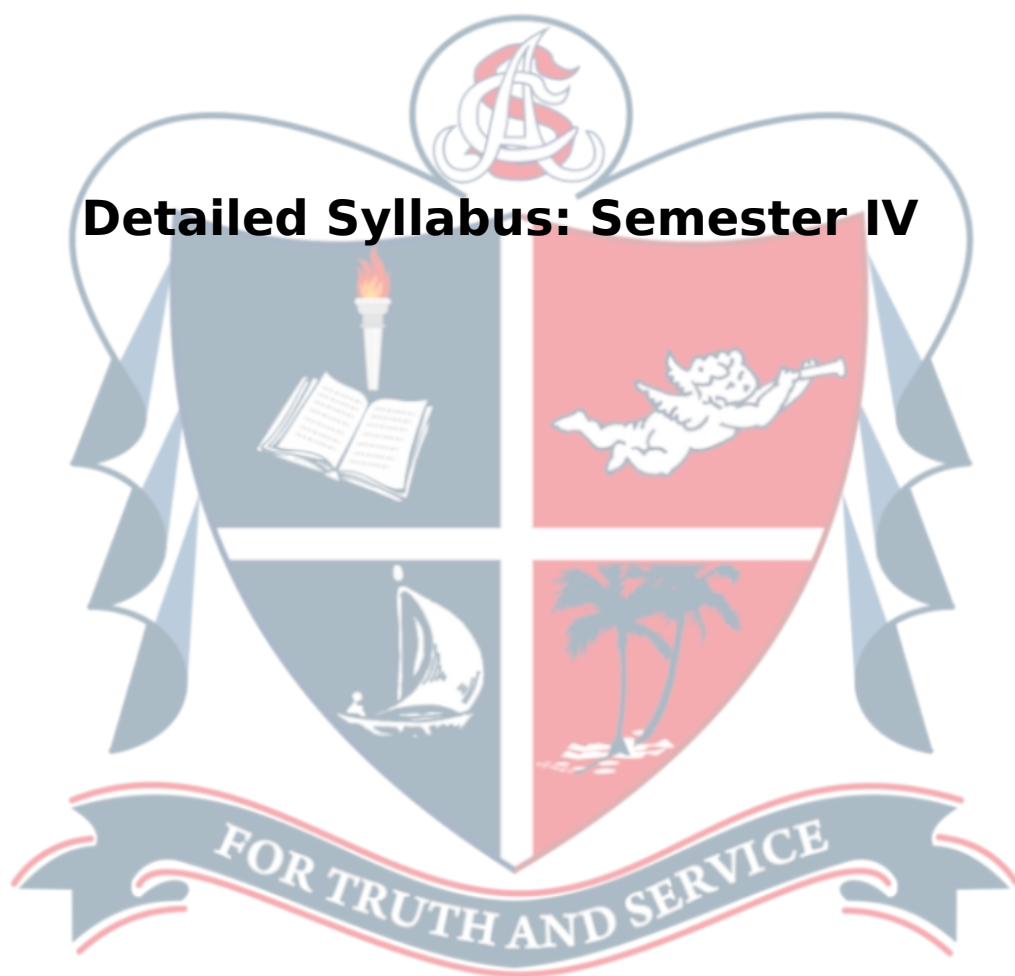
23. Study of path of a Projectile in motion with and with out air drag and compare the values .
24. A study of Variation of magnetic field B(T) with critical temperature in superconductivity
25. Generation of output waveform of a Half wave / full wave rectifier.
26. Charging /discharging of a capacitor 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 $kT = .025\text{eV}$ at 300K
32. Solve the following differential equation and study periodic and aperiodic behavior.

$$\frac{dy}{dx} = \sigma(y - x), \frac{dy}{dx} = x(\rho - z) - y, \frac{dy}{dx} = xy - \beta z$$

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.

