# MAHATMA GANDHI UNIVERSITY

KOTTAYAM

KERALA

# M.Sc. PROGRAMME IN PHYSICS

UNDER

CREDIT AND SEMESTER SYSTEM

(2012 admissions onwards)

MAHATMA GANDHI UNIVERSITY, KOTTAYAM

Board of Studies in Physics (P G)

1. Dr. N.V. Unnikrishnan, Professor, School of Pure and Applied Physics, Mahatma Gandhi. University, Kottayam (CHAIRMAN)
2. Dr. Chandu Venugopal, Professor, School of Pure and Applied Physics, Mahatma Gandhi. University, Kottayam
3. Dr. M. Abdul Khadar, Professor, School of Pure and Applied Physics, University of Kerala, Kariavattom, Thiruvanathapuram
4. Prof. L. Sushama, Associate Professor, Department of Physics, Union Christian College, Aluva.
5. Prof. Johny Joseph, Associate Professor, Department of Physics, St. Berchman's College, Changanassery
6. Dr. P.I. Paulose, Associate Professor, Department of Physics, Maharaja's College, Ernakula
7. Prof. Johny Thomas, Associate Professor, Department of Physics, Kuriakose Elias College, Mannanam
8. Prof. M.N. Gopalakrishnan, Associate Professor, Department of Physics, Devaswom Board. College, Thalayolaparambu.
9. Dr. B. Syamala Kumari, Associate Professor, Department of Physics, Maharaja's College, Ernakulam.
10. Dr. N.V. Joshy, Associate Professor, Department of Physics, St. Paul's College, Kalamassery.
11. Prof. V.M. George, Associate Professor, Department of Physics, Sacred Heart College, Thevara

# *Acknowledgements*

*The P.G. Board of Studies puts on record our sincere thanks to the honorable Vice Chancellor of Mahatma Gandhi University, Dr. Rajan Gurukkal, for the guidance and help extended to us during the restructuring of M.Sc. Physics syllabus to suite the Credit and Semester System. The vision and experience in the realm of higher education that he shared with us on various occasions have been very helpful and encouraging.*

*We thank the Pro-Vice Chancellor of the University, Dr. Rajan Varghese, for the constant monitoring of the process. His unparalleled enthusiasm and willingness to hear and acknowledge sincere efforts is worth mentioning.*

*The Board of Studies thanks the members of M.G. University Syndicate for all the help extended to us at various stages of restructuring of this P G syllabus.*

*We thank the Registrar of the University, the Academic Section and the Finance Section for extending their service for the smooth completion of the syllabus restructuring.*

*Special thanks are due to the representatives from all the colleges affiliated to M.G. University, who have actively participated in the three day work shop. The Board of Studies acknowledges the contributions from the participants of the workshop. The suggestions and recommendations of the sub-groups formed in the workshop have* *helped us to make the syllabus in the present form. It is heartening to note the enthusiasm and sincerity shown by the younger generation teachers from various colleges in the context of syllabus restructuring.*

*The P.G. Board of studies thanks all the members of the faculty of School of Pure and Applied Physics (SPAP), M.G. University for sharing their knowledge and experience in the emerging fields of physics and technology. Their active participation in the workshop for syllabus restructuring was of immense help.*

*Thanks are also due to the research scholars, library and office staff of SPAP for their cooperation extended during the workshop.*

*We thank Dr. M.K. Jayaraj, Professor, Department of Physics, Dr. Johnny Isaac, Professor, Department of Instrumentation, Cochin University of Science and Technology, Dr. V. Unnikrishnan Nair, visiting Professor, ISER, Thiruvananthapuram, for the fruitful discussions in the making of the new syllabus.*

*We acknowledge the goodwill of our friends in various other Universities and Institutions in sharing their views in accommodating some specialized topics in various courses of the syllabus.*

*Dr. N.V. Unnikrishnan*
*Chairman, PG Board of Studies,*
*Mahatma Gandhi University,*
*Kottayam*

# Contents

## Preface

The P.G. syllabus in Physics is restructured to suit the credit and semester system to be followed by the affiliated colleges under Mahatma Gandhi (M.G.) University, Kottayam, from the academic year 2012- 2013. The last revision of the syllabus was carried out in 2001, when P.G. courses in the affiliated colleges came under semester system. Now as the continuation of the credit and semester system being followed in the U.G. courses in the university, the present restructuring of P.G. curriculum becomes inevitable.

In the restructuring of the P.G. syllabus, the Board of Studies has taken into account the emerging trends in the various fields of theoretical and experimental physics. The thrust was given to inculcate in students the spirit of hard work and research aptitude to pursue higher education in the nationally/internationally reputed institutions and laboratories.Wide discussion in this matter was carried out among the physics teaching community of the M.G. University and experts from various other universities and institutions across the country. A three day workshop was conducted on February 22, 23 and 24, 2012 with representatives from P.G. departments of all affiliated colleges of the university and members of the faculty of School of Pure and Applied Physics (SPAP), M.G. University, Kottayam.

In order to accommodate various front running fields in physics, and for the students to have option to select the courses of their interest, the Board has decided to present four Elective Bunches and an Open Elective Bunch with four courses each in the P.G. syllabus. The elective courses are accommodated in the third and fourth semesters of the P G programme.

The syllabus of physics practicals is also revised keeping in view of the advances in various fields of physics and technology. Each semester will have one practical each with two practical exams at the end of even semesters. This syllabus is to be followed by all the affiliated colleges under M.G. University. The syllabi of three parallel M.Sc. programmes run by three different colleges are also restructured to accommodate in the Credit and Semester System.

Chapter – I is dedicated to the General Scheme of the Syllabi. The general M.Sc. programme in physics with the course structures in all four semesters are also given in this chapter. Grading and Evaluation is discussed in Chapter – II. The pattern of question papers of theory and practicals and the respective internal and external evaluation schemes are discussed here. In Chapter – III, the syllabi of the general M.Sc Physics programme is given. Chapter – IV is dedicated for the the syllabi of three parallel M.Sc.Physics programmes.

# CHAPTER – I

## 1. GENERAL SCHEME OF THE SYLLABI

**1.1 Theory Courses:** There are sixteen theory courses spread equally in all four semesters in the M.Sc. Programme. 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 and Semester IV will have **two** core courses each. **Two** elective courses each will come in Semester III and Semester IV. The fourth Elective course appearing in Semester IV is the Open Elective Course. There are four Elective Bunches and an Open Elective Bunch offered in this syllabus. An Elective Bunch has three theory courses while the Open Elective Bunch has four theory courses. A college can choose one Elective Bunch and any one course from the Open 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 very 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 with separate weights.

**1.5 Course Code:** The 12 core courses in the programmme are coded according to the following criteria. The first two letters of the code indicates the name of programme, ie. PH stands for Physics. One digit to indicate the semester. ie., PH1 (Physics, 1st Semester), letter C to indicate core, lastly digits 01, 02 …….12 run for twelve core courses. (eg: PH3C11 – Physics, 3rd semester, core course number eleven of the progamme. (Refer Table 1.1)

The elective courses are coded in similar pattern, PH3EA2 with letter E stands for Elective, while the letter A (it can be B, C, or D) stands for the Elective Bunch selected by the college, the digit 2 stands for the 2nd course of the Elective Bunch. (Refer Table 1.2)

The lone Open Elective course appearing in Semester IV is coded as PH4OE3. The letters OE stand for Open Elective and the digit 3 stands for the 3rd course of the Open Elective Bunch. (Refer Table 1.3)

Laboratory Practical courses are similarly coded. (Eg: PH3P03 means Physics, III Sem, Practicals, course number 3) The course code of project/dissertation is PH4D05. The course code of viva voce is PH4V06. The letters D and V stand for dissertation of the project and viva voce respectively. These codes remain the same for all four categories of electives.

**1.6 Course Structure of M.Sc. Physics Programme:**

This is the PG programme followed by all affiliated colleges under Mahatma Gandhi University. Apart from this, three affiliated colleges have one more PG progamme in Physics with different course structures. This is discussed in Chapter IV. The detailed structure of the Core courses common to all students of the programme is given in Table 1.1

| SEM | Name of the course with course code | No.of Hrs/ week | No. of cred it | Total Hrs/ SEM. |
|---|---|---|---|---|
| I | **PH1C01:**Mathematical Methods in Physics- I | 4 | 4 | 72 |
| I | **PH1C02**: Classical Mechanics | 4 | 4 | 72 |
| I | **PH1C03**: Electrodynamics | 4 | 4 | 72 |
| I | **PH1C04**: Electronics | 4 | 4 | 72 |
| I | **PH1P01**: General Physics Practicals | 9 | 3 | 162 |
| II | **PH2C05**:MathematicalMethodsinPhysics- II | 4 | 4 | 72 |
| II | **PH2C06**: Quantum Mechanics - I | 4 | 4 | 72 |
| II | **PH2C07**: Thermodynamics and Statistical Mechanics | 4 | 4 | 72 |
| II | **PH2C08**: Condensed Matter Physics | 4 | 4 | 72 |
| II | **PH2P02**: Electronics Practicals | 9 | 3 | 162 |
| III | **PH3C09**: Quantum Mechanics - II | 4 | 4 | 72 |
| III | **PH3C10**: Computational Physics | 4 | 4 | 72 |
| III | **PH3P03**: Computational Physics Practicals | 9 | 3 | 162 |
| IV | **PH4C11**: Atomic and Molecular Physics | 4 | 4 | 72 |
| IV | **PH4C12**: Nuclear and Particle Physics | 4 | 4 | 72 |
| IV | **PH4D05**: Project/Dissertation | Nil | 2 | Nil |
| IV | **PH4V06**: Viva Voce | Nil | 2 | Nil |

*Table 1.1: Structure of PGCSS Physics M.Sc. Common Courses*

**1.7 The Elective Bunches:**

There are four Electives Bunches offered in this PGCSS Programme. Each elective consists of a bunch of **three** theory courses and **one** laboratory course. The first two theory courses of a bunch are placed in the Semester III, while the third theory course and the laboratory course go to the 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: Informatics

(iii) Bunch C: Material Science

(iv) Bunch D: Theoretical Physics.

| Elective | SEM | Name of the course with course code | No. of Hrs/ week | No. of credit | Total Hrs/ SEM |
|---|---|---|---|---|---|
| **Bunch A:** Electronics | III | **PH3EA1:**Integrated Electronics and Digital Signal Processing | 4 | 4 | 72 |
| | III | **PH3EA2:** Microelectronics and Semiconductors Devices. | 4 | 4 | 72 |
| | IV | **PH4EA3:** Instrumentation and Communication Electronics. | 4 | 4 | 72 |
| | IV | **PH4PA4:**Advanced Electronics Practicals | 9 | 3 | 162 |
| **Bunch B:** Informatics | III | **PH3EB1:**Data Communication and Internet working | 4 | 4 | 72 |
| | III | **PH3EB2:**Java and Linux Operating System | 4 | 4 | 72 |
| | IV | **PH4EB3:**Computer Applications in Physics | 4 | 4 | 72 |
| | IV | **PH4PB4:**Practicals - Informatics Elective | 9 | 3 | 162 |
| **Bunch C:** Material Science | III | **PH3EC1:**Solid State Physics | 4 | 4 | 72 |
| | III | **PH3EC2:**Crystal Growth Techniques | 4 | 4 | 72 |
| | IV | **PH4EC3:**Nanostructures and Characterization | 4 | 4 | 72 |
| | IV | **PH4PC4:** Material Science Practical | 9 | 3 | 162 |
| **Bunch D:** Theoretical Physics | III | **PH3ED1:**Astrophysics | 4 | 4 | 72 |
| | III | **PH3ED2:**Nonlinear Dynamics | 4 | 4 | 72 |
| | IV | **PH4ED3:**Quantum Field Theory | 4 | 4 | 72 |
| | IV | **PH4PD4:**Special Computational Practicals | 9 | 3 | 162 |

*Table 1.2: Course Structure of Electives*

**1.8 The Open Elective Bunch**: The Open Elective Bunch has four specialized theory courses. A college has the choice to select any one of these courses. The 4th theory course of the Semester IV comes from the open elective bunch. The course structure of Open Elective Bunch is given in Table 1.3 below. The change of Elective Bunch/Open Elective course is permitted with proper request application to the relevant body of the University

| SEM | Name of the course with course code | No. of Hrs/ week | No. of credit | Total Hrs./ SEM. |
|---|---|---|---|---|
| IV | **PH4OE1:**Optoelectronics | 4 | 4 | 72 |
| IV | **PH4OE2:**Software Engineering and Web design | 4 | 4 | 72 |
| IV | **PH4OE3:**Thin films and Nanoscience | 4 | 4 | 72 |
| IV | **PH4OE4:**General Relativity and Cosmology | 4 | 4 | 72 |

*Table 1.3: Open Elective Courses*

**1.9 Distribution of Credit:** The total credit for the programme is fixed at 80. The distribution of credit points in each semester and allocation of the number of credit for theory courses, practicals, project and viva is as follows. The credit of theory courses is 4 per course, while that of laboratory practical course is 3 per course. The project and viva voce will have a credit of 2 each. The distribution of credit is shown in Table 1.4. Distribution of the credit remains unchanged for parallel PG programmes in physics, discussed in Chapter IV.

| Semester | Courses | Credit | Total Credit |
|---|---|---|---|
| I | 4 Theory courses | 4 x 4 = 16 | 16 |
| II | 4 Theory Course<br>2 Laboratory Practical | 4 x 4 = 16<br>2 x 3 = 6 | 22 |
| III | 4 Theory courses | 4 x 4 = 16 | 16 |
| IV | 4 Theory Course<br>2 Laboratory Practical<br>1 Project/dissertation<br>1 Viva – voce | 4 x 4 = 16<br>2 x 3 = 6<br>1 x 2 = 2<br>1 x 2 = 2 | 26 |
| Total credit of the M.Sc. Programme | | | 80 |

*Table 1.4: Distribution of creditin the PGCSS Programme.*

# CHAPTER - II

## 2. GRADING AND EVALUATION

### 2.1 Examinations

The evaluation of each course shall contain two parts such as Internal or In-Semester Assessment (IA) and External or End-Semester Assessment (EA). The ratio between internal and external examinations shall be 1:3. The Internal and External examinations shall be evaluated using Direct Grading system based on 5-point scale.

### 2.2 Internal or In-Semester Assessment (IA)

Internal evaluation is to be done by continuous assessments of the following components. The components of the internal evaluation for theory and practicals and their weights are as in the Table 2.1. The internal assessment should be fair and transparent. The evaluation of the components should be published and acknowledged by students. All documents of internal assessments are to be kept in the institution for 2 years and shall be made available for verification by the university. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teach the course. The two test papers should be in the same model as the end semester examination question paper, the model of which is discussed in the Section 2.3. The duration and the number of questions in the paper may be adjusted judiciously by the college for the sake of convenience.

| **THEORY** | | **PRACTICALS** | |
| --- | --- | --- | --- |
| Component | Weights | Component | Weights |
| Attendance | 2 | Attendance | 2 |
| Assignments | 2 | Laboratory Involvement | 2 |
| Seminar | 2 | Test [*Best of Two*] | 2 |
| Test - I | 2 | Record | 2 |
| Test - II | 2 | Viva | 2 |
| Total Weight of Theory = 10 | | Total Weight of Practicals = 10 | |

*Table 2.1: Distribution of weights and components of theory and practical*

### 2.2.1 Attendance, Assignment and Seminar

The split up of Attendance grade and different components of Assignment and Seminar is given in the Table 2.2. Monitoring of attendance is very important in the credit and semester system. All the teachers handling the respective courses are to document the attendance in each semester. Students with attendance less than 75% in a course are not eligible to attend external examination of that course. The performance of students in the seminar and assignment should also be documented.

| Attendance | | Assignments | | Seminar | |
|---|---|---|---|---|---|
| %of Attendance | Grade | Components | Weig-hts | Components | Weig-hts |
| ≥ 90 % | A | Punctuality | 1 | Innovation of Topic | 1 |
| ≥ 85 % and < 90% | B | Review | 2 | Review/ Reference | 1 |
| ≥ 80 % and < 85% | C | Content | 4 | Content | 3 |
| ≥ 75 % and < 80% | D | Conclusion | 2 | Presentation | 3 |
| <75 % | E | References | 1 | Conclusion | 2 |

*Table 2.2: split up of attendance grade and components of Seminar & Assignment*

### 2.2.2 Project Evaluation

The internal evaluation of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the beginning of the Semester III. The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in student(s), the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of three students may be allowed to perform one project work if the volume of the work demands it.

Project evaluation begins with (i) the selection of problem, (ii) literature survey, (iii) work plan, (iv) experimental / theoretical setup/data collection, (v) characterization techniques/computation/analysis (vi) use of modern software for data analysis/experiments (Origin, LABView, MATLAB, …etc) and (vi) preparation of dissertation. The project internal grades are to be submitted at the end of Semester IV. The internal evaluation is to done as per the following general criteria given in Table 2.3

| **Component** | **Weights** |
|---|---|
| Literature Survey | 3 |
| Experimental/Theoretical setup/Data Collection | 4 |
| Result and Discussion | 3 |

*Table 2.3: Criteria for internal evaluation of Project*

### 2.2.3 General Instructions

**(i)** The assignments/ seminars / test papers are to be conducted at regular intervals. The time for conduct of two test papers will be notified by the university from time to time. These should be marked and promptly returned to the students.

**(ii)** One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheet for internal evaluation in the department in the format supplied by the University. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for end semester examinations. The grade sheet should be signed by the coordinator and counter signed by the Head of the Department and the college Principal.

**(iii)** The consolidated grades in specific format supplied by the university are to be kept in the college for future references. The consolidated grades in each course should be uploaded to the University Portal at the end of each semester as directed by the University.

**(iv)** A candidate who fails to register for the examination in a particular semester is not eligible to continue in the subsequent semester.

**(v)** Grievance Redress Mechanism for Internal evaluation: There will be provision for grievance redress at four levels, viz,

a) at the level of teacher concerned,
b) at the level of departmental committee consisting of Head of the Department, Coordinator and teacher concerned,
c) at the level of college committee consisting of the Principal, Head of the Department and one member of the college council, nominated by the principal each year,
d) at the university level committee consisting of Pro-Vice Chancellor / Dean of the Faculty, the controller of examinations and the Convener of the Standing Committee on Academic Affairs of the Syndicate.

College level complaints should be filed within one week of the publication of results and decisions taken within two the next two weeks. University level complaints will be made within the time stipulated by the University and decisions will be taken within one month of the last date fixed for filing complaints.

**2.3 External Evaluation (EA)**

The external examination of all semesters shall be conducted by the university on the close of each semester. There will be no supplementary examinations.

### 2.3.1 Question Paper Pattern for Theory Courses.

All the theory question papers are of three hour duration. All question papers will have three parts.

**Part A:** Questions from this part are very short answer type. Six questions have to be answered from among ten questions. Each question will have weight one and the Part A will have a total weight of six. A minimum of two questions must be asked from each unit of the course.

**Part B:** Part B is fully dedicated to solving problems from the course concerned. Four problems out of six given have to be answered. Each question has a weight two making the Part B to have total weight eight. A minimum of one problem from each unit is required. The problems need not always be of numerical in nature.

**Part C:** Part C will have four questions. Two questions of equal standard must be asked from each unit with internal option. Each question will have a weight four making the total weight sixteen in Part C

### 2.3.2 Directions for question setters

**(i)** Follow the as far as possible the text book specified in the syllabus.

**(ii)** The question paper should cover uniformly the entire syllabus. For that the section 2.3.1 should be strictly followed.

**(iii)** Set Part A questions to be answered in five minutes each, Part B questions in ten minutes each and Part C questions in twenty five minutes each.

Weightage to objectives and difficulty levels in the question paper should be as given in the Table 2.4 below.

*Table 2.4: Weightage to objectives and difficulty levels*

| Weightage to Objectives | | Weightage to Difficulty Levels | |
|---|---|---|---|
| Objective | % | Level of Difficulty | % |
| Information | 20 | Easy | 30 |
| Understanding | 60 | Average | 50 |
| Application | 20 | Difficult | 20 |

### 2.3.3 Practical, Project and Viva Voce Examinations

**Practical Examination:** First and second semester practical examinations are conducted at the end of Semester II and third and fourth semester practical examinations are conducted at the end of Semester IV. The practical examinations are conducted immediately after the second and fourth semester theory examinations respectively. There will be two practical examination boards every year to conduct these practical exams. All practical examinations will be of five hours duration. Two examiners from the panel of examiners of the university will be deputed by the board chairman to each of the examination centers for the fair and transparent conduct of examinations. Practical examination is conducted in batches having a maximum of eight students. The board enjoys the right to decide on the components of practical and the respective weights.

**Project Evaluation:** The project is evaluated by the two external examiners deputed from the board of practical examination. The dissertation of the project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the head of the department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project. The different weight for assessment of different components is shown in Table 2.5.

**Viva Voce Examination:** Viva voce examination is conducted only by the two external examiners of the board of practical examinations. The viva voce examination is given a credit two. The examination should be conducted in the following format shown in Table 2.6 below.

| **Component** | **Weights** |
|---|---|
| Quality of project under study | 1 |
| Presentation of the project | 3 |
| Experimental/Theoretical setup/Data Collection | 4 |
| Result and Dissertation layout | 2 |

*Table 2.5: Components and weights of Project*

| Type of Questions | Percentage | Weightage to Difficulty Level | |
|---|---|---|---|
| B.Sc/ + 2 level | 20 | Level of Difficulty | % |
| M.Sc. Syllabus Based | 40 | Easy | 30 |
| Subject of Interest | 20 | Average | 50 |
| Advanced Level | 20 | Difficult | 20 |

*Table 2.6: Format for viva voce Examination*

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

**2.3.4 Reappearance/Improvement:** For reappearance / improvement as per university rules, students can appear along with the next regular batch of students of their particular semester. A maximum of two chances will be given for each failed paper. Only those papers in which candidate have failed need be repeated. Chances of reappearance will be available only during eight continuous semesters starting with the semester in which admission/readmission is given to the candidate.

# CHAPTER - III

## 3. M. Sc. PHYSICS SYLLABUS

### 3.1 Introduction:

This chapter deals with the Syllabi of all Core courses, Elective courses and Open Elective courses of the M.Sc. Physics Programme under Credit and Semester System. The semester wise distribution of the courses is given. In Semester III and Semester IV, the courses from Elective Bunches and Open Elective Bunch will come as opted by the colleges concerned. The titles of the courses with course codes of all categories of courses are discussed in the Chapter – I.

### 3.2 CORE COURSES

## SEMESTER - I

### PH1CO1 MATHEMATICAL METHODS IN PHYSICS – I

**Unit I**

**Vectors and Vector Spaces (18 Hrs)**

Integral forms of gradient, divergence and curl, Line, surface and volume integrals – Stoke's, Gauss's and Green's theorems - Potential theory - scalar, gravitational and centrifugal potentials. Orthogonal curvilinear coordinates - gradient, divergence and curl in Cartesian, spherical and cylindrical coordinates. Equation of continuity - Linear vector spaces - Hermitian, unitary and projection operators with their properties- inner product space - Schmidt orthogonalization - Hilbert space - Schwartz inequality.

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press (Chapter 1 & 2)
2. Mathematical Physics, P.K Chattopadhyay, New Age International (chapter 7)
3. Theory and problems of vector analysis, Murray R. Spiegel (Schaum's outline series)

**Unit II**

**Matrices (12 Hrs)**

Direct sum and direct product of matrices, diagonal matrices, Matrix inversion (Gauss-Jordan inversion method) orthoganal, unitary and Hermitian matrices, normal matrices, Pauli spin matrices, Cayley-Hamilton theorem. Similarity transformation - unitary and orthogonal transformation. Eigen values and eigenvectors – Diagonalisation using normalized eigenvectors. Solution of linear equation-Gauss elimination method. Normal modes of vibrations.

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press (Chapter 3)
2. Mathematical Physics, P.K Chattopadhyay, New Age International (Chapter 7)

**Probability theory and distributions (6 Hrs)**

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

Text Books

1. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press (Chapter 24)
2. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4$^{th}$ Edition, Academic Press. (Chapter 19)

**Unit III**

**Differential Geometry (16 Hrs)**

Definition of tensors, basic properties of tensors. Covariant, contravariant and mixed tensors. Levi-Civita tensor, Metric tensor and its properties, Tensor algebra, Christoffel symbols and their transformation laws, covariant differentiation, geodesic equation, Riemann-Christoffel tensor, Ricci tensor and Ricci scalar.

Text Books

1. Introduction to Mathematical Physics, Charlie Harper, PHI
2. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill
3. Mathematical Physics, B.S. Rajput, Y. Prakash 9$^{th}$ Ed, Pragati Prakashan (Chapter 10)
4. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press

**Unit IV**

**Special functions and Differential equations (20 Hrs)**

Gamma and Beta functions, different forms of beta and gamma functions, evaluation of standard integrals. Dirac delta function, Kronecker Delta - properties and applications.

Bessel's differential equation – Bessel and Neumann functions – Legendre differential equation - Associated Legendre functions- Hermite differential equation - Laguerre differential equation – Associated Laguerre polynomials. (Generating function, recurrence relations, and orthogonality condition for all functions), Rodrigue's formula

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press
2. Mathematical Physics, B.S Rajput, Pragati Prakashan

**Reference Books:**


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

## PH1C02 CLASSICAL MECHANICS

### Unit I

**Hamiltonian Mechanics (10 Hrs)**

Review of Newtonian and Lagrangian formalisms - cyclic co-ordinates - conservation theorems and symmetry properties - velocity dependent potentials and dissipation function - Hamilton's equations of motion - Least action principle - physical significance.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed., (Chap. 1, 2 & 8)

**Variational Principle and Lagrange's equations (6 Hrs)**

Hamilton's principle - calculus of variations – examples - Lagrange's equations from Hamilton's principle.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed., (Chapter 2)

### Unit II

**Mechanics of Small Oscillations (6 Hrs)**

Stable and unstable equilibrium - two-coupled oscillators – Lagrange's equations of motion for small oscillations - normal co-ordinates and normal modes - oscillations of linear tri-atomic molecules.

Text Book:

1. Classical Mechanics, S.L. Gupta, V. Kumar & H.V. Sharma, Pragati Prakashan, 2007. (Chapter 8)

**Canonical Transformations (7 Hrs)**

Equations of canonical transformation- examples of canonical transformation - harmonic oscillator.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed. (Chapter 9)

Poisson brackets - Lagrange brackets - properties- equations of motion in Poisson bracket form - angular momentum Poisson brackets - invariance under canonical transformations.

Text Book:

1. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 7)

**Hamilton-Jacobi Theory (7 Hrs)**

Hamilton-Jacobi equation for Hamilton's principal function - harmonic oscillator problem - Hamilton - Jacobi equation for Hamilton's characteristic function- action angle variables in systems of one degree of freedom - Hamilton-Jacobi equation as the short wavelength limit of Schroedinger equation.

Text Books:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Edn. (Chapter 10)
2. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 8)

**Unit III**

**Central Force Problem (9 Hrs)**

Reduction to the equivalent one body problem - equations of motion and first integrals - equivalent one-dimensional problem and classification of orbits - differential equation for the orbits – virial theorem - Kepler problem.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.. (Chapter 3)

**Rigid Body Dynamics (9 Hrs)**

Angular momentum - kinetic energy - inertia tensor - principal axes - Euler's angles- infinitesimal rotations - rate of change of a vector - Coriolis force - Euler's equations of motion of a symmetric top - heavy symmetric top with one point fixed.

Text Book:

1. Classical Mechanics, G. Aruldhas, Prentice Hall 2009, (Chapter 8)

**Unit IV**

**General Theory of Relativity (9 Hrs)**

Principle of equivalence - principle of general covariance - motion of a mass point in a gravitational field - the Newtonian approximation - time dilation - rates of clocks in a gravitational field - shift in the spectral lines – energy-momentum tensor- Einstein's field equations and the Poisson approximation.

Text Book:

1. The Theory of Relativity, R.K. Pathria, Dover Pub. Inc. NY,2003 (Chap 6,7& 8)

**Classical Chaos (9 Hrs)**

Linear and non-linear systems - integration of linear equation: Quadrature method - the pendulum equation – phase plane analysis of dynamical systems – phase curve of simple harmonic oscillator and damped oscillator- phase portrait of the pendulum - bifurcation - logistic map – attractors - universality of chaos - Lyapunov exponent - fractals - fractal dimension.

Text Book:

1. Classical Mechanics, G. Aruldhas, Prentice Hall 2009, (Chap.11& 12)

**Reference Books:**

1. Classical Mechanics, N.C. Rana and P.S. Joag, Tata Mc Graw Hill
2. Introduction to Classical Mechanics, R.G. Takwale and P.S. Puranik, TMGH.
3. Langrangian and Hamiltonian Mechanics, M.G. Calkin, World Scientific Pub.Co Ltd
4. Introduction to General Relativity, R. Adler, M. Bazin, M. Schiffer, TMGH.
5. An introduction to general relativity, S. K. Bose, Wiley Eastern.
6. Relativistic Mechanics, Satya Prakash, Pragathi prakashan Pub.
7. Chaos in Classical and Quantum Mechanics, M.C.Gutzwiller, Springer, 1990.
8. Deterministic Chaos, N. Kumar, University Press,
9. Chaotic Dynamics, G.L.Baker & J.P.Gollub, Cambridge Uni. Press, 1996
10. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition

## PH1C03 ELECTRODYNAMICS

**Unit I**

**Electrostatic fields in matter and Electrodynamics (10 Hrs)**

Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor.

**Electromagnetic waves (8 Hrs)**

Maxwell's equations in phasor notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI.

**Unit II**

**Relativistic Electrodynamics (18 Hrs)**

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics - Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI

**Unit III**

**Electromagnetic Radiation (20 Hrs)**

Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI

**Unit IV**

**Antenna, Wave Guides and Transmission Lines (16 Hrs)**

Radiation resistance of a short dipole, Radiation from quarter wave monopole or half wave dipole. Antenna parameters. Waves between parallel conducting plane TE, TM and TEM waves, TE and TM waves in Rectangular wave guides, Impossibility of TEM waves in rectangular wave guides. Transmission Lines-Principles-Characteristic impedance, standing waves-quarter and half wavelength lines

Text Books:

1. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968
2. Antenna and wave guide propagation, K. D Prasad, Satya Prakashan.

**Reference Books:**

1. Antennas, J.D Kraus, Tata Mc-Graw Hill.
2. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.

3. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
4. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.
5. Electromagnetic Waves and Fields, V.V. Sarwate, Wiley Eastern Ltd, New Age Inernational
6. The Feymann Lectures in Physics, Vol. 2, R.P. Feymann, R.B. Leighton & M. Sands.
7. Electronic Communication Systems, G. Kennedy & B. Davis, TMH.

## PH1C04 ELECTRONICS

### Unit I

**Semiconductor Devices** (**5 Hrs**)

FET devices - structure, characteristics, frequency dependence and applications

Text Book:

1. Fundamentals of Semiconductor Devices, Betty Anderson, Richard Anderson, TMH. (Chapter 7, 8 and 9)

**Op-amp with Negative Feedback (13 Hrs)**

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

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Edn. PHI, (Chapter 2 & 3)

**Unit II**

**The Practical Op-amp (6 Hrs)**

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

Text Book:

1. Op-amp and linear integrated circuits, R.A. Gayakwad 4th Ed. PHI. (Chapter 4)

**General Linear Applications (with design) (12 Hrs)**

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

Text Book:

1 Op-amps and linear integrated circuits, R.A. Gayakwad 4th Ed. PHI. (Chap. 6)

**Unit III**

**Frequency Response of an Op-amp (6 Hrs)**

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

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Edn.PHI, (Chap.5)

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

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

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Ed. PHI, (Chap. 7)

**Unit IV**

**Comparators and Converters (8 Hrs)**

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

Text Book:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4$^{th}$ Edn. PHI. (Chap. 8)

**IC555 Timer (3 Hrs)**

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

Text Book:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4$^{th}$ Edn. PHI. (Chap. 10)

**Analog Communication (7 Hrs)**

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

Text Book:

1. Electronic Communication Systems, Kennedy & Davis 4$^{th}$Ed.TMH, (Chap. 6)

**Reference Books:**

1. Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
2. Fundamentals of Electronic Devices and Circuits 5$^{th}$ Ed. David A. Bell, Cambridge.

3. Electronic Communications Dennis Roddy and John Coolen, 4th Ed. Pearson.
4. Modern digital and analog communication systems, B.P. Lathi & Zhi Ding 4th Ed., Oxford University Press.
5. Linear Integrated Circuits and Op Amps, S Bali, TMH

**PH1P01 GENERAL PHYSICS PRACTICALS**

(Minimum of 12 Experiments with Error analysis of the experiment is to be done)

1. Y, n, σ Cornu's method (a) Elliptical fringes and (b) Hyperbolic fringes.
2. Absorption spectrum –KMnO4 solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method
3. Frank and Hertz Experiment – determination of ionization potential.
4. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.
5. Resistivity of semiconductor specimen–Four Probe Method.
6. Band gap energy measurement of silicon.
7. Magnetic Susceptibility-Guoy's method / Quincke's method.
8. Michelson Interferometer - λ and dλ / thickness of mica.
9. Ultrasonic-Acousto-optic technique-elastic property of a liquid.
10. B - H Curve-Hysteresis.
11. Oscillating Disc-Viscosity of a liquid.
12. e/m of the electron-Thomson's method.

15. Characteristic of a thermistor - Determination of the relevant parameters.
16. Dielectric constant of a non-polar liquid.
17. Dipole moment of an organic molecule (acetone).
18. Young's modulus of steel using the flexural vibrations of a bar.
19. Verification of Stefan's law and determination of Stefan's constant of radiation
20. Temperature dependence of a ceramic capacitor and verification of Curie-Wiess law
21. Experiments using GM counter- absorption co-efficient of beta rays in materials.
22. Multichannel analyzer for alpha energy determination.
23. Zeemann effect setup – measurement of Bohr magnetron
24. Photoelectric effect – determination of Plank's constant using excel or origin.
25. Magneto-optic effect (Faraday effect)- rotation of plane of polarization as a function of magnetic flux density.
26. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.
27. Silicon diode as a temperature sensor.
29. Electrical and thermal conductivity of copper and determination of Lorentz number.

