# ST.PHILOMENA'S COLLEGE (AUTONOMOUS), MYSURU

***(AFFILIATED TO UNIVERSITY OF MYSORE & REACCREDITED BY NAAC WITH $B^{++}$ GRADE)***

## POST GRADUATE COURSE - SEMESTER SCHEME

## PG DEPARTMENT OF PHYSICS

**CBCS with Learning Outcome Based Curriculum**

**Academic years: 2020-22**

**{ Approved in the Academic Council Meeting held on 12.01.2021}**

**{ The Academic Year of 2020-21 was commenced on 24.01.2021 due to first wave of Covid-19 Pandemic}**

## ST.PHILOMENA'S COLLEGE (AUTONOMOUS), MYSURU
### *(AFFILIATED TO UNIVERSITY OF MYSORE & REACCREDITED BY NAAC WITH $B^{++}$ GRADE)*
### PROGRAMME: M.Sc PHYSICS

### Preamble

The zest of post-graduation programme is to provide high quality education and an intellectual stimulus for advanced study through effective teaching learning process. Higher education has to foster in students the spirit of robust learning and ethical research to pursue further studies at globally reputed institutions and laboratories.

Physics being the science of the universe and everything in it, describes the behaviour of all physical systems around us. Nothing can get away from physics because all matter is made up of atoms and molecules. Having evolved with time, physics now overlaps with many other disciplines of sciences leading to profound creativity by exposing new areas of research. The curriculum designed provides firm foundation in various tools developed and used for understanding different natural phenomena. The programme lays emphasis in nurturing a stimulating learning environment that advances learning capacity with innovative strategies and teaching practices which will motivate the students to reach high standards, enable them to acquire real insight into physics and become committed, adaptable graduates.

The programme is well found on the courses that constitute core components, while providing students with a spectrum of optional papers covering most areas of physics. To inculcate interdisciplinary knowledge the programme also provides an opportunity for post graduate students of Mathematics, Chemistry and Biochemistry to register for any one of the interdisciplinary elective courses. In these courses, the students will learn to apply the tools of Physics in the selected interdisciplines of science. The programme offers three Specializations, Condensed Matter Physics, Nuclear Physics and Theoretical Physics, so that, those who wish to pursue higher studies in these domains are thereby well equipped to choose their branch of study. The programme also gives adequate skills in understanding the basic and advanced experiments in physics.

**Changes in the Curriculum**

| Sl. No | Semester | Course | Justification | Percentage of Change |
|---|---|---|---|---|
| 1. | First | **Experimental Techniques in Physics** Newly introduced | To familiarize students with current techniques that are used in experimental physics | 100 |
| 2. | | **Electronics** Newly introduced | Analysis and design of various digital and analog electronic circuits are of high importance in experimental physics | 100 |
| 3. | Second | **Matlab** Newly introduced | Learning matlab equips students with Computations and simulations abilities that are of great importance in scientific research. | 100 |
| 4. | | **Cellular and Molecular Biophysics** Newly introduced | An interdisciplinary course to understand the physics of cells and molecules. | 100 |
| 5. | Third | **Medical Physics** Newly introduced | Medical physics offers a broad spectrum of career opportunities ranging from clinical activities, to quality assurance, radiation safety, and research – including diagnostic radiology physics, radiation therapy physics, and nuclear medicine physics. | 100 |
| 6. | | **Atmospheric Physics** Newly introduced | The course gives introductory knowledge in atmospheric physics which help to acquaint physical processes in atmosphere . | 100 |
| 7. | | **Riemannian Geometry and Gravitational Field** Newly introduced | The course provides a firm mathematical foundation to general relativity and cosmology. | 100 |
| 8. | | **Rotation and Lie Groups in Physics** Newly introduced | The course provides a firm mathematical foundation to understand concepts of rotations and angular momentum in physics. | 100 |

| | | | | |
|---|---|---|---|---|
| 9. | | **Analytical Techniques in Theoretical Physics 1** Newly introduced | The course is designed to various analytical techniques in theoretical physics. | |
| 10. | Fourth | **Quantum Field Theory** Newly introduced | This course introduces quantum field theory, the combination of quantum mechanics and relativity that explains the fundamental structure of matter and the physics of the early universe. | 100 |
| 11. | | **Angular Momentum and Density Matrix Theory** Newly introduced | The course facilitates the understanding of quantum mechanical and statistical phenomenon in physics | 100 |
| 12. | | **Analytical Techniques in Theoretical Physics 2** Newly introduced | The course is designed to various analytical techniques in theoretical physics. | 100 |
| 13. | | **Biomolecular Structure and Molecular Motors** Newly introduced | An interdisciplinary course to understand the physics of structure and function of biomolecules and motors. | 100 |
| 14. | | **Ceramics and Polymers** Newly introduced | The course provides the basic knowledge , understanding, processing and applications of Ceramics and Polymers | 100 |

Total percentage of change in curriculum is 28% (approximately)

## PG DEPARTMENT OF PHYSICS
## ST.PHILOMENA'S COLLEGE (Autonomous), MYSURU
## Master of Science in Physics

### VISION AND MISSION OF THE COLLEGE

**VISION:**
The college is guided by the visionary zeal of providing value- based education to everyone irrespective of religion, caste, creed or sex by which the character is formed, intellect is explained and one can stand on his/her feet.

**MISSION:**
To transform young men and women who come to learn not from books, but also from life and to share the experience of working and playing together, which inculcates life skills to become good citizens with integrity and discipline.

### VISION AND MISSION OF THE DEPARTMENT

**VISION:**
The department strives to empower the students with scientific temper, logical reasoning and analytical power towards overall development in the modern society.

**MISSION:**

1. Promoting the knowledge of Physics among students of the college and among the general public.
2. Developing an aptitude for science and moulding generations that build nations through scientific research and experiments.

| PEO No. | Programme Educational Objectives (PEOs) |
|---|---|
| **PEO-1** | To kindle and foster strong interest and impart quality education in physics. |
| **PEO-2** | To develop a strong hold in the subject to be effective and efficient physicist to impart knowledge to the future generations. |
| **PEO-3** | To develop the skill to identify, execute, analyze and interpret the results of an extended experimental or theoretical Physics based problems in a research environment. |
| **PEO-4** | To facilitate professional development through continues learning with higher education and scientific research. |

### Mapping of Mission of the department with Programme Educational Objectives

| Mission | Programme Educational Objectives (PEOs) | | | |
|---|---|---|---|---|
| | PEOs-1 | PEOs-2 | PEOs-3 | PEOs-4 |
| M1 | ✓ | ✓ | | |
| M2 | | | ✓ | ✓ |

## Programme Outcomes (POs)

***POs describe what students are expected to know or be able to do by the time of graduation from the programme.***

| PO No. | Upon completion of the programme the student will be able to : |
|---|---|
| PO-1 | understand physical problems and obtain admissible mathematical and physical solutions by applying laws/ principles of physics. |
| PO-2 | set up, conduct and interpret the data of basic and advanced experiments in physics. |
| PO-3 | enhance and adopt new skills through seminar, internship and dissertation to be efficient in teaching and research. |
| PO-4 | appreciate the need and involve in team/self-reliant lifelong learning in the context of their chosen disciplines. |
| PO-5 | fare well at any degree of competitive examinations. |

## Programme Specific Outcomes PSOs

| PSO No. | Upon completion of the programme the student will : |
|---|---|
| PSO-1 | elucidate principles of physics in understanding various natural phenomena. |
| PSO-2 | be able to particularly have fundamental and advanced knowledge in core concepts along with their choice of specialization. |
| PSO-3 | design, execute, analyze and interpret basic and advanced experiments in physics. |
| PSO-4 | develop a strong hold in the subject to be effective and efficient teachers at school and college level |
| PSO-5 | be able to engage in research motives a ethically and produce results. |

## Mapping of programme Educational Objectives with Programme Outcomes and Programme Specific Outcomes

| | Programme Outcomes | | | | | Programme Specific Outcomes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PEO | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PSO-1 | PSO-2 | PSO-3 | PSO-4 | PSO-5 |
| PEOs-2 | | | | ✓ | | ✓ | | | | |
| PEOs-3 | ✓ | | | | | ✓ | ✓ | | | |
| PEOs-4 | | ✓ | ✓ | | | | ✓ | ✓ | | |
| PEOs-4 | | | ✓ | ✓ | ✓ | | | | ✓ | ✓ |

**Scheme of Teaching**
**(L: Lecture, T: Tutorial, P: Practical)**

| Sl. No. | Code | Subject | Type HC/SC/OE | Credit Pattern L:T:P | Credits |
|---|---|---|---|---|---|
| **FIRST SEMESTER** | | | | | |
| 1 | A0210 | Classical Mechanics | HC | 3:0:0 | 3 |
| 2 | A0220 | Elements of Mathematical Physics | HC | 3:1:0 | 4 |
| 3 | A0230 | Thermodynamics and Statistical Physics | HC | 3:0:0 | 3 |
| 4 | A0240 | Electrodynamics and Optics | HC | 2:0:0 | 2 |
| 5 | AP210 | Experiments in Electronics | HC | 0:0:8 | 4 |
| 6 | - | Any one of the Ability Enhancing Course from list A | SC | 0:0:4 | 2 |
| 7 | - | Any one of the Soft Core Course from list B | SC | 2:0:0 | 2 |
| **Total Credits : 20 [HC: 16, SC: 4]** | | | | | |
| **SECOND SEMESTER** | | | | | |
| 8 | B0210 | Theory of Relativity | HC | 3:0:0 | 3 |
| 9 | B0220 | Quantum Physics | HC | 3:1:0 | 4 |
| 10 | B0230 | Solid State Physics | HC | 3:0:0 | 3 |
| 11 | BP210 | Experiments in Optics | HC | 0:0:8 | 4 |
| 12 | - | Any one of the Interdisciplinary course from list C | SC | 2:0:0 | 2 |
| 13 | - | Any one of the Ability Enhancing Course from list A | SC | 0:0:4 | 2 |
| **Total Credits : 22 [HC: 14, SC: 4, OE: 2]** | | | | | |
| **THIRD SEMESTER** | | | | | |
| 14 | C0210 | Advanced Quantum Physics | HC | 3:0:0 | 3 |
| 15 | C0220 | Nuclear and Particle Physics | HC | 3:0:0 | 3 |
| 16 | CP210 | Experiments in Solid State Physics * | HC | 0:0:8 | 4 |
| 17 | CP220 | Experiments in Nuclear Physics * | HC | 0:0:8 | 4 |
| 18 | - | Any one of the Self Study Course from list D | SC | 2:0:0 | 2 |
| 19 | - | Any one of the Soft Core Group from list B | SC | - | 2+2+3 |
| **Total Credits : 19 [HC: 10, SC: 9, OE: 2]** | | | | | |
| **FOURTH SEMESTER** | | | | | |
| 20 | CP210 | Experiments in Solid State Physics * | HC | 0:0:8 | 4 |
| 21 | CP220 | Experiments in Nuclear Physics * | HC | 0:0:8 | 4 |
| 22 | DP410 | Project Work | Skill | - | 6 |
| 23 | - | Any one of the Interdisciplinary course from list C | SC | 2:0:0 | 2 |
| 24 | - | Any one of the Soft Core Group from list B | SC | - | 2+2+3 |
| **Total Credits : 19 [HC: 10, SC: 09]** | | | | | |
| MOOC: 04 | | | | | |

**Total Credits earned during the whole programme: 80**

* Students must complete one of these courses in the third semester and take the other in the fourth semester.

| **List A - Soft Core Semester wise Ability Enhancing Course** | | | | | | |
|---|---|---|---|---|---|---|
| **Code** | **Semester** | **Title of the paper** | **L** | **T** | **P** | **Credits** |
| AP510 | First | Scientific Text Processing using Latex | 0 | 0 | 2 | 2 |
| AP520 | First | Computations in Physics Using C- Language | 0 | 0 | 2 | 2 |
| BP510 | Second | Experiments in General Physics | 0 | 0 | 2 | 2 |
| BP520 | Second | Matlab | 0 | 0 | 2 | 2 |

| **List B- Soft Core Semester wise theory and Practicals** | | | | | | |
|---|---|---|---|---|---|---|
| **Code** | **Semester** | **Title of the paper** | **L** | **T** | **P** | **Credits** |
| A0310 | First | Experimental Techniques in Physics | 2 | 0 | 0 | 2 |
| A0320 | First | Electronics | 2 | 0 | 0 | 2 |
| A0330 | First | Spectroscopy | 2 | 0 | 0 | 2 |
| **Students are permitted to register for any one of the following groups** | | | | | | |
| **Condensed Matter Physics Group** | | | | | | |
| C0310 | Third | Nanomaterials and Thin Films | 2 | 0 | 0 | 2 |
| C0320 | Third | Condensed Matter Physics 1 | 2 | 0 | 0 | 2 |
| CP310 | Third | Experiments in Condensed Matter Physics 1 | 0 | 1 | 4 | 3 |
| **Nuclear Physics Group** | | | | | | |
| C0330 | Third | Nuclear Models and Heavy ion Physics | 2 | 0 | 0 | 2 |
| C0340 | Third | Nuclear Decay Modes and Electronics | 2 | 0 | 0 | 2 |
| CP320 | Third | Experiments in Nuclear Physics 1 | 0 | 1 | 4 | 3 |
| **Theoretical Physics Group** | | | | | | |
| CO350 | Third | Riemannian Geometry and Gravitational Field | 2 | 0 | 0 | 2 |
| C0360 | Third | Rotation and Lie Groups in Physics | 2 | 0 | 0 | 2 |
| CP330 | Third | Analytical Techniques in Theoretical Physics 1 | 0 | 1 | 4 | 3 |
| **Students must continue with the same group that was opted in Third Semester** | | | | | | |
| **Condensed Matter Physics Group** | | | | | | |
| D0310 | Fourth | Condensed Matter Physics 2 | 2 | 0 | 0 | 2 |
| DO320 | Fourth | Condensed Matter Physics 3 | 2 | 0 | 0 | 2 |
| DP310 | Fourth | Experiments in Condensed Matter Physics 2 | 0 | 1 | 4 | 3 |
| **Nuclear Physics Group** | | | | | | |
| D0330 | Fourth | Nuclear Reactor Theory | 2 | 0 | 0 | 2 |
| DO340 | Fourth | Two particle systems and Nuclear Reactions | 2 | 0 | 0 | 2 |
| DP320 | Fourth | Experiments in Nuclear Physics 2 | 0 | 1 | 4 | 3 |
| **Theoretical Physics Group** | | | | | | |
| D0350 | Fourth | Quantum Field Theory | 2 | 0 | 0 | 2 |
| D0360 | Fourth | Angular Momentum and Density Matrix Theory | 2 | 0 | 0 | 2 |
| DP330 | Fourth | Analytical Techniques in Theoretical Physics 2 | 0 | 1 | 4 | 3 |

| **List C - Soft Core Semester wise Inter Disciplinary course** | | | | | | |
|---|---|---|---|---|---|---|
| **Code** | **Semester** | **Title of the paper** | **L** | **T** | **P** | **Credits** |
| B1510 | Second | Cellular and Molecular Biophysics | 2 | 0 | 0 | 2 |
| B1520 | Second | Materials Science | 2 | 0 | 0 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| D1510 | Fourth | Biomolecular Structure and Molecular Motors | 2 | 0 | 0 | 2 |
| D1520 | Fourth | Ceramics and Polymers | 2 | 0 | 0 | 2 |

| **List D - Soft Core Semester wise Self Study Course** | | | | | | |
|---|---|---|---|---|---|---|
| **Code** | **Semester** | **Title of the paper** | **L** | **T** | **P** | **Credits** |
| C0710 | Third | Accelerator Physics | 2 | 0 | 0 | 2 |
| C0720 | Third | Space and Astrophysics | 2 | 0 | 0 | 2 |
| C0730 | Third | Medical Physics | 2 | 0 | 0 | 2 |
| C0740 | Third | Liquid Crystals | 2 | 0 | 0 | 2 |
| C0750 | Third | Atmospheric Physics | 2 | 0 | 0 | 2 |