Reference books

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



Nuclear and Particle Physics (PPH4CRT0122)

90 Hours

4 Credits

Course Outcomes

At the end of this course, students will be able to:

- Identify the various properties of nucleus, nuclear forces, and nuclear models.
- Discuss about the different nuclear decay processes, interactions, their characteristics and analyses beta decay in detail.
- Classify the elementary particles, nuclear interactions, symmetries and their conservation law.
- Solve problems in Nuclear Physics.
- Explain the basic ideas of Higg's boson and the LHC experiments; detection of gravitational waves and LIGO.

Module I: Nuclear Properties and Force between Nucleons (18 Hours)

- 1.1 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.
- 1.2 Nuclear angular momentum and parity ; Nuclear electromagnetic moments- quadrupole moment.
- 1.3 The deuteron-binding energy, spin, parity, magnetic moment and electric quadrupole moment.
- 1.4 Nucleon-nucleon scattering; proton-proton and neutron-neutron interactions
- 1.5 Properties of nuclear forces
- 1.6 Exchange force model.

Module II: Nuclear Models and Nuclear Decay (18 Hours)

- 2.1 Liquid drop model, Bethe-Weizacker formula, Applications of semi-empirical binding energy formula.
- 2.2 Shell Model-Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons .
- 2.3 Collective structure- Nuclear vibrations, Nuclear rotations.
- 2.4 Beta decay- energy release in beta decay ; Fermi theory of beta decay
- 2.5 Angular momentum and parity selection rules- allowed and forbidden transitions.
Comparative half lives and forbidden decays; non-conservation of parity in beta decay
- 2.6 Gamma decay- angular momentum and parity selection rules ; internal conversion.

Module III: Nuclear Reactions (18 Hours)

- 3.1 Types of reactions and conservation laws, energetics of nuclear reactions, isospin.
- 3.2 Reaction cross sections, Coulomb scattering- Rutherford formula, nuclear scattering.
- 3.3 Scattering and reaction cross sections in terms of partial wave amplitudes.
- 3.4 Compound-nucleus reactions; Direct reactions.
- 3.5 Resonance Reactions.

Module IV: Particle Physics**(18 Hours)**

- 4.1 Yukawa's hypothesis; properties of pi mesons- electric charge, isospin, mass, spin and parity.
- 4.2 Decay modes and production of pi-mesons
- 4.3 Types of interactions between elementary particles, Hadrons and leptons .
- 4.4 Symmetries and conservation laws, C P and CPT invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions.
- 4.5 Quark model, confined quarks, coloured quarks and gluons, experimental evidences for quark model, quark-gluon interaction, quark dynamics.
- 4.6 Grand unified theories, standard model of particle physics.

Module V: Nuclear Astrophysics and Practical Applications of Nuclear Physics (18 Hours.)

- 5.1 Particle and nuclear interactions in the early universe, primordial nucleosynthesis
- 5.2 Stellar nucleosynthesis (for both $A < 60$ and $A > 60$)
- 5.3 Higg's boson and the LHC experiments; detection of gravitational waves and LIGO (qualitative ideas only)
- 5.4 Rutherford Backscattering spectroscopy and applications
- 5.5 Computerized Axial Tomography (CAT)
- 5.6 Positron Emission Tomography (PET)

Text Books

- Introductory Nuclear Physics, K. S. Krane John Wiley
- Nuclear Physics, S.N. Ghoshal, S. Chand & Company.
- Nuclear Physics: Problem-based Approach Including MATLAB, Hari M Agarwal, PHI Learning Private Limited, Delhi .