## SEMESTER – II

## PH2C05 MATHEMATICAL METHODS IN PHYSICS – II

**Unit I**

**Complex Analysis (18 Hrs)**

Functions of a complex variable - Analytic functions - Cauchy-Riemann equation - integration in a complex plane – Cauchy's theorem-deformation of contours - Cauchy's integral formula - Taylor and Laurent expansion-poles, residue and residue theorem – Cauchy's Principle value theorem - Evaluation of integrals.

Text Books:

1. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
2. Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)
3. Introduction to Mathematical physics, Charlie Harper, PHI

**Unit II**

**Integral Transforms (18 Hrs)**

Introduction to Fourier series and Fourier integral form - Fourier transform - square wave, full wave rectifier and finite wave train – momentum representation of hydrogen atom ground state and harmonic oscillator. Laplace transform –inverse Laplace transform-properties and applications – Earth's nutation, LCR circuit, wave equation in a dispersive medium, damped, driven oscillator, solution of differential equations.

Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber $4^{th}$ Edition, Academic Press.
2. Mathematical Physics, H.K Dass & Dr. Rama Verma, S. Chand &Co.

**Unit III**

**Group theory (18 Hrs)**

Introductory definition and concepts of group - point group, cyclic group, homomorphism and isomorphism-classes, reducible and irreducible representations- Schur's Lemmas and Great Orthogonality theorem. Group character table- C2V, C3V and C4V groups, Lie group, concept of generators- rotation group SO(2), SO(3), Unitary Group SU(2) and SU(3) Homomorphism between SU(2) and SO(3) – Irreducible Representation of SU(2).

Text Books:

1. Elements of Group Theory for Physicists, A.W. Joshi, New Age India
2. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
3. Group theory- Schaum's series, Benjamin Baumslag & Bruce Chandler, MGH.

**Unit IV**

**Partial Differential Equations (18 Hrs)**

Characteristics and boundary conditions for partial differential equations. Nonlinear partial differential equations – separation of variables in Cartesian, cylindrical and spherical polar coordinates. Heat equation, Laplace's equation and Poisson's equation. Nonhomogeneous equation - Green's function - symmetry of Green's function - Green's function for Poisson equation, Laplace equation and Helmholtz equation - Application of Green's function in scattering problem

Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4th Edition, Academic Press.
2. Mathematical Physics, B.S Rajput, Pragati Prakashan

**Reference Books:**

(Given Under **PH1C01**)

## PH2C06 QUANTUM MECHANICS – I

### Unit I

**Basics of Quantum Mechanics (14 Hrs)**

Stern - Gerlach experiment leading to vector space concept, Dirac notation for state vectors- ket space, bra space, inner products - algebraic manipulation of operators – unitary operators, eigenkets and eigenvalues – Hermitian operators-concept of complete set-representation of an operator by square matrix – matrix elements of an operator - expectation values of Hermitian and anti-Hermitian operators – generalized uncertainty product — change of basis-orthonormal basis and unitary matrix, transformation matrix-unitary equivalent observables-eigenkets of position-infinitesimal operator and its properties – linear momentum as generator of translation – canonical commutation relations – properties of wave function in position space and momentum space - relations between operator formalism and wave function formalism-momentum operator in position basis – momentum space wave function – computation of expectation values x, $x^2$, p and $p^2$ for a Gaussian wave packet.

Text Book:

1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education (Chapter 1)

**Unit II**

**Quantum Dynamics (18Hrs)**

Time evolution operator and its properties-Schrodinger equation for the time evolution operator - energy eigenkets - time dependence of expectation values - time energy uncertainty relation - Schrodinger picture and Heisenberg picture - behaviour of state kets and observables in Schrodinger picture and Heisenberg picture - Heisenberg equation of motion - Ehrenfest's theorem - time evolution of base kets - transition amplitude - energy eigenket and eigen values of a simple harmonic oscillator using creation and annihilation operators

Text Book:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 2)

**Identical particles**

Identity of particles - spin and statistics-Pauli's exclusion principle - Helium atom

Text Book:

1. Quantum Mechanics, V. K. Thankappan, New Age International, 1996, (Chapter 9)

**Unit III**

**Angular momentum (20 Hrs)**

Commutation relation between infinitesimal and rotation-infinitesimal rotations in quantum mechanics-fundamental commutation relations of angular momentum - rotation operator for spin ½ system - Pauli two component formalism - Pauli spin matrices - 2x2 matrix representation of rotation operator – commutation relations for $J^2$, $J_x$ – eigenvalues of $J^2$ and $J_x$ - matrix elements of angular momentum operators - representation of the rotation operator – rotation matrix-properties of the rotation matrix-orbital angular momentum as a rotation generator - addition of angular momentum and spin angular momentum - addition of spin angular momenta and Clebsch-Gordon coefficients for two spin ½ particles

Text Book:

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

**Unit IV**

**Solutions of Schrodinger equation and Approximation Methods (20 Hrs)**

Motion in a central potential - Hydrogen atom WKB approximation - WKB wave function –validity of the approximation - connection formula (proof not needed) potential well - barrier penetration variational methods - bound states – hydrogen molecule ion - stationary state perturbation theory - non degenerate case - anharmonic oscillator - degenerate case -applications - first order Stark effect and Zeeman effect in hydrogen

Text Book:

1. Quantum mechanics, V.K. Thankappan New Age International 1996 (Chapter 4, 8)
2. Quantum Mechanics, G Aruldhas, PHI, 2002, (Chapter 10)

**Reference Books:**

1. A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.
2. Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996
3. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
4. Quantum Mechanics, E. Merzbacher, John Wiley, 1996
5. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
6. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill
7. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
8. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.
9. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.

## PH2C07 THERMODYNAMICS AND STATISTICAL MECHANICS

### Unit I

### Fundamental of Thermodynamics (10 Hrs)

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 1 and 2)

### Foundations of Statistical Mechanics (8 Hrs)

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 3 and 4)

## Unit II

### The Canonical Ensemble (12 Hrs)

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, $2^{nd}$ Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

### Statistics of Identical Particles (4 Hrs)

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, $2^{nd}$ Edn. 2007, Oxford University Press, Indian Edition, (Chapter 6)

## Unit III

### Maxwell Distribution and Planck's Distribution (12 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory –

Planck's distribution – derivation of the Planck's distribution – the free energy – Einstein's model vibrations in a solid – Debye's model of vibrations in a solid.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7 and 8)

**Grand Canonical Ensemble (8 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 9)

**Unit IV**

**Fermi and Bose Particles (6 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 10)

**Phase Transitions (12 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, $2^{nd}$ Edn. 2007, Oxford University Press, Indian Edition, (Chaptr 11& 12)

**Reference Books:**


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

## PH2C08 CONDENSED MATTER PHYSICS

**Unit I**

**Elements of Crystal Structure (6 Hrs)**

Review of crystal lattice fundamentals and interpretation of Bragg's equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity - atomic, geometrical and crystal structure factors- physical significance.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 8)

**Free Electron Theory of Metals (12 Hrs)**

Review of Drude-Lorentz model - electrons moving in a one dimensional potential well - three dimensional well - quantum state and degeneracy - density of states - Fermi-Dirac statistics - effect of temperature on Fermi-Dirac distribution - electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 10)

**Unit II**

**Band Theory of Metals (6 Hrs)**

Bloch theorem - Kronig-Penney model - Brillouin zone construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - effective mass of electron - nearly free electron model – conductors - semiconductors - insulators.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2$^{nd}$ Edn. 2010, (Chapter 11)

**Band theory of semiconductors (10 Hrs)**

Generation and recombination - minority carrier life-time - mobility of current carriers - drift and diffusion - general study of excess carrier movement- diffusion length.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6$^{th}$ Edn. 2010,(Chapter 10).

Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors - junction properties- metal-metal, metal-semiconductor and semiconductor-semiconductor junctions.

Ref. Text:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2$^{nd}$ Edn. 2010, (Chapter 13)

**Unit III**

**Lattice Dynamics (14 Hrs)**

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 4).

Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 7 &9)

**Dielectric Properties of Solids (6 Hrs)**

Review of basic terms and relations, ferroelectricity, hysteresis, dipole theory - Curie-Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 11).

Ferroelectric domain, antiferroelectricity and ferrielectricity.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 14)

**Unit IV**

**Magnetic properties of solids (10 hrs)**

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism -

spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 9).

**Superconductivity (4 Hrs)**

Thermodynamics and electrodynamics of superconductors- BCS theory- flux quantization-single particle tunneling- Josephson superconductor tunneling- macroscopic quantum interference

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 12).
2. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 8 ).

**Nanotechnology and Metamaterials (Qualitative) (4 Hrs)**

Properties of metal, semiconductor, rare gas and molecular nanoclusters- superconducting fullerene- quantum confined materials-quantum wells, wires, dots and rings- metamaterials- graphene

Text Book:

1. Introduction to Nanotechnology, Charles P Poole and Frank J Owens, Wiley India (Chapter 4, 5, 9)

**Reference Books:**

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th Indian Reprint (2011).
2. Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co (1981)
3. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
4. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
5. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
6. Solid State Physics, Dan Wei, Cengage Learning (2008)
7. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)

**PH2P02 ELECTRONICS PRACTICALS**

(Minimum of 12 experiments should be done)

1. R C Coupled CE amplifier - Two stages with feedback - Frequency response and voltage gain.
2. Differential amplifiers using transistors and constant current source - Frequency response, CMRR.
3. Push-pull amplifier using complementary - symmetry transistors-power gain and frequency response.
4. R F amplifier - frequency response & band width - Effect of damping.
5. Voltage controlled oscillator using transistors.
6. Voltage controlled oscillator using IC 555
7. R F Oscillator - above 1 MHz frequency measurement.
8. Differential amplifier - using op-amp.

9. Active filters – low pass and high pass-first and second order-frequency response and rolloff rate.
10. Band pass filter using single op-amp-frequency response and bandwidth.
11. Wein-bridge Oscillator – using op-amp with amplitude stabilization.
12. Op-amp-measurement of parameters such as open loop gain - offset voltage – open loop response.
13. Crystal Oscillator
14. RC phase shift oscillator
15. AM generation and demodulation
16. Solving differential equation using IC 741
17. Solving simultaneous equation using IC 741
18. Current to voltage and voltage to current converter (IC 741)
19. Temperature measurement using ADC and microprocessor.
20. Op-amp-triangular wave generator with specified amplitude.
21. μp - stepper motor control.
22. μp- measurement of analog voltage.
23. μp-Digital synthesis of wave form using D/A Converter.
24. Analog to digital and digital to analog converter ADC0800 & DAC0800

## SEMESTER – III

**PH3C09 QUANTUM MECHANICS – II**

**Unit I**

**Time Dependent Perturbation Theory (16 hrs)**

Time dependent potentials - interaction picture - time evolution operator in interaction picture - time dependent perturbation theory - Dyson series – transition probability - constant perturbation - Fermi-Golden rule - harmonic perturbation - interaction with classical radiation field - absorption and stimulated emission - electric dipole approximation - photo electric effect – energy shift and decay width - sudden and adiabatic approximation

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 5)
2. Quantum mechanics – V. K. Thankappan New Age Int. Pub 1996 (Chapter 8)

**Unit II**

**Scattering (18 hrs)**Asymptotic wave function and differential cross section, Born approximation, Yukawa potential, Rutherford scattering. The partial wave expansion, hard sphere scattering, S-wave scattering for the finite potential well, resonances - Ramsaur- Townsend effect

Text Book:

1. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books Pvt Ltd, MGH (Chapter 13)**Unit III**

**Relativistic Quantum Mechanics (18 hrs)**

Need for relativistic wave equation - Klein-Gordon equation - Probability conservation - covariant notation - derivation of Dirac equation - conserved current representation - large and small components - approximate Hamiltonian for electrostatic problem - free particle at rest -plane wave solutions - gamma matrices - bilinear covariant – relativistic covariance of Dirac equation - angular momentum as constant of motion.

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 3)

**Unit IV**

**Elements of Field Theory (20 hrs)**

Euler-Lagrange equation for fields - Hamiltonian formulation – functional derivatives -conservation laws for classical field theory - Noether's theorem - Non relativistic quantum field theory - quantization rules for Bose particles, Fermi particles - relativistic quantum field theory - quantization of neutral Klein Gordon field - canonical quantization of Dirac field – plane wave expansion of field operator - positive definite Hamiltonian

Text Book:

1. Field Quantization, W Greiner , J Reinhardt, Springer, (Chapter 2, 3, 4 & 5)
2. Quantum mechanics - V.K. Thankappan, New Age Int. Publishers

**Reference Books:**

(In addition to books given under PH2C06, the following books are also recommended)

1. Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta,1989
2. Quantum Field Theory, Claude Itzykson & Jean Bernard Zuber, MGH, 1986
3. Introduction to Quantum Field Theory, S.J. Chang, World Scientific, 1990
4. Quantum Field Theory, Franz Mandl & Graham. Shaw, Wiley 1990

## PH3C10 COMPUTATIONAL PHYSICS

**Unit I**

**Curve Fitting and Interpolation (20Hrs)**

The least squares method for fitting a straight line, parabola, power and exponential curves with the help of principle of least square fit. Interpolation - Introduction to finite difference operators, Newton's forward and backward difference interpolation formulae, Lagrange's interpolation formula, Newton's divided difference formula with error term, interpolation in two dimensions. Cubic spline interpolation end conditions. Statistical tests - $\Psi^{2-}$ test and T-test.

**Unit II**

**Numerical Differentiation and Integration (16 Hrs)**

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

**Unit III**

**Numerical Solution of Ordinary Differential Equations (20Hrs)**

Euler method - modified Euler method and Runge - Kutta $4^{th}$ order methods - adaptive step size R-K method, predictor - corrector methods - Milne's method, Adam-Mouton method.

**Numerical Solution of System of Equations**

Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss elimination method and Gauss-Jordan method to find inverse of a matrix. Power method and Jacobi's method to solve eigenvalue problems.

**Unit IV**

**Numerical solutions of partial differential equations (16Hrs)**

Elementary ideas and basic concepts in finite difference method, Schmidt Method, Crank - Nicholson method, Weighted average implicit method. Concept of stability.

Text Books:

1. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.
2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

**Reference Books:**

1. An Introduction to Computational Physics, Tao Pang, Cambridge University Press

2. Numerical methods for scientific and Engineering computation M.K Jain,S.R.K Iyengar, R.K. Jain, New Age International Publishers
3. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
4. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
5. Numerical Mathematical Analysis, J.B. Scarborough, 4th Edn, 1958

**PH3P03 COMPUTATIONAL PHYSICS PRACTICALS**

(Minimum of 12 Experiments should be done with C++ as the programming language)

1. Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.
2. Study the path of a projectile for different angles of projection. From graph find the variation in range and maximum height with angle of projection.
3. Study graphically the variation of magnetic field B(T) with critical temperature in superconductivity using the relationship $B(T) = B_0 [1 - (T/T_c)^2]$, for different substances.
4. Discuss the charging /discharging of a capacitor through an inductor and resistor, by plotting time –charge graphs for a) non oscillatory, b) critical) oscillatory charging.

5. Analyze a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.
6. Study the variation in phase relation between applied voltage and current of a series L.C.R circuit with given values of L C Find the resonant frequency and maximum current.
7. A set of observations of $\pi$ meson disintegration is given. Fit the values to a graph based on appropriate theory and hence calculate life time $\tau$ of $\pi$ mesons.
8. Draw graphs for radioactive disintegrations with different decay rates for different substances. Also calculate the half-life's in each case.
9. Half-life period of a Radium sample is 1620 years. Analytically calculate amount of radium remaining in a sample of 5gm after 1000 years.Varify your answer by plotting a graph between time of decay and amount of substance of the same sample.
10. Plot the trajectory of a $\alpha$-particle in Rutherford scattering and ditermine the values of the impact parameter.
11. Draw the phase plots for the following systems.
    (i) A conservative case (simple pendulum)
    (ii) A dissipative case (damped pendulum)
    (iii) A nonlinear case (coupled pendulums).
12. Two masses $m_1$ and $m_2$ are connected to each other by a spring of spring constant k and the system is made to oscillate as a two

coupled pendulum. . Plot the positions of the masses as a function of time.

13. Plot the motion of an electron in (i) in uniform electric field perpendicular to initial velocity (ii) uniform magnetic field at an angle with the velocity. and (iii) simultaneous electric and magnetic fields in perpendicular directions with different field strengths.
14. A proton is incident on a rectangular barrier, calculate the probability of transmission for fixed values of $V_0$ and E ($V_0 > E$) for the width of barrier ranges from 5 to 10 Fermi, and plot the same.
15. Generate the interference pattern in Young's double slit-interference and study the variation of intensity with variation of distance of the screen from the slit.
16. Analyze the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference
17. Generate the pattern of electric field due to a point charge
18. Sketch the ground state wave function and corresponding probability distribution function for different values of dispalcements of the harmonic oscillator.
19. Gauss elimination method for solving a system of linear equations.

20. Solving a second order differential equation using $4^{th}$ order Runge- Kutta method.

21. Finding the roots of a nonlinear equation by bisection method.

**Reference Books:**

1. Computational physics, An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt. Ltd.
2. An Introduction to computational Physics, Tao Pang, Cambridge University Press.
3. Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, R.H. Silsbee & J. Drager, Cambridge University Press.
4. Numerical Recipes: the Art of Scientific Computing, W.H. Press, B.P. Flannery, S.A. Teukolsky & W.T.Vettering, Cambridge University Press.

## SEMESTER - IV

## PH4C11 ATOMIC AND MOLECULAR PHYSICS

### Unit I

### Atomic Spectra (18 Hrs)

The hydrogen atom and the three quantum numbers $n$, $l$ and $m_l$ - electron spin - spectroscopic terms. Spin-orbit interaction, derivation of spin-orbit interaction energy, fine structure in sodium atom, selection rules. Lande g-factor, normal and anomalous Zeeman effects, Paschen–Back effect and

Stark effect in one electron system. L S and j j coupling schemes (vector diagram) - examples, derivation of interaction energy, Hund's rule, Lande interval rule. Hyperfine structure and width of spectral lines.(qualitative ideas only).

Text Book:

1. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons

**Unit II**

**Microwave and Infra Red Spectroscopy (18 Hrs)**

**Microwave Spectroscopy**: Rotational spectra of diatomic molecules - intensity of spectral
lines - effect of isotopic substitution. Non–rigid rotor - rotational spectra of polyatomic molecules - linear and symmetric top - Interpretation of rotational spectra.

**IR Spectroscopy:** Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - influence of rotation on the spectra of polyatomic molecules - linear and symmetric top - analysis by IR technique - Fourier transform IR spectroscopy.

Text Books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, Tata McGraw Hill
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.

**Unit III**

**Raman and Electronic Spectroscopy. (18 Hrs)**

**Raman Spectroscopy:** Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - mutual exclusion principle - rotational fine structure - structure determination from Raman and IR spectroscopy.

Non- linear Raman effects - hyper Raman effect - classical treatment - stimulated Raman effect - CARS, PARS - inverse Raman effect

**Electronic Spectroscopy:** Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy and dissociation products - Rotational fine structure of electronic-vibrational transition - Fortrat parabola - Pre-dissociation.

Text books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
3. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern

**Unit IV**

**Spin Resonance Spectroscopy (18 Hrs)**

**NMR:** Quantum mechanical and classical descriptions - Bloch equations - relaxation processes - chemical shift - spin–spin coupling - CW spectrometer - applications of NMR.

**ESR:** Theory of ESR - thermal equilibrium and relaxation - g- factor - hyperfine structure -applications.

**Mossbauer spectroscopy**: Mossbauer effect - recoilless emission and absorption - hyperfine interactions – chemical isomer shift - magnetic hyperfine and electronic quadrupole interactions - applications.

Text Book:

1. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
2. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons

**Reference Books:**


1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill
2. Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Science paperbacks 1976
3. Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
4. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
5. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.
6. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.
8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India

**PH4C12 NUCLEAR AND PARTICLE PHYSICS**

**Unit I**

**Nuclear Properties and Force between Nucleons (18 Hrs)**

Nuclear radius, mass and abundance of nuclides, nuclear binding energy, nuclear angular momentum and parity, nuclear electromagnetic moments, nuclear excited states

Duetron, nucleon-nucleon scattering, proton-proton and neutron-neutron interactions, properties of nuclear forces, exchange force model

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 3&4)

**Unit II**

**Nuclear Decay and Nuclear Reactions (18 Hrs)**

Beta decay, energy release, Fermi theory, experimental tests, angular momentum and parity selection rules, Comparative half lives and forbidden decays, neutrino physics, non conservation of parity

Types of reactions and conservation laws, energetics of nuclear reactions, isospin, Reaction cross sections, Coulomb scattering, nuclear scattering, scattering and reaction cross sections, compound-nucleus reactions, direct reactions, heavy ion reactions.

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 9&11)

**Unit III**

**Nuclear Models, Fission and Fusion (18 Hrs)**

Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula

Characteristics of fission - energy in fission - fission and nuclear structure, Controlled fission reactions - Fission reactors.

Fusion processes, Characteristics of fusion, Controlled fusion reactors

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 5, 13 &14)

**Unit IV**

**Particle Physics (18 Hrs)**

Types of interactions between elementary particles, Hadrons and leptons-masses, spin, parity and decay structure. Quark model, confined quarks, coloured quarks, experimental evidences for quark model, quark-gluon interaction. Gell-Mann-Nishijima formula, symmetries and conservation laws, C, P and T invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions. Grand unified theories.

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 18)
2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House (Chapter 16)

**Reference Books:**

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)

2. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, NewDelhi, (1983).
3. The particle Hunters - Yuval Ne'eman & Yoram kirsh CUP, (1996)
4. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).
5. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).
6. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
7. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi, (1989).
8. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).
9. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi, (1981).
10. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company
11. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York, (1971).
12. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison-Wesley, Tokyo, (1995).
13. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.
14. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer (2002)
15. Elementary Particles and Symmetries, L.H. Ryder, Gordon and Breach, Science Publishers, NY, 1986

## 3.3 ELECTIVES

## 3.3.1 BUNCH – A: ELECTRONICS

### PH3EA1: INTEGRATED ELECTRONICS AND DIGITAL SIGNAL PROCESSING

**Unit I**

**Integrated Circuit Fabrication and Characteristics (16 Hrs)**

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

**Unit II**

**Basics of Digital Signal Processing (18 Hours)**

Signals and representation – classification - continuous time (CT) and discrete time (DT) signals - standard CT and DT signals - Fourier Analysis of periodic and aperiodic continuous time signals - convolution and correlation of DT and CT Signals – classification of systems CT – DT - causal, noncausal, static and dynamic systems - stable systems - FIR and IIR systems -frequency domain representation of systems

**Unit III**

**DSP Techniques (18 Hrs)**

Frequency analysis of DT signals - discrete Fourier Transform - Fast Fourier Transform (FFT) - Decimation in time and decimation in frequency algorithm - Z-Transform regional convergence and properties - relation to

Fourier Transform - Poles and Zeros of system function - Gibb's phenomenon

**Unit IV**

**Digital Filters (20 Hrs)**

FIR and IIR Filters - IIR Filter design techniques - Approximation of derivatives -Impulse invariant method - Bilinear transformation - FIR filter design techniques - Fourier Series method - Window techniques - FIR filter using rectangular window - Realisation of IIR systems - Direct form I & form II realization - Direct form and cascade form realization of FIR systems - Finite word length affecting digital signal processing.

Text Books

1. Integrated Electronics – Analog and Digital Circuits and Systems, J. Millmann & C.C. Halkias, TMGH
2. Digital Signal Processing: Theor, Analysis and Digital-Filter Design, B. Somanathan Nair, PHI (2004)
3. Digital Signal Processing, P. Ramesh Babu, Scitech
4. Digital Signal Processing, Alan V. Oppenheim & R.W. Schafer, PHI

**Reference Books:**

1. Computer applications in physics, Suresh Chandra, Alpha Science International (2006)
2. Digital Signal Processing, S. Salivahanan, A. Vallavaraj, C. Gnanapriya, TMH
3. Signals and Systems, Allan V. Oppenheim, Alan S. Willsky, S.H. Nawab, PHI
4. Digital Signal Processing, John G. Proakis, Dimitris G. Manolakis, PHI

5. Digital signal processing, Sanjay Sharma, S.K. Kataria & Sons, 2010
6. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber.Elsavier, Academic Press

## PH3EA2 MICROELECTRONICS AND SEMICONDUCTOR DEVICES

**Unit I**

**Basics of Digital Techniques (18 Hrs)**

Review of 8085 microprocessor - General organization of a microprocessor based microcomputer system – memory organization – main memory array – memory management – cache memory – virtual memory - input/output - standard I/O – memory mapped I/O – microcomputer I/O circuits – interrupt driven I/O –DMA – RAM - hard disk - CD – Flash memory.

**Unit II**

**8086 Microprocessor (19 Hrs)**

The Intel 8086 - architecture - MN/MX modes - 8086 addressing modes - instruction set- instruction format - assembler directives and operators - Programming with 8086 - interfacing memory and I/O ports - Comparison of 8086 and 8088 - Coprocessors - Intel 8087 - Familiarisation with Debug utility.

**Unit III**

**Microcontrollers (19 Hrs)**

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

**Unit IV**

**Semiconductor Devices (16 hrs)**

Schottky barrier diode - qualitative characteristics – ideal junction properties – nonlinear effects on barrier height – current voltage relationship – comparison with junction diode – metal semiconductor ohmic contact – ideal non rectifying barriers – tunnelling barrier – specific contact resistances – hetro-junctions – hetro junction materials – energy band diagram – two dimensional electron gas – equilibrium electrostatics – current voltage characteristics

Text Books

1. Microprocessors and Microcomputer based system design, H. Rafiquizzaman, Universal Book stall, New Delhi
2. Microprocessor and Peripherals, S.P. Chowdhury & S. Chowdhury- SCITECH Publications
3. Microprocessor Architecture Programming and Applications with 8085, R.S. Gaonkar – Penram int. Pub. Mumbai
4. The 8051 microcontroller, Architecture Programming and Applications, Kenneth J Ayala- Penram Int. Pub. Mumbai.
5. Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill

**Reference Books:**

1. 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
2. Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi –TMH.
3. Microprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
4. Operating system Principles, Abraham Silberschatz & Peter Baer Galvin & Greg Gagne, John Wiley

## PH4EA3 INSTRUMENTATION AND COMMUNICATION ELECTRONICS

**Unit I**

**Transducers and Digital Instrumentation (20 Hrs)**

**Transducers:** Classification of transducers - electrical transducer - resistive transducer - strain gauges- piezo-electric and magnetostrictive transducers - Hall effect transducers -thermistor inductive transducer - differential output transducers - pressure transducers - pressure cell - photoelectric transducers - photo voltaic cell – semi conductor photo diode – thermo electric transducers – mechanical transducers – ionization transducers – digital transducers - electro chemical transducers.

**Digital Instrumentation:** Digital counters and timers - digital voltmeter – RAMP - voltage to time conversion - voltage to frequency conversion - frequency to voltage conversion - digital multimeter - digital phase meter - digital frequency meter - time and frequency measurement – tachometer - pH meter.

**Unit II**

**Measurement of Basic Parameters and Recorders (18 Hrs)**

Transistor Voltmeter - amplified DC meter – A.C voltmeters using rectifiers – precision rectifier – true RMS responding voltmeter – chopper type DC amplifier voltmeter - milli voltmeter using operational amplifier – differential voltmeter – Ohm meter – electronic multimeter – commercial multimeter – output power meters - stroboscope – phase meter – vector impedance meter – Q meter – RF measurement – transistor testers – CRO (Basic ideas)

**Recorders:** Strip chart recorders - XY recorders - digital XY plotters - magnetic recorders -digital data recording - Storage oscilloscope – Digital storage oscilloscope

**Unit III**

**Introduction to Communication (18 Hrs)**

Bandwidth requirements – SSB technique – radio wave propagation – Ionosphere – Ionosphere variations – Space waves – Extraterrestrial communication - Transmission lines – Basic principles – Characteristic impedance – Losses – Standing waves – Quarter and half wavelength lines.

Television fundamentals – Monochrome transmission – Scanning – Composite TV video wave form – Monochrome reception – Deflection circuits – Colour Television. Basic ideas of high definition TV – LCD & LED TV

**Unit IV**

**Digital Communication (16 hrs)**

Pulse Communication – Information theory – Coding – Noise – Pulse modulation – PAM – PTM – PCM – PPM. Digital communication – Data Communication – Digital codes – Data Sets and interconnection requirements.

Multiplexing techniques – Frequency division and time division multiplexing. Microwave generators – Klystron and Magnetron – Satellite communication. Digital cellular systems GSM, TDMA and CDMA – basic ideas of GPS

Text Books:

1. Electronic Instrumentation, H.S. Kalsi, TMH (1995)
2. Transducers and instrumentation, D.V.S. Murty, PHI (1995)
3. Monochrome and Colour Television R.R. Gulati, New Age India
4. Electronic communication systems, George Kennedy, TMH
5. Mobile Cellular Telecommunication Systems, William C.Y. Lee, MGH

**Reference Books:**

1. Modern electronic Instrumentation and Measurement Techniques, A.D. Helfric & W.D. Cooper,PHI, (1997)
2. Instrumentation-Devices and Systems 2nd Edn. C.S. Rangan, G.R. Sarma, V.S.V. Mani, TMH, (1998)

3. Electronic Measurements and Instrumentation, M.B. Olive & J.M. Cage, MGH, (1975)
4. Digital Instrumentation, A.J. Bouwens,TMH, (1998)
5. Elements of Electronic Instrumentation, J. Jha, M. Puri, K.R. Sukesh, & M.Kovar., Narosa, (1996)
6. Instrumentation Measurement and Analysis, B.C. Nakra & K.K. Chaudhry, TMH, (1998)
7. Op-amps and Linear Integrated Circuits, R.A. Gaykward, PHI, (1989)
8. Electronic fundamentals and Applications, John D. Ryder, PHI.
9. Satellite communication, Robert M.Gagliardi, CBS Publishers, Delhi.
10. Electric and electronic measurements and instrumentation $10^{th}$ Edn. A.K. Sawhney, Dhanpath Rai & Company.

## PH4PA4 ADVANCED ELECTRONICS PRACTICALS

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

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

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.

**[B] Communication Electronics**

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

**[C] Electronic Instrumentation**

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

**[D] Optoelectronics**

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

### 3.3.2 BUNCH – B: INFORMATICS

**PH3EBI DATA COMMUNICATION AND INTERNET WORKING**

**Unit I**

**Data Communication (18 Hrs)**

Data Communication Terminology – Channel-Baud-Bandwidth-Frequency. Modes of data transmission – Serial and Parallel - Synchronous, Asynchronous & Isochronous Communications - Analog & Digital Data Transmission - Transmission impairments – Attenuation-Delay Distortion-Noise- Concept of Delays. Transmission Media and its Characteristics – Magnetic media-Twisted pair-Base band coaxial cable - Broadband Coaxial cable - Optical Fiber -Comparison between optical fiber and copper wire - Wireless transmission – Microwave Transmission - Radio Transmission - Infrared and millimeter waves - Wireless LAN

**Unit II**

**Data Communication (cont..) (18 Hrs)**

Multiplexing (FDM, TDM) – Switching paradigms (circuit, packet and cell switching) – propagation delay – clock synchronization.

Network access control (Centralized, decentralized, distributed) – Overview of satellite communication – Fourier series & transforms and their applications to data communication.

**Unit III**

**Computer Networks (18 Hrs)**

Importance of Networks – Components of Networks - Classification of Networks – Broad cast networks - Switched networks - Switching Techniques - Types of Networks – LAN – MAN – WAN.

Networking Models – OSI reference model – TCP/IP reference model - Network Topology – Bus-Star-Ring-Tree-Mesh-Cellular - Network Architecture – Client/Server, Peer-to-Peer

**Unit IV**

**The Internet (18 Hrs)**

Internet Protocols – Internet Protocol (IP)-Transmission Control Protocol (TCP) - Internet Address – Structure of Internet Servers Address-Address Space - Internet Infrastructure - Services on Internet – Domain Name System-SMTP and Electronic mail – Http and World Wide Web-Usenet and News groups-FTP-Telnet - Network Security – Ideas of secret key Algorithms and Public key Algorithms-Digital Signature-E-mail Privacy - Internet Tools – Search Engines-Web browsers

Text Books

1. Data and Computer communication, William Staling, 7th Edn. PHI
2. Computer Networks, A.S. Tanenbaum, PHI
3. Internet and World Wide Web, Harvey M. Deitel, PHI
4. Computer Network, Behrouz. A. Forouzan, Sophia Chung Fegan, MGH.

**Reference Books:**

1. Data communication - Reid and Bartskor

2. Data networks, D.P. Bertsekas & R.G. Gallager, Pearson.
3. Communication networks, Alberto Leon – Gracia and IndraWidjaja, MGH, (2003)
4. Introduction to communication systems, Simon S. Haykins, Wiley
5. Analog and digital Communication, Simon S Haykins, Wiley
6. Computer Communications and Networking Technologies, Michal A. Gallo and William M. Hancock, Thomson Asia 2nd Reprint, 2002.
7. Networks, Tirothy S. Ramteke, 2nd Edn. Pearson Education , New Delhi, 2004

**PH3EB2 JAVA AND LINUX OPERATING SYSTEM**

**Unit I (18 Hrs)**

Fundamentals of Object oriented programming, Java Evolution (basic Ideas only) **(2 hrs)**

Over view of Java language – constants, variables, and data types – Operators and expressions – Decision making and branching – decision making and looping. **(16 hrs)**

Text Book:

1. Programming With Java – A Primer, E. Balagurusamy 3rd Edn TMH. (Ch. 1,2,3,4,5,6,7 )

**Unit II (18 Hrs)**

Classes, objects and methods – Arrays, strings and Vectors – interfaces – Packages

Text Book:

1. Programming With Java– A Primer, E. Balagurusamy 3rd Edn. TMH. (Ch.8,9,10,11)

**Unit III (18 Hrs)**

Multithreaded programming – Managing errors and exceptions – Applet programming – Graphics programming

Text Book:

1. Programming With Java – A Primer, E. Balagurusamy 3rd Edn TMH. (Ch.12,13,14,15)

**Unit IV**

**Linux Operating System (18 Hrs)**

Features of Linux – Drawbacks of Linux - Components of Linux – Memory management sub system - Linux process and thread management - File management sub system - Device Drivers.