**Open Elective papers offered for post graduate students of other departments**

| **List E- Soft Core Semester wise Generic** | | | | | | |
|---|---|---|---|---|---|---|
| **Code** | **Semester** | **Title of the paper** | **L** | **T** | **P** | **Credits** |
| B6220/ C7190 | Second/ Third | Nanoscience and Nanotechnology | 2 | 0 | 0 | 2 |
| B6320/C7200 | Second/ Third | Environmental Physics | 2 | 0 | 0 | 2 |

## FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="8">Classical Mechanics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>48</td><td>Hours/Week</td><td>03</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">A0210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | learn and understand Lagrangian and Hamiltonian formulations and apply to solve problems in mechanics. |
| CO-2 | understand canonical transformations and evaluate Poisson brackets. |
| CO-3 | acquire knowledge to derive Euler's equations and to apply them for rigid body dynamics. |
| CO-4 | understand Theory of small oscillations. |

<table>
<tr><td colspan="4">Mapping of CLOs with PSOs & CDLs</td></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>solve problems with symbolic (rather than numeric) parameters.</td><td>PSO-1</td><td>Apply</td></tr>
<tr><td>CLO-2</td><td>use Lagrangian and Hamiltonian methods to solve mechanics problems.</td><td>PSO-2</td><td>Apply</td></tr>
<tr><td>CLO-3</td><td>analyze the dynamics of rigid body using Lagrangian approach.</td><td>PSO-2</td><td>Analyze</td></tr>
</table>

## Course Outline

**Module-1 Lagrangian Mechanics** **16hrs**

- 1.1 Constraints and their classifications
- 1.2 Generalized coordinates, virtual displacement
- 1.3 D'Alembert's principle and Lagrangian equations (first and second kind)
- 1.4 Lagrangian formulations of (i) single particle in Cartesian, spherical, polar and cylindrical polar coordinate systems, (ii) Atwood's machine, (iii) bead sliding on a rotating wire in a force-free space, and (iv) simple pendulum (v) simple electrical circuits
- 1.5 Velocity dependent potential: the Lagrangian for a charged particle in an external electromagnetic field
- 1.6 Hamilton's principle, Lagrangian equations from Hamilton's principle
- 1.7 Noether's theorem statement
- 1.8 Kepler problem and inverse Kepler problem
- 1.9 Virial theorem[Ref.1]

**Key words:**Degrees of freedom, conservation

**Module-2 Hamiltonian Mechanics** **16hrs**

| | | |
|---|---|---|
| 2.1 | Generalized momenta, Hamilton's equations of motion | |
| 2.2 | Hamiltonian formulations of (i) simple harmonic oscillator, (ii) simple pendulum, (iii) compound pendulum, (iv) motion of a particle in a central force field, (v) charged particle moving in an electromagnetic field, and (vi) a free particle in different coordinates | |
| 2.3 | Cyclic coordinates, physical significance of the Hamiltonian function, | |
| 2.4 | Hamilton's equations from variational principle | |
| 2.5 | Canonical transformations [Ref.1,2,4] | |
| 2.5.1 | Definition, generating functions (four basic types), examples of canonical transformations | |
| 2.5.2 | Harmonic oscillator as an example to canonical transformation, infinitesimal contact transformation | |
| 2.6 | Poisson brackets, properties of Poisson brackets, angular momentum and Poisson bracket relations, equations of motion in the Poisson bracket notation | |
| 2.7 | The Hamilton-Jacobi equation, example of the harmonic oscillator treated by the Hamilton-Jacobi method | |

**Key words:** Least action, Hamilton Jacobi equation

**Module-3 Rigid body dynamics and small oscillations** **16hrs**

| | | |
|---|---|---|
| 3.1 | Mechanics of rigid bodies [Ref.1] | |
| 3.1.1 | Degrees of freedom of a free rigid body | |
| 3.1.2 | Angular momentum and kinetic energy of a rigid body | |
| 3.1.3 | Moment of inertia tensor, principal moments of inertia, products of inertia | |
| 3.1.4 | Euler equations of motion for a rigid body | |
| 3.1.5 | Torque free motion of a rigid body, precession of earth's axis of rotation | |
| 3.1.6 | Euler angles, angular velocity of a rigid body | |
| 3.2 | Small oscillations of a mechanical system[Ref.1] | |
| 3.2.1 | Introduction, types of equilibria, quadratic forms of kinetic and potential energies of a system in equilibrium | |
| 3.2.2 | General theory of small oscillations, secular equation and Eigenvalue equation | |
| 3.2.3 | Small oscillations in normal coordinates and normal modes, examples of two coupled oscillators, vibrations of a linear tri-atomic molecule | |

**Key words:** Rigid body, small oscillations

**Reference**


1 Classical Mechanics, Upadhyaya J.C., Himalaya Publishing House, Mumbai. 2006.

2 Classical Mechanics, Goldstein H., Poole C. and Safko J., Pearson Education, 3rd Edn., New Delhi. 2002.

3 Classical Mechanics, Srinivasa Rao K.N., Universities Press, Hyderabad, 2003.

4 Introduction to Classical Mechanics, Takwale R.G. and Puranik S., Tata McGraw, New Delhi, 1991.

5 Classical Mechanics, B.A Kagali and T. Shivalingaswamy, Himalaya Publishing House, Mumbai, 2018.

6 Classical Mechanics, John R. Taylor, University Science Books, 2004.

## FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="9">Elements of Mathematical Physics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>64</td><td>Hours/Week</td><td>04</td><td>Credits</td><td>04</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">A0220</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | learn advanced mathematical concepts used in physics. |
| CO-2 | understand the methods and solutions of special functions of mathematical physics. |
| CO-3 | use Fourier series, Fourier and Laplace transforms to solve physical problems. |

<table>
<tr><th colspan="4">Mapping of CLOs with PSOs & CDLs</th></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>be familiar with the main mathematical methods used in physics.</td><td>PSO-1</td><td>Understand</td></tr>
<tr><td>CLO-2</td><td>explain the origin of Bessel functions, Legendre polynomial, Hermite polynomial and Laguerre polynomials and use their properties in relevant problems in physics.</td><td>PSO-1<br>PSO-4<br>PSO-5</td><td>Understand</td></tr>
<tr><td>CLO-3</td><td>learn to apply Fourier series, Fourier and Laplace transforms, their inverse transforms in relevant problems in physics.</td><td>PSO-1<br>PSO-4<br>PSO-5</td><td>Apply</td></tr>
</table>

## Course Outline

**Module-1 Differential Equations** **16hrs**

1.1 Regular and irregular singular points of a second order ordinary differential equations, Fuch theorem, superposition principle

1.2 Special functions [Ref.1-3]

1.2.1 Bessel functions: Frobenius Series solution, generating functions, recurrence relations, orthogonality properties, Bessel function of the first kind, Neumann functions, spherical Bessel functions(definition only)

1.2.2 Legendre functions and polynomials: Power Series solution, generating functions, orthogonality properties, Rodrigue's representation, Spherical harmonics. Associated functions, separation of variables – Helmholtz equation in Cartesian, cylindrical and spherical polar coordinates

1.2.3 Hermite functions and polynomials: Power Series solution, generating functions, recurrence relations, orthogonality properties, Rodrigue's representation

1.2.4 Laguerre functions and polynomials: Power Series solution, generating functions, recurrence relations, orthogonality properties, Rodrigue's representation

**Key words:** Special functions, Helmholtz equation, Power Series solution

| | | |
|---|---|---|
| **Module-2** | **Fourier Transforms** | **16hrs** |
| 2.1 | Introduction to Fourier series, Integral transforms | |
| 2.2 | Development of the Fourier integral, Fourier transforms – inversion theorem, Fourier transform of derivatives, convolution theorem, momentum representation[Ref.1] | |
| 2.3 | Fourier transform of Dirac delta function | |
| 2.4 | Integral equations[Ref.1] | |
| 2.4.1 | Types of linear integral equations – definitions | |
| 2.4.2 | Transformation of a differential equation into an integral equation | |
| 2.4.3 | Abel's equation, Neumann series, separable kernels | |

**Key words:** Fourier transforms, integral transforms

| | | |
|---|---|---|
| **Module-3** | **Tensor Analysis** | **16hrs** |
| 3.1 | Tensors of rank r as a r-linear form in base vectors, transformation rules for base vectors and tensor components, invariance of tensors under transformation of coordinates. | |
| 3.2 | Sum, difference and outer products of tensors, contraction, symmetric and antisymmetric tensors. | |
| 3.3 | Curvilinear coordinates in the Euclidean 3-dimensional space, covariant and contravariant basis vectors, covariant and contravariant components of the metric tensor, raising and lowering of indices, differentials of base vector fields | |
| 3.4 | Christoffel symbols, covariant differentiation, the contracted Christoffel symbols. Gradient, divergence, curl and Laplacian in arbitrary curvilinear coordinates. [Ref.3,5] | |

**Key words:** Tensors, Christoffel symbols

**Reference**


1 Mathematical Methods for Physicists, Arfken G.B. and Weber H.J., Academic Press, 4thEdn., New York (Prism Books, Bangalore, India), 1995.

2 Introduction to Mathematical Physics, Harper C., PHI Learning Pvt. Ltd., New Delhi, 1976.

3 Mathematical Physics, 4thEdn., Guptha B.D., Vikas Publishing House Pvt. Ltd., Noida, 2011.

4 Introduction to Modern Theoretical Physics, Harris E.G., John Wiley, Vol. 1, New York, 1975.

5 Matrices and Tensors in Physics, Joshi A.W., New Age International Publishers, New Delhi, 1995.

6 Mathematical Methods in Physical Sciences, Mary Boas, Wiley, 3rdEdn., 2006.

7 Advanced engineering Mathematics, Erwin Kreyszig, Wiley, 9thEdn., 2011.

## FIRST YEAR - SEMESTER – I

| Course Title | **Thermodynamics and Statistical Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Theory | | Total Hours | 48 | Hours/Week | 03 | Credits | 03 |
| Course Code | A0230 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | explain various physical phenomena and processes observed in nature related to temperature and energy. |
| CO-2 | analyse physical problems at the atomic level. |
| CO-3 | understand the laws and formalism of thermodynamics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| **CLOs No.** | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | solve statistical mechanics problems for simple non-interacting systems. | PSO-4 | Apply |
| CLO-2 | explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. | PSO-1<br>PSO-2 | Understand |
| CLO-3 | describe the behaviour of particles using distribution functions. | PSO-1<br>PSO-2 | Understand |

## Course Outline

**Module-I Thermodynamics** **16hrs**

1.1 Maxwell's thermodynamic relations, thermodynamic potentials
1.2 Expression for specific heat.
1.3 The third law of thermodynamics
1.4 Thermodynamic description of phase transitions - phase equilibria, equilibrium conditions
1.5 Classification of phase transitions, phase diagrams
1.6 Clausius-Clapeyron equation and applications
1.7 Van der Waal's equation of state [Ref.1]

**Key words:** Potentials, phase transitions

**Module-2 Classical Statistical Physics** **16hrs**

2.1 Classical statistical mechanics[Ref.2,3]
2.1.1 Phase space, division of phase space into cells

| | |
|---|---|
| 2.1.2 | Ensembles, Ergodic hypothesis |
| 2.1.3 | Average values in phase space, density distribution in phase space |
| 2.1.4 | Liouville theorem, statistical equilibrium, |
| 2.1.5 | Postulate of equal apriori probability, Stirling approximations, concept of probability |
| 2.1.6 | Microstates and macrostates |
| 2.1.7 | Microcanonical ensemble, canonical ensemble, grand canonical ensemble |
| 2.1.8 | General expression for probability, the most probable distribution |
| 2.1.9 | Maxwell-Boltzmann distribution, partition function of system of particles |
| 2.1.10 | Translational partition function (monoatomic), vibrational partition function of diatomic molecules (Einstein relations), rotational partition function (diatomic) |
| 2.1.11 | Electronic partition function- Boltzmann theorem of equipartition of energy, application to heat capacities of gases and solids |

**Key words:** Phase space, ensembles, partition functions

| | | |
|---|---|---|
| **Module-3** | **Quantum Statistical Physics** | **16hrs** |
| 3.1 | Quantum statistical mechanics[Ref.2,3] | |
| 3.1.1 | The postulates of quantum statistical mechanics, symmetry of wave functions | |
| 3.1.2 | Condition for statistical equilibrium, ensembles in quantum mechanics. | |
| 3.1.3 | The quantum distribution functions - Bose Einstein and Fermi Dirac, the derivation of the corresponding distribution functions | |
| 3.1.4 | The Boltzmann limit of Boson and Fermion gases | |
| 3.2 | Applications of quantum statistics[Ref.2,3] | |
| 3.2.1 | Equation of state of an ideal Fermi gas (derivation not expected) | |
| 3.2.2 | Application of Fermi-Dirac statistics to the theory of free electrons in metals - Fermi energy, electronic specific heat | |
| 3.2.3 | Application of Bose Einstein statistics to the photon gas - derivation of Planck's law, comments on the rest mass of photon, Bose-Einstein condensation | |

**Key words:** Quantum statistics, black body radiation

**Reference**


1 Statistical Mechanics, Huang K., Wiley-Eastern, 3rdEdn., 2013.
2 Fundamentals of Statistical Mechanics, Laud B.B., New Age International Pub., 2ndEdn., India, 2012.
3 Statistical Mechanics, Agarwal B.K. and Eisner M., New Age International Pub., 3rdEdn., India, 2013.
4 Thermal Physics and Statistical Mechanics, Roy S.K., New Age International (P) Limited, Publishers, New Delhi., India, 2000.
5 Statistical Mechanics and Properties of Matter, Gopal E.S.R., Ellis Horwood Ltd., UK, 1976.
6 An Introduction to Thermal Physics, Schroeder D.V., Pearson Education, New Delhi, 2008.
7 Introduction to Statistical Physics, Salinas S.R.A., Springer, (India) Private limited, 2004.

## FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="9">Electrodynamics and Optics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">A0240</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

### Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand basic theories of classical electrodynamics, Maxwell's equations and their consequences to electromagnetism. |

<table>
<tr><th colspan="4">Mapping of CLOs with PSOs & CDLs</th></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>have a deep understanding of the theoretical foundations of electromagnetic phenomena.</td><td>PSO-2<br>PSO-4</td><td>Understand</td></tr>
</table>

### Course Outline

**Module-1 Electrodynamics** **16hrs**

1.1 Monopole, dipole and quadrupole. Electric multipole moments[Ref.1,2]

1.1.1 The electric dipole and multipole moments of a system of charges

1.1.2 Multipole expansion of the scalar potential of an arbitrary charge distribution

1.2 Potential formulation[Ref.1,2]

1.2.1 Maxwell equations in terms of electromagnetic potentials

1.2.2 Gauge transformations, the Lorentz, Coulomb and radiation gauges

1.3 Fields of moving charges and radiation[Ref.1,2]

1.3.1 Retarded potentials, the Lienard-Wiechert potentials

1.3.2 Fields due to an arbitrarily moving point charge, the special case of a charge moving with constant velocity

**Key words:** Electric multipole, Maxwell's equations

**Module-2 Optics** **16hrs**

2.1 Electromagnetic waves

2.1.1 Monochromatic plane waves - velocity, phase and polarization

2.1.2 Propagation of plane electromagnetic waves in (i) conducting media and (ii) ionized gases. [Ref.3]

2.1.3 Reflection and refraction of electromagnetic waves - Fresnel formulae for parallel and perpendicular components, Brewster law. [Ref.4]

2.2 Propagation of light in an anisotropic medium[Ref.4]

2.2.1 Structure of a plane electromagnetic wave in an anisotropic medium, dielectric tensor

2.2.2 Fresnel's formulae for the light propagation in crystals, optical classification of crystals, light propagation in uniaxial and biaxial crystals

2.3 Interference[Ref.4]

2.3.1 General theory of interference of two monochromatic waves

2.3.2 Two-beam and multiple-beam interference with a plane-parallel plate

2.3.2 Fabry-Perot interferometer: etalon construction, resolving power, applications

2.4 Diffraction[Ref.4]

2.4.1 Fresnel-Kirchhoff diffraction formula

2.4.2 Conditions for Fraunhofer and Fresnel diffraction, Fraunhofer diffraction due to a circular aperture

**Key words:** EM waves, interference, diffraction

## Reference


1 Introduction to Electrodynamics, Griffiths D.J., Prentice-Hall of India, 5thEdn., New Delhi, 2003

2 Electromagnetics, Laud B.B., Wiley Eastern Limited, India, 2000.

3 Electrodynamics, Gupta S.L., Kumar V., Singh S. P., PragatiPrakashan, Meerut, 2008.

4 Principles of Optics, Born M. and Wolf E., Pergamon Press, 6thEdn., Oxford, 1970.

5 Classical Electrodynamics, Jackson J.D., Wiley-Eastern Ltd, 2ndEdn., India, 1998.

6 Optics, Mateev A.N., Mir Publishers, Moscow, 1988.


## FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="8">Experiments in Electronics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Practicals</td><td>Total Hours</td><td>112</td><td>Hours/Week</td><td>07</td><td>Credits</td><td>04</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">AP210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>04Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | make the students to understand experimental physics. |
| CO-2 | design and conduct analog electronics experiments using opamp IC 741C. |
| CO-3 | analyze errors and their propagation in experiments. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyze and design circuits employing integrated circuit operational amplifiers. | PSO-3 PSO-4 | Analyze |
| CLO-2 | identify errors and their propagation. | PSO-5 | Understand |

## Course Outline

***Any eight of the following experiments:***

1 Regulated power supply.
2 Op-amp characteristics.
3 Op-amp as summing and difference amplifier.
4 Op-amp voltage follower.
5 Op-amp active filters: low pass and high pass (first order).
6 Op-amp active filters: low pass and high pass (second order).
7 Op-amp as integrator and differentiator.
8 Op-amp phase shift oscillator.
9 Op-amp Wein bridge oscillator.
10 Encoder and decoder.
11 Verification of Boolean laws.
12 Half adder and full adder, half subtractor and full subtractor.
13 RS and JK flip-flops.

## FIRST YEAR - SEMESTER – I

| Course Title | **Scientific Text Processing Using LaTeX** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practicals | Total Hours | 64 | Hours/Week | | 04 | Credits | 02 |
| Course Code | AP510 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | inculcate the skills in use of computers. |
| CO-2 | familiar with the use of open source operating system LINUX. |
| CO-3 | use scientific text processing package LaTeX, plotting package GNUPLOT. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn: | PSOs Addressed | CLDs |
| CLO-1 | to work on different tools provided on Linux platform. | PSO-3<br>PSO-4 | Apply |
| CLO-2 | scientific writing using LaTeXpackage. | PSO-5 | Understand |

## Course Outline

| | | |
|---|---|---|
| 1 | Basics of Linux operating system: Login procedure; creating, deleting directories; copy, delete, renaming files; absolute and relative paths; permissions-setting, changing-using text editor. | (4 sessions) |
| 2 | Scientific text processing with LaTeX: Typeset text using text effects, special symbols, lists, table, mathematics and including figures in documents | (6 sessions) |
| 3 | Presentation using beamer | (4 sessions) |
| 4 | Using the plotting programme GNUPLOT: Plotting commands: to plot data from an experiment and applying least-squares fit to the data points, including a plot in a LaTeXfile | (2 sessions) |

## FIRST YEAR - SEMESTER – I

| Course Title | **Computations in Physics Using C-Language** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- practicals | | Total Hours | 64 | Hours/Week | 04 | Credits | 02 |
| Course Code | AP520 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | develop and execute a few C program aimed at solving simple mathematical and basic physics problems. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | generate and execute C programme for different problems using Linux. | PSO-4 | Apply |
| CLO-2 | solve programmes for special functions in Physics using C. | PSO-4<br>PSO-5 | Apply |

## Course Outline

**Part A**

| Sl. No | A minimum of six of the following program: |
|---|---|
| 1 | Check whether given number is odd or even. |
| 2 | Check whether the input number is prime or not. |
| 3 | Compute the Fibonacci sequence. |
| 4 | Compute the roots of a quadratic equation. |
| 5 | Addition of two m $\times$ n matrices. |
| 6 | Matrix multiplication. |
| 7 | Find the largest and smallest number in the input set. |
| 8 | Generate Pascal's triangle. |
| 9 | To find the sum and average of a data stored in a file. |
| 10 | Linear least-squares fitting to data in a file. |

**Part B**

| Sl. No | A minimum of six of the following program: |
|---|---|
| 1 | The trajectory of a projectile shot with an initial velocity at an angle. |
| 2 | The Legendre polynomials generator. |
| 3 | The Bessel functions generator. |
| 4 | Classical scattering. |
| 5 | Eigen value problem of the 1D Schrodinger equation. |
| 6 | Discrete and fast Fourier transforms. |
| 7 | The Maxwell velocity distribution generator. |
| 8 | Simulation of diffraction as Fourier transformation. |

## FIRST YEAR - SEMESTER – I

| Course Title | **Experimental Techniques In Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | A0310 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand some of the experimental techniques and the information they provide. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will: | PSOs Addressed | CLDs |
| CLO-1 | gain a basic knowledge of current experimental techniques. | PSO-1 | Understand |
| CLO-2 | sknow which technique to apply to gain the required information to solve a problem. | PSO-3 | Apply |

## Course Outline

| | | |
|---|---|---|
| **Module -1** | **Experimental Techniques 1** | **16Hrs** |
| 1.1 | Sensors and Actuators: sensor and actuator. Active and Passive sensors. Factors important for selection of sensors. Sensors for different variables. Sensors dependent on resistance. Sensors producing an output voltage. Sensors dependent on variable coupling. Capacitance sensors. [1-3] | 4Hrs |
| 1.2 | Vacuum Techniques: Units for measurement of vacuum. Pumping speed of a pump. Conductance. Rotary pump. Diffusion pump. Turbomolecular pump. Cryopump. Gauges for measuring vacuum. Leak testing. [4-6] | 4Hrs |
| 1.3 | Cryogenic techniques: Production of low temperatures. Liquefier and closed circuit refrigerator. Storage of cryogenic liquids. Temperature measurement. Dipstick cryostat. Continuous flow cryostat. [7] | 4Hrs |
| 1.4 | Thin film techniques: Evaporation. Sputtering. Schematic of a DC sputtering system. Magnetron sputtering. Measurement of thickness of film. [8-11] | 4Hrs |
| **Module -2** | **Experimental Techniques 2** | **16Hrs** |
| 2.1 | X Ray and Neutron Powder Diffraction : Bragg's Law. Powder diffractometer and how it works. Indexing of X ray Powder photographs. Identification of phases. Limitations of X ray diffraction. Neutron diffraction – advantages in finding the position of light atoms and in magnetic ordering studies. [12-14] | 4Hrs |
| 2.2 | Electron Microscopy: Principle. Preparation of samples. Scanning electron microscope. Measurement of grain size. Transmission electron microscope. Selected Area Diffraction. [15-18] | 4Hrs |
| 2.3 | NMR and EPR Spectroscopy: Principle, Frequencies of operation; Absorption and Relaxation; Applications in Chemical Physics [19-22] | 3Hrs |
| 2.4 | IR,Visible UV Absorption and Raman Spectroscopy: Range of electromagnetic spectrum. Dispersion elements for IR, Visible and UV spectroscopes. Raman spectroscopy. Applications in chemical Physics [23-25] | 5Hrs |

### Reference


1 Sensors and Transducers, D. Patranabis Prentice Hall India Learning Private Ltd. 2 Edition (2003)

2 Introduction to Instrumentation and Measurements, Robert B. Northrop, Taylor and Francis, 2 Edition (2005) (e book)

3 "A new perspective on Magnetic Field Sensing" Carl H. Smith Robert Schneider, Michael J. Caruso, and Tamara Bratland, http//www.sensorsmag.com/components/a-new-perspective-magnetic-field-sensing.

4 Roth: 'Vacuum Technology", North Holland, Amsterdam, (1976)

5 G. Lewin: 'Fundamentals of Vacuum Science and Technology', McGraw Hill, New York, (1965).

6 John F. O'Hanlon: 'User's guide to Vacuum Technology', John Wiley & Sons Inc., (1989).

7 R.Srinivasan, A.K. Raychaudhri and S. Kasthurirengan, Cryogenics and Measurement of Properties of Solids at Low Temperatures, Allied Publishers

8 Thin film deposition – Principles and Practice Donald Smith, McGrawhill (1995)

9 Preparation of Thin Films, Joy George, CRC Press, (1992)

## First YEAR - SEMESTER – I

| Course Title | **Electronics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 | |
| Course Code | A0320 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | acquire knowledge about analog and digital electronic devices |
| CO-2 | analyse and design combinational logic circuits |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | design op-amp circuits. | PSO-1 PSO-2 | Understand |
| CLO-2 | analyse and design combinational logic circuits. | PSO-1 PSO-2 | Analyze |

## Course Outline

| | | |
|---|---|---|
| **Module-1** | **Operational Amplifiers** | **16hrs** |
| 1.1 | Concepts of differential amplifier, Ideal op-amp, op-amp parame- ters,ideal voltage transfer curve | |
| 1.2 | Open loop and closed op-amp configurations, inverting amplifier, noninverting amplifier | |
| 1.3 | Limitations of open loop op-amp configurations. | |
| 1.4 | Summing, scaling and averaging amplifiers, voltage to current converter with grounded load, current to voltage converter, integrator, differentiator, | |
| 1.5 | Log and antilog amplifiers, Wave form generators, phase shift oscillator, Wein bridge oscillator. | |
| 1.6 | Non-linear circuit applications: Crossing detectors, 555 timer as a mono-stable and astable multivibrators, Active Filters—First and second order Low pass and High pass filters, Butterworth filters. | |
| | **Key words:** Operational amplifiers, non linear circuits | |
| **Module-2** | **Digital Electronics and Combinational Logic Circuits** | **16hrs** |
| 2.1 | Boolean Laws and Theorems, addition and subtraction based on 1's and 2's complements | |
| 2.1.1 | Families of gates, RS and JK flip-flops, The Master-Slave JK flip-flop, D and T flip-flops | |
| 2.1.2 | Karnaugh maps for 3 and 4 variables, Decoders-BCD decoders, Encoders. | |
| 2.2 | Shift registers-series, series in-series out and parallel in parallel out. Half and full adders, Registers | |
| 2.3 | Counters - Binary Ripple Counters, Synchronous Binary counters, Counters based on Shift Registers, Synchronous counters, Synchronous Mod-6 Counter using clocked JK Flip-Flops | |
| 2.4 | Synchronous Mod-6 Counter using clocked D, T, or SR Flip-Flops. Memory cells, memory registers | |
| | **Key words:** Boolean algebra, flip-flops, counters | |

### Reference


1 Electronic devices and circuit theory, Boylestad R.L. and Nashelsky L., Pearson Education, 4th Edn., 2006.

2 Operational amplifiers and linear circuits, Bell D.A., Pearson Education, 2nd Edn., 2004

3 Operational amplifiers and linear integrated circuits, Gaekwad R.A., Prentice-Hall of India, New Delhi, 1993.

4 Digital principles and applications, Malvino A.P. and Leach D.P., Tata McGraw Hill, 4th Edn., 1988.

5 Digital circuits and design, Arivazhagan S. and Salivahananan S., Vikash Publishing House Pvt. Ltd., New Delhi, 2001.

## FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="9">Spectroscopy</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">A0330</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | earn theoretical aspects of modern atomic and molecular spectroscopic techniques and their applications in research field. |