References

- Problems and Solutions in Atomic, Nuclear and Particle Physics: Yung-Kuo Lim, World Scientific.
- Nuclear Physics, S.N. Ghoshal, S. Chand & Company.
- Introduction to Nuclear and Particle Physics : V M Mittal , R C Verma, S C Gupta (Prentice Hall India .
- Concepts of Nuclear Physics: B L Cohen, Tata McGrawHill
- Nuclear Physics: An Introduction – S B Patel, New Age International.
- Nuclear Physics: R R Roy and B P Nigam, New Age International.
- Nuclear Physics: R Prasad, Pearson.
- Atomic Nucleus: R D Evans, Mc GrawHill, New York.
- Nuclear Physics: I Kaplan, Narosa, New Delhi (2/e)
- Nuclear and Particle Physics, B R Martin, John Wiley & Sons, New York, 2006.
- Introduction to Elementary Particles : David Griffith, Wiley-VCH.
- <https://www.ias.ac.in/article/fulltext/reso/022/03/0245-0255>
- <https://www.ias.ac.in/article/fulltext/reso/017/10/0956-0973>
- <https://atlas.cern/updates/atlas-feature/higgs-boson>

Introduction to Embedded Systems (PPH4CRT0222)

90 Hours

3 Credits

Course Outcomes

At the end of this course, students will be able to:

- Understand the basic blocks of microcomputers i.e CPU, Memory, I/O and architecture of microprocessors and Microcontrollers
- Apply knowledge and demonstrate proficiency of designing hardware interfaces for memory and I/O as well as write assembly language programs for target microprocessor and microcontroller.
- Derive specifications of a system based on the requirements of the application and select the appropriate Microprocessor or Microcontroller
- Understand the basics of Embedded systems and learn about incorporating microcontrollers into one
- Learn about the various components of robots and how these components are used for the functioning of a robot.

Module I: Introduction to microprocessors (20 Hours)

- 1.1 Microprocessor organization- General organization of a microprocessor based microcomputer system
- 1.2 Memory organization – main memory array –memory management, cache memory, virtual memory
- 1.3 Input/output operation – Standard I/O – memory mapped I/O- interrupt driven I/O –DMA
- 1.4 8085 Microprocessor –Architecture
- 1.5 8085 addressing modes, instruction set, Pin out diagram,
- 1.6 Simple programming concepts.

Module II: 8086 Microprocessor (16 Hours)

- 2.1 The Intel 8086- Architecture - MN/MX modes –Pin diagram
- 2.2 8086 addressing modes
- 2.3 8086 instruction set- instruction format- assembler directives and operators
- 2.4. Programming with 8086- Familiarisation with Debug utility
- 2.5. Interfacing memory and I/O ports.

Module III: Microcontrollers (19 Hours)

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

Module IV: Embedded Systems (20 Hours)

- 4.1 Introduction to Embedded Systems- History, Classification, Major Applications.
- 4.2 The Typical Embedded System – Core (General Purpose and Domain specific), Memory, Sensors and Actuators,
- 4.3 Communication Interface (Onboard, External), Firmware, Other components;

- 4.4 Characteristics of Embedded Systems, Quality Attributes of Embedded Systems (Operational, Non-Operational);
- 4.5 Application Specific Embedded Systems;
- 4.6 Designing Embedded Systems with the 8051 Microcontroller - factors to be considered in selecting a controller (8051, PIC, Arduino);
- 4.7 Introduction to Embedded C (I/O programming, Logic Operations);

Module V: Introduction to Robotics**(15 Hours)**

- 5.1 Fundamentals of Robotics - Anatomy, Drive systems, Control systems,
- 5.2 Precision of movement,
- 5.3 Sensors, Applications,
- 5.4 Robot Technology: Control systems and components – (Qualitative ideas)
- 5.5 Basic concepts and models, controllers, sensors and actuators,
- 5.6 Motion Analysis and Control - manipulator kinematics, path control, robot dynamics.