Linux Commands and Utilities – Entering the machine - The file system

Linux Utilities and Editor – Useful Commands - Permission modes and Standard Files - Pipes. Filters and Redirection - Shell Scripts - Graphical User Interface-Editor

User to User Communication – Online Communication-Offline Communication - Apache Server Settings-Network Server settings - DNS,NFS

Popular applications in Linux (open office, python etc…) – Familiarization of Ubuntu

Text Books:

1. Linux Bible, Christopher Negus, John Wiley & Sons
2. Operating System: Linux – NIIT, Prentice Hall of India

**Reference Books:**

1. JAVA2, The Complete Reference, Herbert Schidlt, 4th Edn. TMH

2. Object Oriented Design in Java (Mitchell Waite Signature Series), S.Gilbert, B. Mccarty
3. Object Oriented Analysis and Design in Java, Grady Booch
4. http://java.sun.com
5. UNIX and LINUX, Goel, Ritendra, Jagdamba Publishing Company-2004
6. http://www.redhat.com/docs/manuals/linux
7. http://www.linux.org

**PH4EB3 COMPUTER APPLICATIONS IN PHYSICS**

**Unit I**

**Introduction to MATLAB (18 Hrs)**

MATLAB environment – working with data sets – data input/output – logical variables and operators – array and X-Y Plotting – simple graphics – data types matrix, string, cell and structure – manipulating of data of different types – file input –output – matlab files – simple programs.

**Unit II**

**MATLAB Tools (18 Hrs)**

Signal processing – toolbox – digital and analog filter design – spectral analysis – filtering and discrete FFTs – Z-transform – DFT and FFT – MATLAB tools for wavelet transform – instrument control toolbox – partial differential equation toolbox – finite element method.

**Unit III**

**Introduction to LABView (18 Hrs)**

Introduction – palette, controls & functions palette – data types, conversion.

Front Panel: Construction, containers, decorations, vi properties, tabs – parallel data flow, create indicators/controls/constants indicators, controls – math operations, booleans, arrays, case structures, sequences – for loops, while loops, shift registers, clusters.

**Unit IV**

**Interfacing with LABView (18 Hrs)**

Error handling, bundle/unbundle sub VI'S - I/O: reading and writing to files, paths, data taking, charting, graphing timing function, timed loops, event structures signal generation/processing, waveform types, dynamic data, Fourier analysis – connecting to hardware – DAQ, Serial, GPIB, TCP/IP and USB interface.

**Reference Books**


1. Introduction to Matlab, R.L. Spencer & M. Ware, Brigham Young University (2010).
2. Learning MATLAB, The Math Works, Inc (1999).
3. Digital Signal Processing Using Matlab, V.K. Lngle & J.G. Proakis, PWS Publishing Company (1997).
4. Digital Image Processing Using MATLAB, R.C. Gonzalez, R.E. Woods, & S. L. Eddins, Prentice-Hall (2003).
5. LabVIEW Basics I Course Manual, National Instruments Corporation.
6. Electronics with LabVIEW, Kenneth L. Ashley, Analog Pearson Education (2003).
7. Applications of Numerical Techniques with C, Suresh Chandra, Narosa (2006).

**PH4PB4 PRACTICALS - INFORMATICS ELECTIVE**

1. (a) Write and execute a program to find the summed average of two numbers using inheritance.

   (b). Write and execute a program to multiply two numbers using polymorphism.

2. (a). Create an Interface having two methods – division and modulus. Create a class which overrides these methods.

   (b). Write a program in java to display the names and register numbers of students. Initialize the respective array variables for 10 students. Handle ArrayIndexOutOfBounds Exception so that any such problem doesn't cause illegal termination of program.

3. (a) Write a program for generating two threads, one for printing even numbers and the other for printing odd numbers.

   (b). Write a program to read a statement from console, convert it into upper case and again print on console.

4. Write a program to introduce a 'text filed' and 'text area' activated by three buttons.

5. Write a java applet program which reads your name and address in different text fields and when a button named find is pressed the sum of the length of characters in name and address is displayed in another text field. Use appropriate colors and layout to make your applet look good.

6. Write and execute a program in Java to display an ordinary working calculator on the screen.

7. Write and execute an applet in java to display the applet with following conditions.

   (a). There should be a menu with options LINE,RECTANGLE, CIRCLE, ELLIPSE and EXIT.

   (b). If the option ELLIPSE is selected and if the mouse is clicked and dragged, an ellipse with varying size should be displayed on the screen.

   ( c). Suitable display should be generated when other options other than EXIT are selected.

   (d). When EXIT is selected the applet should exit from the screen.
8. Write and execute a program to display a round running clock.

**Linux experiments for getting an idea of Linux only. You can do more.**

9. Execute the following commands on your operating system and write down the results and use of each command.

   Man

   Cd

   ls, ls –a, ls -al

   cd. & cd..

   pwd

   ls –al | more

   cat passwd

   chmod

10. Try to explore the file system, write what is there in /bin, /user/bin, /sbin, /tmp, and /boot. Find and list the devices that are available in your system.
11. Make your own directories, subdirectories in the root.
12. Create a file using the vi editor. Copy this file to other directories. Change the permissions of your file.
13. Send a message to all the users.
14. Create a small text file and send it to another user.
15. Write a shell script to display a message on the screen.

16. Experiments using MATLAB/Python for physics applications

17. (a). Create a Web Page With appropriate content and insert an image towards the left hand side of the page. When the user clicks on the image it should open another web page.

    (b). Create a web page. When the user clicks on the link it should go to the bottom of the Page.

18. (a). Create a web page having two frames, one containing the links and when the links are clicked appropriate contents should be displayed in frame 2

    (b). Design a page with a text box called “name” and a button with label “enter”. When you click on the button another page should open, with the message “welcome<name>” where the name should be equal to the name entered in the first page.

19. Design a single page web site for a university containing a description of the courses offered. It should also contain some general information

about the university such as its history, the campus, and its unique features and so on. The site should be colored and each section should have a different color.

20. Make out a brief Bio – data of yours and code it as an HTML page. Use tables to show your academic history.
21. Create a web page showing your personal information using text boxes, radio buttons, check boxes, Select tag and Pull Down lists. The form should contain First name, Middle name, Last name, Date of Birth, Marital status, Gender, Pin code, Country, Education, Annual income, City, state, Occupation, Industry etc.
22. Create a web page having minimum of 4 pages with home page containing links to other pages. Use maximum number of tags in the program.
23. Use internet with various Browsers & search engines, create your own E-mail address, try browsing for your syllabus portions and practice all the uses of the internet.
24. (a). Write a Java Script code block using arrays and generate the current date in words. This should include the day, the month and the year.]

    (b). Write a java script code that converts the entered text into upper case.

    (c). Write a program to display the multiplication table.
25. (a). Write a Java script code to accept radius and display the area of the circle.

    (b). Write a code to create a Scrolling text in a text box.

    (c). Write a program to change the colour of a text randomly.
26. Using Java script create a digital clock.

27. Create an HTML form that inputs student details and when submitted display the same on the HTML page.

### 3.3.3 BUNCH - C: MATERIAL SCIENCE

**PH3EC1 SOLID STATE PHYSICS**

**Unit I**

**Crystals and Symmetry Properties (20 Hrs)**

Crystalline state – Anisotropy - Symmetry elements – Translational, Rotational, Reflection – Restrictions on Symmetry elements – Possible combinations of Rotational Symmetries- Crystal systems - 14 Bravais lattices.

Stereographic projection and point groups – principles – Constructions - Construction with the Wulff net - Macroscopic Symmetry elements- Orthorhombic system- Tetragonal system- Cubic system - Hexagonal system - Trigonal system - Monoclinic system- Triclinic system - Laue groups - Space groups.

**Unit II**

**Optical Properties and Crystal Lasers (16 Hrs)**

Lattice vacancies – diffusion – colour centres – F-centre and other centres in alkali halides – ionic conductivity – colour of crystals – excitons in molecular crystals – model of an ideal photoconductor – traps – space charge effects – experimental techniques – transit time excitation and emission Aicalf mechanism – model for thallium activated alkali halides - electroluminescence.

**Lasers:** Properties of laser beams - temporal coherence - spatial coherence – directionality – single mode operation - frequency stabilization - mode locking - Q-Switching - measurement of distance - Ruby laser - four-level solid state lasers - semiconductor lasers - Neodymium lasers (Nd:YAG, Nd:Glass) .

**Unit III**

**Semiconductor crystals (18 Hrs)**

Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration - impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions.

**Plasmons, Polaritons and Polarons:** Dielectric function of the electron gas – plasmons - electrostatic screening- **p**olaritons and the LST relation – electron - electron interaction - Fermi liquid - electron-phonon interaction - Polarons- Peierls instability of linear metals.

**Unit IV**

**Imperfections and Dislocations (18 Hrs)**

Types of imperfections in crystals - thermodynamic theory of atomic imperfections – experimental proof – diffusion mechanisms - atomic diffusion theory – experimental determination of diffusion constant – ionic conduction – shear strength of single crystals - slip and plastic deformations. Dislocations - Burgers vectors – edge and screw dislocations – motion of dislocation – climb - stress and strain fields of dislocation – forces acting on a dislocation – stress and strain fields of dislocation – forces acting on a dislocation – energy of dislocation – interaction – between dislocation densities – dislocation and crystal growth – Dislocation – Frank – Read mechanism - point defects - twinning.

**Reference Books**


1. Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley
2. Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI
3. Solid State Physics, A.J.Dekker, Macmillan, (1967).
4. Lasers Theory and Applications, K.Thyagarajan, A.K. Ghatak, Plenum Press
5. Lasers and Non-Linear Optics, B B Laud, New Age International.
6. Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.
7. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.
8. Solid State Physics,J.S. Blakemore, W.B.Saunders & Co. Philadelphia.
9. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole (1976).
10. Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.
11. A short course in Solid State Physics, Vol. I, F.C Auluck, Thomson Press ( INDIA) Ltd.
12. Crystalline Solids, Duncan McKie, Christine McKie, Wiley

**PH3EC2 CRYSTAL GROWTH TECHNIQUES**

**Unit I**

**Crystal Growth phenomena (18 Hrs)**

The historical development of crystal growth – significance of single crystals - crystal growth techniques - the chemical physics of crystal growth.

Theories of nucleation - Gibb's Thompson equation for vapour, melt and solution- energy of formation of spherical nucleus- heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory- The Muller- Krumbhaar model.

**Unit II**

**Crystal Growth from Melt and Solution Growth (18Hrs)**

Growth from the melt - the Bridgmann technique – crystal pulling - Czochralski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil flame fusion technique.

Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

**Unit III**

**Vapour Growth and Epitaxial Growth (18 Hrs)**

Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet.

Advantages of epitaxial growth, epitaxial techniques - liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, chemical beam epitaxy and atomic layer epitaxy

**Unit IV**

**Materials for Semiconductor Devices (18Hrs)**

Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quaternary alloys.

Semiconductor Devices - Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

**Reference Books:**


1. The Growth of Single Crystal, R.A. Laudise, Prentice Hall, NJ.
2. Crystal Growth: Principles and Progress , A.W. Vere, Plenum Press, NY.
3. Crystal Growth Processes and methods, P.S. Raghavan and P. Ramasamy, KRU Publications.
4. A Short course in Solid State Physics, Vol. I, F.C. Auluck, Thomson Press India Ltd.
5. Crystal Growth, B.R. Pamplin, Pergamon, (1980)
6. Crystal Growth in Gel, Heinz K Henish, Dover Publication

## PH4EC3 NANOSTRUCTURES AND CHARACTERIZATION

**Unit I**

**Low Dimensional Structures (18hrs)**

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications - infrared detectors - quantum dot lasers - superconductivity.

Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) –Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches.

**Unit II**

**Carbon Nanostructures (18hrs)**

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters -Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties - Mechanical Properties - Applications of Carbon Nano Tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials - Mechanical Properties – Nano structured Multi layers -Electrical Properties - Porous Silicon - Metal Nano cluster - Composite Glasses.

**Unit III**

**Thermal, Microscopic and Infrared Analysis (18 Hrs)**

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.

Microscopy – Electron microscopy – Principles and instrumentation – resolution limit – scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM. Atomic force microscope – Instrumentation.

IR spectrophotometers – Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy – Principles, Instrumentation and Applications. Microwave Spectroscopy -Instrumentation and Applications

**Unit IV**

**Mass Spectrometry, Resonance Spectroscopy (18 Hrs)**

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications.

NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR –Instrumentation - Interpretation of ESR spectra - Applications.

**Reference Books:**

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)

2. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).
3. Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya
4. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.
5. Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.
6. Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.
7. Instrumental methods of chemical analysis, G W Ewing, MGH
8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.


**PH4PC4 MATERIAL SCIENCE PRACTICALS**

1. Ultrasonic Interferometer – ultrasonic velocity in liquids
2. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
3. Determination of dielectric constant
4. Determination of forbidden energy gap
5. Determination of Stephan's constant

6. Determination of Fermi energy of copper
7. Study of ionic conductivity in KCl / NaCl crystals
8. Thermo emf of bulk samples of metals (aluminium or copper)
9. Study of physical properties of crystals (specific heat,thermal expansion,thermal conductivity,dielectric constant)
10. Study of variation of dielectric constant of a ferro electric material with temperature(barium titanate)
11. Study of variation of magnetic properties with composition of a ferrite specimen
12. Four probe method – energy gap
13. Energy gap of Ge or Si
14. Hall effect – Hall constant
15. Thin film coating by polimerisation
16. Measurement of thickness of a thin film
17. Study of dielectric properties of a thin film
18. Study of electrical properties of a thin film(sheet resistance)
19. Growth of single crystal from solution and the determination of its structural,electrical and optical properties (NaCl,KBr,KCl,$NH_4Cl$ etc.)
20. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal
21. Observation of dislocation – etch pit method
22. Michelson Interferometer – Thickness of transparent film
23. X-ray diffraction – lattice constant
24. Optical absorption coefficient of thin films by filterphotometry

25. Temperature measurement with sensor interfaced to a PC or a microprocessor
26. ESR spectrometer – g factor
27. Beam profile of diode laser
28. Track width of a CD using laser beam
29. He – Ne laser- verification of Malus law , measurement of Brewster angle,refractive index of a material

### 3.3.4 BUNCH - D: THEORETICAL PHYSICS

**PH3ED1 ASTROPHYSICS**

**Unit I**

**Basic Concepts in Astrophysics (18 Hrs)**

A brief history of the universe; big-bang hypothesis; the synthesis of helium; Gravitational contraction, free fall, hydrostatic equilibrium; equilibrium of a gas of non-relativistic particles; equilibrium of a gas of ultra-relativistic particles, equilibrium and the adiabatic index; star formation, conditions for gravitational collapse, contraction of a protostar, conditions for stardom; The Hertzsprung – Russell diagram, luminosity and surface temperature

**Unit II**

**Properties of Matter and Radiation (18 Hrs)**

Electrons in stars – degenerate electron gas, density-temperature diagram, electrons in massive stars; Photons in stars – The Photon gas, radiation pressure in stars, The Saha equation, ionization in stars, stellar interiors, stellar atmosphere.

**Unit III**

**Thermonuclear Fusion and Heat Transfer in Stars (18 hours)**

The physics of nuclear fusion, barrier penetration, fusion cross-section, thermonuclear reaction rates. Hydrogen burning- proton-proton chain, Carbon Nitrogen cycle, solar neutrinos. Helium burning, carbon production

Heat transfer by conduction by ions and electrons, radiation, convection.

**Unit IV**

**Stellar Structure and stellar evolution (18 hours)**

Simple stellar models; pressure, density and temperature inside stars; modeling the Sun, solar luminosity; minimum and maximum mass of stars.

White dwarfs- mass, central density and radius, collapse of a stellar core, the onset of collapse, nuclear photodisintegration, electron capture, the aftermath. Neutron stars- the size of neutron stars, gravitational binding energy of neutron stars, rotating neutron stars and pulsars, The maximum mass of neutron star; black holes.

**Text Book:**

1. The Physics of Stars, A.C Phillips, 2nd Edn. John Wiley & Sons Ltd. (Chapters I to VI)

**Reference Books**:

1. Stellar Interiors, Hansen and Kawler, Springer Verlag.
2. Astrophysics – Stars and Galaxies, K.D.Abyankar, Universities Presss.
3. Stars: their structure and evolution, R.J. Taylor, CambridgeUniversity Press.

4. Introduction to Modern Astrophysics, B.W. Carroll & D.A.Ostie, Addison Wesley.
5. A Course on Theoretical Astro physics, Vol. II, T. Padmanabhan, Cambridge Uni. Press.
6. AnIntroduction to Astrophysics, Baidyanath Basu, Prentice Hall India.

**PH3ED2 NONLINEAR DYNAMICS**

**Unit I**

**Basic Concepts (18 Hrs)**

What is Nonlinearity? Dynamical Systems: Linear and Nonlinear Systems- Linear Superposition Principle - Working Definition of Nonlinearity.

Linear and Nonlinear Oscillators - Linear Oscillators and Predictability - Damped and Driven Nonlinear Oscillators - Forced Oscillations – Primary Resonance and Jump Phenomenon (Hysteresis) Secondary Resonances (subharmonic and superharmonic) Nonlinear Oscillations and Bifurcations

**Unit II**

**Qualitative Features of non-linear systems (18 Hrs)**

Autonomous and Nonautonomous Systems - Dynamical Systems as Coupled First-Order

Differential Equations; Equilibrium Points ; Phase Space/Phase Plane and Phase Trajectories:

Stability, Attractors and Repellers ; Classification of Equilibrium Points: Two-Dimensional Case - General Criteria for Stability; Limit Cycle Motion – Periodic Attractor- Poincar´e–Bendixson Theorem.

Higher Dimensional Systems - Lorenz Equations ; More Complicated Attractors - Torus - Quasiperiodic Attractor - Poincar´e Map - Chaotic Attractor ; Dissipative and Conservative Systems -Hamiltonian Systems

**Unit III**

**Chaos in Dissipative Systems (18 Hrs)**

Bifurcations and Onset of Chaos in Dissipative Systems: Some Simple Bifurcations- Saddle- Node Bifurcation -The Pitchfork Bifurcation - Transcritical Bifurcation - Hopf Bifurcation ; Discrete Dynamical Systems ; The Logistic Map - Equilibrium Points and Their Stability - Periodic Solutions or Cycles -Period Doubling Phenomenon - Onset of Chaos – Lyapunov Exponent - Bifurcation Diagram - exact Solution at $a = 4$ - Logistic Map: A Geometric Construction of the Dynamics – Cobweb

Chaos in Dissipative Nonlinear Oscillators and Criteria for Chaos: Bifurcation Scenario in Duffing Oscillator - Period Doubling Route to Chaos - Intermittency Transition - Quasiperiodic Route to Chaos - Strange Nonchaotic Attractors (SNAs) ; Lorenz Equations - Period Doubling Bifurcations and Chaos ; Necessary Conditions for Occurrence of Chaos - Continuous Time Dynamical Systems -Discrete Time Systems

**Unit III**

**Chaos in Conservative Systems (18 Hrs)**

Poincar´e Cross Section ; Possible Orbits in Conservative Systems - Regular Trajectories - Irregular Trajectories - Canonical Perturbation Theory: Overlapping Resonances and Chaos; H´enon–Heiles System - Equilibrium Points - Poincar´e Surface of Section of the System - Numerical Results; Periodically Driven Undamped Duffing Oscillator ; The Standard Map -

Linear Stability and Invariant Curves - Numerical Analysis: Regular and Chaotic Motions; Kolmogorov–Arnold–Moser Theorem (qualitative ideas only).

Text Book

1. Nonlinear dynamics: integrability, chaos, and patterns, M. Lakshmanan & S. Rajasekar, Springer Verlag, (Chapters 1-5,7)

**Reference Books:**


1. Deterministic Chaos, N. Kumar, Universities Press.
2. Chaos and Nonlinear Dynamics, RC. Hilborn, Oxford University Press.
3. Chaotic Dynamics: An Introduction, G.L. Baker, and J.P. Gollub, CUP, 1993.
4. Deterministic Chaos, H.G. Schuster, Wiley, N.Y., 1995.
5. Chaos in Dynamical System, E. Ott, Cambridge University Press.
6. Encounters with Chaos, D. Gullick, MGH, 1992.
7. Introduction to Chaos and coherence, J. Froyland, IOP Publishing Ltd.
8. Nonlinear Dynamics and Chaos, J.M.T. Thomson& I. Stewart, John Wiley & Sons.

**PH4ED3 QUANTUM FIELD THEORY**

**Unit I**

**Path Integrals and Quantum Mechanics (18 Hrs)**

Review of single particle relativistic wave equations – Klein- Gordon equation, Dirac equation, Maxwell and Proca equations; Path integral formulation of quantum mechanics; perturbation theory and the S matrix; Coulomb scattering; Functional calculus: differentiation, generating functional for scalar fields. Functional integration

**Unit II**

**Path Integral Quantization of Scalar and Spinor Fields (18 Hrs)**

Free particle Green's functions, Generating functional for interacting field; φ^4 theory – generating functional, 2-point function, 4-point function; generating functional for connected diagrams; fermions and functional methods, The S – matrix and reduction formula, pion-nucleon scattering amplitude, scattering cross-section

**Unit III**

**Path Integral Quantization of Gauge Field Fields (18 Hrs)**

Propagators and gauge conditions in QED; Non-abelian gauge fields and Faddeev - Popov method; Self-energy operator and vertex functions; Ward – Takahashi identities in QED, Becchi – Rouet – Stora transformations; Slavnov – Taylor identities.

**Unit IV**

**The Weinberg – Salam Model (18 hours)**

Field theory vacuum; the Goldstone theorem; Spontaneous symmetry breaking of gauge symmetries; superconductivity; Higgs boson; The Weinberg – Salam model; Experimental confirmation of the models

Text Book

1. Quantum Field Theory, Lewis H. Ryder, 2nd Edn, Cambridge University Press,(1996), (Chapters 5, 6, 7, 8.),

**PH4PD4 SPECIAL COMPTATIONAL PRACTICALS**

(The experiments are to be done on the PC by developing the required algorithm and program including graphical displays. Students may use C++ or Python.)

1. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance
2. Phase space trajectories of a pendulum- with and without damping.
3. Phase space trajectories of a pendulum – with non-linear term.
4. Trajectory of a particle moving in a Coulomb field (Rutherford scattering) and to determine the deflection angle as a function of the impact parameter
5. Trajectory of a ion in the combined Coulomb and nuclear potential and determine the angle of scattering for different impact parameters
6. Simulation of the wave function for a particle in a box - To plot the wave function and probability density; Schrödinger equation to be solved and eigen value calculated numerically.

7. Iterates of the logistic map.
8. Bifurcation diagram for the logistic map.
9. Calculation and plotting of the Lyapunov exponents.
10. Plotting of Julia set.
11. Plotting of Mandelbrot set.
12. Creating a fractal by Iteration Function Scheme

**Reference Books:**

1. Computational Physics- RC Verma, P.K. Ahluwalia & K.C. Sharma- New Age.
2. Chaos & Fractals- Peitgen, Jurgens & Saupe – Springer.

## 3.4 OPTIONAL ELECTIVE BUNCH

### PH4OE1: OPTOELECTRONICS

**Unit I**

**Semiconductor Science and Light Emitting Diodes (10 hrs)**

Semiconductor energy bands - semiconductor statistics – extrinsic semiconductors – compensation doping – degenerate and non degenerate semiconductors – energy band diagrams in applied field - direct and indirect bandgap semiconductors, - p-n junction principles - open circuit- forward and reverse bias – depletion layer capacitance – recombination life time – p-n junction band diagram - open circuit - forward and reverse bias – light emitting diodes – principles - device structures - LED materials, heterojunction high intensity LEDs – double heterostructure - LED characteristics and LEDs for optical fiber communications - surface and edge emitting LEDs.

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson 2009, (Chapter 3)

**Fiber Optics (10 Hrs)**

Symmetric planar dielectric slab waveguide – waveguide condition – single and multimode waveguides – TE and TM modes – modal and waveguide dispersion in the planar waveguide – dispersion diagram – intermodal dispersion – intramodal dispersion – dispersion in single mode fibers – material dispersion – waveguide dispersion – chromatic dispersion – profile and polarization dispersion – dispersion flattened fibers - bit rate and dispersion – optical and electrical bandwidth – graded index optical fiber - light absorption and scattering – attenuation in optical fibers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 2)

**Unit II**

**Laser Principles (10 hrs)**

Laser oscillation conditions - diode laser principles - heterostructure laser diode – double heterostructure – stripe geometry – buried heterostructure – gain and index guiding - laser diode characteristics – laser diode equation - single frequency solid state lasers – distributed feedback –quantum well lasers - vertical cavity surface emitting laser - optical laser amplifiers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 4)

**Laser Output Control (6 hrs)**

Generation of high power pulses, Q-factor, Q-switching for giant pulses, methods of Q-switching, mode locking and techniques for mode locking.

Text Book:

1. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. (2009), (Chapter 13)

**Unit III**

**Photodetectors and Photovoltaics (18 hrs)**

Principle of p-n junction photodiode - Ramo's theorem and external photocurrent - absorption coefficient and photodiode materials - quantum efficiency and responsivity - PIN-photodiode – avalanche photodiode – phototransistor - photoconductive detectors and photoconductive gain - noise in photo-detectors – noise in avalanche photodiode - solar energy spectrum - photovoltaic device principles – I-V characteristics - series resistance and equivalent circuit - temperature effects - solar cell materials, device and efficiencies

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 5 & 6)

**Unit IV**

**Optoelectronic Modulators (10 Hrs)**

Optical polarization, birefringence, retardation plates, electro-optic modulators – Pockels effect - longitudinal and transverse electro-optic modulators, Kerr effect, Magneto-optic effect, acousto-optic effect – Raman Nath and Bragg-types.

Text Books:

1. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press, (2004), (Chapter 9 )
2. Optoelectronics: an Introduction, J. Wilson and J.F.B. Hawkes, PHI, (2000), (Chapter 3)

**Non-linear optics(8 Hrs)**

Wave propagation in an anisotropic crystal - polarization response of materials to light - second order non-linear optical processes - second harmonic generation - sum and frequency generation, optical parametric oscillation - third order non-linear optical processes - third harmonic generation - intensity dependent refractive index - self-focusing - non-linear optical materials, phase matching - angle tuning - saturable absorption - optical bistability - two photon absorption.

Text Book:

1. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. 2009, (Chapter 16)

**Reference Books:**

1. Semiconductor optoelectronic devices: Pallab Bhattacharya, Pearson(2008)
2. Optoelectronics: An introduction to materials and devices, Jasprit Singh, Mc Graw Hill International Edn., (1996).
3. Optical waves in crystals: Propagation and Control of Laser Radiation, A. Yariv and P. Yeh, John Wiley and Sons Pub. (2003)

## PH4OE2 SOFTWARE ENGINEERING AND WEB DESIGN

**Unit I**

**Software Engineering (18 Hrs)**

Introduction to Software Engineering – Software development and Life cycle – Project Size and its categories – Planning a Software Project – Project Control – Project team standards-Design of solution strategies-Software cost estimation and evaluation techniques-Software design-design concepts and notations-Modern design techniques- Verification and validation methods-Documentation and implementation procedures-Performance of software systems.

**Unit II**

**The HTML (18 Hrs)**

What is HTML?- Basic Tags of HTML – HTML – TITLE - BODY

Starting an HTML document – The <!DOCTYPE>declaration - setting boundaries with <HTML> - the HEAD element - the BODY element - the STYLE element and the SCRIPT element.

Formatting of text – Headers-Formatting Tags - PRE tag - FONT tag - Special Characters. Working with Images - META tag - Links – Anchor Tag.

Lists – Unordered Lists-Ordered Lists-Definition Lists

Tables – TABLE, TR and TD Tags-Cell Spacing and Cell Padding- Colspan and Rowspan

Frames – Frameset-FRAME Tag-NOFRAMES Tag

**Unit III**

**The HTML (18 Hrs)**

Forms – FORM and INPUT Tag - Text Box - Radio Button-Checkbox - SELECT Tag and Pull Down Lists - Hidden-Submit and Reset.

Some Special Tags – COLGROUP-THREAD, TBODY – TFOOT – blank - self, parent – top –IRFRAME – LABEL - Attribute for <SELECT> - TEXTAREA

Style sheets

Introduction to scripting and HTML – purpose of scripting – JavaScript – VB Script – including scripts in an HTML document

**Unit IV**

**JAVASCRIPT (18Hrs)**

JavaScript Variables and Data Types – Declaring Variables-Data Types

Statements and Operators

Control Structures – Conditional Statements-Loop Statements

Object Based Programming – Functions-Executing Deferred Scripts-Objects

Message Box in JavaScript – Dialog Boxes-Alert Boxes-Confirm Boxes-Prompt Boxes

JavaScript with HTML – Events-Event Handlers

Forms – Forms Array – form validation

Ideas about Dreamweaver or Microsoft Publisher

Text Books

1. Software Engineering, R.S. Pressman, McGraw Hill
2. Software Engineering Concepts, R.E. Fairley, McGraw Hill

3. HTML4, $2^{nd}$ Edn. Rick Darnell, Techmedia
4. HTML, The Complete Reference, Tata Mc Graw Hill
5. JavaScript Programmers Reference, Cliff Wootton, Wrox Press Inc.
6. Beginning JavaScrpit, Paul Wilton, Wrox Press Inc. $1^{st}$ Edn.

**Reference Books**


**1.** Software Engineering – A Practitioner's Approach, R.S. Pressman, MGH

2. Software Engineering, Ian Sommerville, $6^{th}$ Edn. Pearson (2001)
3. Mastering HTML4 – Ray D.S. and Ray E.J. – BPB
4. The JavaScript Bible, Danny Goodman, John Wiley & Sons Inc.


## PH4OE3 THIN FILM AND NANO SCIENCE

**Unit I**

**Thin Film (18 Hrs)**

Nucleation – Langmuir theory of condensation – Theories of nucleation – Liquid like coalescence and growth process – Epitaxial growth – Structural defects in thin films – Electrical conduction in metallic, semiconducting and insulator films. Optical properties of thin films.

**Unit II**

**Deposition of Films (18 Hrs)**

Production of Vacuum, Different types of vacuum pumps, Measurement of Vacuum Gauges, Working principle, Deposition of thin films, Various deposition techniques, Thickness measurement – optical methods, thickness monitors - Thin film applications.

**Unit III**

**Nano materials and Applications (18 hours)**

Nano structured Crystals -Natural Nano crystals -Crystals of Metal-Nano particles –Nano particle Lattices in Colloidal Suspensions -Photonic Crystals.

Synthesis and purification of carbon nanotubes, Single-walled carbon nanotubes and multiwalled carbon nanotubes, Structure-property relationships, physical properties, applications.

Overview of different nano materials available, Potential uses of nano materials in electronics, robotics, computers, sensors in textiles, sports equipment, mobile electronic devices, vehicles and transportation. Medical applications of nano materials.

**Unit IV**

**Synthesis of Nano materials (18hrs)**

Top-down techniques: photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, focused ion beam, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled mono layers, directed assembly, layer-by-layer assembly. Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

Pattern replication techniques: soft lithography, nano imprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly).

**Reference Books:**


1. Thin film phenomena, K.L Chopra, McGraw Hill, New York
2. Thin film fundamentals, A. Goswami, New Age International
3. Vacuumm deposition of Thin films, L. Holland, Chapman Hall, London
4. Handbook of thin film Technology, L.I Maissel and R. Glang, McGraw Hill
5. Optical Properties of Thin Films, O. S. Heaven, Dover Publications
6. Nano: the essentials, T. Pradeep, TMH, 2007
7. Nanoscale Materials, L.M. Liz-Marzán & P.V. Kamat, Kluwer Academic Pub. (2003)
8. Nanoscience, Nanotechnologies and Nanophysics, C. Dupas, P. Houdy & M. Lahmani, Springer-Verlag , (2007).
9. Nanotechnology 101, John Mongillo, Greenwood Press, (2007).
10. What is What in the Nanoworld A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, (2008).

11. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley
12. Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, ARTECH HOUSE, (2004).
13. Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto, K. Kaneto, S. Mashiko Elsevier Science, Elsevier Science, (2003).
14. Semiconductors for Micro and Nanotechnology—An Introduction for Engineers Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag, (2002).

## PH4OE4 GENERAL RELATIVITY AND COSMOLOGY

**Unit I**

**Basic Concepts in relativity and tensor analysis (18 Hrs)**

**Overview of special relativity** - Principles of special relativity - Line interval, Proper time, Lorentz transformation, Minkowski spacetime, Lightcones, Relativistic momentum 4-vectors, Lorentz transformation of electromagnetic field

**Conceptual foundations of GR and curved spacetime** - Principle of equivalence, Connection between gravity and geometry, Form of metric in Newtonian limit, Metric tensor and its properties, Concept of curved spaces and spacetimes, Tangent space and four vectors, Tensor algebra, Tensor calculus, Covariant differentiation, Parallel transport, Riemann curvature tensor Geodesics, Particle trajectories in gravitational field

**Unit II**

**Einstein's field equations (18 Hrs)**

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

**Unit III**

**Applications of General Relativity (18 Hrs)**

Gravitational waves - Wave equation in linearised theory, Plane waves, Transverse traceless gauge, Effect on test particles, Principles of detection and generation of gravitational waves

Types of detectors, Landau-Lifshitz formula, Hulse Taylor binary pulsar

Models of the universe - Friedmann-Robertson-Walker models, Hubble's law, Angular size

Source counts, Cosmological constant, Horizons

## Unit IV

**Big Bang model (18 Hrs)**

Relics of the big bang - The early universe, Thermodynamics of the early universe, Primordial neutrinos, Helium synthesis and other nuclei, Microwave background

**Formation of large scale structure** - Jeans mass in the expanding universe, Growth in the postrecombination era, Observational constraints, Elementary ideas on structure formation

**Observations of the cosmological significance** - Measurement of Hubble's constant, Anisotropy of large-scale velocity fields, Age of the universe, Abundance of light nuclei, Dark matter, Microwave background, Gravitational wave stochastic background.