<table>
<tr><th colspan="4">Mapping of CLOs with PSOs & CDLs</th></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>explain the change in behaviour of atoms in external applied electric and magnetic field.</td><td>PSO-2<br>PSO-4</td><td>Understand</td></tr>
<tr><td>CLO-2</td><td>explain rotational, vibrational, electronic and Raman spectra of molecules.</td><td>PSO-2<br>PSO-4</td><td>Understand</td></tr>
<tr><td>CLO-3</td><td>describe electron spin and nuclear magnetic resonance spectroscopy and their applications.</td><td>PSO-2<br>PSO-4</td><td>Understand</td></tr>
</table>

## Course Outline

**Module-1 Atomic Spectroscopy and Molecular Spectroscopy-1** **16hrs**

1.1 Atomic spectroscopy [Ref.1]

1.1.1 Spectroscopic terms and their notations. Spin-orbit interaction, quantum mechanical relativistic correction, Lamb shift

1.1.2 Zeeman effect, normal and anomalous Zeeman effect

1.1.3 Paschen-Back effect, Stark effect, weak field and strong field effects

1.1.4 Hyperfine structure of spectral lines - nuclear spin and hyperfine splitting, intensity ratio and determination of nuclear spin, breadth of spectral lines, natural breadth, Doppler effect and external effect

1.2 Molecular spectroscopy-1

1.2.1 Microwave spectroscopy-Introduction, classification of molecules. The rotational spectra of rigid diatomic rotator and spectra of non-rigid diatomic rotator, microwave spectrometer. [Ref.2]

1.2.2 Infrared spectroscopy –Introduction, Vibrational energy of diatomic molecule, anharmonic oscillator, the diatomic vibrating rotator, example of the CO molecule IR and FTIR spectrometers. [Ref.2]

**Key words:** Spin-orbit interaction, Zeeman effect, rotational and vibrational spectra

| | | | |
|---|---|---|---|
| **Module-2** | **Molecular Spectroscopy-2** | **16hrs** |
| 2.1 | Raman spectroscopy[Ref.2] | |
| 2.1.1 | The quantum theory of Raman effect, pure rotational Raman spectra of linear molecules and symmetric top molecules | |
| 2.1.2 | Vibrational Raman spectra, rotational fine structure, instrumentation technique in Raman spectroscopy | |
| 2.2 | Electronic spectroscopy of molecules[Ref.2] | |
| 2.2.1 | Electronic spectra of diatomic molecules, Vibrational coarse structure | |
| 2.2.2 | The Frank-Condon principle, rotational fine structure of electronic-vibration transitions, fluorescence and phosphorescence, techniques and instrumentation | |
| 2.3 | NMR spectroscopy[Ref.2] | |
| 2.3.1 | Resonance condition, spin-lattice and spin-spin relaxation, chemical shift and coupling – example of ethyl alcohol | |
| 2.3.2 | Continuous wave and FTNMR spectroscopy, note on CNMR and MRI | |
| 2.4 | ESR spectroscopy[Ref.2] | |
| 2.4.1 | Resonance condition, electron-nucleus and electron-electron coupling, double resonance, ESR spectrometer | |

**Key words:** Raman effect, NMR, ESR

**Reference**


1 Atomic and Molecular Spectra Laser, Rajkumar, KedarNath Ram Nath, India, 2015.

2 Fundamentals of Molecular Spectroscopy, Banwell C.N. and Mccash E.M., Tata McGraw-Hill, 4th Edn., New Delhi, 1995.

3 Atomic Theory, Tralli N. and Pomilla P.R., Tata McGraw-Hill, New York, 1999.

4 Atomic and Molecular Spectroscopy, RitaKakkar, CambridgeUniversity Press, 1stEdn., Cambridge, 2015.

5 Molecular Spectroscopy, McHale J. L., Pearson Education, India, 2008.

## FIRST YEAR - SEMESTER – II

| Course Title | **Theory of Relativity** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Theory | | Total Hours | 48 | Hours/Week | 03 | Credits | 03 |
| Course Code | B0210 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand basic concepts of special theory of relativity such as Minkowski space time continuum. |
| CO-2 | extend their understanding of special theory of relativity by including the relativistic electrodynamics. |
| CO-3 | understand theory of general relativity and its consequences. |
| CO-4 | understand the theory of gravitational waves and detection. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the paradoxes in special relativity. | PSO-1<br>PSO-2 | Understand |
| CLO-2 | understand the significance of the postulates of special and general relativity. | PSO-1<br>PSO-2 | Understand |
| CLO-3 | understand the invariance of Maxwell's field equations. | PSO-1<br>PSO-2 | Understand |
| CLO-4 | identify and experimentally detect gravitational waves. | PSO-3<br>PSO-4 | Analyze |

## Course Outline

**Module-1 Special Theory of Relativity** **16hrs**

1.1 Minkowski space time[Ref.1-3]

1.1.1 Real coordinates in Minkowski space time

1.1.2 Definition of 4-tensors, the Minkowski scalar product and the Minkowski metric

1.1.3 Orthogonality of 4-vectors, time like, null like and space like vectors and worldlines, the light-cone at an event.

1.2 Relativistic mechanics of a material particle[Ref.1-3]

1.2.1 The proper-time interval $d\tau$ along the world- line of a material particle

1.2.2 The instantaneous (inertial) rest-frame of a material particle and the components of 4-velocity, 4-acceleration, 4-momentum and 4-force vector in this frame, statement of second law of Newton in this frame.

1.2.3 Motion of a particle under the conservative 3-force field and the energy integral, the rest energy and the relativistic kinetic energy of a particle.

**Key words:** Special relativity, Minkowski space, 4-tensors

**Module-2 General Theory of Relativity** **16hrs**

2.1 Einstein's equations[Ref.4]

2.1.1 Newtonian gravitational potential, inconsistencies of Newtonian gravitation with STR

2.1.2 The concepts of inertial and gravitational mass, the weak equivalence principle

2.1.3 Eötvös experiment, Einstein's elevator thought experiment

2.1.4 The Einstein equivalence principle, metrics, parallel transport, geodesics, curvature tensor and its properties

2.1.5 Gravitation as space time curvature, logical steps leading to Einstein's field equations of gravitation and its Newtonian limits.

2.2 Applications of general theory of relativity[Ref.4]

2.2.1 Schwarzschild's solution of Einstein's vacuum field equations

2.2.2 Motion of particles and light rays in the Schwarzschild field, explanation of the (i) perihelion advance of planet mercury, (ii) gravitational red shift, (iii) gravitational bending of light, and, (iv) gravitational waves, the Schwarzschild singularity and the Schwarzschild black hole (qualitative).

**Key words:** General relativity, Einstein's equations, space time curvature, Schwarzschild's solution

**Module 3 Relativistic Electrodynamics and Gravitational Radiation** **16hrs**

3.1 Electrodynamics in covariant form[Ref.1-3]

3.1.1 The 4-potential $A_i$ and the 4-current density $J_i$, the Maxwell field tensor $F_{ij}$ and its dual

3.1.2 Maxwell's field equations in covariant form, the equation of continuity

3.1.3 The Lorentz 4-force on a charge, the guage invariance of $F_{ij}$ in terms of the 4-potential.

3.2 Gravitational radiation [Ref. 5,6]

3.2.1 Introduction to gravitational waves

3.2.2 Linearized approximation : Plane waves

3.2.3 Radiation of gravitational waves

3.2.4 Cosmic sources of gravitational waves :i)coalescing binaries ii) explosive sources

3.2.5 Experimental detection of gravitational waves: i) bar detectors ii) LASER interferometer iii) LISA From space (qualitative)

**Key words:** Covariant formulations, Gravitational radiation, LISA

**Reference**


1 The Classical Theory of Fields, Landau L.D. and Lifshitz E.M., Pergamon Press, 4thEdn., Oxford, 1985.

2 Relativity: The Special Theory, Synge J.L., North-Holland Publishing Company, Amsterdam, 1972.

3 Relativity: Special, General and Cosmological, Rindler R., Oxford University Press, 2006.

4 General Relativity, Wald R.M., The University of Chicago Press, Chicago, 1984.
5 An Introduction to Relativity, Jayant V. Narlikar, Cambridge University Press, 2nd Edn., 2011
6 A First Course in General Relativity, Schutz B.F., Cambridge University Press, Cambridge, 1985.
7 Textbook of Astronomy and Astrophysics with Elements of Cosmology, Bhatia V.B., Narosa Publishing House, New Delhi, 2001.
8 Astrophysics – Stars and Galaxies, Abhyankar K. D., Universities Press, India, 2001.
9 Classical Mechanics, B.A Kagali and T. Shivalingaswamy, Himalaya Publishing House, Mumbai, 2018.

## FIRST YEAR - SEMESTER – II

<table>
<tr><td>Course Title</td><td colspan="8">Quantum Physics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>64</td><td>Hours/Week</td><td>04</td><td>Credits</td><td>04</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">B0220</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | familiar with the basic theoretical concepts and formalism of quantum mechanics. |
| CO-2 | solve Eigenvalue problems for exactly solvable systems. |
| CO-3 | understand time independent perturbation theory along with some of its applications. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | solve the Schrödinger equation for simple configurations. | PSO-2<br>PSO-4 | Apply |
| CLO-2 | solve perturbed systems using quantum mechanics. | PSO-2<br>PSO-4 | Apply |

## Course Outline

**Module-1 Mathematical Aspects and Formalism** **16hrs**

1.1 Linear vector spaces
1.1.1 Definitions, linear dependence, linear independence
1.1.2 Bases, change of bases, inner product spaces
1.1.3 Dual spaces and Dirac notation
1.1.4 Matrix representation of linear operators. [Ref.2].
1.2 Formalism
1.2.1 Postulates of quantum mechanics: Hilbert space, observables
1.2.2 Eigenvalues and Eigenfunctions of a Hermitian operator, expectation values.

| | |
|---|---|
| 1.2.3 | The canonical commutation relations, compatible and non-compatible observables, Generalized uncertainty relations. [Ref.1]. |
| 1.2.4 | Wave functions in position and momentum space, momentum operator in position Eigen basis, position operator in momentum basis. |
| 1.2.5 | Quantum dynamics: Time evolution, The Schrödinger and Heisenberg picture. Interaction picture. Equations of motion. |
| 1.3 | The wave function, the Schrödinger equation, the statistical interpretation, probability, discrete and continuous variables, normalization, momentum, the uncertainty principle. [Ref.1] |

**Key words:** Linear vector spaces, Formalism, Schrödinger equation

**Module-2 The Time Independent Schrödinger Equation 16hrs**

| | |
|---|---|
| 2.1 | Stationary states |
| 2.2 | Review of infinite square well |
| 2.3 | The harmonic oscillator - algebraic and analytical methods, |
| 2.4 | The free particle |
| 2.5 | Gaussian wave packet |
| 2.6 | The delta-function potential |
| 2.7 | The finite square well, potential barrier penetration |
| 2.8 | Quantum Mechanics in three dimensions |
| 2.8.1 | Schrödinger equations in spherical polar co-ordinates, the hydrogen atom, angular momentum and spin. |
| 2.9 | Identical particles: Two particle systems. |

**Key words:** Stationary states, hydrogen atom

**Module-3 The Time Independent Perturbation Theory 16hrs**

| | |
|---|---|
| 3.1 | Non-degenerate perturbation theory, first and second order perturbation |
| 3.2 | Degenerate perturbation theory |
| 3.3 | Fine structure of hydrogen atom |
| 3.4 | Zeeman effect |
| 3.5 | The variational principle: theory-the ground state of helium, ionic state of diatomic hydrogen |
| 3.6 | The WKB approximation: The classical turning points, Bohr quantization formula tunnelling. [Ref.1] |

**Key words:**Perturbations, approximations

**Reference**


1 Introduction to Quantum Mechanics, Griffiths D.J., Pearson, 2nd Edn., India, 2014.
2 Principles of Quantum Mechanics, Shankar R., Springer (India) Pvt. limited, 2ndEdn., 1994.
3 Quantum Mechanics, Thankappan V.K., New Age International (P) Limited Publishers, 2ndEdn., New Delhi, 2003.
4 Quantum Mechanics, Claude cohen-Tannoudji, Bernard Diu, Frank Laloe, Wiley, 2006.
5 Quantum mechanics, Schiff L.I., Tata McGraw-Hill, 3rdEdn., New Delhi 1968.
6 Modern Quantum Mechanics, Sakkurai J. J., Pearson, 2nd Edn., 2010.
7 Quantum Mechanics, Mathew P. M. and Venkateshan K., Tata McGraw-Hill, 2010.