Text books

- Microprocessor Architecture Programming and Applications with 8085, R.S.Gaonkar – Penram int. Pub. Mumbai [1]
- The 8051 microcontroller, Architecture Programming and Applications, Kenneth J Ayala-Penram Int. Pub. Mumbai [3]
- Fundamentals of Microprocessors and microcomputers - B. Ram (DhanpatRaiPub.) [1,2,3]
- Introduction of Embedded Systems - K. V. Shibu (McGraw Hill) [4]
- Embedded Systems: An Integrated Approach - Lyla B. Das (Pearson) [4]
- Industrial Robotics: Technology, Programming and Applications - Groover (McGraw Hill) [5]

References

- 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
- Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi –TMH
- Microprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
- Microprocessor and Peripherals, S.P. Chowdhury& S. Chowdhury- SCITECH Publications.
- 8051 Microcontrollers and Embedded Systems - Mazidi, Mazidi and McKinlay (Pearson)
- Introduction to Robotics, Mechanics and Control - John J. Craig (Pearson)
- Fundamentals of Robotics, Robert J. Schilling (Prentice-Hall)

Semiconductor Devices (PPH4CRT0322)

90 Hours

3 Credits

Course Outcomes

At the end of this course, students will be able to:

- Explain the basic properties of PN junction including the band structure, charge flow, behaviour under different biasing modes, junction capacitance.
- Explain concepts of Schottky and heterojunctions for fabricating semiconductor devices.
- Describe the working and design considerations for the various optoelectronic devices like photodetectors, solar-cells, LEDs and diode lasers
- Develop basic understanding of JFET, MOSFET, CMOS
- Identify the fabrication methods of integrated circuits

Module I: P-N Junctions**(18 Hours)**

- 1.1 Basic Structure,
- 1.2 zero applied bias-built in potential-electric field-space charge width,
- 1.3 forward bias- electric field-space charge width,
- 1.4 reverse bias- electric field-space charge width,
- 1.5 Junction capacitance.
- 1.6 Qualitative description of charge flow in pn junction, Ideal current-voltage relationship

Module II: Metal-semiconductor and semiconductor hetero-junctions**(18 Hours)**

- 2.1 Metal-semiconductor - Schottky barrier diode qualitative characteristics – ideal junction properties- Current-voltage relationship, Comparison with junction diode.
- 2.2 Metal semiconductor ohmic contact: Ideal non rectifying barriers – tunnelling barrier.
- 2.3 Semiconductor hetero-junctions: hetero-junction materials – energy band diagram –Two-dimensional electron gas.

Module III: Optoelectronic devices**(18 Hours)**

- 3.1 Photodetectors: photoconductors – photodiodes – avalanche photodiodes – PIN Photodiode- Photo transistor,
- 3.2 photovoltaic effect – solar cells: p-n junction solar cell-Conversion efficiency-hetero junction solar cell,
- 3.3 Generation of light: LED devices, Laser diodes

Module IV: Field effects transistors**(18 Hours)**

- 4.1 JFET: Operation- pn JFET-
- 4.2 Device characteristics- ideal I-V relationship-
- 4.3 Trans conductance-
- 4.4 The MESFET-Non ideal effects,

- 4.4 MOSFET: Energy band diagram- depletion layer thickness-work function difference-
4.5 Ideal C-V Characteristics-I-V relationship Combinational Circuit Design:
4.6 Static CMOS Circuits - CMOS Inverter (Elementary ideas only).

Module V: Integrated Circuit Fabrication and Characteristics**(18 Hours)**

- 5.1 Integrated circuit technology –
5.2 Basic monolithic IC – epitaxial growth –marking and etching, diffusion of impurities
5.3 Transistor for monolithic circuit, Monolithic diodes –
5.4 Integrated resistors, capacitors, and inductors, monolithic circuit layout
5.5 Additional isolation methods -MSI, LSI, VLSI– the metal-semiconductor contact.