**Text Books:**


1. First course in general relativity, B. F. Schutz Cambridge: Cambridge University Press.
2. General Relativity and Cosmology, J. V. Narlikar Delhi: Macmillan Company of India Ltd.
3. General Relativity, I. R. Kenyon, Oxford University Press.
4. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press.
5. Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press.

## CHAPTER – IV

## 4. PARALLEL PGCSS PHYSICS PROGRAMMES

### 4.1 Introduction:

In this chapter, three parallel PGCSS programmes coming under the umbrala subject physics are presented. These three PG Programmes are taught in three colleges affiliated to M.G.University. The colleges and the respective PG Prograames are given in Table 4.1. The number of hours per week, number of credit per course and the total hours per semester allocated to a course in these parallel PGCSS programmes will remain same as those for M.Sc. Physics programme as described in Chapter – I. These programmes have 12 Core corses and 4 Elective courses each. There will not be any open elective bunch for these programs. The four Elective courses are accommodated two each in Semester III and Semester IV.

| Sl. No. | Name of college | PGCSS Programme |
|---|---|---|
| 1 | C.M.S. College, Kottayam | M.Sc. Applied Physics |
| 2 | S. B. College, Changanassery | M.Sc. Renewable Energy |
| 3 | Catholicate College, Pathanamthitta | M.Sc. Material Science |

*Table 4.1 Colleges and parallel PGCSS Programmes*

The examination pattern and question paper modal remain the same as that described in Chapter –II. The mode of conduct of these programmes are required to follow the rules depicted in Chapter – II. The changes are only in the Course Codes and Course Titles. These are given in the repective Tables.

| SEM | Name of the course with course code | No. of Hrs/ week | No. of credit | Total Hrs/ SEM |
|---|---|---|---|---|
| I | **AP1C01:** Applied Mathematics- I | 4 | 4 | 72 |
| I | **AP1C02**: Thermal and Statistical Physics | 4 | 4 | 72 |
| I | **AP1C03**: Solid State Physics | 4 | 4 | 72 |
| I | **AP1C04**: Classical Mechanics and Nonlinear Dynamics | 4 | 4 | 72 |
| I | **AP1P01**: General Physics Practicals | 9 | 3 | 162 |
| II | **AP2C05**: Applied Mathematics- II | 4 | 4 | 72 |
| II | **AP2C06**: Electronics and Communication | 4 | 4 | 72 |
| II | **AP2C07**: Spectroscopy | 4 | 4 | 72 |
| II | **AP2C08**: Quantum Mechanics- I | 4 | 4 | 72 |
| II | **AP2P02**: Electronics Practicals | 9 | 3 | 162 |
| III | **AP3C09**: Electromagnetic Theory | 4 | 4 | 72 |
| III | **AP3C10**: Quantum Mechanics - II | 4 | 4 | 72 |
| III | **AP3E01**: Photonics - I | 4 | 4 | 72 |
| III | **AP3E02**: Laser Physics | 4 | 4 | 72 |
| III | **AP3P03**: Computational Physics Practicals | 9 | 3 | 162 |
| IV | **AP4C11**: Nuclear Physics and Astrophysics | 4 | 4 | 72 |
| IV | **AP4C12**: Computational Physics | 4 | 4 | 72 |
| IV | **AP4E03:** Photonics - II | 4 | 4 | 72 |
| IV | **AP4E04:** Fibre Optics | 4 | 4 | 72 |
| IV | **AP4P04:** Photonics Practicals | 9 | 3 | 162 |
| IV | **AP4D05**: Project/Dissertation | Nil | 2 | Nil |
| IV | **AP4V06**: Viva Voce | Nil | 2 | Nil |

*Table 4.1 Course and course code of M.Sc. Applied Physics*

## 4.2 M.Sc. APPLIED PHYSICS

### 4.2.1 Course Code

The first two letters AP stand for Applied Physics, and the letters C, P, E, D and V have the usual meaning. Here the core courses are numbered from 01 to 12. Elective courses are numberd from 01 to 04 and laboratory Practicals are numbered from 01 to 04 as done in general M.Sc. Physics.

## SEMESTER – I

### AP1C01 APPLIED MATHEMATICS – I

**Unit I**

**Functions of a complex variable (18 hrs)**

Functions of a complex variable - Analytic functions – Cauchy–Reimann equations - Laplaces equations - Cauchy's Integral Theorem - Cauchy's theorem for multiply connected domains - Cauchy's integral formula - Derivatives of analytic functions - Taylor & Laurent expansion - Singularities-poles and zeros - Residue theorem - Evaluation of definite integrals-Jordan's lemma - Cauchy principal value.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber, Academic Press

**Unit II**

**Linear Algebra: Matrices (12 hrs)**

Linear system of equations-Gauss elimination method - Product theorem-Direct product -Diagonal matrices - Trace - Matrix inversion:Gauss-Jordan matrix inversion - Orthogonal matrices - Euler angles-Complex matrices:Hermition, Skew-Hermition,Unitary - Pauli matrices - Symmetry properties & similarity transformation:Orthogonal & Unitary-Eigen vectors & eigen values - Cayley Hamilton theorem - Diagonalization of matrices:normalized eigen vectors - Normal modes of vibration.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber, Academic Press

**Probability (6 hrs)**

Laws of probability – Random variables – Binomial - Poisson and Gauss's normal distributions.

Text Book:

1. Mathematical Physics, P.K Chattopadhyay, New Age International.

**Unit III**

**Vector Calculus (18 hrs)**

Differential Calculus: Gradient, Divergence, Curl - Successive applications of grad - Integral calculus: line, surface & volume integrals - Fundamental theorem for gradients, divergences and curls - Equation of continuity - Potential theory - Gauss's law and Poissons equation

Orthogonal curvilinear coordinates: Spherical & Cylindrical - Differential vector operators in orthogonal coordinates - Dirac delta function - its properties and integral forms

Linear vector spaces - Self adjoint, unitary & projection operators - Eigen values & Eigen vectors of self adjoint operators-inner product space-Schimdt orthogonalisation - Hilbert space -Schwartz inequality.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber, Academic Press

**Unit IV**

**Fourier Analysis: Fourier series, Integrals & Transforms (18 hrs)**

Periodic functions - Fourier series:Functions of period 2π & functions for any period - Even and Odd functions - Half range expansions - Fourier integrals - Fourier transform - Cosine and Sine transform - Square wave – Gaussian - full wave rectifier - finite wave train - Linearity theorem -Fourier transform of derivatives - Convolution theorem - Parseval's theorem - Momentum representation - Harmonic oscillator - ground state of hydrogen atom.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber, Academic Press

**Laplace Transforms**

Laplace transform - Inverse Laplace transform - Partial fraction expansion - Heavyside expansion formula - Linearity - first shifting theorem - Laplace transform of derivatives & integrals - applications to simple differential equations - Earth's nutation-LCR circuit - wave equation in a dispersive medium-second shifting theorem - Differentiation and integration of transforms - convolution theorem.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber, Academic Press

**References Books:**


1. Advanced Engineering Mathematics, C.R. Wylie - Tata McGraw Hill.
2. Advanced Mathematics for Engineers & Scientists- Schaum's outline M.R. Spiegel Tata McGraw Hill.
3. Vector Analysis, Schaum's outline M.R. Spiegel Tata McGrawhill.
4. Complex variables - Schaum's outline M.$. Spiegel Tata McGraw Hill.
5. Introduction to Mathematical Physics, Charlie Harper, PHI.
6. Mathematical Physics, P.K. Chattopadhyay, New Age International.
7. Mathematical methods for Physics and Engineering, K.F. Riley, M.P. Hobson & S.J Bence, Cambridge University Press.
8. Advanced Engineering Mathematics, Eewin Kreyzing, John Wiley & Sons.
9. Matrices and Tensors, A.W. Joshi, Wiley
10. Probability-Schaum's outlinees-Seymour Lipschutz & Marc Lipson.


## AP1C02 THERMAL AND STATISTICAL PHYSICS

### Unit I

### Thermodynamics and Statistical Theory (18 hrs)

Basic ideas about heat, temperature, work done - Laws of thermodynamics & their consequences - T S diagrams & equations-Physical significance of entropy - Claussius Clapeyron equation - Thermodynamic potentials -

Maxwell's relations. Micro and Macrostates -Thermodynamic probability - Phase Space - Concept of Entropy and Thermodynamic probability - Microcanonical, Canonical & Grand Canonical ensembles.

Text Book:

1. Heat Thermodynamics, M.W. Zeemansky, Tata McGraw Hill (1997).
2. Thermodynamics & Statistical Mechanics-Brijlal and Subrahmanyam, S. Chand & Co.

**Unit II**

**Classical and Quantum Statistical Mechanics (20 hrs)**

Classical Statistical Mechanics: Classical Statistical Mechanics - Thermodynamics of an ideal monatomic gas - Gibb's Paradox - Partition function - Canonical and grand canonical partition function - Translational, rotational & vibrational partition functions - electronic & nuclear partitionfunctions - homonuclear molecules.

Quantum Statistical Mechanics: Need of quantum statistics - Symmetry of wave functions-Bosons - Fermions - Pauli's exclusion principle - BE & FD Distribution. Density matrix -Equation of motion of the density matrix - ensembles in quantum statistical mechanics -Calculation of Partition functions.

Text Book:

1. Statistical Mechanics, R. K. Pathria, Butterworth-Heinemann

**Unit III**

**Ideal Bose and Fermi gases (16 hrs)**

Ideal Fermi gas-Equation of state of an ideal Fermi gas - High & Low temperature limits - electron gas at absolute zero-degeneracy - free electron model. Ideal Bose gas - Equation of state - Photons – Black body radiation & Planck's distribution law – Phonons - BE Condensation - Liquid Helium - Lambda transition

Text Book:

1. Statistical Mechanics, R. K. Pathria, Butterworth-Heinemann

**Unit IV**

**Fluctuations & Phase transitions (18 hrs)**

Energy fluctuations in canonical ensembles - Density fluctuations in grand canonical ensembles - Fluctuations in quantum statistics - One dimensional random walk problem-Brownian motion and random walk - Correlation function - Weiner-Khintchine theorem - Fokker Planck equation. First & second order phase transitions - Critical exponents - Scaling hypothesis - Ising model.

Text Book:

1. Statistical Mechanics, R. K. Pathria, Butterworth-Heinemann

**References Books:**

1. Statistical Mechanics, Kerson Huang, Wiley Eastern.
2. Introductory Statistical Mechanics,R. Bowley and M. Sanchez, Oxford University Press
3. Statistical Mechanics, B. K. Agarwal & M. Eisner, New Age Int.Pub.1998.
4. Fundamentals of Statistical Mechanics, B. B. Laud, New Age Int.Pub.1998.
5. Thermodynamics, M.W. Zeemansky, Tata McGraw Hill (1997).

6. Thermodynamics and Statistical Mechanics, W.G. Greiner, Neise and Stoker, Springer
7. Phase Transitions and Critical Phenomena, H. E. Stanley, Oxford Univ. Press.

**AP1C03 SOLID STATE PHYSICS**

**Unit I**

**Crystal Structure (8 hrs)**

Crystal structure fundamentals - Bragg law - reciprocal lattice vectors Van Laue formulation of x-ray diffraction by crystals - Equivalence of the Bragg and von Laue formulations. Ewald construction – Brilliouin zones – reciprocal lattice to SC, BCC and FCC lattices - the geometrical structure factor-structure factor of BCC and FCC lattices - the atomic form factor.

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Lattice Vibrations (10 hrs)**

Vibrations of monoatomic lattices-lattice with two atoms per primitive cell - quantization of lattice vibrations - phonon momentum.

Lattice heat capacity - Einstein model - density of modes - Debye model - Anharmonic crystal interactions - thermal expansion - thermal conductivity - thermal resistivity - umklapp processes - second sound.

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Unit II**

**Free Electron Theory (9 hrs)**

Drude - Lorentz theory of metals (quantitative idea) - Fermi–Dirac distribution - Sommerfield theory – Free electron gas in one and three dimensions - Heat capacity of the electron gas – electrical conductivity and Ohm's law - experimental electrical resistivity of metals. Motion in magnetic fields. Hall Effect – thermal conductivity of metals - The Wiedmann-Franz law.

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Energy Bands (11 hrs)**

Nearly free electron model-origin of energy gap - Bloch functions - Kronig-Penny model - Wave equation of electron in a periodic potential - solution of the central equation – approximate solution near a zone boundary - number of orbitals in a band – Metal insulators and semiconductors. Brilliouin zone in one and two dimensions – extended - reduced and periodic zone schemes - representations

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Unit III**

**Magnetic Properties (10 hrs)**

Vibrations of monoatomic lattices-lattice with two atoms per primitive cell - quantization of lattice vibrations - phonon momentum.

Lattice heat capacity - Einstein model - density of modes - Debye model - Anharmonic crystal interactions - thermal expansion - thermal conductivity - thermal resistivity - umklapp processes - second sound.

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Unit II**

**Free Electron Theory (9 hrs)**

Drude - Lorentz theory of metals (quantitative idea) - Fermi–Dirac distribution - Sommerfield theory – Free electron gas in one and three dimensions - Heat capacity of the electron gas – electrical conductivity and Ohm's law - experimental electrical resistivity of metals. Motion in magnetic fields. Hall Effect – thermal conductivity of metals - The Wiedmann-Franz law.

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Energy Bands (11 hrs)**

Nearly free electron model-origin of energy gap - Bloch functions - Kronig-Penny model - Wave equation of electron in a periodic potential - solution of the central equation – approximate solution near a zone boundary - number of orbitals in a band – Metal insulators and semiconductors. Brilliouin zone in one and two dimensions – extended - reduced and periodic zone schemes - representations

Text Book:

1 Introduction to solid state physics, C. Kittel, Wiley India Pub.

**Unit III**

**Magnetic Properties (10 hrs)**

Langevin diamagnetism equation-quantum theory of paramagenetism - Hund rules - Cooling by adiabatic demagnetization of a paramagnetic salt.

Ferromagnetic order-Curie point and exchange integral. Antiferromagnetic order - Susceptibility below Neel temperature-Ferrimagnetisms and ferrites. Ferromagnetic domains.

Text Book:

1. Introduction to solid state physics, C. Kittel, Wiley India Pub.
2. Solid State Physics Structure and properties of materials, M.A. Wahab Narosa Pub. House (2010).

**Dielectric Properties (8 hrs)**

Dielectrics - Local electric field at an atom - dielectric constant and polarizability (Clausius-Mossotti relation) - electronic polarizability - Ferroeelctric crystals - Polarization catastrophe - Landau theory of phase transition - ferroelectric domains - antiferroelectricity.

Text Books:

1. Introduction to solid state physics, C. Kittel, Wiley India Pub.
2. Solid State Physics Structure and properties of materials, M. A. Wahab Narosa Pub. House (2010).

**Unit IV**

**Superconductivity (16 hrs)**

Superconductivity - Meissner effect - energy gap - isotope effect - type I, type II superconductors - thermodynamics of superconducting transition - London equation - BCS theory - dc and ac Josephson effects - Flux quantization – High Te superconductivity- applications.

Text Books:

1. Introduction to solid state physics, C. Kittel, Wiley India Pub.
2. Solid State Physics Structure and properties of materials, M. A. Wahab Narosa Pub. House (2010).

**Reference Books:**

1. Solid State Physics, N.W. Ashcroft and N D Mermin, Cengage Learning Pub(2011).
2. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd.(1967).
3. Elementary Solid State Physics, M. Ali Omar, Pearson Edu. Pub.(2004).
4. Elements of Solid State Physics, J. P. Srivastava, PHI (2004).
5. Solid State Physics, S .O. Pillai, New Age Int. Publishers (2010).
6. Solid State Physics, C. M. Kachava, TMH (1990).
7. Solid State Physics, R. L. Singhal, Kedar Nath Ram Nath & Co. (1981).

**AP1C04 CLASSICAL MECHANICS AND NONLINEAR DYNAMICS**

**Unit I**

**Rigid Body Dynamics (12 hrs)**

Independent coordinates - Orthogonal transformation - inertia tensor - Euler's equations, force free motion of a rigid body - cases of symmetrical top, heavy Symmetrical top, fast top, Sleeping top, Precession of charged bodies in magnetic field, Infinitesimal rotation, Coriolis force and its effects

**Theory of Oscillations (6 hrs)**

Formulation of the problem – Eigen value equation - Coupled Oscillators – Normal coordinates, Oscillations of linear triatomic molecules - monoatomic chain lattice – diatomic chain lattice

Text Books:

1. 1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.
2. Classical Mechanics, J. C. Upadhyaya, Himalaya Pub. House.

**Unit II**

**Hamiltonian Methods (18 hrs)**

Critical review of Newtonian , Lagrangian and Hamiltonian approaches- application of Lagrange's equations to velocity dependent potentials - Hamiltonian equations of motion - Cyclic coordinates conservation theorems - Homogeneity of space and time –Action for an arbitrary motion, Physical significance of principal of least action, canonical transformations - Poisson brackets - Hamilonian's characteristic function, Hamilton-Jacobi theory -

Harmonic oscillator problem - Action Angle variables – Transition to wave mechanics

Text Books:

1. 1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.
2. Classical Mechanics, J. C. Upadhyaya, Himalaya Pub. House.

**Unit III**

Lagrangian formulation for continuous systems – Sound variations in gas – Hamiltonian formulation for continuous systems - Description of fields

Principle of equivalence - Principle of General Covariance - Equation of motion of a particle in a weak gravitational field – Time dilation in gravitational field and gravitational red shift energy - momentum tensor and Einstein field equations.

Text Books:

1. 1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.
2. Theory of relativity, R.K Pathria, Dover Pub. Inc. NY.

**Unit IV**

**Classical Perturbation theory (10hrs)**

Classical perturbation theory- Time dependent perturbation-Illustration-Case of simple pendulum with finite amplitudes-Kepler problem and precession of the equinoxes of satellite orbits-Time dependent perturbation First order with one degree of freedom

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.

**Non-linear dynamical system (8 hrs)**

Classification of dynamical systems-conservation systems- Integrable systems- Non-linear perturbation-KAM theorem(qualitative) Hamiltonian chaos –Dissipative systems –Continuous systems-Duffing oscillator discrete system logistic map intermittency –crisis –atractors limit cycles –chaotic attractors.

Text Books:

1. Deterministic Chaos, N. Kumar, University press 1996
2. Chaos and Integrebility in Nonlinear Dynamics, M. Tabor, John Wiley & Sons

**Reference Books:**

1. Classical Mechanics, N. C. Rana and P. S. Joag Tata McGraw Hill.
2. Classical Mechanics,A. K. Raychauduri, Oxford Uni. Press.
3. Dynamics, S. N. Rasband, John Wiley.
4. Introduction to Dynamics, I. Percival and D. Richard, Cambridge University Press.
5. Langrangian and Hamiltonian Mechanics, Calkin M. G. Allied Pub. Ltd.
6. Chaos in Classical and Quantum Mechanics, Gutzwiller, Springer
7. Chaotic Dynamics- an Introduction, G. L. Baker and J. P. Gollub, Cambridge University Press

8. Introduction to General Relativity, R. Addler, M. Bazim, M. Schiffer, MGH.
9. Gravitation and Cosmology: Principle and Applications of General Theory of Relativity, S. Weinberg, John Wiley & Sons

## AP1P01 GENERAL PHYSICS PRACTICALS

1. Y, n, σ – Cornu's method (i) Elliptical fringes (ii) Hyperbolic fringes
2. Absorption spectrum of KMnO4 solution and Iodine vapour
3. Arc spectra (i) iron (ii) copper (iii) brass
4. Arc spectrum – Identification of elements of an alloy
5. Hall effect (i) carrier concentration (ii) mobility (iii) Hall coefficient
6. Resistivity of (i) Ge (ii) Si at various temperatures by Four Probe Method and determination of band gap
7. Band gap energy of (i) Ge (ii) Si
8. Ultrasonics
9. Oscillating disc – Viscosity of a liquid
10. e/m – Thomson's method
11. Charge of electron – Millikan's experiment
12. Determination of e/k using diode
13. Study of absorption spectrum – Hartman's method

## SEMESTER - II

**AP2C05 APPLIED MATHEMATICS – II**

**Unit I**

**Differential Equations & Special Functions (18 hrs)**

Gamma and Beta functions-Different forms-evaluation of standard integrals Bessel differential equation- series solution- the Bessel function of first kind and the second kind- generating function for Bessel functions- Recurrence relations, Legedre differential equation- series solution-Legendre polynomials- generating function for the Legendre polynomials- Recurrence formula- Orthogonality of Legendre polynomials- Rodrigues formula for Legendre polynomials- Spherical harmonics

Hermite differential equations – series solution- Hermite polynomial- Recurrence relation- generating function- orthogonality property of Hermite polynomial – Quantum mechanical harmonic oscillator-Leguerre differential equation- Associated Leguerre polynomials

Text Book:

1. Mathematical Physics, B. D. Gupta, Vikas Publishing House, New Delhi

**Unit II**

**Tensor Analysis (18 hrs)**

Tensors-co-ordinate transformations-contravariant,covariant and mixed tensors-Einstien summation convention-symmetric & skew-symmetric tensors-fundamental operation with tensors-contraction & Direct product-Quotient rule-Levi-civita symbol-Dual tensors-Christoffel symbols & their transformation laws-covariant differentiation-tensor form of gradient,divergence curl & Laplacian-Geodesic equation.

Text Book:

1. Mathematical method for physics, G. B. Arfken & H. J. Weber.

**Unit III**

**Group Theory (18 hrs)**

Introduction to group theory-Definition of group-cyclic groups-point groups-homomorphism & isomorphism-classes-reducible & irreducible representations-Schru's lemma-great orthogonality theorem-Group character table-C2v & C3v groups-generators of continous groups-Rotation groups SO(2) & SO(3)-Lie group & Lie algebra-poincare-Lorentz group-SU(2) & SU(3)

Text Book:

1. Elements of Group Theory for physicists, A. W. Joshy, New Age India Pub.

**Unit IV**

**Partial differential equations (18 hrs)**

Introduction to partial differential equations-separation of variables: Cartesian coordinates, circular cylindrical coordinates, spherical polar coordinates

Examples of partial differential equations and boundary conditions-Heat equation-Wave equation-Laplace equation-Inhomogeneous partial differential equation:Poissons equation & Quantum mechanical scattering-Green's function.

Text Book:

1. Mathematical method for physics, G.B. Arfken & H. J. Weber.

**Reference Books:**

1. Mathematical method for physics, G. B. Arfken & H. J. Weber.
2. Mathematical Physics, B.D. Gupta, Vikas Pub. House Pvt Ltd, New Delhi,1997.
3. Advanced engineering mathematics, Cr Wylie, Tata McGraw Hill.
4. Advanced Mathematics for Engineers & Scientists, Schaum's outline M R Spiegel Tata McGraw Hill.
5. Matrices & Tensors in Physics, A.W Joshi, New Age India Pub.

## AP2C06 ELECTRONICS AND COMMUNICATIONS

**Unit I**

**Linear Integrated Circuits (18 hours)**

Differential amplifier- Frequency response of an OPAMP – Compensating networks – General linear applications – Instrumentation amplifier – Active filters – First and second order Butterworth filters – Phase shift and Wien bridge oscillators – Square - Traiangualr and Saw tooth wave generators – Comparators and Converters-D/A and A/D converter – Successive approximation – Dual slope integrator – 555 timer – Internal architecture – VCO - Phase locked loop – Voltage regulators.

Text Book:

1. OP-Amp and Linear integrated circuits, Ramakant Gayakwad, 4th Edition, TMH.

**Unit II**

**Communication Systems (18 hours)**

Modulation – Bandwidth requirements - Amplitude modulation – SSB technique – Frequency modulation – Frequency spectrum of FM wave – Phase modulation – Generation of FM – Pulse communications – Pulse modulation – Pulse width, pulse position, pulse code modulation – Digital communication – Digital codes – Error detection and correction – Modem classification – Modem interfacing.

Text Book:

1. Electronic communication system, George Kennedy, TMH.

**Unit III**

**Microprocessors and Microcontrollers (18 hours)**

Intel 8086 – Architecture – Addressing modes – Accessing and register data – Accessing memory and I/O ports – Addressing modes – Instruction set – Instruction format – Assembler dependent instructions – System design using 8086 – System concepts – Interfacing memory – Programmed I/O – 8086 based microcomputer – Basic ideas of 8088, 80186, 80286, 80386, 80486 and Pentium processors.

Evolution of microcontrollers – Comparison of microprocessors and microcontrollers – 8 bit microcontrollers – 8051 architecture – hardware – I/O pins, ports and circuits – External memory – Basic programming concepts – applications.

Text Books:

1. Microprocessor and Microcomputer based system design, M. Rafiquzzaman , Universal Book Stall, New Delhi.
2. The 8051 Microcontroller, Architecture, Programming and Applications, Kenneth J. Ayala Penram Int Pub, Mumbai.

**Unit IV**

**Digital Signal Processing (18 hours)**

Continuous time (CT) and Discrete time (DT) signals – Some elementary discrete time signals – Classification of discrete time signals – discrete time systems – classification of discre time systems – Convolution sum – Correlation of discrete time signal – Z transform- Analysis of CT signals – Fourier series and Fourier transforms – Analysis of DT signals – Fourier series and Fourier transforms - Discrete Fourier transform of DT signals – Fast Fourier transform –Digital filtering in time domain – FIR filters – IIR filters.

Text Books:

1. Signals and Systems, A.V. Oppenheim, A. S. Willsley and I. T. Young, PHI.
2. Digital Signal Processing, John G. Proakis, Dimitris G. Manolakis, 4$^{th}$ Edn. PHI.

**Reference Books:**

1. Op. Amps and Linear Circuits, R. A. Gayakwad, PHI (1997).
2. Microprocessor Architecture and Applications, R.S. Gaonkar, Wiley Eastern.
3. The Intel Microprocessors – 8086, 8088, 80186, 80286, 80386 and 80486,B.B. Bery, PHI.

4. Electronic fundamentals and applications, John Ryder.
5. Digital Signal Processing, John G. Proakis, Dimitris G. Manolakis,4$^{th}$ Edn. PHI.
6. Advance microprocessors and peripherals, A. K. Ray and K. M. Burchandi, TMH.

**AP2C07 SPECTROSCOPY**

**Unit I**

**Atomic Spectra (18 hrs)**

Vector atom model-electron spin-Stern-Grelach experiment-LS and jj coupling schemes-spectroscopic terms-Pauli's exclusion principle-spin-orbit interaction-interaction energy-interaction energy in LS and jj coupling schemes-selection rule-Hund's rule-Lande interval rule- normal and anomalous Zeeman effect-Paschen-Back effect and Stark effect in one electron systems-hyperfine structure-width of spectral lines.

Text Books:

1. Introduction to atomic spectra, White H. E., McGraw Hill.
2. Spectroscopy Volume 1, Straughan and Walker, John Wiley & Sons.

**Unit II**

**Resonance Spectroscopy (18 hrs)**

ESR-theory-relaxation process-experimental setup-hyperfine structure-applications.

NMR-classical and quantum theories-relaxation process-experimental technique-chemical shift-spin-spin coupling-applications.

Mössbauer effect-theory-experimental technique-chemical isomer shift-magnetic hyperfine interactions-electric quadrapole interaction-applications

Text Books:

1. Spectroscopy volume 2 Straughan and Walker, John Wiley & Sons.
2. Molecular structure and spectroscopy, G. Aruldhas, PHI.

**Unit III**

**Microwave and Infrared Spectroscopy (18 hrs)**

Rotational spectra of rigid diatomic molecules-isotopic effect-intensity of rotational lines-non rigid rotator-linear polyatomic molecules-symmetric top molecules-microwave spectrometer-informations from rotational spectra.

Vibrating diatomic molecules as harmonic and anharmonic oscillators-diatomic vibrating rotator-breakdown of Born-Opeenheimer approximation-vibrational spectra of polyatomic molecules-overtones and combinations-influence of rotation on the spectra of linear and symmetric top molecules-IR spectroscopic analysis-FT-IR spectroscopy.

Text Books:

1. Molecular structure and spectroscopy, G. Aruldhas, PHI.
2. Fundamentals of molecular spectroscopy, C. N. Banwell and E. M. McCash, TMH.

**Unit IV**

**Raman Spectroscopy (9 hrs)**

Raman effect, theory, rotational Raman spectra-linear molecules-symmetric top molecules-vibrational Raman spectra-rotational fine structure-Raman activity-mutual exclusion principle-structure determination using Raman and IR spectroscopy-laser Raman spectrometer, basic idea of nonlinear Raman effects, stimulated Raman effects, Hyper Raman effect, inverse Raman effect and CARS.

**Electronic Spectroscopy (9 hrs)**

Electronic spectra of diatomic molecules- progressions and sequences- Frank Condon principle- rotational fine structure of electronic vibration spectra-the Fortrat parabola-dissociation-pre dissociation-fluorescence and phosphorescence.

Text Books:

1. Molecular structure and spectroscopy, G. Aruldhas, PHI.
2. Fundamentals of molecular spectroscopy, C. N. Banwell and E. M. McCash, TMH.
3. Raman spectroscopy, D. A. Long, McGraw Hill Inc.

**Reference Books:**

1. Introduction to atomic spectra, H. E. White.
2. Introduction to molecular spectroscopy, G. M. Barrow McGraw Hill.
3. Elements of spectroscopy, Gupta, Kumar and Sharma, Prgathi Prakshan.
4. Molecular spectra and molecular structure, Vol. I, II & III, Hertzberg G., Van Nostrad, London.
5. The infrared spectra of complex molecules, Vol I and II, Bellamy L. J. Chapman and Hall.

**AP2C08 QUANTUM MECHANICS – I**

**Unit I**

**Applications of Schrodinger Equation (16 hrs)**

Harmonic Oscillator-Three dimensional square well potential-Spherically symmetric potentials in three dimensions-Central force problems—the rigid rotor-Hydrogen atom

Text Book:

1. Quantum concepts and Applications, Nouredine Zettili, John Wiley & Sons.

**Unit II**

**Mathematical Tools of Quantum Mechanics (18 hrs)**

Hilbert space-Dimension and Basis of a vector space-Dirac notation-Ket space-Bra space-inner products-Operators-eigen values and eigen vectors of an operator-Hermition ,Unitary operators (eigen values & eigen vectors)-Projection operators-Compatible Obsevables-Uncertainity relation between two operators-Matrix representations of Kets,Bras & Operators-Change of Bases & Unitary transformations-Unitary equivalent observables-Position representation-Translation-Momentum as a generator of translation-Position-momentum uncertainity relation-Canonical commutation relations-Position space wave function-Momentum operator in the position basis-Momentum space function-Connection between position and momentum space function-Gaussian wave packets-Expectation value of $x$,$x^2$,$p$,$p^2$ for a Gaussian wave packet.

Text Book:

1. Modern Quantum Mechanics - J. J. Sakurai, Pearson Education.

**Unit III**

**Quantum Dynamics (20 hrs)**

Time evolution Operator-Schrodinger equation for the time evolution operator-Schrodinger picture & Heisenberg picture: Behaviour of state kets & Observables-Heisenberg equation of motion-Ehrenfest'stheorem-Energy eigenkets & eigenvalues of a simple Harmonic Oscillator using creation and annihilation operators.

Text Book:

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

**Time Independent Perturbations:** Time independent perturbation theory-Nondegenerate case-Correction to wave function and energy to second order. anharmonic oscillator-Quadratic Stark effect-Degenerate case-Secular equation-linear Stark Effect & Zeeman effect in hydrogen.

Text Books:

1. Modern Quantum Mechanics - J . J. Sakurai, Pearson Education.
2. Quantum concepts and Applications, Nouredine Zettili, John Wiley & Sons.

**Unit IV**

**Scattering (18 hrs)**

Scattering amplitude-Differential Scattering cross section & Total Scattering cross section-The Born approximation: The first Born approximation & its validity-Application of Born approximation to square well, Yukawa & Screened Coulomb potential.

Method of Partial waves-Scattering by a perfectly rigid sphere & by a square well potential-Optical theorem-Ramsaur-Townsend effect-Resonance Scattering.

Text Books:

1. A modern approach to Quantum Mechanics, Townsend.
2. Introduction to Quantum Mechanics, David J. Griffiths.

**References:**


1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education.
2. Introduction to Quantum Mechanics, David J. Griffiths.
3. A Text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan.
4. Quantum Mechanics, L. I. Schiff.
5. A modern approach to Quantum Mechanics-Townsend, Viva Books Pvt. Ltd. MGH
6. Quantum Mechanics, Ghatak and Loknathan.
7. Quantum Mechanics, G. Aruldas, PHI
8. Quantum Mechanics,V. K. Thankappan, New Age Int. Pub.
9. Quantum Mechanics, L. D. Landau and E. M. Lifshitz.
10. Quantum Mechanics, Messiah A. P. Q. Q. M - Vol I & II.
11. Quantum Mechanics- an Introduction, W. Greiner, Springer Verlag.