## FIRST YEAR - SEMESTER – II

| Course Title | **Solid State Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Theory | | Total Hours | 48 | Hours/Week | 03 | Credits | 03 | |
| Course Code | B0230 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | explore the rich behaviour of solid systems under a wide range of conditions. |
| CO-2 | analyze the crystal structure using X-ray, electron and neutron diffraction techniques. |
| CO-3 | understand the magnetic properties of solids, semiconductors and superconductors. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | find the structure of small and macro molecules. | PSO-1 | Understand |
| CLO-2 | explain material response to external magnetic field. | PSO-2 | Understand |
| CLO-3 | design components using semiconducting material. | PSO-5 | Create |

## Course Outline

**Module-1 Crystal Geometry** **16 hrs**

1.1 Atoms in crystals [Ref.1,2]

1.1.1 Crystalline solids – crystalline, semi-crystalline and non- crystalline solids. reference axes, equation of a plane

1.1.2 Periodicity in crystals, space lattice and translational vectors, basis and the crystal structure

1.1.3 Miller indices – site indices, indices of direction, indices of a lattice plane, representation of planes of known Miller indices, inter planar spacing, density of atoms in a crystal plane

1.1.4 Symmetry operations – translational operation, point operation, hybrid operation, screw and glide operations

1.1.5 Crystal types - two and three dimensional lattices, crystal systems and Bravais lattices

1.1.6 Point groups and space groups, analysis of the space group symbol

1.2 Diffraction of X-rays by crystals

1.2.1 Laue equations, reciprocal lattice, Ewalds construction, equivalence of Laue and Bragg equations

1.3 Experimental techniques[Ref.2,3]

1.3.1 Laue, powder and counter methods.

1.4 Crystal growth[Ref.4,5]

| | | |
|---|---|---|
| 1.4.1 | Crystal growth from melt: Bridgemann technique, Czochralski's method | |
| 1.4.2 | Growth from solutions, zone refining method of purification | |
| 1.5 | Electron and neutron diffraction[Ref.4] | |
| 1.5.1 | Basic principles, a comparison with X-ray diffraction, applications (qualitative) | |
| | **Key words:** crystal, Miller indices, X-ray diffraction | |
| **Module-2** | **Crystal Elasticity, Lattice Vibrations and Magnetic Properties** | **16 hrs** |
| 2.1 | Elastic constants of crystals | |
| 2.1.1 | Definition of elastic strains and stresses in a solid | |
| 2.1.2 | Elastic compliance and stiffness constants, applications to cubic crystals and isotropic solids | |
| 2.1.3 | Elastic waves and experimental determination of elastic constants [Ref.6] | |
| 2.2 | Crystal lattice dynamics[Ref.7] | |
| 2.2.1 | Vibration of an infinite one-dimensional mono atomic lattice, symmetry in k-space (first Brillouin zone), group velocity, finite lattice and boundary conditions | |
| 2.2.2 | Vibrations of a linear diatomic lattice - optical and acoustical branches | |
| 2.2.3 | Experimental measurements of dispersion relation | |
| 2.3 | Properties of dia and para magnetic solids | |
| 2.3.1 | Definition of magnetisation and susceptibility, Hund's rule, calculation of L, S and J for 3d and 4f shells | |
| 2.3.2 | Diamagnetic solids: Diamagnetism and its origin, expression for diamagnetic susceptibility | |
| 2.3.3 | Paramagnetic solids: Quantum theory of paramagnetism, Curie's law, Brillouin function, comparison of theory and experiment for paramagnetic salts [Ref.8] | |
| | **Key words:** Crystal elasticity, Brillouin zone, magnetic properties | |
| **Module-3** | **Semiconductors and Superconductors** | **16 hrs** |
| 3.1 | Semiconductors [Ref.9] | |
| 3.1.1 | Intrinsic semiconductors: Expressions for electron and hole concentrations, intrinsic carrier concentration, effect of temperature on carrier concentration. Fermi energy, electrical conductivity and experimental determination of energy gap | |
| 3.1.2 | Extrinsic Semiconductors: Carrier concentration, effect of temperature and impurity density. Fermi energy - Fermi energy when the Boltzmann approximation is valid for electrons and holes, Fermi energy at very low temperatures, effect of impurity density. Electrical conductivity - expression for electrical conductivity, effect of temperature and impurity concentration | |
| 3.2 | Superconductors[Ref.6] | |
| 3.2.1 | A brief introduction on the observed experimental facts | |
| 3.2.2 | Type I and type II superconductors | |
| 3.2.3 | Phenomenological theory-London equations, Meissner effect | |
| 3.2.4 | Thermodynamical theory of superconductors - entropy and specific heat in the superconducting state, change in entropy and specific heat at superconducting transition | |
| 3.2.5 | High frequency behaviour | |
| | **Key words:** Semiconductors, superconductors | |

**Reference**


1 Structure Determination by X-ray Crystallography, Ladd M.F.C. and Palmer R.A., Plenum Press, USA, 1977.
2 Elementary Crystallography, BuergerM.J., AcademicPress,UK,1956.
3 Crystals, X-rays and Proteins, Sherwood D., Longman, UK, 1976.
4 Modern Crystallography, Vainshtein B.K., Springer-Verlag, Vol. I, Germany, 1981.
5 The Structure and Properties of Materials, Rose R.M., Shepard L.A. and Wulff J., Electronic Properties, Wiley Eastern, Vol. 4, 1965.
6 Introduction to Solid State Physics, Kittel C., John Wiley, 7th Edn., New York, 1996.
7 Solid State Physics, Wahab M.A., Narosa Publishing House, New Delhi, 1999.
8 Solid State Physics, Dekker A.J., Macmillan India Ltd., New Delhi, 2008.
9 Solid State and Semiconductor Physics, Mckelvey J.P., Harper and Row, 2nd Edn., USA, 1966.
10 Solid State Physics, Pillai S.O., New Age International, 2006.


## FIRST YEAR - SEMESTER – II

| Course Title | **Experiments in Optics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Practicals | | Total Hours | 112 | Hours/Week | 07 | | Credits | 04 |
| Course Code | BP210 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | develop skills in use of advanced optical equipment's to study these phenomena and verify laws of optics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | set up and operate advanced experiments in optics. | PSO-3<br>PSO-4 | Apply |
| CLO-2 | study and verify different optical phenomena. | PSO-3<br>PSO-4 | Apply |

## Course Outline

1 Verification of the Brewster's law of polarization.
2 Verification of Fresnel laws of reflection from a plane dielectric surface.
3 Birefringence of mica using Babinet compensator.
4 Birefringence of mica by using the quarter-wave plate.

5 Experiments with Michelson interferometer.
6 Determination of the size of lycopodium spores by the method of diffraction haloes.
7 Determination of the wavelength of light by using the Fabry-Perot etalon.
8 Verification of Malus' law.
9 Experiments with source laser.
10 Study of elliptically polarized light.
11 Determination of the refractive index of air by Jamin interferometer.
12 Determination of Stokes vector of a partially polarized light beam.
13 Determination of thickness of mica sheet using Edser Butler Fringes.
14 Determination of wavelength of He-Ne laser by Michelson interferometer.
15 a Diffraction of laser light by single slit and diffraction grating: determination of wavelength of laser,
15 b Determination of distance between two slits using interference of laser light through double slit.

## FIRST YEAR - SEMESTER – II

| Course Title | **Cellular and Molecular Biophysics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | B1510 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | learn selected biological phenomena using physical principles |
| CO-2 | understand the building blocks of biological molecules and their structure |
| CO-3 | understand the fundamental aspects of biological problems at the molecular level |
| CO-4 | learn selected biological phenomena using physical principles |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | apply key principles of biophysics toward evaluating and analyzing primary literature in the field | PSO-2 | Apply |
| CLO-2 | explain key concepts in physiology and biophysics (and supporting disciplines). | PSO-5 | Understand |
| CLO-3 | elucidate the structure of biological molecules | PSO-5 | Analyze |

***Offered to post-graduate students of Physics, Biochemistry and Mathematics***

**Course Outline**

| | | |
|---|---|---|
| **Module-1** | **Biophysics and Thermodynamics** | **16hrs** |
| 1.1 | Introduction[Ref.1] | |
| 1.1.1 | The broad characteristics of a typical cell, cell organelles, the molecular composition of a cell | |
| 1.1.2 | Biological molecules and their general character, cell behaviour, viruses, genetics and biophysics | |
| 1.2 | Molecular physics[Ref.1] | |
| 1.2.1 | The conservation of energy in biological process, metabolism or chemical energy turnover | |
| 1.3 | Statistical thermodynamics and biology[Ref.1] | |
| 1.3.1 | The theory of absolute reaction rates, thermal inactivation, the entropy transfer of living organisms | |
| 1.4 | Information theory [Ref.1] | |
| 1.4.1 | Relation between entropy and biological systems, content of a bacterial cell | |
| | **Key words:** Biomolecules, metabolism, thermodynamics | |
| **Module-2** | **Structure Analysis of Biomolecules** | **16hrs** |
| 2.1 | Determination of size and shape of molecules[Ref.1] | |
| 2.1.1 | Introduction - random motion, diffusion, sedimentation, Optical methods: rotational diffusion and birefringence | |
| 2.2 | X-ray analysis and molecular structure[Ref.1] | |
| 2.2.1. | Diffraction of X-rays, crystal structure and the unit cell | |
| 2.2.2 | Diffraction patterns of some protein fibers | |
| 2.2.3 | The structure of globular proteins | |
| 2.2.4 | The structure of polypeptide chains - the pleated sheets and beta-keratin, the alpha-helix and alpha-keratin | |
| 2.2.5 | The structure of nucleic acid polymers, the structure of nucleoproteins, the analysis of virus structures | |
| | **Key words:** molecular structure, small molecules | |

**Reference**


1 Molecular Biophysics, Setlow R.B. and Pollard E.C., Pergamon Press, London-Paris, 1962.
2 Biophysics, Volkenshtein M.V., Mir Publishers, Moscow, 1983.
3 Biophysics, Sarn K., Rajat Publications, India, 2005.
4 Biophysics: An Introduction, Rodney C., Johy-Wiley & Sons, 2003.
5 Biophysics, An Introduction, Glaser R., Springer, 2004.
6 Textbook of Biophysics, Nihaluddin, Sonali Publications, New Delhi, 2009.

## FIRST YEAR - SEMESTER – II

| Course Title | **Materials Science** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 | |
| Course Code | B1520 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand basic principles and implementation of material structure, processing, properties and performance of different classes of materials |
| CO-2 | expand their knowledge in specialized areas at the forefront of materials development. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | relate theoretical knowledge to modern materials physics | PSO-2 | Understand |
| CLO-2 | the techniques of preparing and fabricating ceramic materials | PSO-5 | Understand |

***Offered to post-graduate students of Physics and Chemistry***

## Course Outline

**Module-1 Introduction** **16hrs**

1.1 Introduction to materials[Ref.1-3]
1.1.1 Relationship of Science and Technology
1.1.2 Classification of materials - levels of structure, structure-property relationship in materials. crystalline and amorphous materials
1.1.3 Centrosymmetric and Non-centrosymmetric materials, Amorphous, Glasses, Metals
1.1.4 High Tc super conductors, alloys and composites, semiconductors
1.1.5 Solar energy materials, luminescent and optoelectronic materials, polymer
1.1.6 Liquid crystals and quasi crystals
1.2 Structure of solids [Ref.1-3]
1.2.1 The crystalline and non-crystalline states
1.2.2 Covalent solids, metals and alloys, ionic solids, the structure of silica and silicates
1.3 Nano-structured materials:
1.3.1 Nanorods, nanotubes/wires and quantum dots
1.3.2 Fullerenes and tubules, single wall and multiwall nanotubes

**Key words:** Materials, liquid crystals, nano materials

| | | |
|---|---|---|
| **Module-2** | **Phase Transition** | **16hrs** |
| 2.1 | Solid phases and phase diagrams[Ref.1-3] | |
| 2.1.1 | Introduction, Single and multiphase solids, Alloys, solid solutions, Substitutional Solid solutions and Hume-Rothery rules | |
| 2.1.2 | Intermediate phase, the inter metallic and interstitial compounds | |
| 2.1.3 | Properties of alloys: solid solutions and two component alloy systems | |
| 2.2 | Phase Diagrams | |
| 2.2.1 | Gibbs phase rule, Unary and Binary phase diagrams, construction of phase diagrams, Lever rule | |
| 2.2.2 | Some typical phase diagrams: Pb-Sn, Ag-Pt and Fe-Fe3C, eutectic, eutectoid, peritectic and peritectoid systems | |
| 2.2.3 | Order disorder phenomenon in binary alloys, long range order, super lattice, short range order | |
| 2.3 | Phase transformation[Ref.1-3] | |
| 2.3.1 | Time scale for phase changes | |
| 2.3.2 | Nucleation and growth, nucleation kinetics, growth and overall transformation kinetics | |
| 2.3.3 | Applications - transformation in steel- precipitation processes | |

**Key words:** Alloys, phase diagrams, phase transformation

**Reference**


1 Elements of Materials Science and Engineering, Van Vlack L. H., 6th Edn. Addison Wesley, 1989.
2 Materials Science and Engineering, Raghvan V., Prentice Hall of India, 5th Edn., 2009.
3 Materials Science and Processes, HazraChaudary S. K., Indian Book Distr. Co., 1977.
4 Thin Film Phenomena, Chopra K. L., Robert E K Publishing Company, 1979.
5 Engineering Materials, Budinski K. G. and Budinski M. K., Prentice-Hall of India Pvt. Ltd, 8th Edn., 2004.
6 Materials Science and Engineering. An Introduction, William D. Callister, Wiley, 2006


## FIRST YEAR - SEMESTER – II

| Course Title | **Experiments in General Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practicals | | Total Hours | 64 | Hours/Week | 04 | Credits | 02 |
| Course Code | BP510 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | develop skills in the design and conduction of experiments to demonstrate physical laws and phenomena. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | set up, and carry out basic and advanced experiments in different areas of physics. | PSO-3<br>PSO-4 | apply |

## Course Outline

**Any eight of the following experiments**

1 Determination of the modes of vibration of a fixed-free bar.
2 The Franck-Hertz experiment.
3 Electron spin resonance.
4 Analysis of spectroscopic data.
5 Zeeman effect.
6 Estimation of birefringence of quartz.
7 Determination of molecular polarizability of liquids and solutions.
8 Birefringence of crystals by prism technique.
9 Determination of velocity of ultrasonic waves using mechanical method.
10 Optical rotatory dispersion of quartz.
11 Determination of the modes of vibration of a fixed-free bar.
12 Determination of inversion temperature of a thermocouple.
13 Verification of law of intermediate metals.
14 Determination of Stefan's constant using photovoltaic cell.
15 Calibration of silicon diode and copper constantan thermocouple as temperature sensors.
16 Absorption coefficient of solutions.