Text books

- Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill
- Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, “Digital Integrated Circuits – A Design Perspective”, Pearson Education India, 2nd edition, 2016
- Integrated Electronics-Analogue and Digital Circuits and Systems, J Millmann and C C Halkias, TMGH

References

- Semiconductor Optoelectronic Devices: Introduction to Physics and Simulation, Book by Joachim Piprek, Elsevier, 2013
- Solid state electronic devices, Streetman and Banerjee, PHI, 2010
- Physics of semiconductor devices, Michael Shur, PHI, 2002
- Introduction to semiconductor materials and devices, M S Tyagi, John Wiley and Sons, 2000



Communication Systems (PPH4CRT0322)

90 Hours

3 Credits

Course Outcomes

At the end of this course, students will be able to:

- Summarize the basic concepts of digital communication.
- Describe the underlying concepts in mobile communication.
- Explain different modes of communication and satellite communication in detail.
- Elucidate the merits of Fiber optic communication.
- Discuss the features of Radar systems.

Module I: Digital Communication

(18 Hours)

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

Module II: Mobile communication

(20 Hours)

- 2.1 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
- 2.2 Wireless communication systems—2G-3G - 4G
- 2.3 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
- 2.4 Basic idea of Path Loss and Multipath Fading
- 2.5 Multiple Access Techniques –Introduction-FDMA-TDMA-SSMA:- FHMA-CDMA- Hybrid Spread Spectrum Techniques-SDMA
- 2.6 GSM.

Module III: Satellite Communication

(16 Hours)

- 3.1 Satellite Communication Fundamentals-Satellite Orbits-Satellite Positioning-Frequency Allocations-Polarization-Antennas—gain-beam width-Multiple Access Techniques
- 3.2 Geostationary Satellite communication-Satellite parameters
- 3.3 VSAT (Basic Idea)

- 3.4 Geostationary Satellite Path/Link Budget
- 3.5 Satellite TV Systems-Satellite TV broadcasting
- 3.6 GPS.

Module IV: Fiber Optics Communication**(20 Hours)**

- 4.1 Introduction
- 4.2 Ray theory transmission-Total Internal Reflection-Acceptance Angle-Numerical aperture-Skew rays
- 4.3 Electromagnetic mode theory for optical propagation-Electromagnetic waves-Modes in a planar guide-Phase and group velocity
- 4.4 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
- 4.5 Dispersion:- chromatic-intermodal-Non linear effects
- 4.6 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 Hours)**

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

Text Books

- Optical fiber communications-Principles and Practice John M Senior, Pearson publications, 3rdedition, (Module-4).

Recommended References

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

Advanced Practicals in Electronics (PPH4CRP0222)

180 Hours

5 Credits

Course Outcomes

At the end of this course, students will be able to:

- Learn to carry out experiments in basic as well as certain advanced areas of physics such as condensed matter physics, Electronics.
- Capability for planning, executing the experiment and to Interpret findings using the correct physical scientific framework and tools.
- Ability to present the results of a theoretical or experimental investigation in a systematic way.
- Evaluate possible causes of error in experimental observations and results.
- To demonstrate proficiency in communicating competently in groups.

(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- μ p kit)

1. Sorting of numbers in ascending/descending order.
2. Find the largest and smallest of numbers in array of memory.
3. Conversion of Hexadecimal number to ASCII and ASCII to Hexadecimal number.
4. Multi channel analog voltage measurements using AC card.
5. Generation of square wave of different periods using a microcontroller.
6. Measurement of frequency, current and voltage using microprocessors.
7. LCD interfacing with the 8051 microcontroller,
8. LCD interfacing with Arduino

[B] Communication Electronics

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

[C] Semiconductor devices

14. Study of characteristics of MOSFET
15. Operation of the step down chopper using MOSFET

[D] Electronic Instrumentation

16. DC and AC milli-voltmeter construction and calibration.
17. Amplified DC voltmeter using FET.
18. Instrumentation amplifier using a transducer.
19. Generation of BH curve and diode characteristics on CRO.
20. Voltage to frequency and frequency to voltage conversion.
21. Construction of digital frequency meter.
22. Characterization of PLL and frequency multiplier and FM detector.