**AP2P02 ELECTRONICS PRACTICALS**

1. Differential amplifier using Op amp.
2. Diiferential Amplifier using Transistors(With constant current source)
3. RC coupled CE Amplifier
4. First order lowpass & High pass filter
5. Second order lowpass & High pass filter
6. Square wave Generator
7. Triangular wave generator
8. Astable Multivibrator
9. Wein-Bridge Oscillator using Op.Amp.
10. Voltage regulator using Op.Amp.
11. Wave form generators using Op.Amp.
12. Voltage controlled Oscillator – IC 555
13. PLL and frequency multiplier
14. Frequency mixing, AM and demodulation
15. Frequency modulation and demodulation
16. DC and AC milli – voltmeter construction and calibration
17. Instrumentation amplifier using transducer
18. Amplified DC meter (FET Voltmeter)
19. Pulse width modulation

## SEMESTER – III

**AP3C09 ELECTROMAGNETIC THEORY**

**Unit I**

**Electrostatics and Magnetostatics (18 hrs)**

Electrostatics: Gauss's law & its applications- Laplace & Poisson's equations- electrostatic boundary conditions-Magnetostatics: Biot-Savart's law & application- Amperes law & application-magnetostatic boundary conditions.

Text Book:

1. Introduction to Electrodynamics, D. J. Griffiths-PHI.

**Unit II**

**Electrostatic Fields in matter & Electrodynamics (18 hrs)**

Electrostatic fields in matter: Polarization, Field of a polarized object, Gauss's law in dielectrics, Electric displacement, Linear dielectrics

Electrodynamics: Maxwell's equations in free space &linear isotropic media- Boundary conditions on field vectors D,E,B &H - Scalar & Vector Potentials-Coulomb and Lorentz guage - Lorentz force law in potential form. Energy & momentum in electrodynamics-Newton's third law- Poynting's Theorem-Maxwell's stress tensor.

Text Book:

1. Introduction to Electrodynamics, D. J. Griffiths-PHI.

**Unit III**

**Electromagnetic Waves & Relativistic Electrodynamics (18 hrs)**

Electromagnetic waves: Electromagnetic waves in free space, conductors & dielectrics-Energy & momentum of electromagnetic waves-Reflection & Transmission of EM waves in non-conducting media. Relativistic Electrodynamics: Lorentz transformation of EM field- EM field. Tensor-electrodynamics in tensor notation-Potential formulations of relativistic electrodynamics.

Text Book:

1. Introduction to Electrodynamics, D. J. Griffiths-PHI.

**Unit IV**

**Electromagnetic Radiation & Waveguides (18 hrs)**

Electromagnetic radiation:Radition from electric & magnetic dipoles-Lienard-Wiechert potential-Radiation from a moving point charge-TE & TM waves in rectangular waveguides-Impossibility of TEM wave in rectangular wave guide.

Text Book:

1. Antenna & waveguide propagation, K. D. Prasad.
2. Introduction to Electrodynamics, D. J. Griffiths-PHI.

**Reference Books:**

1. Introduction to Electrodynamics, D. J. Griffiths, PHI.
2. Electromagnetic waves & Radiating Systems, E.C Jordan & K. G. Balmain, PHI.
3. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.

4. Elements of electromagnetic, Mathew N. O. Sadiku, Oxford University Press.
5. Electromagnetics-Schaum's outline series, Joseph A. Edminister.
6. Electromagnetic waves & radiating system, Jordan & Balmain.

**AP3C10 QUANTUM MECHANICS - II**

**Unit I**

**Theory of Angular Momentum (20 hrs)**

Finite Versus Infinitesimal Rotations-Commutation relation between rotation operations about different axes-Infinitesimal Rotations in Quantum Mechanics-Fundamental commutation relations of angular momentum-Rotation operator for a spin ½ system-Pauli two component Formalism-Pauli Spin Matrices-2x2 matrix representation of rotation operator-Euler rotations-Commutation Relations and the Ladder Operators of Angular momentum-Eigen values of $J^2$ & $J_z$-Matrix elements of Angular-Momentum Operators-Representation of the rotation operator-Rotation matrix-Properties of the rotation matrix-Orbital angular momentum as a rotation generator-Spherical Harmonics-Spherical Harmonics as Rotation Matrices-Addition of angular momentum and spin angular momentum-addition of spin angular momenta of two spin ½ particles.(Mention Clebsch-Gordan coefficients)

Text Book:

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

**Unit II**

**Time dependent Perturbation Theory (16 hrs)**

Interaction Picture-equation of motion for the state vectors & operators-Time dependent perturbation theory-Dyson series-Transition probability-Constant perturbation-Harmonic perturbation-Adiabatic & Sudden approximations-Interaction of atoms with classical radiation field-Electric dipole approximation.

Text Book:

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

**Unit III**

**Relativistic Quantum Mechanics (18 hrs)**

Klein Gordan equation-Probability conservation-Dirac equation-Conserved current representation-large and small components-approximate Hamiltonian for an electrostatic problem-free particles at rest-Plane wave solutions-Dirac matrices-Positive and negative energy solutions-Physical interpretation-Non-relativistic limit of Dirac equation-Relativistic covariance of Dirac equation-Zitterbewegung.

Text Book:

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

**Unit IV**

**Second Quantization (18 hrs)**

Lagrangian and Hamilton formalism of classical field theory-Canonical quantization-quantization of nonrelativistic Schrodinger equation-number operator-creation and annihilation operators-Fock space representation-Concept of a vaccum state-Bosons and Fermions-Occupation number Formalism

Relativistic quantum field theory-Second quantization of free fields-scalar field-Dirac field-Electromagnetic fields quantization.

Text Books:

1. Field quantisation- W. Greiner, J. Reinhardt, Springer.
2. Quantum Mechanics-V. K. Thankappan, New Age Int. Pub.1996.

**References**


1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education.
2. Introduction to Quantum Mechanics, David J. Griffiths.
3. Quantum Mechanics, Nouredine Zettili.
4. A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan.
5. Quantum Mechanics, L. I. Schiff.
6. Relativistic Quantum Mechanics, P. Strang.
7. Quantum Field Theory, L. Ryder, Academic Publishers,Calcutta,1989.
8. Quantum Field Theory, C. Itzykson and J. Zuber.
9. Advanced quantum mechanics, J. J. Sakurai, Pearson Education.
10. Quantum Mechanics, V. K. Thankappan, New Age Int. Pub., 1996.

**AP3E01 PHOTONICS – I**

**Unit I**

**Properties of Semiconductors (18 hrs)**

Electronic properties of semiconductors – Carrier effective masses and band structure – Effect of temperature and pressure on band gap- PN junction – Conduction process in semi-conductor

Optical processes in semiconductors – Direct and indirect band gap semiconductors – Electron- Hole pair formation and recombination- Absorption in semiconductors –Effect of electric field on absorption- Absorption in quantum wells – Radiation in semiconductors

Text Book:

1. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, PHI (1995).

**Unit II**

**Display Devices (18 hrs)**

Photo luminescence – Cathodo luminescence – Electro luminescence – LED – LED materials – Device configuration and efficiency – Hetero junction, surface emitting, edge emitting, stripe geometry LEDs – Drive circuitary – Performance and characteristics – Plasma display – Liquid crystal – Properties – Numeric displays

Text Book:

1. Optoelectronics an Introduction, J. Wilson and J.F.B. Hawkes, PHI (2000).

**Unit III**

**Optoelectronic Modulators (18 hrs)**

Modulation of light – Birefringence – Electro optic effect – Pockel's electro optic modulator – Kerr modulator – Magneto optic effect – Optical isolator – Acousto optic effect – Acousto optic modulator – Scanning and switching – Self electro optic device – Bipolar controlled modulator – Quantum well modulator.

Text Books:

1. Optoelectronics an Introduction: J. Wilson and J. F. B. Hawkes, PHI (2000).
2. Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2000).

**Unit IV**

**Nanophotonics (18 hrs)**

Photons and electrons: similarities and differences-free space propagation -Confinement of photons and electrons-propagation through a classically forbidden zone : Tunneling-Localizationunder periodic potential : Band gap-Cooperative effects for photons and electrons-nanoscale optical interactions-axial and lateral nanoscopic localization -quantum confined materials; quantum wells, quantum wires, quantum dots, quantum rings – quantum confined stark effect-dielectric confinement effect-super lattices - photonic crystals-features of photonic crystals-photonic crystal sensors-industrial nanophotonics-nanolithography (basic idea)-two photon lithography-sunscreen nanoparticles-self-cleaning glasses – fluorescent quantum dots-nanobarcodes-introduction to nanotoxicology.

Text Book:

1. Nano Photonics, P. N. Prasad, Wiley Interscience (2003).

**Reference Books:**


1. Optical fibre Communications, John M. Senior, PHI (1995).
2. Semiconductor Opto electronics, Jasprit Singh, TMH (1995).
3. Opto electronic Devices and Systems, S. C. Gupta, PHI (2005).
4. Light emitting Diodes, E. Fred Scheubert, Cambridge University Press (2003).
5. Principles of Nanophotonics, Lukas Novotny and Bert Hecht, CUP.
6. Nanophtonics, H. Rigneault, J.M. Lourtioz, C.D., J.A. Levenson, ISTE Pub. Co. (2006).
7. Optoelectronic Devices and Systems, S. C. Gupta, PHI (2005).


## AP3E02 LASER PHYSICS

### Unit I

**Lasers – Operating principles (20 hrs)**

Thermal equilibrium– Absorption, spontaneous and stimulated emissions – Absorption and stimulated emission coefficients – Absorption and gain on homogeneously and inhomogeneously broadened radiative transitions – Gain coefficient and stimulated emission cross section for homogeneous and inhomogeneous broadening – Relationship of gain coefficient and stimulated emission cross section to absorption coefficient and absorption cross section– Population inversion and saturation intensity – exponential growth factor- Threshold requirements for laser with and without mirrors– Laser amplifiers – Pumping mechanism

Text Book:

1. Laser fundamental-W. T. Silfvast, Cambridge University Press (1996).

**Unit II**

**Theory of Lasers -I (20 hrs)**

Three and four level systems and rate equations –Laser spiking – Laser cavity modes- Longitudinal laser cavity modes- Fabry-Perot resonator- Longitudinal mode number- Transverse laser cavity modes- Development of transverse modes in a cavity with plane parallel mirrors- Properties of laser modes- Stable curved mirror cavities- Properties of Gaussian beams- Properties of real laser beams- Quality factor- The ultimate line width of the laser

Text Book:

1. Laser fundamental, W. T. Silfvast, Cambridge University Press (1996).
2. Lasers-Theory, and Applications, K. Thyagarajan and A. K. Ghatak, McMillian (2002).

**Unit III**

**Theory of Lasers – II and Applications (16 hrs)**

Q - Switching – Methods of Q – switching – Mode locking – Methods of mode locking –Ring lasers- Distributed feedback lasers- Properties of laser beams – Temporal coherence – Spatial coherence – Directionality

Applications of lasers (Qualitative idea)- Lasers in science, industry and medicine- Laser induced fusion- Lasers and holography- Laser cooling

Text Book:

1. Laser fundamental-W. T. Silfvast, Cambridge University Press (1996).
2. Lasers-Theory, and Applications –K. Thyagarajan and A. K. Ghatak, McMillian (2002).

**Unit IV**

**Laser Systems (16 hrs)**

Gas lasers – He-Ne laser, CO2 laser, Nitrogen laser, Argon ion laser – Solid state lasers- Ruby laser – Nd – YAG lser – Excimer lasers – Dye lasers – Fiber lasers- Generation of ultra-fast optical pulses – Femto second laser Semiconductor lasers – Junction laser operating principles – Hetero junction lasers – Quantum well lasers

Text Book:

1. Laser fundamental-W. T. Silfvast, Cambridge University Press (1996).
2. Lasers-Theory, and Applications –K. Thyagarajan and A. K. Ghatak, McMillian (2002).

**Reference Books:**

1. Laser Electronics, J. T. Vardeyan, PHI, 1989.
2. Solid State laser Engineering, W. Koechner, Springer Verlag, 2006.
3. Quantum Electronics, A. Yariv, John Wiley.
4. Laser Physics, Tarasov, MIR Pub, 1985.
5. Fiber optics and optoelectronics, R. P. Khare, Oxford University Press, 2004.
6. Optical Fiber Communications, John M. Senior,PHI(1994).

7. Dye laser, Schaffer, Springer Verlag,1977.
8. Lasers principles and applications, J. F. B. Hawkes and Wilson, PHI.

**AP3P03 COMPUTATIONAL PHYSICS PRACTICALS**

(Programs are to be written in C++ language. Method, Algorithm and Flow chart are to be furnished)

1. Motion of a Spherical body in a viscous medium
2. Projectile motion
3. SHM – Damped and Forced
4. Formation of Standing waves
5. Electric field due to a point charge and equipotential surface
6. LCR circuits with AC and DC sources
7. Gauss elimination method for solving a system of linear equations
8. Finding the roots of a nonlinear equation by Bi section method
9. R.K Method
10. Euler Method
11. Integration by Monte Carlo method
12. Matlab – Matrix operations
13. Matlab – Digital signal processing
14. Matlab – Solving ordinary differential equations
15. Matlab –Plot unit impulse,step,ramp and random noise
16. Matlab-Generationof waveforms(Sinusoidal,square,triangular,exponential)
17. Matlab-Linear Convolution
18. Matlab-Circular Convolution

19. Matlab-Linear Convolution using Circular Convolution
20. Matlab-Random Sequence Generator
21. Matlab-Amplitude Modulation
22. Frequency Modulation using Matlab
23. Pulse width Modulation using Matlab
24. Inverse Discrete Fourier Transform using Matlab
25. Discrete Fourier Transform using Matlab

## SEMESTER – IV

### AP4C11 NUCLEAR PHYSICS AND ASTROPHYSICS

**Unit I**

**Nuclear Properties and Forces (4 hrs)**

Nuclear Angular Momentum – Parity – Nuclear magnetic dipole moment – electric quadrupole moment – Simple theory of Deuteron – Properties of Nuclear forces –Spin dependence of nuclear force.

**Nuclear Models (14 hrs)**

Binding energy, semi-empirical mass formula, liquid drop model. Evidence of shell structure, single-particle shell model, its validity and limitations, Spin orbit coupling, Schmidt's lines and prediction of angular momentum and parity of nuclear ground states. Collective model of Bohr and Mottelson – rotational States and Vibrational levels.

Text Books:

1. Introductory Nuclear Physics, K. S. Krane, Wiley.
2. Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

**Unit II**

**Radioactivity, Fission and Fusion (18 hrs)**

Radio activity, Units, alpha and beta decay, Gamow's theory, neutrino, Fermi's theory of beta decay, Radiation hazards. Nuclear fission, controlled fission reactions, fission reactors, nuclear fusion, controlled Fusion reactors.

**Detectors, accelerators**

Particle detectors - Ionization chamber, GM counter, bubble chamber, cloud chamber. Particle accelerators -Van de Graff generator, Cyclotron, Synchrotron.

Text Books:

1. Introductory Nuclear Physics, K. S. Krane, Wiley.
2. Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

**Unit III**

**Particle Physics (18 hrs)**

Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, confined quarks, coloured quarks, quark-gluon interaction, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics, Grand unified theories.

Text Books:

1. Introductory Nuclear Physics, K. S. Krane, Wiley.
2. Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

**Unit IV**

**Astrophysics (18 hrs)**

**Sun**

Solar structure - photosphere, chromosphere and corona. Activity in the sun - sunspots, flares, solar oscillations, helioseismology.

**Expanding universe**-red shift-Hubble's law. Fundamental assumptions - homogeneity and isotropy, the FRW metric, density evolution, critical density, cosmological constant. Conditions in the early universe – big bang nucleosynthesis.

**Galaxies**

Milky way galaxy-stellar population –spiral structure.

**Compact Objects**

Physical properties of black holes, white dwarfs, and neutron stars, formation of compact objects, pulsar phenomena, gravitational and neutrino radiation from supernova collapse and binary coalescence.

Text Books:


1. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press.
2. Astrophysics: Stars and Galaxies, K.D.Abhyankar


**Reference Books:**


1. Introduction to High Energy Physics, D. H. Perkins.
2. Introduction to Elementary Particles, David Griffith, Harper and Row, N.Y, 1987.
3. B. L. Cohen, Concepts of Nuclear Physics, TMH, 1971.
4. R. R. Roy and B. P. Nigam, Nuclear Physics, New Age Int. ,1983.

5. Subatomic Particles, Frauenfelder and Henley, PHI.
6. The Ideas of Particle Physics, G. D. Coughlan and J. E. Dodd.
7. Introduction to Nuclear Physics, Herald A Enge, Addison, Wesley Pub, ( 1972).
8. Nuclear Physics, I. Kaplan, Narosa publishing House,(1962).
9. Nuclear Radiation detectors, Price.
10. Particle Hunters, Neeman, Y. Kirch ,Cambridge Univ. Press.
11. Elementary particles and symmetries, I. H. Ryder, Gordon and Breach, (1975) (Text).
12. The cosmic onion-Quarks and nature of Universe, Frank Close, AIP (1983).
13. Elements of Nuclear Physics, W. E. Burcham, Longmans (1981).
14. University Physics with Modern Physics, H. D. Young & R. A. Freedman, $11^{th}$ Edn, (2004).
15. Elements of Nuclear Physics, M. L. Pandya & R. P. S. Yadav, 7th Edn, ( 2002).
16. The New Cosmology, Albrecht Unsold.
17. Astrophysics, B. Basu.
18. The Physical Universe, F. H. Shu.
19. Astrophysics: Stars and Galaxies. K. D. Abhyankar.
20. Black Holes, White Dwarfs and Neutron Stars, S.Shapiro & S. Teukolsky, Wiley, 1983.
21. Glendenning, Compact Stars: Nuclear Physics, Particle Physics and General Relativity, $2^{nd}$ ed., Springer, 2000.

## AP4C12 COMPUTATIONAL PHYSICS

### Unit I

### Numerical Methods of Analysis (18 hrs)

Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Text Book:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall India.

### Unit II

### Fortran (18 hrs)

Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Text Book:

1. Computer Programming in FORTRAN 77, Rajaraman.

**Unit III**

**Object Oriented Analysis and C++ (18 hrs)**

Principle of Object Oriented Programming, Software evaluation, OOP paradigm, Basic concept of OOP, Benefits of OOP, Application of OOP, Introduction to C++,Tokens, Keywords, Identifiers, Constants, Operators, Manipulators, Expressions and control structure, Pointers, Functions, Function prototyping, Parameters passing in functions, Values Return by functions, Inline functions – friend and virtual functions, Classes, objects, constructors and destructors, Operator overloading, Type conversions , Type of constructors , Function over loading

Text Books:

1. Object Oriented Programming with C++ , Balagurusamy, TMH.
2. Object Oriented Programming in Turbo C++ , Robert Lafore.

**Unit IV**

**Matlab Programming (18 hrs)**

Introduction-Matlab Features-Desktop Windows: Command, Workspace, Command History, Array Editor and Current Directory -Matlab Help and Demos- Matlab Functions, Characters, Operators and Commands. Basic Arithmetic in Matlab-Basic Operations with Scalars, Vectors and Arrays- Matrices and Matrix Operations-Complex Numbers- Matlab Built-In Functions-Illustrative Examples.

Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break* Statement-Input/Output Commands-Function m Files-Script m Files-Controlling Output

Text Books:

1. Engineering and Scientific Computations Using Matlab, Sergey E. Lyshevski, Wiley
2. Matlab Programming-David Kuncicky, Prentice Hall.

**Reference Books:**


1. Numerical methods in Science and Engineering, M.K. Venkataraman, National Publishing Co. Madras.
2. Applied Numerical Analysis, Gerald, Person Educaton.
3. Numerical Methods for Engineers and Scientists, Joe D. Hoffman.
4. Numerical Methods For Scientific And Engineering Computation, M.K. Jain , New Age International.
5. Computational Methods in Physics and Engineering, Wong.
6. Computer Oriented Numerical Methods, Rajaraman.
7. Programming in C++, Schaum's Series.
8. A Guide to Matlab for Beginners & Experienced Users, B. Hunt, R. Lipsman, J. Rosenberg, Cambridge University Press.
9. Matlab Primer, T. A. Davis & K. Sigmon, Chapman & Hall CRC Press- London.
10. Getting Started With Matlab, Rudra Pratap, Oxford University Press, New Delhi.
11. An Introduction to Programming and Numerical Methods in MATLAB, S.R. Otto and J.P. Denier, Springer-Verlag-London.
12. Numerical Methods Using Matlab-John Mathews & Kurtis Fink, Prentice Hall-New Jersey.

**AP4E03 PHOTONICS – II**

**Unit I**

**Fiber Optic Communication (18 hrs)**

Fibre optic communication system- Advantages of fiber optic system- System design considerations for point to point links- Digital systems- Link power budget- Rise time budget- Line coding- Analog systems- System architecture- Point to point links- Distribution networks- Local area networks

Text Book:

1. Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).

**Unit II**

**Optical Amplifiers and Detectors (18 hrs)**

Qualitative ideas of semiconductor optical amplifiers, Erbium doped fiber amplifiers and Raman amplifiers

Optical detection principle-Absorption coefficient- Quantum efficiency- Responsivity- Long wavelength cutoff- PN photo diode- PIN photo diode- Avalanche photo diode- Photo transistor-Photo conducting detectors- Photomultiplier- CCD- Photo voltaic effect and solar cells- Noise- Thermal noise- Dark current noise- Quantum noise

Text Books:

1. Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).
2. Optical fiber Communications, John M. Senior, PHI (1995).

**Unit III**

**Fiber Cables and Connections (18 hrs)**

Fiber material requirements- Fiber fabrication methods- Liquid – phase(Melting) Methods – Vapour-phase deposition methods- OVPO method- VAD method- MCVD method- PCVD method-Fiber optic cables- Fiber connections and related losses- Loss due to Fresnel reflection- fiber to fiber misalignment losses- loss due to other factors- Connection losses due to intrinsic parameters- Fiber splices- Fusion splices- Mechanical splices- Multiple splices- Fiber optic connectors- Butt-jointed connectors- Expanded beam connectors- multi fiber connectors

Text Book:

1. Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).

**Unit IV**

**Frequency Multiplication and other Nonlinear Effects (18 hrs)**

Wave propagation in an anisotropic crystal- Polarization response of materials to light- Second harmonic generation- Sum and difference frequency generation- Parametric oscillation- Third harmonic generation- Self focusing- Nonlinear optical materials- Phase matching- Acive phase matching- Saturable absorption- Optical bistability-Two photon absorption- Stimulated Raman scattering- Harmonic generation in gases.

Text Book:

1. Laser Fundamental, W.T. Silfvast, Cambridge University Press (1996).

**Reference Books**:

1. Fiber Optic Communication, D.C. Agarwal, Wheeler Publications (1993).
2. Optical Fiber Communication System, J. Gowar, PHI (1995).
3. Fiber Optic Communication, Joseph Palais, PHI (1998).
4. Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc. (2006).
5. Optoelectronic Devices and Systems, S. C. Gupta, PHI (2005).

**AP4E04 FIBRE OPTICS**

**Unit I**

**Optical Waveguides (18 hrs)**

Ray theory theory of transmission - Total internal reflection -Acceptance angle - Numerical aperture - Skew Rays. EM Theory for Optical propagation – Modes in a planar waveguide –Phase velocity and group velocity – Evanescent field - Optical fiber as a cylindrical waveguide- Modes – Mode coupling (elementary idea) – Classification of fibers – Step index fiber – Graded index fiber – Single mode fiber – Number of modes and cut off parameters – Mode field diameter and spot size

Text Book:

1. Optical Fiber Communications, John M. Senior,PHI (1994

**Unit II**

**Transmission Characteristics of Optical Fibers (18 hrs)**

Attenuation – Absorption losses – Linear scattering losses – Nonlinear scattering losses – Wavelengths for Communication – Fiber bend loss – Dispersion effects in fibers - Intra modal dispersion – Inter modal dispersion

– Over all fiber dispersion – Modal birefringence – Polarization maintaining fibers.

Text Book:

1. Optical Fiber Communications, John M. Senior, PHI (1994)

**Unit III**

**Optical Fiber Measurements (18 hrs)**

Attenuation measurements – Dispersion measurements – Refractive index profile measurements – Cut off wavelength measurements – Numerical aperture measurements – Diameter measurements – Field measurements – OTDR – Eye pattern technique

Text Book:

1. Optical Fiber Communications, John M. Senior, PHI (1994).

**Unit IV**

**Optical Sensor Systems (18 hrs)**

Intensity modulated sensors – Phase modulated sensors – Interferometric sensors – Sagnac effect and Fiber optic gyroscope – Polarization modulated sensors – Spectrally modulated sensors – Temperature, pressure, force and chemical sensors

Text Book:

1. Optical Fiber Communications, John M. Senior, PHI (1994).

**Reference Books:**

1. Fiber Optics and Optoelectronics, R.P. Khare, Oxford University Press (2004).
2. Fiber Optic Communication, D.C. Agarwal, Wheeler Publications (1993).

3. Optical Fiber Communication System, J. Gowar, PHI (1995).
4. Fiber Optic Communication, Joseph Palais, PHI (1998).
5. Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc (2006).
6. Optoelectronic Devices and Systems, S.C. Gupta, PHI (2005).

## AP4P04 PHOTONICS PRACTICALS

1. Determination of Wavelength of laser beam using reflection and diffraction gratings
2. Beam profile of a laser
3. Bending laws of an optical fiber
4. Numerical aperture of an optical fiber
5. Data transmission and reception through optical fiber link
6. Coupling laws of an optical fiber
7. Michelson Interferometer
8. Comparison of resolving limit of optical instruments with human eye (A world view of Physics by Prof. D.P. Khandelwal et al – Page 300-301, South Asian Publishers Pvt. Ltd, New Delhi 1999)
9. Characteristics of photo diode, photo transistor, LDR, LED
10. Solar cell characteristics
11. Dispersion through a medium – C++
12. Young’s double slit – Interference - C++
13. Diffraction due to a grating – C++
14. Polarization birefringence – C++

## 4.3 M.Sc. PHYSICS - NEW AND RENEWABLE ENERGY

### 4.3.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter R stands for Renewable Energy. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicate the semester concerned. The Course and course code are given in Table 4.2

| SEM | Name of the course with course code | No. of Hrs / week | No. of credit | Total Hrs/ SEM |
|---|---|---|---|---|
| I | **PH1RC1**: Mathematical Physics- I | 4 | 4 | 72 |
| I | **PH1RC2**: Classical Mechanics and Relativity | 4 | 4 | 72 |
| I | **PH1RC3**: Electro Dynamics and Nonlinear Optics | 4 | 4 | 72 |
| I | **PH1RC4**: Advanced Electronics | 4 | 4 | 72 |
| I | **PH1RP1**: General Physics Practicals | 9 | 3 | 162 |
| II | **PH2RC1**: Mathematical Physics- II | 4 | 4 | 72 |
| II | **PH2RC2**: Elementary Quantum Mechanics | 4 | 4 | 72 |
| II | **PH2RC3**: Thermodynamics and Statistical Mechanics | 4 | 4 | 72 |
| II | **PH2RC4**: Condensed Matter Physics | 4 | 4 | 72 |
| II | **PH2RP2:** Computational Physics Practicals | 9 | 3 | 162 |
| III | **PH3RC1**: Advanced Quantum Mechanics | 4 | 4 | 72 |
| III | **PH3RC2**: Numerical Methods in Physics | 4 | 4 | 72 |
| III | **PH3RE2**: Renewable Energy Sources | 4 | 4 | 72 |
| III | **PH3RE3**: Microprocessors and Microcontrollers | 4 | 4 | 72 |
| III | **PH3RP3**: Electronics Practicals | 9 | 3 | 162 |
| IV | **PH4RC1**: Atomic and Molecular Spectroscopy | 4 | 4 | 72 |
| IV | **PH4RC2**: Advanced Nuclear Physics | 4 | 4 | 72 |
| IV | **PH4RE3:** Solar Thermal Collection and Storage | 4 | 4 | 72 |
| IV | **PH4RE4:** Solar Photovoltaics | 4 | 4 | 72 |
| IV | **PH4RP4:** Renewable Energy Practicals | 9 | 3 | 162 |
| IV | **PH4D05**: Project/Dissertation | Nil | 2 | Nil |
| IV | **PH4V06**: Viva Voce | Nil | 2 | Nil |

*Table 4.2 Course and course code of M.Sc.Physics – New and Renewable Energy*

## SEMESTER – I

## PH1RC1 MATHEMATICAL PHYSICS –I

### Unit I

**Vector Analysis (15 Hrs)**

Rotation of the coordinate axes, Scalar and Vector products, Gradient, Divergence and Curl, Vector integration, Gauss' and Stokes theorems, Potential theory, Gauss' law, Poisson's equation, Helmholtz theorem, Orthogonal coordinates, Differential vector operators, Rectangular, Cylindrical and Spherical polar coordinates.

**Error Analysis (3 Hrs)**

Propagation of errors, Plotting of graphs, Least square fitting, Goodness of fit, Chi square test.

### Unit II

**Matrices (15 Hrs)**

Basic properties of Matrices, Orthogonal Matrices, Hermitian and Unitary Matrices, Diagonalization of Matrices, Normal Matrices, Normal modes of vibration, Matrix inversion, Pauli spin matrices, Moment of inertia matrix.

**Probability (3 Hrs)**

Definitions, Simple properties, Binomial, Poisson and Normal distributions.

### Unit III

**Tensors (18 Hrs)**

Definition of Tensors, Associated Tensors, Metric Tensor, Contraction, Direct Product, Quotient Rule, Covariant Differentiation, Christoffel Symbols, Levi Cevita Symbol, Pseudo Tensors, Dual Tensors, Geodesic.

**Unit IV**

**Differential Equations and Special Functions (18 Hrs)**

Beta, Gamma and Dirac Delta functions (Properties only), Series solution of linear second order differential equations – Frobenius method, Bessel function of the first kind (Generating function, Recurrence relations, Orthogonality), Neumann function, Spherical Bessel function, Legendre polynomials (Generating function, Recurrence relations, Orthogonality, Rodrigues' formula), Spherical Harmonics, Hermite polynomials, Laguerre polynomials.

**Reference Books:**


1. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
2. Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan
3. Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)
4. Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.
5. Elements of Group Theory for Physicists, A.W. Joshy, New Age India.
6. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.

**PH1RC2 CLASSICAL MECHANICS AND RELATIVITY**

**Unit I**

**Hamiltonian Methods (18 Hrs)**

Review of Lagrangian dynamics - applications of Lagrange's equations to velocity dependent potentials - Hamilton's equations of motion - cyclic coordinates - conservation theorems - homogeneity of space and time- action for an arbitrary motion - variational principle and Hamilton's equations - Physical significance of principle of least action –Proof-Physical significance- Canonical transformations – Lagrange brackets- Poisson brackets –Equation of motion in Poisson bracket form - Hamilton's characteristic function - Hamilton Jacobi theory - harmonic oscillator problem - action angle variables – Kepler problem- transition to Wave mechanics.

**Unit II**

**Rigid Body Dynamics (12 Hrs)**

Independent Coordinates – Orthogonal Transformations – Inertia Tensor – Euler's Angles .

Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top- Sleeping top - Precession of Charged bodies in magnetic field - Infinitesimal rotation - Coriolis Force and its effects.

**Theory of Small Oscillations (8 Hrs)**

Formulation of the problem – Eigen value equation – Coupled oscillators – Normal coordinates.Oscillations of linear triatomic molecules – monoatomic chain lattice – diatomic chain lattice.

**Unit III**

**Continuous Systems and Fields & Perturbation Theory (16 Hrs)**

Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields. Classical perturbation theory - time dependent perturbation - illustration case of simple pendulum with finite amplitude – Kepler problem and precession of the equinoxes of satellite orbits - time independent perturbation - first order with one degree of freedom.

**Unit IV**

**Relativity (18 Hrs)**

Review of Lorentz transformation - variation of length, mass and time with velocity - law of addition of velocities - mass energy relation - relativistic Doppler effect - four vectors. Lagrangian and Hamiltonian of a relativistic particle - charged particle in electromagnetic field - invariance of Maxwell's equations - electromagnetic field tensor.

General theory of relativity - principle of equivalence - principle of general covariance - gravitational mass and inertial mass - curvature of space time - curvature tensor - Einstein's field equations - aberration of light. Perihelion of Mercury: -Schwarzschild Solutions.

**Reference Books:**

1. Classical Mechanics, N. C. Rana & P.S. Joag, Tata Mc Graw Hill
2. Classical Mechanics, H Goldstein, Poole & Safko, Pearson. 3rd Ed. Narosa Pub. Co.
3. Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press
4. Dynamics, S.N. Rasband, John Wiley & Sons, 1983

5. Introduction to Dynamics, I.Percival & D Richards, Cambridge Univ. Press 1982
6. Lagrangian and Hamiltonian Mechanics, M.G. Calkin, Allied Pub. Ltd.
7. Theory of Relativity - R. K. Patharia, Dover Pub. Inc. NY, 2003
8. An Introduction to General Theory of Relativity, S.K. Bose, Wiley Eastern.
9. Mathematical Physics, B.S. Rajput, Pragati Prakashan.

## PH1RC3 ELECTRODYNAMICS AND NON LINEAR OPTICS

**Unit I**

**Electrostatic Fields in Matter and Electrodynamics (10 hours)**

Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor

**Electromagnetic Waves (8 hours)**

Maxwell's equations in phaser notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Book:

1. Introduction to Electrodynamics, D.J Griffiths, PHI.

**Unit II**

**Relativistic Electrodynamics (18 hours)**

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics-Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

1. Introduction to Electrodynamics, D.J Griffiths, PHI.

**Unit III**

**Electromagnetic Radiation (20 hours)**

Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction.

Text Book:

1. Introduction to Electrodynamics, D.J Griffiths, PHI.

**Unit IV**

**Non Linear Optics (16 hrs)**

Introduction – Second Harmonis generation – phase matching condition – third harmonic generation – optical mixing – parametric generation of light – self focusing of light- multiquatum photoelectric effect- two photon process- three photon process- parametric light oscillator – frequency up conversion – phase conjugate optics – sum frequency generation – difference in frequency generation – saturable absorption.

Text Book:

1. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968
2. Non Linear Optics, Robert W. Boyd, Academic Press.

**Reference books:**

1. Antennas, J.D. Kraus, Mc-Graw Hill.
2. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.
3. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
4. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.
5. Lasers and Non Linear optics, B.B Laud, New Age International.
6. Introduction to Optics, Germain Chartier, Springer.
7. Contemporary optics, A.Ghatak & K. Thyagarajan, McMillan India Ltd.