## FIRST YEAR - SEMESTER – II

| Course Title | **MATLAB** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practicals | | Total Hours | 64 | Hours/Week | 04 | Credits | 02 |
| Course Code | BP520 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will |
|---|---|
| CO-1 | be familiar with MATLAB as an important tool in computational physics. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | write and execute simple MATLAB programmes | PSO-3 PSO-4 | apply |

## Course Outline

1 Basic syntax, variable and expression in MATLAB
2 Use of semicolon (;), operators, special characters
3 Saving and loading file
4 Command, in-built function, colon notation
5 Vector, matrix, array operation
6 Character, structure, cell array
7 Plotting commands in 2D, 3D graph, subplot graph
8 M-file: script and function file
9 Load and plot data from text file

## SECOND YEAR - SEMESTER – III

<table>
<tr><td>Course Title</td><td colspan="8">Advanced Quantum Physics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>48</td><td>Hours/Week</td><td>03</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">C0210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand time-dependent perturbation theory and its applications. |
| CO-2 | understand theory of scattering and calculation of scattering cross section, optical theorem ,Born and partial wave analysis etc. |
| CO-3 | understand Relativistic Quantum Mechanics and its consequences. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand relativistic effects in quantum physics.. | PSO-2<br>PSO-4 | Understand |
| CLO-2 | evaluate quantum systems using perturbation techniques. | PSO-5 | Evaluate |
| CLO-3 | be familiar with quantum scattering theory. | PSO-2<br>PSO-4 | Understand |

### Course Outline

**Module-1 Perturbation Theory** **16hrs**

1.1 Time-dependent perturbation theory

1.1.1 Two level systems, the perturbed system, first order and second order equations, sinusoidal perturbations, transition probability

1.1.2 Emission and absorption of radiation - stimulated and spontaneous emission

1.1.3 Incoherent perturbations, transition rates, spontaneous emission - Einstein A and B coefficients, life time of an excited state, selection rules. [Ref.1]

1.2 The adiabatic approximation

1.2.1 Adiabatic process, Born-Oppenheimer approximation, adiabatic theorem

1.2.2 Berry's phase, non-holonomic processes, geometric phase

**Key words:** Perturbations, two level systems, approximations

**Module-2 Scattering** **16hrs**

2.1.0 Classical scattering theory - differential scattering cross section, hard sphere scattering example, the total cross section

2.2.0 Quantum scattering theory - scattering amplitude, partial wave analysis: optical theorem, the Born approximation, integral form of the Schrödinger equation, the Green's function, the first born approximation, low energy soft sphere scattering, Yukawa scattering, Rutherford scattering. [Ref.1]

2.3 Relativistic kinematics

2.3.1 Relativistic kinematics of scattering and reactions, elastic, inelastic reactions, decay of a particle: $A \rightarrow B + C, A + B \rightarrow C, P + \bar{P} \rightarrow P + P + \bar{P} + P + P + \bar{P}$ [Ref.2]

**Key words:** Scattering, relativistic kinematics

**Module-3 Relativistic Quantum Physics** **16hrs**

3.1 The Klein-Gordon (K-G) equation, plane-wave solutions, negative energy states, equation of continuity, the short comings of the Klein-Gordon equation, the non-relativistic limit of the K-G equation

3.2 The Dirac equation - the free-particle Dirac equation in the Hamiltonian form, the algebra of Dirac matrices, plane wave solutions of the free-particle equation

3.3 The two-component form of the solution in the Dirac-Pauli representation, standard normalization of the solution, negative energy states and the hole theory

3.4 Non-conservation of the orbital angular momentum operator $\vec{L}$ , the spin operator $\vec{S}$ and the conservation of $\vec{J}$ , helicity operator

3.5 Dirac particle in electromagnetic field, spin-orbit interaction, the magnetic moment of the electron (non-relativistic), a brief discussion of the hydrogen atom energies according to the Dirac equation [Ref.2,3]

**Key words:** Relativistic wave equations

**Reference**

1 Introduction to Quantum Mechanics, Griffiths D.J., Pearson, 2ndEdn., India, 2005.
2 Introduction to Elementary Particles, Griffiths D.J., John Wiley and Sons, New York, 2008.
3 Advanced Quantum Mechanics, Sakurai J.J. and Tuan S.F. (Edr.), Addison Wesley, India, 1999.
4 Elementary Particle Physics, Gasiorowicz S., John-Wiley, New York, 1966.
5 The Physics of Elementary Particles, Muirhead H., Pergamon Press, London, 1965.

## SECOND YEAR - SEMESTER – III

| Course Title | **Nuclear and Particle Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Theory | | Total Hours | 48 | Hours/Week | 03 | Credits | 03 |
| Course Code | C0220 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand the basic structure, properties of atomic nucleus |
| CO-2 | understand various nuclear decays modes and models |
| CO-3 | understand Interaction of nuclear radiation with matter and various nuclear reactions |
| CO-4 | understand physics of elementary particles |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the importance of models in describing the properties of nuclei and nuclear interactions. | PSO-1<br>PSO-2 | Understand |
| CLO-2 | analyze the nuclear decay modes | PSO-2 | Analyze |
| CLO-3 | be familiar with main theoretical concepts and experimental techniques used in elementary particle physics. | PSO-1 | Understand |
| CLO-4 | make quantitative estimates of phenomena involving nuclei. | PSO-4<br>PSO-5 | Apply |

## Course Outline

**Module-1 Nuclear Properties and Models** **16hrs**

1.1 Properties of the nucleus

1.1.1 Nuclear radius - determination by mirror nuclei, Mesic X-rays and electron scattering methods

1.1.3 Nuclear moments: spin, magnetic dipole moment

1.1.3 Relation between J and µ on the basis of single particle model

1.1.4 Determination of nuclear magnetic moment by Rabi's molecular beam experiment

Electric quadrupole moment [Ref.1,2]

1.2 Nuclear models

1.2.1 Liquid drop model: Weissacker's formula and its application to (i) stability of isobars and (ii) fission process

1.2.2 Fermi gas model: well depth, level density and nuclear evaporation. [Ref.1,2].

1.2.3 Shell model: single particle potentials, spin-orbit coupling, magic numbers

| | | |
|---|---|---|
| 1.3 | Nuclear reactions | |
| 1.3.1 | Q-values, threshold energy, reactions induced by proton, deuteron and other particles, photodisintegration. [Ref.1,2]. | |
| | **Key words:** Nuclear properties, nuclear models, nuclear reactions | |
| **Module-2** | **Radioactivity, Radiations and Reactors** | **16hrs** |
| 2.1 | Nuclear decay modes | |
| 2.1.1 | Beta decay: Beta ray spectrum, Pauli neutrino hypothesis, mass of the neutrino from beta ray spectral shape | |
| 2.1.2 | Fermi theory of beta decay, Kurie plot, ft- values and forbidden transitions | |
| 2.1.3 | Methods of excitation of nuclei, nuclear isomerism, Mossbäuer effect, Auger effect (qualitative) [Ref.3]. | |
| 2.2 | Interaction of nuclear radiation with matter and detectors | |
| 2.2.1 | Energy loss due to ionization for proton-like charged particles, Bethe-Bloch formula | |
| 2.2.2 | Range-energy relations | |
| 2.2.3 | Ionization and radiation loss of fast electrons (Bremsstrahlung) (qualitative) | |
| 2.2.4 | Interaction of gamma and X-rays with matter, brief description of NaI (Tl) gamma ray spectrometer, boron triflouride counter. [Ref.3,4]. | |
| 2.3 | Nuclear reactors | |
| 2.3.1 | Condition for controlled chain reactions, slowing down of neutrons, logarithmic decrement in energy, homogeneous spherical reactor, critical size, effect of reflectors, breeder reactor (qualitative). [Ref.3]. | |
| | **Key words:** Nuclear transitions, Radiation protection, reactor theory | |
| **Module-3** | **Particle Physics** | **16hrs** |
| 3.1 | Nuclear forces and elementary particles | |
| 3.1.1 | General features of nuclear forces: spin dependence, charge independence, exchange character, etc.. | |
| 3.1.2 | Meson theory of nuclear forces - Yukawa's theory | |
| 3.1.3 | Properties of pi mesons - charge, isospin, mass, spin and parity, decay modes, meson resonances. [Ref.2] | |
| 3.2 | Particle interactions and families | |
| 3.2.1 | Conservation laws | |
| 3.2.2 | Classification of fundamental forces and elementary particles | |
| 3.2.3 | Associated particle production, Gellmann-Nishijima scheme, strange particles | |
| 3.2.3 | CP violation in Kaon decay | |
| 3.2.4 | Symmetries: eight-fold way symmetry, quarks and gluons | |
| 3.2.5 | Elementary ideas of the standard model. [Ref.2]. | |
| | **Key words:** Nuclear forces, high energy physics, subatomic particles | |

### Reference


1 Nuclear Physics, Tayal D.C., Himalaya Publishing House, New Delhi, 2012.
2 Introductory Nuclear Physics, Krane K.S., Wiley, New York, 1987.
3 Nuclear Physics, Ghoshal S.N., S. Chand and Company, Delhi, 1994.

4 Nuclear Radiation Detectors, Kapoor S.S. and Ramamoorthy V., Wiley Eastern, Bangalore,2007.
5 Introductory Nuclear Physics, Wong S.S.M., Prentice Hall of India, Delhi, 1998.
6 Introduction to Particle Physics, Khanna M.P., Prentice Hall of India, Delhi, 2008.

## SECOND YEAR - SEMESTER – III

| Course Title | **Experiments in Solids State Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Practicals | | Total Hours | 112 | Hours/Week | 07 | Credits | 04 | |
| Course Code | CP210 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | | |

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | setup and demonstrate experiments that are selected from areas such as magnetic properties, semiconductor physics and X-ray crystallography. |
| CO-2 | observe the behaviours of matter in a lab environment. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyse the given x-ray diffraction data | PSO-3 | Analyze |
| CLO-2 | determine the type of semiconducting materials and their properties. | PSO-5 | Create |

### Course Outline

**Any eight of the following Experiments:**

1 Determination of temperature coefficient of resistance of a thermistor.
2 Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
3 Determination of thermionic work function of a metal (Richardson-Dushmann formula).
4 Verification of Langmuir-Child's law.
5 Magnetic hysteresis.
6 Indexing X-ray powder diffractogram (graphical method).
7 Indexing X-ray powder diffractogram. (mathematical method)
8 Energy gap of an intrinsic semiconductor.
9 Determination of $\frac{e}{k_B}$ using the given p-n junction diode.
10 Energy gap of material of photovoltaic cell.
11 Energy gap of material of photoconductive cell.
12 Optical rotatory dispersion of a uniaxial crystal.

## SECOND YEAR - SEMESTER – III

| Course Title | **Experiments in Nuclear Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Practicals | | Total Hours | 112 | Hours/Week | 07 | Credits | 04 | |
| Course Code | CP220 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics. |
| CO-2 | verify some of the concepts learnt in the theory course of Nuclear and Particle Physics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | perform advanced nuclear electronics experiments independently. | PSO-3 PSO-5 | Create |
| CLO-2 | perform and analyse experiments using gamma ray spectrometer. | PSO-3 PSO-5 | Analyze |

## Course Outline

**Any eight of the following Experiments:**

1 Dead time of GM counter by two source method.
2 Randomocity of radioactive decay.
3 Beta absorption coefficient measurement.
4 Gamma ray spectrometer.
5 Gamma-ray absorption coefficient measurement.
6 Schmitt trigger.
7 Coincidence circuit.
8 FET common source amplifier.
9 Astable multivibrator using timer IC 555.
10 Clippers and clampers.
11 Op-amp inverting amplifier-frequency response.

## SECOND YEAR - SEMESTER – III

<table>
<tr><td>Course Title</td><td colspan="9">Accelerator Physics</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">C0710</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | find applications of accelerators in X-ray science, spectrometers, electron microscopes, lithographic devices etc |
| CO-2 | understand theoretical aspects of charged particle beams and the technology used for their acceleration. |

<table>
<tr><td colspan="4">Mapping of CLOs with PSOs & CDLs</td></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>understand how various types of accelerators work and understand differences between them</td><td>PSO-1<br>PSO-2</td><td>Understand</td></tr>
<tr><td>CLO-2</td><td>understand major applications of accelerators and the recent new concept</td><td>PSO-1<br>PSO-4</td><td>Understand</td></tr>
</table>

## Course Outline

**Module-1 Charged Particles and their Acceleration** **16hrs**

1.1 Townsend theory-comparison of theory and experiment for ion production, examples of ion sources, properties of ion sources, insulation at high voltages, spark voltage.

1.2 Paschen's law for gas breakdown, penning effect[Ref.1,2]

1.3 Focussing properties of linear fields, electrostatic and magnetic lenses. [Ref.1,2].

1.4 Direct-voltage accelerators: Cockroft-Walton generator, Van de Graff generator, tandem accelerators, pelletron.

**Key words:** Ion optics, direct-voltage accelerators

**Module-2 Particle Accelerators** **16hrs**

2.1 Resonance accelerators: Cyclotron - fixed and variable energy, principles and longitudinal dynamics of the uniform field cyclotron. Linear accelerators. [Ref.2-4].

2.2 Betatron, beam focusing and betatron oscillation, microtron.

2.3 Synchronous accelerators: principle of phase stability, mathematical theory for principle of phase stability, electron synchrotron, proton synchrotron.
2.4 Alternating gradient machines: alternating gradient principle, AG proton synchrotron. [Ref.2-4].

**Key words:** Cyclotron, betatron, synchrotron

**Reference**


1 Ion Implantation, Sputtering and Their Applications, Townsend P.D., Kelly J.C. and Hartley N.E.W., Academic Press, London, 1976.
2 Principles of Charged Particle Acceleration, Humphrey S. Jr., John Wiley, 1986.
3 Fundamentals of Nuclear Physics, Arya A.P., Allyn and Bacon, USA, 1968.
4 Atomic and Nuclear Physics, Ghoshal S.N., S. Chand and Company, Vol. 2, Delhi, 1994.
5 Advanced Experimental Techniques in Modern Physics, Varier K.M., Joseph A. and Pradyumnan P.P., PragathiPrakashan, Meerut, 2006.


## SECOND YEAR - SEMESTER – III

| Course Title | **Space and Astrophysics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | C0720 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | elucidate the concepts of space science and the universe. |
| CO-2 | study the formation and characteristics of the solar system, including the galaxies, stars, planets; observational techniques; birth and death of star and stellar physics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | explain the birth and death of stars. | PSO-1 | Understand |
| CLO-2 | explain the features of sun. | PSO-1 PSO-2 | Understand |

## Course Outline

**Module-1 Basic Concepts and Properties of Stars** **16hrs**

1.1 Properties of Stars
Spectra of stars, Spectral sequence-temperature and luminosity classifications, H-R diagram, Stellar structure equations, Star formation and main sequence evolution, mass luminosity relation, Chandrasekhar limit, White dwarfs, Pulsars , Neutron stars and Black holes.

1.2 Star clusters, Galaxies and the Universe
Open and global clusters, the structure and contents of milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, Hubble's law, Big bang origin of the universe, cosmic microwave background radiation and evolution of the universe.

1.3 Observational techniques
Radio telescopes, detectors for X-ray and gamma rays

**Key words:** Stars, Stellar structure, astronomical bodies

**Module-2 Stellar Physics** **16hrs**

2.1 Solar atmosphere, solar corona, EM radiations from the sun, solar cycles, solar energy particles, solar wind, solar flares, coronal mass ejections,

2.2 The Planetary System, Major characteristics of planets, bulk atmospheric composition, planetary magnetism, magnetic dipole, tilted dipole models, spherical harmonic models, magnetic fields of outer planets MHD equations,

2.3 Alfven waves, Frozen in field, Planetary bow shocks, interaction with magnetized planets, plasma sources in magnetosphere, plasma acceleration, Jovian magnetosphere, plasma flow in magnetosphere

**Key words:** Stellar physics

### Reference

1 A textbook of Astronomy and Astrophysics with Elements of Cosmology, Bhatia V.B., Alpha Science International Ltd., 2001.
2 Physical Universe, Shu F.H., University Science Books, 1982.
3 The Sun, Stix M., Springer-Verlag, 1989.
4 Introduction to Stellar Astrophysics, Bohm-Vitense E., Cambridge Univ. Press, Vol.3, 1989.
5 The Stars- their Structure and Evolution, Taylor R.J., Cambridge Univ. Press,1994.
6 Stars and Galaxies, Abhyankar K.D., Universities Press, 2001.
7 Galaxies: Their Structure and Evolution, Taylor R.J., Cambridge Univ. Press, 1993
8 An Introduction to Galaxies and Cosmology, Jones M. H. and Lambourne R. J.(Editors), Cambridge University Press, 1998.
9 An Invitation to Astrophysics, Padmanabhan T., World Scientific, 2006.
10 Elements of Space Physics, R P Singhal, PHI, 2009
11 The solar Chromosphere and Corona , R Grant Athay, D Reidel publishing, 1976
12 Electrodynamics of Particles and Plasmas, Clemmow and Dougherty, Addison Wesley, 1969.