[E] Optoelectronics

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

References

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

GIST OF CHANGES

Proposed in the syllabus of M.Sc. Physics Programme from 2022 admission onwards

- Introduced a new course under the Elective bunch Electronics entitled PPH4CRT0322 Semiconductor Devices.
- The Course title of the course Microelectronics and Semiconductor devices (PPH3CRT0320) has been changes to Embedded Systems (PPH3CRT0222) with the modification given in the table below.

Deletion from PPH3CRT0320	Addition in PPH3CRT0222
<p style="text-align: center;">Module IV:</p> <p style="text-align: center;">Metal-semiconductor and semiconductor hetero-junctions (17 Hours)</p> <p>4.1 Metal-semiconductor - Schottky barrier diode - qualitative characteristics – ideal junction properties-</p> <p>4.2 Current voltage relationship, Comparison with junction diode</p> <p>4.3 Metal semiconductor ohmic contact</p> <p>4.4 Idealcon rectifying barriers – tunneling barrier – specific contact resistances</p> <p>4.5 Semiconductor hetero-junctions – hetero-junction materials – energy band diagram –Two dimensional electron gas</p> <p>4.6 equilibrium electrostatics – current voltage characteristics.</p>	<p style="text-align: center;">Module IV:</p> <p style="text-align: center;">Embedded Systems (20 Hours)</p> <p>4.1 Introduction to Embedded Systems- History, Classification, Major Applications.</p> <p>4.2 The Typical Embedded System – Core (General Purpose and Domain specific), Memory, Sensors and Actuators,</p> <p>4.3 Communication Interface (Onboard, External), Firmware, Other components</p> <p>4.4 Characteristics of Embedded Systems, Quality Attributes of Embedded Systems (Operational, Non-Operational);</p> <p>4.5 Application Specific Embedded Systems;</p> <p>4.6 Designing Embedded Systems with the 8051 Microcontroller - factors to be considered in selecting a controller (8051, PIC, Arduino);</p> <p>4.7 Introduction to Embedded C (I/O programming, Logic Operations);</p>
<p style="text-align: center;">Module V:</p> <p style="text-align: center;">Integrated Circuit Fabrication and Characteristics (18 Hours)</p> <p>5.1 Integrated circuit technology – basic monolithic IC – epitaxial growth –marking and etching 5.2</p> <p>5.2 diffusion of impurities – transistor for monolithic circuit</p> <p>5.3 Monolithic diodes – integrated resistors, capacitors and inductors</p> <p>5.4 monolithic circuit layout - additional isolation methods -MSI, LSI, VLSI– the metal semiconductor contact.</p>	<p style="text-align: center;">Module V:</p> <p style="text-align: center;">Introduction to Robotics (15 Hours)</p> <p>5.1 Fundamentals of Robotics - Anatomy, Drive systems, Control systems,</p> <p>5.2 Precision of movement,</p> <p>5.3 Sensors, Applications,</p> <p>5.4 Robot Technology: Control systems and components – (Qualitative ideas)</p> <p>5.5 Basic concepts and models, controllers, sensors and actuators,</p> <p>5.6 Motion Analysis and Control - manipulator kinematics, path control, robot dynamics.</p>

- Computational Physics Practicals PPH4CRP0120 is moved from Semester IV to Semester III as Computational Physics Practicals PPH3CRP0122.

- Advanced Practicals in Electronics (PPH3CRP0120) is moved from Semester III to Semester IV as Advanced Practicals in Electronics (PPH4CRP0222) with addition of few experiments given below .

Section	Deletion from PPH3CRP0120	Addition in PPH4CRP0222
Micro controller	Nil	1. Interfacing of LED using Arduino 2. Interfacing of LED using micro controller 8051
Semiconductor devices	Nil	1. Study of characteristics of MOSFET 2. Operation of the step down chopper using MOSFET