## PH1RC4 ADVANCED ELECTRONICS

**Unit I**

**Operational Amplifiers (18 Hrs)**

Review of differential amplifiers - review of operational amplifiers - differential amplifier with one and two op amps - Frequency response of an op amp - compensating networks

**General Linear Applications**

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

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI

**Unit II**

**Active Filters and Oscillators (11 hrs)**

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

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 7)

**Comparators and Converters (7 hrs)**

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

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 8)

**Unit III**

**Power semiconductor Devices (18 Hrs)**

**P**ower Electronics - power semiconductor devices - power diodes, SCR, Power MOSFET, Types of Power Electronic Circuits.

Text Book:

1. Power Electronics, R.S Anandha Murthy, V Nattarasu, 2nd Edn Pearson, (Chapter 1)

Thyristor commutation techniques - Natural commutation, forced commutation, self commutation, impulse commutation, external pulse commutation, load side commutation, line side commutation.

Controlled Rectifiers - Principle of phase - controlled connector operation - Single phase semi converter - single phase full converters - single phase dual converters - single phase series converters

Static Switches - Single phase AC switches - three phase AC switches - three phase reversing switches - DC switches

Text Book:

1. Power Electronics - Circuits - Devices and Applications, M.H. Rashid, PHI, 1988

**Unit IV**

**Inverters (18 Hrs)**

Principle of operation - performance parameters - single phase bridge inverters - three phase inverters - voltage control of single phase inverters - voltage control of three phase inverters -harmonic reductions - series resonant inverters - forced -commuted thyristor inverters - current - source inverters -variable DC link inverter.

Text Book:

1. Power Electronics - Circuits - Devices and Applications, M.H. Rashid, PHI, 1988

**Reference books:**

1. Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI
2. Integrated Electronics, Millman J & Halkias CC, MGH
3. M H Rashid - Power Electronics - Circuits - Devices and Applications (PHI-1988)
4. Power Electronics R.S Anandha Murthy, V Nattarasu, 2nd Edn. Pearson

**PH1RP1 GENERAL PHYSICS PRACTICALS**

(Error Analysis of the experiment is to be done)

1. By Cornu's method, set up elliptical/hyperbolic fringes, and hence determine Young's modulus, Rigidity modulus and Poisson's ratio of the given material.
2. Photograph the absorption spectrum of $KMnO_4$ with a standard spectrum superimposed over it.
3. Analyze the given absorption spectrum of $KMnO_4$ and determine the wavelengths of the absorption bands evaluating the Hartmann's constants using wavelengths of the superimposed standard spectrum.
4. By Frank-Hertz experiment determine the excitation potentials of a gas. Hence deduce the wavelengths of the spectral lines expected.
5. Determine the Hall coefficient, carrier concentration and mobility of the given specimen by the Hall probe method.

6. Determine the resistivity of the given semiconducting crystal at different temperatures by the Four Probe method. Hence calculate the band gap energy.
7. Determine the band gap energy of silicon.
8. Study the variation of magnetic susceptibility of the given solid by Gouy's method. Also calculate the magnetic moment per molecule/atom of the solid.
9. Study the variation of magnetic susceptibility with concentration of the given salt in water. Hence show that water is diamagnetic.
10. Determine $\lambda$ and d $\lambda$ of sodium light using Michelson Interferometer. Also determine the thickness of the given mica sheet.
11. Determine the hysteresis loss of the given specimen in the form of a ring by ballistic method. Also calculate the retentivity and coercivity of the material.
12. Determine the coefficient of viscosity of the given liquid by oscillating disc method.
13. Study the V-I characteristics of the given photodiode. Also study the variation of photodiode current with light intensity and determine the dark resistance of the diode.
14. Calibrate the given silicon diode as a temperature sensor.
15. Study the characteristics of the given thermistor. Determine the temperature coefficients $\alpha$ and $\beta$ of the given thermistor.
16. Study the beam profile of the given LASER. Determine the spot size from the intensity distribution.
17. Study the bending losses in the given optical fiber for different bends.

## SEMESTER – II

## PH2RC1 MATHEMATICAL PHYSICS – II

**Unit I**

**Functions of a Complex Variable (18 Hrs)**

Complex algebra, Cauchy-Riemann conditions, Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent expansion, Poles, Residues, Residue theorem, Evaluation of definite integrals.

**Unit II**

**Integral Transforms (18 Hrs)**

Laplace transforms, Solution of differential equations using Laplace transforms (LCR circuit, Electromagnetic waves in dispersive medium, Damped driven oscillator, and Earth's nutation), Fourier transform, Fourier transform of full wave rectifier, Square wave and finite wave train, Momentum representation for Hydrogen atom (ground state) and Harmonic oscillator.

**Unit III**

**Group Theory (18 Hrs)**

Review of introductory definitions and concepts, Unitary representations, Schur's lemmas, Orthogonality theorem and interpretations, Character of a representation, Character Tables and examples, Irreducible representations of Abelian and Non Abelian groups, Connection with quantum numbers, Symmetry group of the Schrodinger equation, Symmetry and degeneracy, Basic functions of irreducible representations, SU(2) group, SU(3) group, Applications to Nuclear and Particle Physics (qualitative only).

**Unit III**

**Second Order Differential Equations & Green's Function (18 Hrs)**

Partial differential equations of Physics, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Heat equation, Laplace's and Poisson's equations, Nonlinear partial differential equations, Separation of variables (Cartesian, Spherical polar and Cylindrical coordinates),

Non homogeneous equations, Green's function eigenfunction expansion, 1-dimensional Green's function, Green's function integral-differential equation, eigenfunction, eigenvalue equation Green's function and Dirac delta function.

**Reference Books**


1. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
2. Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan#
3. Mathematical Methods in Classical and Quantum Physics, T. Dass & S.K. Sharma, Universities Press (2009)
4. Mathematical Physics, H.K Dass & R. Verma, S.Chand & Co.
5. Elements of Group Theory for Physicists, A.W. Joshy, New Age India.
6. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.

**PH2RC2 ELEMENTARY QUANTUM MECHANICS**

**Unit I**

**The Formation of Quantum Mechanics (22 Hrs)**

Linear vector space, Orthonormality and linear independence, Schmidt's orthogonalization procedure, Hilbert space, dimension and basis, Operators and their properties, commuting operators, Eigen values and Eigen vectors, Bra and ket notation for vectors, representation theory, coordinate and momentum representation, fundamental postulates, Expectation values and probabilities, Superposition principle, observables and operators, The uncertainty principle.

**Unit II**

**Quantum Dynamics (12 Hrs)**

The equation of motion, Schrodinger Heisenberg and interaction pictures, Linear harmonic oscillator in Schrodinger and Heisenberg pictures, Hydrogen atom

**Symmetry and Conservation laws**

Space time symmetries, Displacement of space and conservation of linear momentum, translation in time and conservation of energy, Rotation in space and conservation of angular momentum, Space inversion time reversal, identical particles, Symmetry of Wavefunctions, Spin and statistics, Pauli's exclusion principle, the Helium atom.

**Unit III**

**Theory of Angular Momentum (20 Hrs)**

Angular momentum operators, matrix representation of angular momentum operators, Pauli spin matrices, orbital angular momentum, spherical harmonics, Addition of angular momenta, Clebch Gordon coefficients, calculation of C G coefficients j=1/2 and j=1 cases.

**Unit IV**

**The Theory of Scattering (18 Hrs)**

Scattering cross section and Scattering amplitude, Low energy scattering by a central potential, Partial wave analysis, phase shift and potential, scattering length, optical theorem, Scattering by a square well potential, The Ramsuoer Townsend effect, Scattering by hard sphere, resonance scattering, high energy scattering, The integral equation, Born approximation. Validity condition of Born approximation.

Text Book:

1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern

**Reference Books:**

1. Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley & sons
2. Quantum Mechanics, L.I.Schiff, MGH
3. A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, TMGH
4. Modern Quantum Mechanics, J.J. Sakuerai, Pearson Education.
5. Quantum Mechanics, A Messiah, Wiley.
6. Quantum Physics, Stephen Gasiorowics, Wiley.
7. Quantum Mechanics A. Ghatak & S. Lokanathan, Kluwer Academic Publishers
8. The Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
9. Introductory Quantum Mechanics, Richard L. Liboff, Pearson.

**PH2RC3 THERMODYNAMICS AND STATISTICAL MECHANICS**

**Unit I**

**Fundamental of Thermodynamics (10 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 1 and 2)

**Foundations of Statistical Mechanics (8 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 3 and 4)

**Unit II**

**The Canonical Ensemble (12 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

**Statistics of Identical Particles (4 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 6)

**Unit III**

**Maxwell Distribution and Planck's Distribution (12 Hrs)**

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory –

Planck's distribution – derivation of the Planck's distribution – the free energy – Einstein's model vibrations in a solid – Debye's model of vibrations in a solid.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7 and 8)

**Grand Canonical Ensemble (8 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 9)

**Unit IV**

**Fermi and Bose Particles (6 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 10)

**Phase Transitions (12 Hrs)**

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

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, $2^{nd}$ Edn. 2007, Oxford University Press, Indian Edition, (Chap. 11 &12)

**Reference Books:**


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


**PH2RC4 CONDENSED MATTER PHYSICS**

**Unit I**

**Crystal structure and Nanomaterials (6 Hrs)**

Review of crystal lattice fundamentals and interpretation of Bragg's equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity- atomic, geometrical and crystal structure factors- physical significance. Nanomaterials: Definition, Synthesis and properties of nanostructured materials

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2$^{nd}$ Edn. 2010, (Chapter 8 & Ref. Book 8)

**Free electron theory of metals (12 Hrs)**

Review of Drude-Lorentz model- electrons moving in a one dimensional potential well - three dimensional well - quantum state and degeneracy - density of states - Fermi-Dirac statistics - effect of temperature on Fermi-Dirac distribution - electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2$^{nd}$ Edn. 2010, (Chapter 10)

**Unit II**

**Band Theory of Metals (6 Hrs)**

Bloch theorem - Kronig- Penney model - Brillouin zone construction of Brilloun zone in one and two dimensions – extended - reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - effective mass of electron - nearly free electron model – conductors - semiconductors - insulators.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa $2^{nd}$ Edn. 2010, (Chapter 11)

**Band Theory of Semiconductors (10 Hrs)**

Generation and recombination - minority carrier life - time - mobility of current carriers - drift and diffusion and general study of excess carrier movement- diffusion length.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International $6^{th}$ Edn. 2010, (Chapter 10).

Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors - junction properties- metal-metal, metal-semiconductor and semiconductor-semiconductor junctions.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa $2^{nd}$ Edn. 2010, (Chapter 13)

**Unit III**

**Lattice dynamics (12 Hrs)**

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, $3^{rd}$ Edn. Wiley India. (Chapter 4).

Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 7 and 9)

**Dielectric properties of solids (4 Hrs)**

Review of basic terms and relations, ferroelectricity, hysteresis, dipole theory- Curie- Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 11).

Ferroelectric-domain, antiferroelectricity and ferrielectricity.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 14)

**Optical properties of solids (4 Hrs)**

Drude model - ionic conduction - optical refractive index and relative dielectric constant - optical absorption in metals, insulators and semiconductors.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 12).

**Unit IV**

**Magnetic properties of solids (10 Hrs)**

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism - spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model. Novel magnetic materials: GMR-CMR materials (qualitative)

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6$^{th}$ Edn. 2010, (Chapter 9).

**Superconductivity (8 Hrs)**

Thermodynamics of superconducting transition - London equations – coherence length - BCS th theory (qualitative) – BCS ground state – energy gap- flux quantization - single particle tunneling - Josephson superconductor tunneling - macroscopic quantum interference - high Tc superconductivity and its applications.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3$^{rd}$ Edn. Wiley India. (Chapter 12).

**Reference Books:**

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11$^{th}$ Indian Reprint (2011).
2. Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co (1981)

3. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
4. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
5. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
6. Solid State Physics, Dan Wei, Cengage Learning (2008)
7. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)
8. Nanoclusters and Nanocrystals, Edited by Hari Singh Nalwa, American Scientific Publishers, 2003.

**PH2RP2 COMPUTATIONAL PHYSICS PRACTICALS**

[Programs are to be written in C++ language for experiments in section A and Section B. Method, algorithm and flow chart are to be developed.For Section C suitable simulation software can be used.]

**Section - A: (Graphics)**

1. Write and execute a program to demonstrate the motion of a spherical body in a viscous medium. Study the effect on motion by changing the mass, size of the body and the medium.
2. Write and execute a program for the motion of a projectile in air. Study the motion for different angles of projection.
3. Write and execute a program to find the variation in position, velocity and acceleration of a damped harmonic oscillator. How do the oscillations go from the undamped to the critically damped and to over damped with variation in damping coefficient?

4. Write and execute a program to find the variation in acceleration, velocity, position and energy of a driven oscillator. Plot the position versus time graph for different driving conditions.
5. Write and execute a program to generate a pattern of standing waves. Run this program with different values of amplitude, wavelength and velocity.
6. Write and execute a program to analyze a series LCR circuit with an AC source. Verify the resonance condition.

**Section – B: (Numerical methods)**

7. Write and execute a program for solving a system of linear equations using Gauss elimination method.
8. Write and execute a program to find the root of a non linear equation by bisection method.
9. Write and execute a program for the numerical integration of a function using trapezoidal method.
10. Write and execute a program for the numerical integration of a function using Simpson's 1/3 rule.
11. Write and execute a program to solve the given ordinary differential equation by using Euler method.
12. Write and execute a program to solve the given ordinary differential equation by using Runge-Kutta fourth order method.

**Section – C: (Circuit Simulation)**

13. Design and simulate a single stage RC coupled amplifier with feedback. Study the frequency response

14. Design and simulate a two stage RC coupled amplifier with feedback. Study the frequency response.
15. Design and simulate an RC phase shift oscillator using BJT and observe the sinusoidal output waveform.
16. Design and simulate the first order and second order low pass Butterworth filter for a cut off frequency of 1KHz. Obtain the frequency response curve and determine the roll off rate.
17. Design and simulate a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.
18. Design and simulate a differentiator and integrator using Op-amp. Obtain the output waveform for an input square wave.

## SEMESTER – III

**PH3RC1 ADVANCED QUANTUM MECHANICS**

**Unit I**

**Approximation Methods for Time-Independent Problems (18 Hrs)**

Time-independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, Stark and Zeeman effects in hydrogen. The WKB approximation, connection formulae, validity of the approximation, barrier tunnelling, application to decay - Bound states, Penetration of a potential barrier,

**Variational method**

The variational equation, ground state and excited states, the variation method for bound states, application to ground state of the hydrogen and Helium atoms.

**Unit II**

**Time Dependent Perturbation Theory (18 Hrs)**

Time dependent perturbation theory Transition probability, constant perturbation, Transition to continuum, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Induced emission and absorption, The electric dipole approximation, The Born approximation and scattering amplitude.

**Unit III**

**Relativistic Quantum Mechanics (22 Hrs)**

The Dirac equation, Dirac matrices, Solution of the free-particle Dirac equation, The Dirac equation with potentials, Equation of continuity, Spin of the electron, Non-realistic limit, Spin-orbit coupling, Covariance of the Dirac equation, Hole theory, The Weyl equation for the neutrino, Non-conservation of parity, The Klein-Gordon equation, Charge and current densities, The Klein-Gordon equation with potentials, Wave equation for the photon, Charge conjugation for the Dirac, Weyl and Klein-Gordon equation.

**Unit IV**

**Quantization of fields (14 Hrs)**

The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrodinger wave field for bosons and fermions, Quantization of Electromagnetic waves Coulomb's gauge.

Text Book:

1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern

**Reference Books:**

1. Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley & sons
2. Relativistic Quantum Mechanics, J.D. Bjorken & S. Drell, MGH, (1998)
3. Quantum Mechanics, L.I.Schiff, MGH
4. Advanced Quantum Mechanics, J.J. Sakuerai, Pearson Education.
5. A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, TMGH
6. Quantum Physics, Stephen Gasiorowics, Wiley

## PH3RC2 NUMERICAL METHODS IN PHYSICS

**Unit I (18 Hrs)**

Interpolation and Curve fitting - Errors in Polynomial Interpolation - Finite differences(Forward differences, Backward differences, Central differences) - Detection of errors by use of difference tables-Differences of a polynomial – Newton's formulae for interpolation - Central difference interpolation formulae (Gauss central difference formulae, Stirlings formulae, Evretts formula) - Interpolation with unevenly spaced points (Lagrange's interpolation formulae, Error in Lagrange's interpolation formulae, Hermite's interpolation formulae)

Least squares curve fitting procedures (Fitting a straight line, Nonlinear curve fitting, Curve fitting by a sum of exponentials) - Weighted least squares approximation (Linear Weighted least squares approximation, Nonlinear Weighted least squares approximation) – Method of least squares for continuous Functions (Orthogonal polynomials, Gram-Schmidt orthogonalization process)

**Unit II (18 Hrs)**

Numerical differentiation and integration - Numerical differentiation - Errors in Numerical differentiation - Trapezoidal rule-Simpson's 1/3 rule - Simpson's 3/8 rule - Romberg Integration-Gaussian Integration - Monte Carlo evaluation of integrals - Double Integration -Newton-cotes integration formulae.

**Unit III (18 Hrs)**

Linear system of equations - Solution of linear systems-Matrix inversion method - Gauss elimination method - Gauss-Jordan Method - Modification of Gauss method to compute the inverse of a matrix - Solution of linear systems-Iterative methods - The eigen value problem-Power method and Jacobi's method to solve eignvalue problems. (10 Hrs)

Numerical solution of ordinary differential equations - Solution by Taylor's series - Picards method of successive approximations - Euler's method - Runge-Kutta methods-Predictor-Corrector methods. (8 Hrs)

**Unit IV (18 Hrs)**

Numerical Solutions of partial differential equations - Finite difference approximations to derivatives - Laplace equation-Jacobi's method - Gauss Seidal method - Successive over relaxation - The ADI method - Parabolic equations - Iterative methods for the solution of equations - Hyperbolic equations

Text Books:

1. Mathematical Methods, G. Sanker Rao, K. Keshava Reddy, I.K.International Publishing House, Pvt. Ltd.
2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

**Reference Books:**

1. An Introduction to Computational Physics, Tao Pang, CUP
2. Numerical Recipes in C++,W.H. Press, Saul A. Teukolsky, CUP
3. Numerical methods for scientific and Engineering computation M.K Jain,S.R.K Iyangar: New Age International Publishers
4. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
5. Numerical Methods, Balaguruswami, Tata McGraw Hill, 2009.
6. Numerical Mathematical Analysis, $4^{th}$ Edn, J.B. Scarborough, 1958.

**PH3RE2 RENEWABLE ENERGY SOURCES**

**Unit I**

**Wind Power (18 Hrs)**

Energy and power in wind - wind turbines - power and energy from wind turbines - commercial development and wind energy potential - economics - cost calculation - capital cost.

**Wave Energy**

Wave energy - wave motion - power from wave energy

**Unit II**

**Hydroelectricity (18 Hrs)**

Stored potential energy - power head and flow rate - world resource - types of hydrolectric plants - low, medium and high heads - estimation of power - economics of hydrolectric projects.

**Tidal Power**

Nature of resource - basic physics - power generation -economical and environmental factors.

**Ocean Thermal Energy Conversion (OTEC)**

Introduction - OTEC power generation

**Unit III**

**Geothermal Energy (18 Hrs)**

Earth as a heat engine – miming of geothermal heart - physics of geothermal resources – technologies for geothermal exploration - economics and world potential- of geothermal energy.

**Biomass**

Biomass as a fuel – extraction of energy agricultural resides – energy from refuse - energy from crops new technologies - gas turbine - biomass fuel cell – photo biological fuel production - economics of biomass.

**Unit III**

**Fuel Cells (18 Hrs)**

Design and principle of operation of a Fuel Cell ($H_2$, $O_2$ cell), Classification of Fuel Cells, Types of Fuel Cells, Advantages and Disadvantages of Fuel Cells, Conversion efficiency of Fuel Cells, Work output and EMF of Fuel Cells, Applications of Fuel Cells.

**Hydrogen Energy**

Hydrogen production (Electrolysis method, Thermo-chemical methods, Fossil fuel methods, solar energy methods), Hydrogen storage, Hydrogen transportation, Utilization of Hydrogen Gas, Safety and management, Hydrogen technology development.

**Reference Books:**


1. Solar Energy Priciples of Thermal Collection and Storage, S.P. Sukhatme,2nd Ed. TMH
2. Solar Engineering of Thermal Process, J.A. Duffie & W. A Beckman,2nd Ed. John Wiley & sons.
3. Solar energy, H. P. Garg and J Prakashi,TMH 1997
4. Solar Energy Utilization, G D Rai, Khanna Publishers, 1997.
5. Renewable Energy Source and Conversion Technology, N.K Bansal, M. Kleemanm & M. Melss, TMH.
6. Renewable Eneregy, Godfrey Boyle, Oxford Univ. Press, 1996
7. Renewable Energy 2000, G.T. Wrixon, A.M.E. Rooney & W. Palz, Springer Verlag 1993.
8. Solar Power Plants, C.J. Winter, R.L. Sizmann & L.L Vant-Hull, Springer Verlag.


**PH3RE3 MICROPROCESSORS AND MICROCONTROLLERS**

**Unit I**

**8085 Architecture and Data Transfer Schemes. (18 Hrs)**

**8085** architecture - instruction set (assignment &discussion)) - instruction timings and execution - 8085 interrupts - 8085 Input /Output - standard I/O-memory mapped I/O - address space partitioning - memory interfacing - bus contention - data transfer schemes - classification of data transfer schemes - programmed data transfer - synchronous transfer -asynchronous transfer - interrupt driven data transfer- multiple interrupts - multiple devices, single interrupt level - software polling - hardware polling - direct memory access data transfer.

Text Books:

1. Microprocessor Architecture Programming and Applications, R.S. Gaonkar, Wiley Eastern.
2. Introduction to Microprocessors 3rd Ed. Aditya P. Mathur, TMH

**Unit II**

**Interfacing Devices & Memory Devices (18 Hrs)**

Basics of programmable I/O - the 8155 IC - the 8255 PPI - key board and display interface 8279 - serial communication -The USART - 8251 - DMA controller - 8257 - Programmable Interrupt controller – 8259- (Architecture and programming for all devices) – EPROM and RAM memory devices - 2764 and 6264.

Text Books:

1. Microprocessors and Microcomputer Based System Design, M. Rajiquzzaman, Universal book stall, New Delhi
2. Fundamentals of Microprocessors and Microcomputers,J.S. Ram, DhanpatRai Publications, New Delhi.

**Unit III**

**Interfacing 8055 & Architecture of 8086 (18 Hrs)**

Review of operational amplifier characteristics – transducers and its classification - light sensors – Eg (1) Photoconductive cell (2)

Semiconductor photo diode - temperature sensors –Eg (1) Thermocouple (2) Thermister – force sensors – Eg - Strain gauges - the 8085 based data acquisition system - interfacing ADC (0808) – concept of sample and hold circuit (LF 398) - clock for A/D converter – (circuit) - ADC 0808 (internal diagram) - interfacing circuit for 8085.

**8086 IC**

Architecture of IC 8086 - addressing modes - instruction set (assignment and discussion ) - pin layout – (sample programs using debug utilities) - minimum mode and minimum system mode interface – comparison 8086 & 8088.

Text Books:

1. Fundamentals of Microprocessors and microcomputers, B. Ram, DhanpatRai Publications, New Delhi.
2. Electronic Instrumentation, H.S. Kalsi, 2nd Edn. TMH.
3. The 8088 and 8086 microprocessors, W.A. Triebel & A.Singh, PHI
4. Advanced Microprocessors and Peripherals, Architecture Programming and Interfacing. A.K Ray, K.M Bhurchandi, TMH.

**Unit IV**

**Micro Controllers (18 Hrs)**

Introduction - Difference between microprocessors and micro controllers - types of micro controllers (MC) - internal architecture of typical MC (Intel 8051) - peripheral features - programming concepts – assembly language programming – jump – loop - call instructions - I/O port programming – Address modes – Arithmetic, logic instructions and programs – 8051 programming in C - (sample programs using Kiel utilities) - LCD interfacing.

Text Books:

1. The 8051 Micro Controller, Architecture Programming and Applications, Kenneth J. Ayala, Penram Int, Pub., Mumbai
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, Muhammad Ali Mazidi, 2nd Ed, Pearson.

**Reference Books:**


1. Microprocessor Architecture Programming and Applications, R.S. Goankar, Wiley Eastern.
2. Introduction to Microprocessors, 3rd Ed. Aditya P. Mathur, TMH.
3. 0000 to 8085 - Introduction to Microprocessors for Engineers and Scientists, P.K Ghosh, P.R. Sridhar, PHI Learning Pvt. Ltd.
4. The 8086 Microprocessor: Programming and interfacing the P.C., K.J. Ayala, Penram Pub. India
5. The 8051 Microcontroller and Embedded systems Using Assembly and C, 2nd Ed. Muhammad Ali Mazidi, R. Mckinlay, J.G. Mazidi, Pearson.


**PH3RP3 ELECTRONICS PRACTICALS**

(Use of Bread Boards for assembling electronics circuits is permitted. For Microprocessor experiments microprocessor kit, suitable simulation software or convenient Hex editors are permitted)

1. Design and construct a two stage RC coupled amplifier with feedback. Study the frequency response.

2. Design and construct a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.
3. Design and construct a push-pull power amplifier using transistors in complementary symmetry arrangement. Plot load impedance versus output power graph and determine the optimum load. Also study the frequency response.
4. Design and construct an RF amplifier. Study the effect of damping on the frequency response.
5. Design and construct a voltage controlled oscillator (VCO) using transistors. Plot the graph connecting frequency and control voltage. Repeat the experiment covering the entire audio frequency range.
6. Design and construct a differential amplifier using suitable operational amplifier (Op-amp) and study its frequency response. Also determine its CMRR.
7. Design and construct the first order and second order low pass Butterworth filter for a cut off frequency of 800 Hz. Draw the frequency response curve and determine the roll off rate.
8. Design and construct the first order and second order high pass Butterworth filter for a cut off frequency of 2 kHz. Draw the frequency response curve and determine the roll off rate.
9. Design and construct a band pass filter with multiple feedback using an operational amplifier (Op-amp) so that $f_0$ = 2 kHz. Q =3 and $A_F$ =10. Draw the frequency response curve and determine the pass band.

10. Design and construct a Wein Bridge Oscillator incorporating the amplitude stabilization for a frequency of 2 kHz. Using an operational amplifier (Op-amp). Repeat the experiment for different frequencies.
11. Using an operational amplifier (Op-amp) design and construct a voltage regulator with short circuit protection to obtain a regulated output of 6 volt. Study the load regulation and source regulation.
12. Determine experimentally the following parameters of an operational amplifier (Op-amp). (a). Input offset current (b). Input offset voltage (c). CMRR (d).Slew rate.
13. Using an operational amplifier (Op-amp) design and construct a triangular wave from generator for 1 kHz. With amplitudes 5 V. Measure the amplitude and frequency. Compare with theoretical values. Repeat the experiment for the frequencies of 500 Hz, 2 kHz, 3 kHz and 4 kHz.
14. Design and construct a voltage controlled oscillator (VCO) using IC555. Study variation of output frequency with control voltage and compare with the theoretical value. Also determine the duty cycle and compare with the theoretical value.
15. Design and construct a 4-bit binary synchronous counter using JK flip flops. Construct the up counter and convert it to a down counter.
16. Design and construct an amplitude modulator. Determine the percentage modulation. Trace the wave forms. Repeat the experiment for different amplitudes of the modulating signal.
17. Write and execute a program to control the speed of the stepper motor interfaced with a microprocessor. Rotate the motor in the clockwise

and anticlockwise directions using the program. Repeat the experiment for various time delays.

18. Write and execute a program to measure an analog voltage using a microprocessor kit with an ADC. Repeat for five different analog voltages. Draw a graph connecting the theoretical and measured values.
19. Write and execute a program for generating any two types of wave forms (triangular, square, saw-toothed, sine etc.) using microprocessor in association with a D/A interfaced card. Observe the wave forms using CRO. Measure the frequencies using the CRO and compare it with theoretical values.

## SEMESTER – IV

### PH4RC1 ATOMIC AND MOLECULAR SPECROSCOPY

**Unit I**

**Atomic Spectra (18 Hrs)**

Quantum states of electrons in atoms. electron spin, spectroscopic terms and selection rules. Spectrum of helium and alkali atoms. Hyperfine structure and isotopic shift. Width of spectral lines. Spin orbit interaction. Derivation of spin orbit interaction energy, fine structure in sodium atom, Landau g-factor, Zeeman effect. Paschen–Bach effect and Stark effect in one electron system, LS and JJ coupling schemes (Vector diagram), Hund's rule, Derivation of interaction energy, examples of LS and JJ coupling, Lande interval rule, Hyperfine structure, Width of spectral lines.

Text Book:

1. Spectroscopy Straughan & Walker, Vol. 1- John Wiley & Sons
2. Introduction of atomic spectra, H.E. White, Mc Graw Hill

**Unit II**

**Microwave and Infra Red Spectroscopy (18hrs)**

Microwave Spectroscopy: Rotational spectra of diatomic molecules. Intensity of spectral lines, effect of isotopic substitution.

Non–rigid rotator, rotational spectra of polyatomic molecules - linear, symmetric and asymmetric top molecules. Information derived from rotational spectra.

**IR Spectroscopy:** Vibrating diatomic molecules as anharmonic oscillators, diatomic vibrating rotator – break down of Born Oppenheimer approximation, vibrations of polyatomic molecules, overtone and combination frequencies, influence of rotation on the spectra of polyatomic molecules - linear and symmetric top molecules, analysis by IR technique, IR spectrometer, Fourier Transform Spectroscopy.

Text books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH.
2. Molecular structure and spectroscopy, G. Aruldas, PHI Learning Pvt. Ltd.

**Unit III**

**Raman and Electronic Spectroscopy (18 Hrs)**

Pure rotational Raman Spectra - linear and symmetric top molecules, vibration Raman spectra – Raman activity of vibrations, mutual exclusion principle, rotational fine structure, structure determination from Raman and IR spectroscopy. Non-linear Raman effects - hyper Raman effect, classical treatment, stimulated Raman effect, CARS

**Electronic Spectroscopy:** Electronic spectra of diatomic molecules, intensity of spectral lines, Frank–condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibrational transition, Fortrat diagram, pre-dissociation.

Text books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH
2. Molecular structure and spectroscopy, G.Aruldas, PHI Learning Pvt. Ltd.
3. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern
4. Raman Spectroscopy, D.A. Long, MGH.

**Unit IV**

**Spin Resonance Spectroscopy. (18 Hrs)**

**NMR:** Quantum mechanical description, classical description, the Bloch equations - relaxation processes, Chemical shift, spin–spin coupling for hydrogen molecule, experimental technique – CW and FTNMR spectrometer, applications.

**ESR:** Theory of ESR, thermal equilibrium and relaxation, experimental techniques, g- factor, hyperfine structure, applications, – Mossbauer effect, recoilless emission and absorption, experimental methods, hyperfine interactions – chemical isomer shift, magnetic hyperfine interactions, electronic quadrupole interactions, applications.

Text Book:

1. Spectroscopy Straughan & Walker, Vol.1&2, John Wiley & Sons

**Reference Books:**

1. Introduction to molecular spectroscopy, G.M. Barrow, Mc Graw Hill.
2. Mol. Spectra and Mol. Structure, Vol. 1, 2 & 3, G. Herzberg, Van Nostard, London.
3. Photoluminescence of solutions, C.A. Parker, Elsevier Pub.Co. 1968.
4. Elements of spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan.
5. Spectroscopy, Experimental Techniques, B.K. Sharma, Goel Pub. House.
6. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Wiley & Sons. Vol. 1&2.
7. Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand and Co.
8. Spectroscopy of organic compounds, P.S. Kalsi, New age.
9. Laser Spectroscopic Techniques and Applications, E.R. Menzel, Practical spectroscopic series vol. 18 – Mracel Dekker.
10. Molecular structure and spectroscopy, G.Aruldas, PHI

## PH4RC2 ADVANCED NUCLEAR PHYSICS

### Unit I

### Nuclear Decay (18 Hrs)

Beta decay – introduction, energy release in beta decay, Fermi theory of beta decay, Fermi-Kurie plot, mass of the neutrino, comparative half-life, allowed and forbidden transitions, selection rules, parity violation in beta decay, neutrino Physics.

Gamma decay – energetics, multipole moments, transitions and radiations – classical and quantum mechanical aspects, selection rules, angular correlation and internal conversion.

Nuclear radiation detectors : Gas detectors – Ionization chamber, Proportional counter and G. M. counter, Scintillation detector, Photo Multiplier Tube (PMT).

Text Books:

1. Introductory Nuclear Physics, K.S. Krane, Wiley
2. Nuclear Radiation Detection, Measurements and Analysis, K. Muraleedhara Varier, Narosa

**Unit II**

**Nuclear Forces (18 Hrs)**

General characteristics of nuclear forces, The Deuteron – binding energy, spin, parity, electromagnetic moments, simple theory of the deuteron structure, spin dependence, tensor force, and two nucleon scattering experimental data, scattering cross sections, low energy n-p scattering, partial waves, phase shift, singlet and triplet potentials, scattering length and its sign, effective range theory, low energy p-p scattering, exchange forces and Yukawa theory (Qualitative only).

Text Books:

1. Introductory Nuclear Physics, K.S. Krane, Wiley
2. Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern

**Unit III**

**Nuclear Models, Nuclear Fission and Fusion (18 Hrs)**

Nuclear models: Shell model, single particle potentials, spin-orbit coupling, single particle models, spins and parities of ground states, qaudrupole moments, magnetic moments and Schmidt limits, Nordheim’s rules, isospin symmetry,

Nuclear fission and Fusion: Compound nucleus reactions, fission process, characteristics, energy released, neutrons released in fission, cross sections, types of nuclear reactors, fusion process, characteristics of fusion, solar fusion, controlled fusion reactors.