## SECOND YEAR - SEMESTER – III

| Course Title | **Medical Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | | Credits | 02 |
| Course Code | C0720 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

### Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand the basic techniques required to design simple and handy experimental kits in various streams of physics. |
| CO-2 | study different phenomenon of the subject. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | explain the basic phenomenon underlying in the experimental set-up . | PSO-2 | Understand |
| CLO-2 | study experimental set-up required to study and understand various concepts of Physics. | PSO-4 | Understand |

### Course Outline

**Module-1 X-ray and Magnetic Resonance Imaging** **16hrs**

1.1 Bremsstrahlung -characteristic line spectrum

1.1.1 factors affecting the x-ray spectrum factors affecting the x-ray spectrum Attenuation of heterogeneous and homogeneous X-rays

1.2 Attenuation coefficients and Attenuation mechanisms

1.2.1 Radiographic image quality, factors affecting image quality

1.2.2 Focal spot-Heel Effect, Filters, Grids, Intensifying Screens, X-ray film

1.3 Diagnostic applications of X-rays

1.3.1 Skeletal system, soft tissues, the Chest, mobile and dental x-ray machine-mammography

1.4 Basic Principles of MRI

1.4.1 Spin, Processing, Relaxation time, Free induction decay, T1, T2 proton density weighted image, Pulse sequences, Basic and advance Pulse sequences

1.5 MR instrumentation and MR Spectroscopy

1.5.1 Image formation, Localisation of the signal, Factors influencing signal intensity, contrast and resolution

1.5.2 FMRI, MR Artifacts, safety aspects in MRI

**Key words:** MEdical imaging, X-ray, MRI

| | | |
|---|---|---|
| **Module-2** | **Diagnostic Ultrasound and Clinical Scanning** | **16hrs** |
| 2.1 | Ultrasonic waves | |
| 2.1.1 | Beam characteristics, attenuation of ultrasound, Specific acoustic impedance, reflection at body interfaces, Coupling medium, Interaction ultrasound with tissues | |
| 2..1.2 | A scan B scan and M mode-real time scanners Image clarity, Resolution-axial and lateral resolution | |
| 2.1.3 | Artifacts Pulse echo imaging, Obsterics abdominal investigations Echo cardiograph (UCG). The Doppler Effect, Doppler Shift, continuous wave Doppler system-pulsed wave Doppler systems | |
| 2.2 | Bone Scanning | |
| 2.2.1 | Principal agents for bone scanning, 99m Tc, indications for bone scanning, various agents for bone scanning , interpretation, Pitfalls in bone scanning, limitations | |
| 2,3 | Radio pharmaceuticals used for brain scanning | |
| 2.3.1 | Technique with Technetium pertechnetate scan, clinical applications | |
| 2.3.2 | Radio pharmaceuticals in liver scanning comparison, technique with 99m Tc, sulfur scans, pitfalls, clinical applications | |
| 2.3.3 | Energy spectrum of Ga-67, optimization of parameters for 67Ga scanning - clinical applications | |

**Key words:** Ultrasound, scanning

### Reference


1 Christensen's Physics of Diagnostic Radiology, Thomas S Curry, Lippincott Williams & Wilkins, IV Edition, 1990.

2 The Essential Physics for Medical Imaging, Jerrold T Bushberg, Lippincott Williams & Wilkins, 2 nd Edn., 2002.

3 Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 2012

4 MRI, Perry Sprawls, Medical Physics Publishing, Madison, Wisconsin-2000


## SECOND YEAR - SEMESTER – III

<table>
<tr><td>Course Title</td><td colspan="8">Liquid Crystals</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">C0740</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | elucidate basic as well as advanced topics of liquid crystals. |
| CO-2 | measure physical properties, chemical structure and theories of liquid crystals. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | describe lyotropic, nematic and smectic A & C thermotropic liquid crystals. | PSO-2 | Understand |
| CLO-2 | predict whether it will exhibit liquid crystalline behaviour based on the structure of a molecule. | PSO-4 | Analyze |

## Course Outline

**Module-1 Anisotropic Fluids** **16hrs**

1.1 Main types and properties, the building blocks, small organic molecules, long helical rods, associated structures, nematics - nematics proper, static pre-transitional effects above TN-I

1.2 Cholesterics - a distorted form of the nematic phase, Smectics - smectic A, smectic B, smectic C, other smectic phases, exotic smectics

1.3 Long range order in a system of long rods, lyotropic systems. [Ref.1-3]

1.4 Remarkable features of liquid crystals, applications of liquid crystals in devices like thermometers, calculators, displays, etc. [Ref. 4]

**Key words:** Cholesterics

**Module-2 Nematics, Smectics and Cholesterics** **16hrs**

2.1 Nematics : Long and short range order

2.1.1 Definition of an order parameter, microscopic approach, order parameter from optical method and from diamagnetic anisotropy [Ref.1, 2]

2.1.2 Defects and textures : Observation, black filaments, schlieren structures, types of defects (qualitative). [Ref.1,2]

2.2 Smectics: Continuum description of smectics A and C, mean field description of SmA -N transition. [Ref.1,2]

2.3 Cholesterics : Optical properties of an ideal helix - the planar texture, Bragg reflection, transmission properties at arbitrary wavelengths (normal incidence), the Mauguin limit, rotatory power, textures in cholesterics. [Ref.1,2]

2.4 Ferroelectric liquid crystals : general properties and applications

**Key words:** Nematics, Smectics, Cholesterics

### Reference


1 The Physics of Liquid Crystals, de Gennes P.G. and Prost J., Clarendon Press, 2ndEdn., Oxford,1998.

2 Liquid Crystals, Chandrashekhar S., Cambridge University Press, 1977.

3 Smectic Liquid Crystals: Textures and Structures, Gray G.W.and Goodby J.W., LeanardHill, London, 1984.

4 Applications of Liquid Crystals, Maier G.,Sackmann E.and Grabmanier I.G., Springer Verlag, 1975.

5 Molecular Structure and the Properties of Liquid Crystals, Gray G.W., AcademicPress, 1962.

## SECOND YEAR - SEMESTER – III

| Course Title | **Atmospheric Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | | Credits | 02 |
| Course Code | C0750 | Evaluation | Internal | C1+C2 = 15+15 | | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | | 70 Marks | |

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand various processes in atmosphere |
| CO-2 | describe the effect of aerosols to predict atmospheric changes |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the composition of Atmosphere and its thermodynamics | PSO-1<br>PSO-2 | Understand |
| CLO-2 | explain the process of cloud formation by applying basic physical principles | PSO-1<br>PSO-4 | Apply |

### Course Outline

**Module-1 Atmospheric Composition and Thermodynamics** **16 hrs**

1.1 Atmospheric composition: Energy in the atmosphere, heating of the atmosphere, motions in the atmosphere. Variations in atmospheric composition, Structure on the basis of composition. Thermal structure of the atmosphere.

1.2 Thermodynamics: Entropy of dry air, vertical motion of saturated air, tephigram, potential energy of an air column.

1.3 Dynamics: Escape of hydrogen, photodissociation of oxygen, photo chemical processes. Equations of motion, the geostrophic approximation, cyclostrophic motion.

**Key words:** Atmospheric composition, Thermodynamics of atmosphere

**Module-2 Radiation and Physics of Clouds** **16 hrs**

2.1 Terrestrial and extra terrestrial radiation: General features of direct, diffuse and global radiation-attenuation of direct solar radiation-Rayleigh and Mie scattering. Angstrom turbidity for- mula for all aerosols. Direct transmittance due to continuum attenuation, diffuse spectral irradiance due to Rayleigh and aerosol scattering.

2.2 Aerosols: Production and properties of aerosols. Aerosol optical depth, Beer's law—Sun photometer. Optical filters.

2.3 Clouds: Microphysics of clouds, Macrocharacterization of clouds. Radiative transfer in clouds and aerosols.

**Key words:** Radiation, aerosols, clouds

## Reference


1 Fundamentals of atmospheric physics, Salby M.L., Academic Press, USA, 2006.
2 The physics of the atmosphere, Houghton J., Cambridge University Press, 2002.
3 Atmosphere, weather and climate, Siddhartha K., Kisalaya Publications, 2000.
4 The atmosphere: An introduction to meteorology, Lutgens F.K. and Tarbuk E.K., Prentice Hall, USA, 1986.
5 Dynamic meteorology, Holton, J.R., Academic Press, 3rd edition, USA, 1992.
6 The physics of monsoons, Keshvamurthy R.N. and Shankar Rao M., Allied Publishers, 1992.
7 An introduction to solar radiation, Iqbal M., Academic Press, USA, 1983.


## SECOND YEAR - SEMESTER – III

| Course Title | **Nanomaterials and Thin Films** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 | |
| Course Code | C0310 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | familiarize the students to the various facets related to synthesis, characterization. |
| CO-2 | study of diverse properties and applications of nanomaterials and thin films |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | methods to synthesis Nanomaterials | PSO-1<br>PSO-3 | Understand |
| CLO-2 | characterize and analyze different properties of nanomaterials and thin films | PSO-5 | Analyze |

## Course Outline

| | | |
|---|---|---|
| **Module-1** | **Nanomaterials** | **16 hrs** |
| 1.1 | Nanoparticles | |
| 1.1.1 | Introduction to nanoscale materials and material systems | |
| 1.1.2 | Properties of nanostructured materials – electronic, optical, mechanical, thermal, magnetic and chemical properties. [Ref.1,2]. | |
| 1.2 | Preparation of nanoparticles | |
| 1.2.1 | Physical methods - laser ablation, sputtering, MBE | |
| 1.2.2 | Chemical methods - precipitation, hydrothermal, solvothermal, chemical vapour deposition, sol-gel process | |
| 1.2.3 | Lithographic techniques - AFM based nanolithography, e-beam, ion beam and, X-ray based lithography | |
| 1.2.4 | Synthesis of nanoparticles involving biological substances: Microorganisms, Proteins, DNA template [Ref. 1,2]. | |
| 1.3 | Characterization techniques | |
| 1.3.1 | Microscopes - optical, SEM, TEM, STM, AFM | |
| 1.3.2 | Diffraction techniques - XRD, EXAFS, neutron diffraction | |
| 1.3.3 | Spectroscopes - UV-visible-IR absorption, FTIR, photoluminescence. [Ref. 1,2] | |
| 1.4 | Applications | |
| 1.4.1 | Semiconductor electronics, sensors, actuators | |
| 1.4.2 | Biomedical and environmental applications (qualitative). [Ref. 1,2] | |
| | **Key words:** Nanoparticles, lithography | |
| **Module-2** | **Thin Films** | **16 hrs** |
| 2.1 | Introduction to Thin films and their properties | |
| 2.2 | Preparation techniques | |
| 2.2.1 | Physical vapour deposition methods, thermal evaporation - resistive heating, electron beam, laser | |
| 2.2.2 | Sputtering deposition – DC (diode), RF and magnetron sputtering | |
| 2.2.2 | Chemical vapour deposition – types of CVD, low pressure CVD (LPCVD) and plasma enhanced CVD (PECVD), metal organic CVD (MOCVD) | |
| 2.2.4 | Chemical methods - electro deposition, electroless deposition and spray pyrolysis [Ref.3,4] | |
| 2.3 | Thickness measurements | |
| 2.3.1 | Electrical methods (resistivity and capacitance measurements), optical methods (optical absorption and interference), mechanical methods (quartz crystal monitor) | |
| 2.4 | Characterization techniques | |
| 2.4.1 | Crystal structure: diffraction technique – X-ray diffraction | |
| 2.4.2 | Chemical analysis: energy dispersive X-ray analysis (EDAX), X-ray photoelectron spectroscopy (XPS, ESCA) [Ref.3,4] | |
| 2.5 | Applications | |
| 2.5.1 | Solar cells, decorative coating, hard coatings, anti-reflection coating (qualitative) [Ref.3,4] | |
| | **Key words:** Thin films, sputtering, chemical analysis | |

**Reference**

1 Nanotechnology: Principles and Practices, Kulkarni S. K., Capital Publ. Co., New Delhi, 2007.
2 Nanocrystals: Synthesis, Rao C.N.R., John Thomas P. and Kulkarni G.U., Properties and Applications, Springer series in Materials Science 95, Springer-Verlag, Berlin, Heidelburg, 2007.
3 Physics of Thin Films, Hass G. and Thun R. E., Academic Press, Vol. IV, London, 1967.
4 Thin Film Phenomena, Chopra K. L., Robert E K Publishing Company, 1979.
5 Nanoscience and Nanotechnology: Fundamentals of Frontiers, M.S.Ramachandra Rao and Shubra Singh, John Wiley and Sons.