Text Books:

1. Introductory Nuclear Physics, K.S. Krane, Wiley
2. Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern

**Unit IV**

**Particle Physics (18 Hrs)**

Types of interactions between elementary particles - hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, coloured quarks, experimental evidences for quark model. The quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions. Exchange bosons of the weak interaction, electroweak unification.

Text Books:

1. The Particle Hunters, Yuval Ne'eman and Yoram Kirsh, , 2nd Ed.,Cambridge University Press,1996
2. Introduction to Elementary Particles, David Griffiths, John Wiley & Sons,1987

**Reference Books:**

1. Nuclear Physics: An Introduction, S.B .Patel, New Age International.
2. Introductory Nuclear Physics, Samuel S.M. Wong, PHI.
3. Concepts of Nuclear Physics, B.L. Cohen, Tata McGraw Hill
4. Nuclear Physics, Irvin Kaplan, Addison Wesley, 1962
5. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
6. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London 1975.
7. Introductory Nuclear Physics, Y.R. Waghmare Oxford-IBH, New Delhi 1981.
8. Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S.Chand &Co.
9. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, John Wiley & Sons.
10. Particles and Nuclei, B. Povh, K. Rith, C. Scholz & F. Zetche, Springer(2002)
11. The ideas of particle physics – An introduction for scientist, G.D.Couoghlan, J.E.Dodd. & Ben M. Gripaios, 2nd Edn. 1991 or 3rd Edn. 2006, CUP.

**PH4RE3 SOLAR THERMAL COLLECTION AND STORAGE**

**Unit I**

**Solar Energy Solar Radiation (18Hrs)**

Structure of the sun - solar radiation outside the earth's atmosphere - solar radiation at the earth's surface - instruments for measuring solar radiation and sunshine - solar radiation geometry - solar radiation on titled surfaces

Text Books:

1. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2$^{nd}$ Edn. TMH, (Chapter 3)

**Thermal Applications Of Solar Energy - An Overview**

Devices for thermal collection and storage - thermal applications, water heating, space heating, space cooling and refrigeration, power generation, distillation, drying and cooking

Text Books:

1. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2$^{nd}$ Edn. TMH, (Chapter 2)

**Selective Surfaces For Solar Energy Conversion**

Introduction - heat balance - physical characteristics - use of selective solar energy collectors - anti-reflection coatings -solar reflector materials - type of selective coatings -preparations of selective coatings

Text Books:

1. Solar Energy Utilization, G.D. Rai, Khanna Publ., 1997 (Chap. 17).

**Unit II**

**Flat Plate Collectors (18Hrs)**

Performance analysis of fluid flat plate collectors - transmissivity of cover system - transmissivity absorptivity product - overall loss coefficient and heat transfer correlation -collector efficiency factor - collector heat removal factor - effects of various parameters performance - testing procedures performance analysis of conventional air heater - other types of air heaters, testing procedures

Text Books:

1. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2$^{nd}$ Edn. TMH, (Chapter 4 & 5)

**Unit III**

**Concentrating Collectors (18 Hrs)**

Parameters characterizing solar concentrators - types of concentrating collectors – cylindrical, parabolic concentrators - performance analysis of cylindrical parabolic concentrators -parametric study of cylindrical concentrating collectors - compound parabolic collector (CPC), CPC geometry -performance analysis - central receiver collector (basic ideas)

Text Books:

1. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2$^{nd}$ Edn. TMH, (Chapter 6)

**Unit IV**

**Solar Refrigeration and Air-Conditioning (18 Hrs)**

Carnot refrigeration cycle - principle of absorption cooling - lithium bromide water absorption system - aqua - ammonia absorption system intermittent absorption refrigeration system) - vapour compression refrigeration – desiccant cooling

Text Books:

1 Solar Energy, H.P. Garg & J. Prakash, TMGH 1997 (Chapter 12)

**Thermal Energy Storage**

Sensible heat storage - Latent heat storage - thermo - chemic$_v$ storage - Solar pond - performance analysis of solar pond

Text Books:

Solar Energy, H.P. Garg & J. Prakash, TMGH 1997 (Chapters 7 & 8)

**Reference Books:**

1. John A Duffie and W. A. Beckman, Solar Engineeering of thermal process 2nd Edition John Wiley & Sons, INC.
2. N K Bansal, M. Klemmann and M. Meliss, Renewable Energy sources and Conversion technology, TMH
3. Godfrey Boyle Renewable Energy, Oxford Univ. Press 1996
4. G T Wrixon, A M E Roney and W. Palz, Renewable energy 2000, Springer Verlag 1993.
5. C. J. Winter, R. L. Sizmann and L L Vaithull, Solar Power Plants, Springer Verlag.

**PH4RE4 SOLAR PHOTOVOLTAICS**

**Unit I**

**SolarCellFundamentals(18Hrs)**

Extrinsic semiconductor, controlling carrier concentration – carrier concentration and distribution – density of energy states – carrier distribution function-number of electrons and holes- electron hole concentration – carrier motion in semiconductors- drift: motion due to electric fields - electric field and energy band bending - diffusion current - diffusion current density – drift and diffusion together – diffusion coefficient – generation of carriers – recombination of carriers – continuity of carrier concentrations.

P-N Junction Diode: An Introduction to Solar Cells - equilibrium condition – space charge region - energy band diagram – junction potential-width of depletion region – carrier movements and current densities – carrier concentration profile – p-n junction non - equilibrium condition - I-V relation (qualitative).

Text Book:

1. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 2,3 and 4)

**Unit II (18 Hrs)**

P-N junction I-V relation: quantitative analysis - P-N junction under illumination – generation of photo voltage (PV) – light generated current – I-V equation for solar cell – solar cell characteristics.

Design of Solar Cells: upper limits of solar cell parameters - short circuit current – open circuit voltage – fill factor – efficiency – losses in solar cell – model of solar cell – effect of series and shunt resistance, solar radiation and temperature on solar cell efficiency – solar cell design - design of high short circuit current – choice of junction depth and orientation – minimisation of optical losses and recombination – Design for high open circuit voltage – design for high fill factor – base resistance – emitter resistance – analytical techniques – solar simulator: I-V measurement – quantum efficiency measurement – minority carrier life time and diffusion length measurement.

Text Book:

1. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chap 4 & 5)

**Unit III (18 Hrs)**

**Solar Cell Technologies:**

Production of silicon (Si) – Silicon requirement –production of metallurgical grade Si - production of electronic grade Si - production of Si wafers – Si sheets – Si feedstock for solar cell industry – Solar grade production of Si wafers – Si usage in solar SPV - Si wafer based solar cell technology - development of commercial Si solar cells – process flow of commercial Si cell technology – processes used in solar cell technology – high efficiency Si solar cells.

**Thin Film Solar Cell Technologies:**

Generic advantages of thin film technologies – materials for thin film technologies – thin film deposition techniques – common features of thin film technology - amorphous Si solar cell technology – cadmium telluride collar cell technology – chalcopyrite solar cell technology – thin film crystalline Si solar cell – microcrystalline Si thin film solar cell – thin film polycrystalline Si solar cell – large grain thin film crystalline Si solar cell – thin film epitaxial Si solar cell

**Concentrator PV Cells and Systems:**

light concentration – concentration ratio – series resistance optimisation of concentrator cells - optics for concentrator SPV.

Emerging Solar Cell Technologies and Concepts. Organic solar cells - Gallium Arsenide solar cells - Thermo photovoltaics.

Text Book:

1.Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 6,7,8 and 9)

**Unit IV**

**Solar Photovoltaic Applications (18 Hrs)**

Solar Photovoltaic (SPV) Modules – SPV from solar cells – series and parallel connections – mismatch in cell module – mismatch in series connection – hot spots in modules – bypass diode- mismatching parallel connection – design and structure of PV modules - number of solar cells-wattage of modules – fabrication of modules – PV module power output – I-V equation of PV modules – rating of PV modules - I-V and power curves of module – effect of solar irradiation and temperature - Balance of Solar PV Systems – electrochemical cells –factors affecting battery performance – batteries for SPV systems

Photovoltaic System Design and Applications.- introduction to SPV systems – stand alone SPV system configurations – design methodology of SPV systems – wire sizing in SPV systems - price sizing of SPV systems - hybrid SPV systems - grid connected SPV systems - simple payback period – life cycle costing

Text Book:

1.Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 12,13 and 14)

**Reference Books:**

1. Practical Photovoltaics: Electricity from Solar Cells Practical Photovoltaics: Electricity from Solar Cells Richard J. Komp 3rd Edn. aatec Publishers, Michigon.
2. The Physics of Solar Cells (Properties of Semiconductor Materials), Jenny Nelson, Imperial College Press, London.

## PH4RP4 RENEWABLE ENERGY PRACTICALS

1. Solar Cell characteristics
2. Efficiency of Solar Flat Plate Collectors
3. Improvement of Power Factor
4. Efficacy of Lamps
5. Study of Bio-gas plant (Lab Model)
6. Stefan - Boltzmann Constant
7. Fluidized Bed Heat Transfer
8. Microprocessor based Sun-tracking System (Lab Model)
9. Performance evaluation of a Single Basin Solar Still
10. Thermal testing of Box-type Solar Cooker
11. Determination of heat Loss Factor $F'U_L$ of linear Solar Absorbers using Indoor Test Facility
12. Determination of Time Constant of Solar Flat Plate Collector
13. Measurement of Solar Reflectance and Absorptance of surfaces
14. Study of Effect of Anti-reflection Coatings of Solar Cells

15. Performance Analysis of a Paraboloid Concentrator
16. Testing of a Solar Cabinet Drier
17. Determination of Optical Efficiency of a Seasonally Adjusted Linear Solar Concentrator
18. Four more experiments of equal standard can be added

## 4.4 M.Sc. PHYSICS - MATERIAL SCIENCE

### 4.4.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter M stands for Material Science. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicates the semester concerned. Course and Coure code of M.Sc. Physics - Material Science are given in Table 4.3

| SEM | Name of the course with course code | No. of Hrs/ week | No. of credit | Total Hrs/ SEM |
|---|---|---|---|---|
| I | **PH1MC1:** Applied Mathematics for Physics - I | 4 | 4 | 72 |
| I | **PH1MC2:** Quantum Mechanics - I | 4 | 4 | 72 |
| I | **PH1MC3:** Advanced Nuclear Physics | 4 | 4 | 72 |
| I | **PH1MC4**: Condensed Matter Physics | 4 | 4 | 72 |
| I | **PH1MP1**: General Physics Practicals | 9 | 3 | 162 |
| II | **PH2MC1**:Applied Mathematics for Physics - II | 4 | 4 | 72 |
| II | **PH2MC2**: Electrodynamics and nonlinear Optics | 4 | 4 | 72 |
| II | **PH2MC3**: Advanced Electronics | 4 | 4 | 72 |
| II | **PH2MC4**: Classical Mechanics and Relativity | 4 | 4 | 72 |
| II | **PH2MP2**: Electronics Practicals | 9 | 3 | 162 |
| III | **PH3MC1**: Computer Application in Physics | 4 | 4 | 72 |
| III | **PH3MC2**: Atomic and Molecular Spectroscopy | 4 | 4 | 72 |
| III | **PH3ME1**: Solid State Physics | 4 | 4 | 72 |
| III | **PH3ME2**: Crystal Growth Techniques | 4 | 4 | 72 |
| III | **PH3MP3**: Computational and Advanced Electronic Practicals | 9 | 3 | 162 |
| IV | **PH4MC1**: Quantum Mechanics - II | 4 | 4 | 72 |
| IV | **PH4MC2**: Statistical Physics and Astrophysics | 4 | 4 | 72 |
| IV | **PH4ME3:** Nanostructres and Characterisation | 4 | 4 | 72 |
| IV | **PH4ME4:** Thin Film and Nanoscience | 4 | 4 | 72 |
| IV | **PH4MP4:** Material Science Practicals | 9 | 3 | 162 |
| IV | **PH4D05**: Project/Dissertation | Nil | 2 | Nil |
| IV | **PH4V06**: Viva Voce | Nil | 2 | Nil |

*Table 4.3 Course and Coure code of M.Sc.Physics - Material Science*

## SEMESTER – I

## PH1MC1 APPLIED MATHEMATICS FOR PHYSICS- I

**Unit 1**

**Complex Analysis (20 Hrs)**

Function of a complex variable Cauchy-Rieman equation for analyticity – Integration in a complex plane – Cauchy's integrant theorem – Cauchy's integral formula -Taylor and Laurent expansions – Poles, residues & residue theorem -Evaluation of integrals.

**Unit II**

**Group theory (18 Hrs)**

Introductory definitions and concepts- cyclic groups - point groups - reducible and irreducible representations - orthogonality theorem - group character table - applications in molecular and crystal physics - 3d rotational group - lie group and lie algebra - Poincare and Lorentz group - SU(2) and SU(3) - examples from particle physics.

**Unit III**

**Integral transforms (18 Hrs)**

Laplace & Fourier transforms – universe transforms – solution of differential equation, wrong L T Earth's mutation, LCR circuit, EM wave in dispersive medium – driven oscillator with damping – FT of square wave, full wave rectifier & finite wave train – momentum representation for hydrogen atom ground state & harmonic oscillator.

**Unit IV**

**Partial Differential Equations (16 hrs)**

Partial differential equation – characteristics - boundary conditions - classes of partial differential equations- heat equation- Laplace's equation - Poisson's equation - non linear partial differential equation and boundary conditions - separation of variables in Cartesian, circular cylindrical and spherical polar coordinates - non homogeneous equation - Green's function- symmetry of Green's functions- forms of Green functions.

**Reference Books:**


1. Mathematical Physics, B.D. Gupta, Vikas Pub. House, New Delhi 1997.
2. Mathematical Methods in Classical & Quantum Physics, Tulsi Dass & S.K.Sharma, University Press Ltd. Hyderabad 1998.
3. Elements of Group Theory for Physicists, A.W. Joshi, New Age India Pub.. 1997.
4. Mathematical Physics, Satyaprakash, S. Chand & Sons
5. Mathematical Method for Physicists, G.B. Arfken & H.J. Weber - 6th Edition: A Comprehensive Guide, Academic Press, San Diego 2005.
6. Mathematical Physics, H. K. Das, S. Chand & Co. Ltd. New Delhi. 1999.
7. Mathematical Physics, B.S Rajput, Pragati Prakasan
8. Complex Variables- Introduction & Applications, M. J. Ablowitz & A.S. Fokes CUP, Foundation Books.
9. Complex Variables, Schaum's outline, M.R. Spiegel, TMH.

10. Advanced Mathematics for Eng. & Physics, L.A. Pipes & L.R. Harvill, MGH.
11. Mathematical methods of Physics, J. Mathew & R.L. Walker, India Book House Pvt. Ltd.
12. Mathematical Methods for Physics & Enginneering, K . F. Riley, M.P. Hobon & S. J. Bence, CUP (low price edition)
13. Advanced Engineering Mathematicsc, E. Keryzing, 7 th ed. John Wiley, 1993.
14. Introduction to Mathematical Methods in Physics, G. Fletcher, TMGH.
15. Advanced Engineering Mathematics, C.R. Wylie, Tata Mc Graw Hill.

**PH1MC2 QUANTUM MECHANICS – I**

**Unit I**

**Schrodinger Wave equation and Matrix Formulation of Quantum Mechanics (20Hrs)**

Schrodinger Wave equation - The one dimensional Wave equation - Extension to three dimensions - Interpretation of the wave function- Energy Eigen functions - One dimensional square well potential. Eigen functions and Eigen values - Interpretive Postulates and Energy Eigen functions momentum Eigen functions.- Discrete Eigen values – Linear Harmonic oscillator – Spherically symmetric potentials in three dimensions – Three dimensional Square well potential – The Hydrogen atom

**Matrix Formulation of Quantum Mechanics**

Matrix representations of operator Row and Column matrices – Hilbert space - Dirac's Bra and Ket notation. The Eigen value equation - Ortho normality of Eigen functions – The completeness Condition - Equations of motion - Schrodinger picture – Heisenberg picture - Interaction picture-Energy representation – Poisson's bracket and Commutator brackets - Quantisation of a classical system - Evaluation of Commutator brackets - velocity and acceleration of a charged particle - The Lorentz Force - Virial theorem – Matrix theory of Harmonic oscillator.

**Unit II**

**Symmetry in Quantum Mechanics (18 Hrs)**

**Space and time Displacements** -Unitary Displacement operator - Equation of motion – Symmetry and Degeneracy - Matrix elements for displaced states - Time displacement.

**Angular momentum** - Angular momentum operators - angular momentum matrices – spin angular momentum-Total angular momentum operators - Eigen values of Total angular momentum – Clebsch-Gordon coefficients - Recursion relations – Construction procedure calculation of C G coefficients j=1/2 and j=1 cases - Matrix elements for rotated states – Product of Tensor operators- Combination of operator and Eigen state - Wigner-Eckart Theorem.

**Unit III**

**The Quantum theory of Scattering (18 Hrs)**

**The scattering matrix:** The Green's functions propagator - Freeparticle Green's functions - Integral equation for Ψ - Integral equation for the propagator - Use of the advanced Green's function - differential equation for the Green's functions - Symbolic relations - Application to scattering - Unitarity of the S matrix - Symmetry properties of the S matrix - Stationary collision theory- Transition matrix - Transition Probability- scattering cross section - Green's functions for Stationary case - Green's functions as inverse operators- Stationary propagator – Free particle propagator - scattering amplitude - ingoing waves - S matrix for Stationary case – Angular momentum representation.

**Approximate calculations-** The Born approximation – Validity of Born approximation Scattering from two potentials - Distorted wave Born approximation – Partial wave analysis of DWBA - Approximate expression for the phase shifts - Scatterer with internal Degrees of freedom - Elastic and inelastic cross sections - Electron scattering from Hydrogen - Production of a cloud chamber track - Second order Perturbation theory - Evaluation of the Second order matrix element - Discussion of the cross section - Eikonal approximation. Scattering by a square well potential - Scattering by a perfectly rigid sphere - Scattering by a Coulomb field: Rutherford Formula- from Born approximation – scattering of Identical particles The Lippmam - Schwinger Equation.

**Unit IV**

**Approximation Methods for Stationary Problems (16 Hrs)**

**Stationary perturbation theory** – Non degenerate case - First order perturbation- Second order perturbation - Perturbation in an Oscillator- Degenerate case –Removal of degeneracy in Second order - Zeeman effect without electron spin- First order Stark effect in Hydrogen atom – Perturbed energy levels- Occurrence of permanent electric dipole moments. The Variation method – Expectation value of the energy - Application to excited states – Ground state of Helium - Electron interaction energy - Variation of the parameter Z - Vander-Waals interaction- Perturbation calculation - Variation calculation. Alternative treatment of the perturbation Series - Second order Stark effect in Hydrogen - Polarizability of Hydrogen - Method of Dalgarno and Lewis - Third order Perturbed energy - Interaction of a Hydrogen atom and a point charge - The WKB Approximation - Classical limit - Approximate solutions - Asymptotic nature of the solutions- solution near a turning point – linear turning point - Connection at the turning point - Asymptotic Connection formula - Energy levels of a potential well - A quantisation rule – Special boundary conditions- tunneling through a barrier.

**Reference Books:**


1. Quantum Mechanics, L.I. Schiff, 3rd Edn. McGraw Hill.
2. Quantum Mechanics-Theory and applications, A. Ghatak & S.Lokanathan,4th Edn. Mc Millan.
3. Quantum Mechanics, V.K. Thankappan 2rd Edn. Wiley Eastern.
4. Modern Quantum Mechanics, J.J. Sakurai. Pearson Education
5. A text book of Quantum Mechanics. P.M. Mathews & K. Venkatesan,TMGH
6. Quantum Mechanics, A. Messiah, North-Holland Publication Company.
7. Quantum Mechanics, G Aruldhas, Prentice Hall of India, 2002.

8. Advanced Quantum Mechanics, Satya Prakash, Kedar Nath Ramnath.
9. Quantum Mechanics –Concepts and applications, N. Zettili, John Wiley & Sons.
10. Introduction to Quantum Mechanics, R.H. Dicke & J.P Wittke, Addison Wesley.
11. Quantum Mechanics, B.N. Srivastava, Pragati Prakashan.

## PH1MC3 ADVANCED NUCLEAR PHYSICS

**Unit I**

**Nuclear Structure and Models (18Hrs)**

Basic properties of nuclei: Masses and relative abundances, mass defect, size and shape, binding energy, magnetic dipole moments and electric quadrupole moments. Liquid drop model - Semi-empirical mass formula of Weizsacker - Nuclear stability Mass parabolas - Bohr-Wheeler theory of fission – Fermi gas model Shell model - Spin-orbit coupling - Magic numbers - Angular momenta and parities of nuclear ground state - qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson - Nilsson Model - oblate and prolate.

**Unit II**

**Nuclear Interactions (18Hrs)**

Nuclear forces - Two body problem - Ground state of deuteron - Magnetic moment - Quadruple moment - Tensor forces - Meson theory of nuclear forces - Yukawa potential - Nucleon-nucleon scattering, scattering cross section - Low energy n-p scattering-phase shift - proton-proton scattering - Effective range theory - Characteristics of nuclear force - Spin dependence, charge independence and charge symmetry - Isospin formalism.

**Unit III**

**Nuclear Reactions and Nuclear Decay (18Hrs)**

Reaction dynamics, the Q value of Nuclear reaction, Scattering and reaction cross sections Compound nucleus formation and breakup, nuclear fission and heavy ion induced reactions, fusion reactions, types of nuclear reactors. Theory of striping reactions.

Beta decay - Fermi's theory - Fermi-Kurie Plot - Fermi and Gamow - Teller selection rules - Allowed and forbidden decays - Decay rates - Theory of Neutrino - Helicity of neutrino - Helicity measurement - Theory of electron capture - Non-conservation of parity - Gamma decay - Internal conversion - Multipole transitions in nuclei - Nuclear isomerism - Angular correlation in successive gamma emissions.

**Unit IV**

**Particle Physics (18Hrs)**

Types of interactions between elementary particles - Hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, coloured quarks, Experimental evidences for quark model. The quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions. Exchange Bosons of the weak interaction, electroweak unification.

**Reference Books:**


1. Introductory Nuclear Physics, Kenneth S. Krane, Wiley, New York (1987).
2. Introduction to Elementary Particle Physics, D. Griffiths, Harper and Row, New York.
3. Nuclear Physics, R.R. Roy and B.P. Nigam,New Age International, New Delhi(1983).
4. The particle Hunters, Yuval Ne'eman & Yoram kirsh, Cambridge University Press.
5. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi(1971).
6. Theory of Nuclear Structure, M.K. Pal, Scientific and Academic Edn (1983).
7. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
8. Nuclear Physics, I. Kaplan, $2^{nd}$ Edn, Narosa, New Delhi (1989).
9. Introduction to Nuclear Physics, H.A. Enge, Addison Wesle, London (1975).
10. Introductory Nuclear Physics, Y.R. Waghmare, Oxford-IBH, New Delhi (1981).
11. Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S. Chand & Co.
12. Elementary Particles, J.M. Longo, McGraw-Hill, New York (1971).
13. Nuclear and Particle Physics, W.E. Burcham & M. Jobes, Addison-Wesley, Tokyo.
14. Subatomic Physics, Frauenfelder &Henley, Prentice-Hall.
15. Particles and Nuclei, B. Povh, K. Rith, C. Scholz & F. Zetche, Springer (2002)

## PH1MC4 CONDENSED MATTER PHYSICS

**Unit I**

**Lattice Vibrations (16 Hrs)**

Vibrations of monatomic and diatomic lattices - acoustic and optical modes - Quantization of lattice vibrations - Phonon Momentum - Inelastic scattering of neutrons by phonons.

Lattice Heat Capacity - Einstein model, Density of modes in one and three dimensions -Debye model of lattice heat capacity – Debye's $T^3$ law - Anharmonic crystal Interactions - Thermal Expansion - Thermal conductivity.

**Unit II**

**Free Electron Theory and Band Theory (18 Hrs)**

Energy levels and density of orbitals in one dimension - Free electron gas in three dimensions - Heat capacity of the electron gas - Electrical conductivity and Ohm's law - Motion in magnetic fields - Hall effect-Thermal conductivity of metals - Wiedemann-Franz law - Nearly free electron model - Wave equation of electron in a periodic potential - Number of orbitals in a band - Construction of Fermi Surfaces -Calculation of Energy Bands - Experimental methods in Fermi surface studies.

**Unit III**

**Dielectric, Ferroelectric and Magnetic properties (20 Hrs)**

Theory of Dielectrics: Polarisation, Dielectric constant, Local Electric field, Dielectric polarisability, Clausius-Mossotti relation, Polarisation from dipole orientation, Dielectric losses, Ferroelectric crystals, Order-disorder type ferroelectrics, Properties of $BaTiO_3$, Polarisation catastrophe, Displacive type ferroelectrics, Landau theory of ferroelectric phase transitions, Ferroelectric domain, Antiferroelectricity, Piezoelectricity, Applications of Piezoelectric Crystals.

Diamagnetism and Para magnetism: Langevin's diamagnetism equation, Quantum theory of diamagnetism of mononuclear systems, Quantum theory of paramagnetism, Hund's rule, Paramagnetic susceptibility of conduction electrons, Ferro, Anti and Ferri magnetism: Curie point and the exchange integral, Magnons, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order. Weiss theory of ferromagnetism, Ferromagnetic domains, Bloch walls, Origin of domains, Novel magnetic materials: GMR-CMR materials (qualitative)

**Unit IV**

**Superconductivity (18 Hrs)**

Meissner effect - Type I and Type II superconductors, Heat capacity, Microwave absorption, Energy gap, Isotope effect, Free energy of superconductor in magnetic field and the stabilization energy, London equation and penetration of magnetic field, Cooper pairs and the BCS ground state and BCS Hamiltonian - Flux quantization, Single particle tunnelling, DC and AC Josephson effects, High $T_c$ superconductors - description of the cuprates - Applications of Superconductivity.

**Reference Books:**


1. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
2. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall
3. Solid State Physics, A.J.Dekker, Macmillan, 1967

4. Solid State Physics, N.W.Ashcroft and N.D. Mermin, Cengage Learning Pub.
5. Elements of Solid State Physics, J.P. Srivastava, Prentice Hall of India (2nd Edition)
6. Solid State Physics-J.S. Blakemore, Cambridge University Press.
7. Solid State Physics, Gupta Kumar, Pragati Prakasan
8. Solid State Physics-Structure and Properties of materials, M.A. Wahab. Narosa.
9. Solid State Physics, S.O.Pillai, New Age International 6th Edn. 2010
10. Elementary Solid State Physics, M. Ali Omar, Pearson.

**PH1MP1 GENERALPHYSICS PRACTICALS**

1. Magnetic susceptibility - Quincke's method
2. Magnetic susceptibility - Guoys method
3. Young's modulus and Poisson's ratio – Cornu's method, (Elliptical or Hyperbolic fringes)
4. Young's modulus and Poisson's ratio – Koenig's method
5. Michelson interferometer – thickness of mica sheet
6. Verification of Hartman's relation – Mercury and $KMnO_4$ spectrum
7. e/m of electron – Thomsons method
8. Study of thermistor – computation of response equation
9. Determination of e/k – silicon transistor
10. Hydrogen spectrum – Rydberg constant
11. Ultrasonics – velocity of sound in liquids

12. Oscillating disc – viscosity of liquid
13. Determination of e – Milliken's method
14. Characteristics of a photodiode
15. B-H curve – Anchor ring
16. Mutual inductance – Carey Foster's bridge
17. Self and mutual inductance – Anderson's bridge
18. Arc spectrum of Iron, Copper and Brass
19. Absorption spectrum of Iodine
20. Raman effect in liquids – plate measurement
21. Identification of elements by spectroscopic method

## SEMESTER – II

## PH2MC1 APPLIED MATHEMATICS FOR PHYSICS - II

**Unit I**

**Vector and Vector Spaces (16 hrs)**

Vector algebra and vector calculus, Orthogonal curvilinear co–ordinates – Spherical, Cylindrical and Polar co–ordinates – Line, Surface and Volume integral – Stokes, Gauss' and Green's theorems – equation of continuity – application in potential theory – Scalar potential, gravitational potential and centrifugal potential. Linear vector space – Hermtian - unitary and projection operators – inner products space – Schmidt Orthogonalisation – vector space of functions – Hilberts space – Schwartz inequality.

**Unit II**

**Matrices, Error analysis and Probability (20 Hrs)**

Diagonalisation – Jacobi's method – solution of linear equations – Gauss elimination method – Matrix inversion – Hermitian and unitary matrices – Pauli spin matrices – Orthogonal matrices – Euler angles –Moment of Inertia matrix – normal modes of vibration.

Error analysis and hypothesis testing – propagation of errors – Standard deviations - Statistical distribution – Poisson, Binomial and Gaussian – least square fitting –criteria for goodness of fit – Chi square test.

**Unit III**

**Differential Equations and Special Functions (20 Hrs)**

Gamma and Beta Functions (review of properties) – Dirac delta function – its property and integral forms. Bessel's differential equations – Legendre differential equations – Associated Legendre functions – Hermite differential equation – Laguerre differential equation – associated Laguerre polynomial – Generating Functions – recurrence relation –orthonormality – Rodrigue's formula – to be discussed for all equations.

**Unit IV**

**Tensors (16 hrs)**

Transformation of coordinates – contravariant, covariant and mixed tensor – symmetric and anti symmetric tensor – associated tensor – raising and lowering of indices – metric tensor – curvilinear coordinates – Riemannian Space – Covariant differentiation – Christoffel Symbols – geodesic.

**Reference Books:**

1. Mathematical Method for Physicists, G.B. Arfken & H.J. Weber, 6th Edn. 2005
2. Mathematical Physics, P.K. Chattopadhyya, New Age International.
3. Theory and Problems of Vector Analysis, M.R. Spiegel, Schaum's Series
4. Mathematical Methods for Physics & Engineering, K.F. Riley, M P Hobson and S. J. Bence, Cambridge University press.
5. Mathematical Physics, B.D. Gupta, Vikas Pub. House, New Delhi
6. Mathematical Physics - B.S Rajput, Y Prakash 9th Ed, Pragati Prakashan
7. Differential Equations with Applications & Programme,,Balachandra Rao & H.R.,Anuradha, University Press 1999.
8. Tensor Calculus, Theory & Problems, A.N. Srivastava, University Press, 1992
9. Vector Analysis and Tensors, M.R. Spiegel, Schaum's Series
10. Advanced Mathematics for Eng.& Scientists, Schaum's outline, M.R. Spiegel,TMH.
11. Vector Analysis, M. R Spiegel, Schaum's Series
12. Data Reduction & Errors Analysis for the Physical Sciences, P.Bevington, D.K.Robinson, MGH.
13. Differential Equations with Applications & Programme, B. Rao & H.R. Anuradha, University Press 1999.

14. Tensor Calculus – Theory & Problems, A.N. Srivastava University Press, 1992
15. Algebra, M. Artin, Prentice Hall of India Pvt. Ltd. N. D. 1999.

**PH2MC2 ELECTRODYNAMICS AND NON LINEAR OPTICS**

**Unit I**

**Electrostatics and Magnetostatics (18Hrs)**

Laplace's Equation – in one, two, three dimensions and its solutions. Boundary conditions and Uniqueness theorems - Conductors and the second Uniqueness theorem. Multipole expansion - Approximate Potentials at large distances - The Monopole and Dipole terms - Origin of coordinates in Multipole expansions - The electric field of a dipole. Linear Dielectrics - Susceptibility, Permittivity, Dielectric Constant - Boundary value problem with linear dielectrics - Energy in dielectric systems - Forces on dielectrics.

Magnetostatics - The divergence and Curl of B - Straight line currents - Applications of Ampere's law - Comparison of magnetostatics and electrostatics. Magnetic vector potential - The vector potential - Magnetostatic boundary conditions- Multipole expansion of the vector potential - The auxiliary field H- Ampere's law in magnetized materials- A deceptive parallel - Boundary conditions.

**Unit II**

**Electrodynamics and Electromagnetic Waves (20Hrs)**

Maxwell's Equations - Electrodynamics before Maxwell - How Maxwell fixed up Ampere's law - Maxwell's equations - Magnetic charge - Maxwell's equations in matter- Boundary conditions. Conservation Laws -

charge and energy - The continuity equation - Poynting`s theorem – Momentum - Newton's third law in Electrodynamics - Maxwell's Stress Tensor - Conservation of Momentum - Angular Momentum.

Electromagnetic Waves - Waves in one dimension - Electromagnetic waves in vacuum - Electromagnetic waves ion matter - Absorption and Dispersion - Guided waves.

Potentials and Fields -The Potential formulation - Continuous Distributions - Retarded Potentials – Jefimenko's equations - Point Charges - Lienard-Wichert Potentials.

**Unit III**

**Radiation and Relativistic Electrodynamics (16Hrs)**

Dipole radiation - Electric dipole radiation and Magnetic dipole radiation - Radiation from an Arbitrary source. Point Charges - Power radiated from a point charge - Radiation reaction - Abraham Lorentz formula.

Relativistic Mechanics - Proper time and velocity-Relativistic energy and Momentum- Relativistic Kinematics- Relativistic dynamics. Relativistic Electrodynamics - Magnetism as a relativistic phenomenon - Transformation of the field - Electromagnetic field tensor - Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics**.**

**Unit IV**

**Non Linear Optics (18Hrs)**

The self focusing phenomenon of light - Harmonic generation - Second Harmonic generation – phase matching condition – third harmonic generation – optical mixing – parametric generation of light –- multi quantum photoelectric effect - two photon processes - three photon processes

- parametric generation of light – frequency up conversion – phase conjugate optics – generation of sum and difference frequencies.

**Reference Books:**


1. Introduction to Electrodynamics, David J Griffiths, PHI Learning, 2009
2. Classical Electrodynamics, J.D. Jackson 3rd Ed. Wiley, 1993.
3. Lasers and Non Linear optics, B.B Laud, Wiley eastern.
4. Optical Electronics, Ajoy Ghatak & K. Thyagarajan, Cambridge 2003.
5. Contemporary optics, Ajoy Ghatak & K. Thyagarajan, Plenum, New York.
6. Introduction to Optics, Germain Chartier, Springer.
7. The Feynman Lectures in Physics,Vol 2, Feynamn, Leighton, Sands.
8. Quantum Electronics, Amion Yariv, Wiley.
9. Introduction to Classical Electrodynamics, Y K Lim, World Scientific.
10. Non Linear Optics, Robert W. Boyd, Academic Press.


**PH2MC3 ADVANCED ELECTRONICS**

**Unit I**

**Multistage Amplifiers (18 Hrs)**

Gain of a Multistage Amplifier - RC coupled two stage Amplifiers - Advantages and disadvantages – Applications - Impedance coupled Amplifier - Transformer coupled Amplifier - Direct coupled Amplifier - Darlington pair - Comparison between Darlington pair and Emitter follower.

Power Amplifiers – Difference between voltage and Power Amplifier - Performance parameters - AC Load line - Classification of Power Amplifiers - Class A - Characteristics & power relations for Class A amplifiers – Transformer coupled Class A Amplifier - Class B Amplifier- Transformer less Class B Push-pull Amplifier - Class C Amplifier. Tuned Amplifiers – Parallel Resonant circuit – Single tuned Voltage Amplifier Double tuned Voltage Amplifier - Stagger tuned Voltage Amplifier.

**Unit II**

**Operational Amplifiers (18 Hrs)**

Differential amplifier- Basic circuit – Operation - Common-mode and Differential mode signals – Double ended input Operation of DA - voltage gain - CMRR-DC Analysis of DA - Overview of DA - Input bias Current - AC Analysis of DA – Common mode voltage gain. Operational amplifiers- Overview - Op-amp Parameters - Frequency response of an op amp - Op-amp with negative feedback - compensating networks.

Applications – Op-amp as a Voltage amplifier – Inverting amplifier - Non-Inverting amplifier - Voltage Follower - Multistage Op-amp circuits - Summing amplifier – Peaking amplifier – Summing, Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Comparators - The Integrator - The Differentiator –Audio Amplifier - OP-amp based Wein-Bridge Oscillator, Colpitt's Oscillator & Crystal Oscillator – Triangular wave Oscillator – A voltage controlled saw tooth Oscillator VCO – A square wave relaxation Oscillator - High impedance voltmeter.

**Unit III**

**Active filters, Oscillators and Integrated Circuits (18 hrs)**

Active filters – First order and second order low pass Butterworth filter - First order and second order high pass Butterworth filter - wide and narrow band pass filter - wide and narrow band reject filter - All pass filter .Oscillators - Phase shift and Wien bridge oscillators using transistor – Tunnel diode oscillator – UJT Sawtooth generator - Multivibrators – astable, monostable & bistable multivibrators- Schmitt Trigger - Transistor blocking oscillator - The 555 Timer - Voltage controlled oscillator.

Integrated Circuits - Advantages and Disadvantages of IC's - IC classification by structure and functions - Linear Integrated circuits - Digital Integrated circuits - Fabrication of IC components - Complete Monolithic Integrated circuits - MOS Integrated circuits.

**Unit IV**

**Field effect Transistors, Amplifiers And Digital Signal Processing (18 Hrs)**

Junction field effect Transistor - working principles of JFET- difference between JFET bipolar transistor- JFET as an amplifier - output characteristics of JFET- advantages of JFET- parameters JFET.

Amplifiers - Biasing the JFET- gate bias - self bias - setting a Q-point - voltage divider bias- Source bias- biasing the enhancement type MOSFET's- biasing the depletion type MOSFET's- small signal FET models - small signal low-frequency and high frequency FET models- common source amplifier—common drain .

**Digital Signal Processing -**Mathematical representations of continuous time (CT) and discrete time (DT) signals – basic concepts of sampling of signals – sampling theorem - Signal energy and power – periodic signals – even and odd signals – exponential and sinusoidal signals – discrete time unit impulse and unit step sequences – examples of DT signal processing systems - interconnections of systems – DT systems with and without memory – invertability and inverse systems – causality – stability – time invariance – linearity.

**Reference Books**


1. Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI
2. A text book of Applied Electronics, R.S. Sedha, S. Chand & Co.
3. Principles of Electronics, V.K.Mehta and Rohit Mehta S. Chand & Co.
4. Basic Electronics, B.L. Theraja, S. Chand & Co.
5. Integrated Electronics, J. Millman and C.C. Halkias, MGH
6. Signals and Systems Alan S. Willsky, Alan V. Oppenheim, S. Hamid 2$^{nd}$ Edn PHI
7. Digital Signal Processing, P.Ramesh Babu, Scitech Publishing.
8. Digital Signal Processing, A. Nagaroor Kani, TMGH.
9. Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis,Dimitris G Manolakis, PHI
10. Digital Signal Processing- A Modern Introduction, Ashok Ambardar, Thomson.
11. Introduction Digital Signal Processing, Johnny R Johnson, PHI

**PH2MC4 CLASSICAL MECHANICS AND RELATIVITY**

**Unit I**

**The motion of Rigid Bodies and Theory of Small Oscillations (20 Hrs)**

Independent co-ordinates of a rigid body - Orthogonal transformations - Inertia Tensor – Euler's angles - Euler's theorem on the motion of a rigid body - Force free motion of a symmetric top - Motion of a heavy symmetric top - Infinitesimal rotation - Precession of Charged bodies in magnetic field - Coriolis Force and its effects. Independent Coordinates – Orthogonal Transformations – Euler's Angles. Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top - Sleeping top.

**Theory of Small Oscillations** - Formulation of the problem – Eigen value equation – Coupled oscillators – Normal coordinates. Oscillations of linear triatomic molecule

**Unit II**

**Hamiltonian Mechanics (18 Hrs)**

Hamilton's equations of motion - cyclic coordinates and conservation theorems - Hamilton's equations from variational principle - Physical significance of principle of least action -Canonical transformations – Poisson brackets – Equation of motion in Poisson bracket formulation- The canonical invariance of Poisson bracket - Lagrange brackets.

The Hamilton Jacobi equation - Hamilton's characteristic function – The Harmonic oscillator in Hamilton Jacobi method - Action angle variables – Kepler's problem in action angle variables - Transition to Wave mechanics.

**Unit III**

**Canonical Perturbation Theory and Lagrangian Formulation for Continuous Systems And Fields (16 Hrs)**

Time dependent perturbation and illustrations - Time independent perturbation theory in first order with one degree of freedom. Time independent perturbation theory to higher order - Kepler problem and precession of the equinoxes of satellite orbits. Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields – Noether's theorem.

**Unit IV**

**The Special Theory of relativity (18 Hrs)**

The postulates of Special Theory of relativity-Lorentz transformation – Velocity transformation - Length contraction-Time dilation - Mass in relativity - mass and energy -Relativistic Lagrangian and Hamiltonian of a particle-Lorentz co-variance - four vectors - Invariance of Maxwell's equations under Lorentz transformations - Electromagnetic field tensor - Principle of Equivalence- Precession of the Perihelion of planetary orbits.

**Reference Books:**


1. Classical Mechanics, Goldstein, Poole & Safko, 3rd Edn. Pearson.
2. Classical mechanics,G. Aruldas, Prentice Hall
3. Classical mechanics, N. C. Rana & P.S. Joag - TMGH
4. Classical mechanics, J.C. Upadhyaya, Himalaya.
5. Classical mechanics, Satyaprakash, Sultan Chand & Company.
6. Classical mechanics, Gupta & Kumar, Pragati Prakasan.
7. Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press

8. Dynamics, S.N. Rasband. John Wiley 1983
9. Introduction to Dynamics,I. Percival & D. Richards, Cambridge Univ. Press 1982
10. Lagrangian and Hamiltonian mechanics, M. G. Calkin - Allied Pub. Ltd.
11. Theory of Relativity - R. K. Ptharia, Dover Pub. Inc. NY,2003
12. An Introduction to General Theory of Relativity, S.K. Bose, Wiley Eastern.

**PH2MP2 ELECTRONICS PRACTICALS**

1. RC coupled CE amplifier – two stages with feed back – frequency response and voltage gain
2. Differential amplifier – using transistors – constant current source – frequency response
3. Active filters – low pass and high pass – first and second orders – frequency response and roll of rate
4. Band pass filter using single op-amp
5. Voltage controlled oscillator using transistors
6. Voltage regulation using op-amp with short circuit protection
7. UJT characteristics
8. Relaxation oscillator using UJT
9. RF amplifier- frequency response and band width
10. Op – amp monostable multivibrator , square wave generator
11. IC 555 monostable multivibrator and astable multivibrator
12. IC 555 pulse width modulation and linear RAMP generator

13. Voltage controlled oscillator using IC 555
14. Shift registers Binary sequence generator
15. Thermistor characteristics
16. Synchronous counters and divide by N counters
17. Op – amp mathematical operations
18. Op – amp Wein bridge oscillator
19. Amplitude modulation using transistors
20. Precision rectifiers – measurement of rectifier efficiency at different frequencies
21. Op- amp triangular wave generator with specified amplitude

## SEMESSTER – III

**PH3MC1 COMPUTER APPLICATION IN PHYSICS**

**Unit I**

**Numerical Methods (20 Hrs)**

Numerical solution of Non-linear equations - The method of iteration - Newton-Raphson method – Method of successive approximation.

Numerical solution of system of linear equations - Gauss Elimination Method – Gauss -Jordan method, matrix inversion method – Jacobi's method - Gauss-Seidel method - Eigen value problem - Power method.

Curve Fitting -The method of least squares - for fitting a straight line- Fitting a polynomial- Fitting a non-linear function – Fitting a geometric curve - Fitting an exponential curve - Fitting a Hyperbola - Fitting a trigonometric function. Interpolation - Lagrange’s interpolation - Finite differences - Forward Backward and Divided differences - Difference Tables - Newton's methods of interpolation- Cubic spline interpolation.

**Unit II**

**Numerical Differentiation and Integrations (16 Hrs)**

Numerical Differentiation, Errors in numerical differentiation, Cubic spline method, Finding maxima and minima of a tabulated function. Newton-Cotes formulae for integration - Trapezoidal Rule, Simpson's Rule, Romberg's integration, Gauss’s Quadrature formula - Double integration.

**Unit III**

**Object Oriented Programming in C++ (16 Hrs)**

Review of C++ - Structures – Functions - Classes and objects – Constructors and Destructors

**Unit IV**

**Operator overloading, Type Conversion and Graphics (20Hrs)**

Operator overloading – overloading unary operators - overloading binary operators - Data conversion - Manipulation of strings using Operators - Rules for overloading operators. Inheritance- Derived class and Base class - Derived class Constructors – overriding member Functions - Class Hierarchies - Public and Private Inheritance - levels of Inheritance – Multiple Inheritance.

Pointers – Pointers and Functions - Pointers to objects- Pointers to Pointers – Virtual Functions – Friend Functions - The this pointer. Graphics –Text mode Graphics Functions – Graphics mode Graphics Functions – rectangles and lines - Motion -Text in Graphics Mode.

**Reference Books:**

1. Introductory Methods of Numerical Analysis,S.S. Sasthry, PHI.
2. Computer oriented Numerical Methods, R.S. Salaria, Khanna Pub.
3. Computer oriented Numerical Methods, V. Rajaraman, PHI.
4. Mathematical Methods, G. Sanker Rao, I.K. International Publishing House.
5. Object Oriented Programming in Microsoft C++,Robert Lafore, Pearson.
6. Object Oriented Programming in C++, E. Balagurusamy, TMGH.
7. Computer Science C++ Sumita Arora ,Gautam Sarkar, Dhanpat Rai & Co.

**PH3MC2 ATOMIC AND MOLECULAR SPECTROSCOPY**

**Unit I**

**Molecular Vibrations, Infra Red Spectroscopy and Microwave Spectroscopy (18hrs)**

Basic principles of Vibrational Spectroscopy - Diatomic molecule - Harmonic Oscillator and Anharmonic Oscillator - Vibrations of Polyatomic molecules - Energy levels and spectral transitions - Description of internal Vibrations - Spectra of some simple molecules- Vibrational assignments - Coupled Vibrations – Time scale.

Infra Red Spectroscopy – The diatomic Vibrating rotator - Asymmetry of rotation- Vibration band - The Vibration-rotation spectrum of carbon monoxide – The interaction of rotations and Vibrations – Linear molecules - Nuclear spin effect- symmetric top molecules- Interpretation of vibrational spectra - Group Frequencies. Microwave Spectroscopy - Theory of Microwave Spectroscopy – The diatomic molecule as a Rigid Rotator - The diatomic molecule as a Non – rigid rotator - Rotational spectra of polyatomic molecules - linear molecule - Symmetric and asymmetric top molecules.

**Unit II**

**Electronic Spectroscopy of Atoms, Photoelectron Spectroscopy and UV Spectroscopy (18hrs)**

Electronic Spectroscopy - Electronic spectra of diatomic molecules, Intensity of spectral lines, Frank – condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic vibrational transition, The Fortrat Parabolae, Pre-dissociation.

Photoelectron Spectroscopy - Principle – Instrumentation and Information from Photoelectron spectra.

UV Spectroscopy - Origin and Theory of Ultraviolet Spectra - Choice of Solvents- Instrumentation – Applications of UV absorption Spectroscopy.

**Unit III**

**Atomic Spectra (18hrs)**

Quantum states of electrons in atoms - Electron spin - spectroscopic terms and selection rules. Spectrum of helium and alkali atoms - Relativistic corrections for energy levels of hydrogen atom - Hyperfine structure and isotopic shift - Width of spectral lines - spin orbit interaction - Derivation of spin orbit interaction energy, fine structure in sodium atom, Landau g-factor, Zeeman effect. Paschen – Bach effect and Stark effect in one electron system, LS and JJ coupling schemes (Vector diagram), Hund’s rule, Derivation of interaction energy, examples of LS and JJ coupling, Lande interval rule, Hyperfine structure, Width of spectral lines.

**Unit IV**

**X-Ray Spectroscopy, Fluorescence Phosphorescence and Raman Spectroscopy (18hrs)**

X-Ray sources and Detectors- Interaction of X-rays with matter— Instrumentation - Applications of X-Ray Absorption methods - X-Ray Diffraction methods and Applications to complexes – Particle size determination.

Fluorescence**,** Phosphorescence, Excitation spectra, Experimental methods, and Applications. Raman spectroscopy- Characteristic properties of Raman lines- Differences between Raman Spectra and Infra red spectra- Mechanism of Raman Effect- intensity of Raman lines.

**Reference Books**


1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill.
2. Vibrational Spectroscopy, D. N. Satyanarayana, New Age International.
3. Fundamentals of Molecular Spectroscopy, C.N. Banwel. McGraw Hill, 1994.
4. Spectroscopy (Vol. 1,2&3), B.P. Straughan, & Walker, Science paperbacks 1976.
5. Molecular Structure and Spectroscopy, G. Aruldas, Prentice Hall of India.
6. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya

7. Introduction to Infrared and Raman Spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley- Academic press NY.
8. Instrumental Methods of Analysis,Willard, Merrit, Dean and Settle,CBS Pub.
9. Instrumental Methods of Chemical Analysis, G.W. Ewing, McGraw Hill
10. Introduction to Spectroscopy, Pavia, Lampman, Kriz. 3rd Edn.
11. Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977 .
12. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
13. Mol. Spectra and Mol. Structure, Vol. 1, 2 & 3. Herzberg G, Van Nostard, London.
14. Photoluminescence of Solutions, C.A. Parker, Elsevier Pub.Comp. 1968.
15. Elements of Spectroscopy, Gupta, Kumar and Sharama, Pragathi Prakasan.
16. Spectroscopy, Experimental techniques, BK. Sharma, Goel Pub. House.
17. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall Vol. 1&2.
18. Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand & Co.
19. Spectroscopy of organic compounds, P.S. Kalsi, New Age International.
20. Laser spectroscopic techniques and applications, E.R. Menzel, Practical spectroscopic series vol. 18, Marcel Dekker.

**PH3ME1 SOLID STATE PHYSICS**

**Unit I**

**Crystals and Symmetry Properties (20 Hrs)**

Crystalline state – Anisotropy - Symmetry elements – Translational, Rotational, Reflection – Restrictions on Symmetry elements – Possible combinations of Rotational Symmetries - Crystal systems - 14 Bravais lattices.

Stereographic projection and point groups – principles – Constructions - Construction with the Wulff net - Macroscopic Symmetry elements- Orthorhombic system- Tetragonal system- Cubic system - Hexagonal system - Trigonal system - Monoclinic system- Triclinic system - Laue groups - Space groups.

**Unit II**

**Optical Properties and Crystal Lasers (16 Hrs)**

Lattice vacancies – diffusion – colour centres – F-centre and other centres in alkali halides – ionic conductivity – colour of crystals – excitons in molecular crystals – model of an ideal photoconductor – traps – space charge effects – experimental techniques – transit time excitation and emission Aicalf mechanism – model for thallium activated alkali halides - electroluminescence.

**Lasers:** Properties of laser beams - temporal coherence - spatial coherence – directionality – single mode operation - frequency stabilization - mode locking - Q-Switching - measurement of distance - Ruby laser - four-level solid state lasers - semiconductor lasers - Neodymium lasers (Nd:YAG, Nd:Glass) .

**Unit III**

**Semiconductor crystals (18 Hrs)**

Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration - impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions.

Plasmons, Polaritons and Polarons: Dielectric function of the electron gas – plasmons - electrostatic screening- **p**olaritons and the LST relation – electron - electron interaction - Fermi liquid - electron-phonon interaction - Polarons- Peierls instability of linear metals.

**Unit IV**

**Imperfections and Dislocations (18 Hrs)**

Types of imperfections in crystals - thermodynamic theory of atomic imperfections – experimental proof – diffusion mechanisms - atomic diffusion theory – experimental determination of diffusion constant – ionic conduction – shear strength of single crystals - slip and plastic deformations. Dislocations - Burgers vectors – edge and screw dislocations – motion of dislocation – climb - stress and strain fields of dislocation – forces acting on a dislocation – stress and strain fields of dislocation – forces acting on a dislocation – energy of dislocation – interaction – between dislocation densities – dislocation and crystal growth – Dislocation – Frank – Read mechanism - point defects - twinning.

**Reference Books:**

1. Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley

2. Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI
3. Solid State Physics, A.J.Dekker, Macmillan, (1967).
4. Lasers Theory and Applications, K.Thyagarajan, A.K. Ghatak, Plenum Press
5. Lasers and Non-Linear Optics, B B Laud, New Age International.
6. Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.
7. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.
8. Solid State Physics,J.S. Blakemore, W.B.Saunders & Co. Philadelphia.
9. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole (1976).
10. Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.
11. A short course in Solid State Physics, Vol. I, F.C Auluck, Thomson Press,India, Ltd.
12. Crystalline Solids, Duncan Mc Kie, Christine Mc Kie, Wiley

**PH3ME2 CRYSTAL GROWTH TECHNIQUES**

**Unit I**

**Crystal Growth phenomena (18 Hrs)**

The historical development of crystal growth – significance of single crystals - crystal growth techniques - the chemical physics of crystal growth.

Theories of nucleation - Gibb’s Thompson equation for vapour, melt and solution- energy of formation of spherical nucleus- heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory- The Muller- Krumbhaar model.

**Unit II**

**Crystal Growth from Melt and Solution Growth (18Hrs)**

Growth from the melt - the Bridgmann technique – crystal pulling - Czocharalski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil’s flame fusion technique.

Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

**Unit III**

**Vapour Growth and Epitaxial Growth (18 Hrs)**

Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet.

Advantages of epitaxial growth, epitaxial techniques - liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, chemical beam epitaxy and atomic layer epitaxy

**Unit IV**

**Materials for Semiconductor Devices (18Hrs)**

Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quarternary alloys.

Semiconductor Devices - Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

**Reference Books:**


1. The Growth of Single Crystal, R.A. Laudise, Prentice Hall, NJ.
2. Crystal Growth: Principles and Progress , A.W. Vere, Plenum Press, NY.
3. Crystal Growth Processes and methods, P.S. Raghavan and P. Ramasamy, KRU Publications.
4. A Short course in Solid State Physics, Vol. I, F.C. Auluck, Thomson Press India Ltd.
5. Crystal Growth, B.R. Pamplin, Pergamon, (1980)
6. Crystal Growth in Gel, Heinz K Henish, Dover Publication


**PH3MP3 COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS**

(Experiments from 1 to 15 are C++ programs)

1. Motion of a spherical body in a viscous medium
2. Projectile motion and motion of a satellite
3. SHM – damped and forced
4. Formation of standing waves
5. Young’s double slit – interference
6. Diffraction due to a grating

7. Polarisation and birefringence
8. Electric field due to a point charge and equipotential surface
9. Motion in electric and magnetic fields – cyclotron
10. Circuit analysis using Kirchoff's laws – LCR circuit with AC & DC sources
11. Solution of Schrodinger equation for harmonic and anharmonic potential
12. Finding the roots of a non-linear equation by bisection method
13. Solving an ordinary differential equation
14. Numerical integration of a function
15. Integration by using Monte Carlo method
16. RF oscillator above 1 MHz – frequency measurement
17. Pulse width modulator
18. Microprocessor – multiplication of two 8 bit binary numbers
19. Microprocessor – Sorting of data in ascending and descending order
20. Microprocessor – measurement of analogue voltage
21. Microprocessor – stepper motor control
22. Fullwave controlled rectifier
23. Frequency modulation and demodulation
24. OPAMP – Inverting amplifier
25. OPAMP – Low distortion sine wave generator
26. OPAMP – Difference amplifier
27. JK flip flop – four bit binary counter
28. JK flip flop – shift register
29. Amplitude modulation

30. Pulse amplitude modulation
31. Attenuators
32. Half adder and full adder

## SEMESTER – IV

## PH4MC1 QUANTUM MECHANICS -II

**Unit I**

**Methods for Time-dependent Problems (18 Hrs)**

Time-dependent perturbation theory- Interaction Picture- – First order perturbation - Harmonic perturbation – Transition probability– constant perturbation – The electric dipole approximation- Ionization of a hydrogen atom - Density of final states - Ionization probability – Second order perturbation- Adiabatic approximation - Choice of phases - Connection with perturbation theory- Discontinuous change in H – Sudden approximation – Disturbance of an Oscillator.

**Unit II**

**Relativistic Quantum Mechanics (20Hrs)**

Schrodinger's relativistic equation – Free particle - Electromagnetic potentials – Separation of the equation - energy levels in a Coulomb field. Klein–Gordon equation – Physical Interpretation - Charge and current densities - Charged spin -zero free particle - charge conjugation - Eigen values of operators- Interaction with electromagnetic field - Bound states in a Coulomb field.

The Dirac's relativistic equation - free particle equation - Dirac matrices for α and β - free particle solutions – charge and current densities – Electromagnetic potentials. Dirac's equation for a central field - Spin angular momentum - spin orbit energy - Zitterbewegung - Separation of the equation - The Hydrogen atom - Classification of energy levels - Negative energy states- electron hole theory - Weyl equation for neutrino and non conservation of parity – the tau matrices - bilinear covariants.

**Unit III**

**Identical particles and Spin ( 16Hrs)**

Identical particles - Physical meaning of identity - Symmetric and anti symmetric wave functions - Construction from unsymmetrized functions - The symmetric group - Distinguishability of Identical particles – Pauli's exclusion principle - Connection with statistical mechanics - collisions of Identical particles. Spin angular momentum – Connection between spin and statistics - spin matrices and eigen functions - collisions of identical particles - electron spin functions- the helium atom - spin functions for three electrons.

Density operator and density matrix – Expectation value and projection operator - density operator - equations of motion - Projection operator for a spin ½ particle - density matrix for a spin ½ particle - polarization vector for a spin s particle - Precession of the Polarization vector. Rearrangement collisions – Notation for Rearrangement collisions - Alternative expression for the T Matrix element - T Matrix element for Rearrangements – Presence of a core Interaction - Elimination of the core term - Exchange collisions of electrons with Hydrogen - Relation between amplitude and Matrix element - Effects of identity and spin - Exchange collisions with Helium.

**Unit IV**

**The Quantization of Wave Fields (18Hrs)**

Classical and Quantum field equations - Coordinates of the field - Time derivatives – Classical Lagrangian and Hamiltonian equations - Quantum equations for the field - Fields with more than one component - Complex field - Quantization of non-relativistic Schrodinger equation - Classical Lagrangian and Hamiltonian equations - Quantum equations - creation annihilation and number operators – Connection with the many particle Schrodinger equation - anti commutation relations - physical implication of anti commutation - representation of the anti commuting $a_k$ operators .

Electromagnetic field in vacuum - Lagrangian equations - Hamiltonian equations - Quantum equations - Commutation relations for E and H - Plane wave representation - Quantized field energy - Quantized field momentum - Commutation relations at different times - Interaction between charged particles and Electromagnetic field - Lagrangian and Hamiltonian equations - Elimination of φ - Quantization of the fields - Perturbation theory of the interparticle interaction- Einstein-Bose case - Fermi-Dirac case - radiation theory - Transition probability for absorption and emission.

**Reference Books:**


1. Quantum Mechanics, L.I. Schiff, 3rd Edn. MGH
2. Quantum Mechanics, B.K. Agarwal , Hari Prakash, PHI
3. A text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, TMGH.

4. Quantum Mechanics, V.K. Thankappan 2rd Edn. Wiley Eastern.
5. Quantum Mechanics,G. Aruldhas, Prentice Hall of India 2002.
6. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education
7. Advanced Quantum Mechanics, Stya Prakash, Kedar Nath Ramnath Company.
8. Quantum Field theory, Claude Itzykson, McGraw Hill
9. Quantum Field theory, Lewis H. Ryder, Cambridge University Press.
10. Introduction to Quantum Mechanics, R.H. Dicke & J.P. Wittke, Addison Wesley.
11. Quantum Mechanics, A Messiah, Dover Publication.
12. Quantum Mechanics, R.K. Srivastava, PHI.

**PH4MC2 STATISTICAL PHYSICS AND ASTROPHYSICS**

**Unit I**

**Quantum Statistical Mechanics and Ideal Gas Systems (18 Hrs)**

The postulates of Quantum statistical mechanics – indistinguishability of particles - exchange degeneracy - Density matrix - Ensembles in Quantum statistical mechanics - statistical distribution – The ideal gas in quantum mechanical micro canonical and other quantum mechanical ensemble – Partition functions and other thermodynamic quantities of monatomic and diatomic molecules. Thermodynamic behaviour of an ideal Fermi gas - Pauli Para magnetism - Thermodynamic behavior of a Bose gas – Bose Einstein condensation — Theory of white dwarf stars.

**Unit II**

**The Canonical and Grand Canonical Ensemble (18 Hrs)**

Equilibrium between a system and heat reservoir – a system in the canonical ensemble – thermo dynamical relations in a canonical ensemble – the classical systems – energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble – equilibrium between a system and a particle energy reservoir – a system in the grand canonical ensemble – physical significance of statistical quantities – density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles.

**Unit III**

**Fluctuations and Phase Transitions (18 Hrs)**

Energy fluctuations in canonical ensemble - Density fluctuation in grand canonical ensemble - one dimensional random walk problem - Brownian motion and Random walk- correlation functions- Spectral analysis of fluctuations: Wiener-Khintchine theorem - Fokker Planck equation. Phase transitions - First and second order phase transition – Bragg–Williams approximation - critical phenomena - critical exponents - scaling hypothesis - Ising model and its solution for a linear chain – equivalence of Ising model to other models - lattice gas and binary alloy- solution of one dimensional Ising model – Liquid crystals and Liquid Helium.

**Unit IV**

**Astrophysics (18 Hrs)**

Stellar spectrum - stellar types - electromagnetic radiation from stars - measuring temperature and distances - excitation and ionization -

application of Saha's Equation - Hertz Sprung Russell diagram- star formation - life of a star - Virial theorem- stellar energy and nuclear reactions - stellar structure - final stages of stellar evolution - white dwarfs - neutron stars - black hole - pulsars.

**Reference Books:**


1. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.
2. Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co.
3. Statistical mechanics, Kerson Huang, John Wiley and Sons.
4. Statistical mechanics, R..K. Pathria, Butterworth-Heinemann
5. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern.
6. Introduction to Statistical Mechanics, S.K. Sinha, Alpha Science International.
7. Statistical Mechanics, Tung Tsang, Rinton Press.
8. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, $2^{nd}$ Edn. Oxford University Press
9. Statistical Mechanics, Gupta, Kumar, Pragati Prakasan.
10. Astrophysics: Stars and Galaxies, K D Abhyenkar, Universities Press.
11. Introduction to Astrophysics, Baidyanath Basu, PHI.

**PH4ME3 NANOSTRUCTURES AND CHARACTERIZATION**

**Unit I**

**Low Dimensional Structures (18hrs)**

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications - infrared detectors - quantum dot lasers - superconductivity.

Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) –Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches.

**Unit II**

**Carbon Nanostructures (18hrs)**

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters -Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties - Mechanical Properties - Applications of Carbon Nano tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials - Mechanical Properties – Nano structured Multi layers -Electrical Properties - Porous Silicon - Metal Nano cluster - Composite Glasses.

**Unit III**

**Thermal, Microscopic and Infrared Analysis (18 Hrs)**

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.

Microscopy – Electron microscopy – Principles and instrumentation – resolution limit – scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM. Atomic force microscope – Instrumentation.

IR spectrophotometers – Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy – Principles, Instrumentation and Applications. Microwave Spectroscopy -Instrumentation and Applications

**Unit IV**

**Mass Spectrometry, Resonance Spectroscopy (18 Hrs)**

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications.

NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR –Instrumentation - Interpretation of ESR spectra - Applications.

**Reference Books:**

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)
2. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).

3. Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya
4. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.
5. Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.
6. Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.
7. Instrumental methods of chemical analysis, G W Ewing, MGH
8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.

## PH4ME4 THIN FILM AND NANO SCIENCE

**Unit I**

**Thin Film (18 Hrs)**

Nucleation – Langmuir theory of condensation – Theories of nucleation – Liquid like coalescence and growth process – Epitaxial growth – Structural defects in thin films – Electrical conduction in metallic, semiconducting and insulator films. Optical properties of thin films.

**Unit II**

**Deposition of Films (18 Hrs)**

Production of Vacuum, Different types of vacuum pumps, Measurement of Vacuum Gauges, Working principle, Deposition of thin films, Various deposition techniques, Thickness measurement – optical methods, thickness monitors - Thin film applications.

**Unit III**

**Nano materials and Applications (18 hours)**

Nano structured Crystals -Natural Nano crystals -Crystals of Metal-Nano particles –Nano particle Lattices in Colloidal Suspensions -Photonic Crystals.

Synthesis and purification of carbon nanotubes, Single-walled carbon nanotubes and multiwalled carbon nanotubes, Structure-property relationships, physical properties, applications.

Overview of different nano materials available, Potential uses of nano materials in electronics, robotics, computers, sensors in textiles, sports equipment, mobile electronic devices, vehicles and transportation. Medical applications of nano materials.

**Unit IV**

**Synthesis of Nano materials (18hrs)**

Top-down techniques: photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, focused ion beam, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled mono layers, directed assembly, layer-by-layer assembly. Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

Pattern replication techniques: soft lithography, nano imprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly).

**Reference Books:**


1. Thin film phenomena, K.L Chopra, McGraw Hill, New York
2. Thin film fundamentals, A. Goswami, New Age International
3. Vacuumm deposition of Thin films, L. Holland, Chapman Hall, London
4. Handbook of thin film Technology, L.I Maissel and R Glang, McGraw Hill
5. Optical Properties of Thin Films, O. S. Heaven, Dover Publications
6. Nano: the essentials, T. Pradeep, TMH, 2007
7. Nanoscale Materials, L.M. Liz-Marzán & P.V. Kamat, Kluwer Academic Pub. (2003)
8. Nanoscience, Nanotechnologies and Nanophysics, C. Dupas, P. Houdy & M. Lahmani, Springer-Verlag , (2007).
9. Nanotechnology 101, John Mongillo, Greenwood Press, (2007).
10. What is What in the Nanoworld A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, (2008).
11. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley
12. Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, ARTECH HOUSE, (2004).

13. Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto, K. Kaneto, S. Mashiko Elsevier Science, Elsevier Science, (2003).
14. Semiconductors for Micro and Nanotechnology—An Introduction for Engineers Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag, (2002).

**PH4MP4 MATERIAL SCIENCE PRACTICALS**

1. Ultrasonic Interferometer – ultrasonic velocity in liquids
2. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
3. Determination of dielectric constant
4. Determination of forbidden energy gap
5. Determination of Stephan's constant
6. Determination of Fermi energy of copper
7. Study of ionic conductivity in KCl / NaCl crystals
8. Thermo-emf of bulk samples of metals (aluminium or copper)
9. Study of physical properties of crystals (specific heat, thermal expansion, thermal conductivity, dielectric constant)
10. Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
11. Study of variation of magnetic properties with composition of a ferrite specimen
12. Four probe method – energy gap

13. Energy gap of Ge or Si
14. Hall effect – Hall constant
15. Thin film coating by polimerisation
16. Measurement of thickness of a thin film
17. Study of dielectric properties of a thin film
18. Study of electrical properties of a thin film(sheet resistance)
19. Growth of single crystal from solution and the determination of its structural, electrical and optical properties (NaCl,KBr,KCl,$NH_4Cl$ etc.)
20. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal
21. Observation of dislocation – etch pit method
22. Michelson Interferometer – Thickness of transparent film
23. X-ray diffraction – lattice constant
24. Optical absorption coefficient of thin films by filterphotometry
25. Temperature measurement with sensor interfaced to a PC or a microprocessor
26. ESR spectrometer – g factor
27. Beam profile of diode laser
28. Track width of a CD using laser beam
29. He – Ne laser- verification of Malus law , measurement of Brewster angle,refractive index of a material