## SECOND YEAR - SEMESTER – III

| Course Title | **Condensed Matter Physics 1** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | C0320 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| **CO No.** | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand electric and magnetic properties of solids |
| CO-2 | explain magnetic resonance techniques of solids so as to lay a strong foundation in understanding the diverse properties of condensed state |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | describe different dielectric and ferroelectric properties. | PSO-1<br>PSO-2<br>PSO-4 | Understand |
| CLO-2 | describe the magnetic properties quantitatively | PSO-1<br>PSO-2<br>PSO-4 | Understand |

## Course Outline

**Module-1 Dielectrics and Ferroelectrics** **16 hrs**

1.1 Dielectric properties of solids

1.1.1 Macroscopic description of static dielectric constant, the static electronic and ionic polarizabilities of molecules, orientation polarization, the static dielectric constant of gases.

| | | |
|---|---|---|
| 1.1.2 | Local electric field at an atom, Lorentz field, field of dipoles inside cavity, Clausius-Mosotti relation, Lorenz-Lorentz relation, The complex dielectric constant and dielectric losses, dielectric losses and Debye relaxation time. | |
| 1.2 | Ferroelectricity | |
| 1.2.1 | General properties of ferroelectric materials, the types of ferroelectric materials, properties of representative types of materials (Rochelle salt, BaTiO3) ferroelectrics, dipole theory of ferroelectricity, objections against the dipole theory. | |
| 1.2.2 | Ionic displacements and behavior of barium titanate above the curie temperature, theory of spontaneous polarization of barium titanate, thermodynamics of ferroelectric transitions, ferroelectric domains. [Ref.1-3]. | |
| | **Key words:** Dielectrics, electric polarization, ferroelectricity | |
| **Module-2** | **Magnetism and Magnetic resonance** | **16 hrs** |
| 2.1 | Ferromagnetism | |
| 2.1.1 | Quantum theory of Ferromagnetism, Curie-Weiss law, Spontaneous magnetisation and its variation with temperature | |
| 2.1.2 | Ferromagnetic domains | |
| 2.2 | Ferromagnetic Spin waves | |
| 2.2.1 | Magnons | |
| 2.2.2 | Magnons in Ferromagnets, Magnon dispersion relation for ferromagnets, Bloch's $T^{3/2}$ law | |
| 2.3 | Antiferromagnetism | |
| 2.3.1 | Two sub-lattice model, susceptibility below and above Neel's temperature. [Ref.3] | |
| 2.3.2 | Magnons in antiferromagnets, Magnon dispersion relation for antiferromagnets [Ref.4] | |
| 2.4 | Magnetic resonance | |
| 2.4.1 | Paramagnetic relaxation : Phenomenological description, relaxation mechanisms – Spin –lattice and spin-spin relaxation, derivation of Casimir-Durpe relation | |
| 2.4.2 | Nuclear Magnetic Resonance : Nuclear magnetic moments, condition for resonance absorption, the Bloch's equations, solutions of the Bloch's equations for the steady state and weak RF field, expression for power absorption, change of inductance near resonance[Ref.3] | |
| | **Key words:** Susceptibility, Curie-Weiss law, magnons, magnetic resonance | |

## Reference


1 Solid State Physics, Wahab M.A., Narosa Publishing House, New Delhi, 1999.
2 Solid State Physics, Pillai S.O., New Age International Publications, 2006.
3 Solid State Physics, Dekker A.J., Macmillan India Ltd., New Delhi, 2008.
4 Solid State Physics, Ashcroft N.W. and Mermin N.D., Saunders College Publishing, 1996.

## SECOND YEAR - SEMESTER – III

<table>
<tr><td>Course Title</td><td colspan="9">Experiments in Condensed Matter Physics 1</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Practical</td><td>Total Hours</td><td>80</td><td>Hours/Week</td><td>05</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">CP310</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30 Marks</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>04Hrs</td><td>70 Marks</td></tr>
</table>

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | perform experiments selected from semiconductor physics and X-ray crystallography |
| CO-2 | understand the practical aspects of Condensed Matter Physics and gain practical experience. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyse the given x-ray diffraction data. | PSO-3<br>PSO-5 | Analyze |
| CLO-2 | determine the type of semiconducting materials and their properties. | PSO-3<br>PSO-5 | Analyze |

### Course Outline

**Any eight of the following experiments:**

1 Determination of Fermi energy of copper
2 Determination of material constant of an intrinsic semiconductor
3 Energy gap of the semiconductor by studying the temperature variation of the junction voltage in the case of a p-n junction diode
4 Determination of magnetoresistance of given semiconductor
5 Determination of Hall coefficient of given semiconductors
6 Temperature variation of Hall coefficient
7 Indexing X-ray powder diffractogram of cubic crystals (analytical method)
8 Indexing X-ray powder diffractogram of non-cubic crystals
9 Determination of ultrasonic velocity and elastic constants of a solid
10 Calculation of thermal expansion coefficient in solids
11 Temperature variation of dielectric constant and determination of Curie point of a ferroelectric material

## SECOND YEAR - SEMESTER – III

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Title | **Nuclear Models and Heavy Ion Physics** | | | | | | | |
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | C0330 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand various nuclear models theoretically |
| CO-2 | understand interaction of heavy ions with nuclear particles |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the importance of models in describing the properties of nuclei and nuclear interactions. | PSO-2<br>PSO-4 | understand |

## Course Outline

**Module-1 Nuclear Models** **16hrs**

1.1 Shell model

1.1.1 Motion in a mean potential, square well and simple harmonic oscillator potential well

1.1.2 Spin-orbit interaction and magic numbers, extreme single particle model, ground state properties of nuclei based on shell model, Nordheim's Rules [Ref.6,7]

1.2 Collective model

1.2.1 Evidences for the collective motion, nuclear rotational motion, rotational energy spectrum and nuclear wave functions for even-even nuclei, odd-A nuclei energy spectrum and wave function [Ref.8,9]

1.3 Nilsson model : Nilsson diagrams [Ref.8,9]

1.4 Many body self-consistent models : Hartree-Fock model [Ref.4]

**Key words:** Nuclear models, shell model, collective model, Nilsson model

**Module-2 Optical Model and Heavy Ion Physics** **16hrs**

2.1 Optical model

2.1.1 Giant resonances, Kapur-Pearls' dispersion formula for potential scattering

2.1.2 Direct reactions - kinematics of stripping and pickup reactions, theory of stripping and pickup reactions

2.1.3 Inverse reactions [Ref.4]
2.2 Heavy ion physics
2.2.1 Special features of heavy ion physics, remote heavy ion electromagnetic interactions, Coulomb excitations, close encounters, heavy ion scattering, grazing interactions, particle transfer, direct and head on collisions, compound nucleus and quasi molecule formation [Ref.5]

**Key words:** Optical model, heavy ion physics

**Reference**


1 Nuclear Radiation Detectors, Kapoor S.S. and Ramamoorthy V., Wiley Eastern, Bangalore, 1993.
2 Nuclear Electronics, Kowalski E., Springer Verlag, Berlin, 1970.
3 Techniques for Nuclear and Particle Physics Experiments, Leo W.R., Springer Verlag, 1992.
4 Nuclear Physics, Roy R.R. and Nigam B.P., New Age International, New Delhi, 1986.
5 Nuclear Physics - Experimental and Theoretical, Hans H.S., New Age International Publishers, 2001.
6 Physics of the Nuclei and Particles, Mermier P. and Sheldon E., Academic Press, Vol. 1 and 2, New York 1970.
7 Nuclei and Particles, Segre E., Benjamin Inc., New York, 1977.
8 Fundamentals of Nuclear Physics, Arya A.P., Allyn and Bacon, USA, 1968.
9 Theoretical Nuclear Physics, Blatt J.M. and Weisskopf V.F., Wiley and Sons, New York, 1991.
10 The Alpha, Beta and Gamma Ray Spectroscopy: Vol. 1 and 2, Siegbahn K., North Holland, Amsterdam, 1965.
11 Nuclear Radiation Detectors, Price J.W., McGraw Hill, New York, 1965.


## SECOND YEAR - SEMESTER – III

| Course Title | **Nuclear Decay Modes and Electronics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | C0340 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | familiar with nuclear detectors, nuclear electronics and nuclear spectroscopic techniques which play a key role in experimental nuclear and particle physics |
| CO-2 | to understand the theories of various nuclear models. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the importance of models in describing the properties of nuclei and nuclear interactions. | PSO-1<br>PSO-4 | Understand |
| CLO-2 | interpret dynamics of heavy-ion reactions in Nuclear Physics | PSO-4<br>PSO-5 | Evaluate |

## Course Outline

**Module-1 Nuclear Decay** **16hrs**

1.1 Beta decay

1.1.1 Classification of beta interactions, matrix elements

1.1.2 Fermi and Gamow-Teller selection rules for allowed beta decay, the non-conservation of parity in beta decay

1.1.3 Wu etal. Experiment.

1.1.4 The universal Fermi interaction. [Ref.3,4]

1.2 Gamma decay

1.2.1 Electromagnetic interactions with nuclei.

1.2.2 Multipole transitions, transition probabilities in nuclear matter

1.2.3 Weisskopf's estimates, structure effects, selection rules,

1.2.4 Internal conversion, photodisintegration of deuteron and radiative capture of neutron by proton. [Ref.4,5]

**Key words:** $\beta$- decay, $\gamma-$ decay

**Module-2 Nuclear Electronics** **16hrs**

2.1 Nuclear detectors

2.1.1 Scintillation processes in inorganic crystals [NaI(Tl)]

2.1.2 Semiconductor detectors -diffused junction, surface barrier and lithium drifted detectors

2.1.3 Relation between applied voltage and depletion layer thickness in junction detectors, hyper pure germanium (HPGe) detectors, Cerenkov detectors [Ref.1,2]

2.2 Nuclear pulse techniques

2.2.1 Pre-amplifier circuits, charge sensitive and voltage sensitive pre-amplifiers

2.2.2 Linear pulse amplifiers, linearity, stability, pulse shaping, pulse stretching

2.2.3 Operational amplifiers - analog to digital converters, scalars, Schmidt trigger as a pulse discriminator

2.2.4 Single channel analyser - integral and differential discriminators, multichannel analyzers, memory devices and online data processing [Ref.3-5]

**Key words:** Nuclear detectors, pulse techniques

### Reference


1 Nuclear Radiation Detectors, Kapoor S.S. and Ramamoorthy V., Wiley Eastern, Bangalore, 1993.

2 Nuclear Electronics, Kowalski E., Springer Verlag, Berlin, 1970.

3 Techniques for Nuclear and Particle Physics Experiments, Leo W.R., Springer Verlag, 1992.
4 Nuclear Physics, Roy R.R. and Nigam B.P., New Age International, New Delhi, 1986.
5 Nuclear Physics - Experimental and Theoretical, Hans H.S., New Age International Publishers, 2001.
6 Physics of the Nuclei and Particles, Vol. 1 and 2, Mermier P. and Sheldon E., Academic Press, New York 1970.
7 Nuclei and Particles, Segre E., Benjamin Inc., New York, 1977.
8 Fundamentals of Nuclear Physics, Arya A.P., Allyn and Bacon, USA, 1968.
9 Theoretical Nuclear Physics, Blatt J.M. and Weisskopf V.F., Wiley and Sons, New York, 1991.

## SECOND YEAR - SEMESTER – III

| Course Title | **Experiments in Nuclear Physics 1** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practical | | Total Hours | 80 | Hours/Week | 05 | Credits | 03 |
| Course Code | CP320 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 Marks | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics. |
| CO-2 | verify some of the concepts learnt in the theory course of Nuclear and Particle Physics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | perform advanced nuclear electronics experiments independently. | PSO-3 PSO-5 | Create |
| CLO-2 | perform and analyse experiments using scintillation detectors and MCA. | PSO-3 PSO-5 | Analyze |

**Course Outline**

**Any eight of the following experiments:**

1 Cockroft-Walton voltage multiplier.
2 Linear pulse amplifier.
3 Transistorised binary circuit.
4 Pulse shaping circuits.
5 Linear gate.
6 Nomogram method: measurement of endpoint energy of beta particles.
7 Study of linearity of the NaI(Tl) gamma ray spectrometer with SCA and hence determination of energy of unknown gamma source.
8 Determination of the rest mass energy of the electron using MCA.
9 Study of the variation of resolution of NaI(Tl) spectrometer as a function of energy.

## SECOND YEAR - SEMESTER – III

<table>
<tr><td>Course Title</td><td colspan="9">Riemannian Geometry and Gravitational Field</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">C0350</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

**Course Objectives (COs)**

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | the mathematics of space time curvatures using Riemannian Geometry |
| CO-2 | the concepts of gravitational field using Einstein's general theory of relativity |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand and be familiar with the concepts of Riemannian geometry | PSO-2 PSO-5 | Understand |
| CLO-2 | evaluate the gravitational field using the field equations in general relativity | PSO-2 PSO-5 | Evaluate |

## Course Outline

**Module 1 Riemannian Geometry** **16hrs**

1.1 Covariant differentiation
1.2 Parallel transport
1.3 Geodesies
1.4 The curvature tensor
1.5 Riemannian space
1.6 The determinant of $g_{\mu\nu}$. Metrical Densities
1.7 The connection of a Riemannian Space: Christoffel Symbols
1.8 Geodesies in a Riemannian space
1.9 The curvature of a Riemannian space: The Riemann tensor.

**Key words:** Parallel transport, Geodesies, Riemannian space

**Module 2 Gravitational Field** **16hrs**

2.1 The principle of equivalence
2.2 The field equations of general relativity
2.3 Metrics with spherical symmetry
2.4 The schwarzschild solution
2.5 Geodesies in the Schwarzschild space
2.6 Advance of the perihelion of a planet
2.7 The deflection of light rays
2.8 Red shift of spectral lines
2.9 The Schwarzschild sphere, gravitational collapse. Black holes.

**Key words:** Gravitational field, Schwarzschild solutions, general reativity, black holes

**Reference**

1 Lectures on general relativity, Papapetrov A., D. Reidel Publishing Company, USA, 1974.
2 The general theory of relativity, Dirac P.A.M., John Wiley and Sons, New York, 1975.
3 Introduction to general relativity, Adler R., Bazin M. and Schiffer M., McGraw-Hill Kogakusha, Ltd. New Delhi, 1965.
4 Gravity: An introduction to Einstein's general relativity, Hartle J.B., Benjamin-Cummings Pub. Co., USA, 2002.

## SECOND YEAR - SEMESTER – III

| Course Title | **Rotation and Lie Groups in Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | C0360 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | the importance of rotation and lie groups in physics |
| CO-2 | the algebra of groups and their applications in physics |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | apply the algebra of rotation and lie groups in angular momentum theory | PSO-2 PSO-5 | Apply |
| CLO-2 | understand the representations and commutation relations of groups | PSO-2 PSO-5 | Understand |

## Course Outline

**Module-1 Rotation Groups** **16hrs**

1.1 Rotation matrix in terms of axis and angle.
1.2 Eigenvalues of a rotation matrix.
1.3 Euler resolution of a rotation.
1.4 Definition of a representation. Equivalence.
1.5 Reducible and irreducible representations.
1.6 Schur's lemma.
1.7 The groups O(3) and SO(3)
1.8 Construction of the D1/2 and D1 representation of SO(3)by exponentiation.
1.9 Mention of the Dj irreps SO(3).

**Key Words:** Rotation matrix, resolution of a rotation, O(3), SO(3)

**Module-2 Lie Groups and Lie Algebra** **16hrs**

2.1 Definition of a Lie group, infinitesimal generators
2.2 structure constants and their properties. Illustrative examples.
2.3 Definition of a Lie algebra. Exponentiation.
2.4 Definition of simple and semi simple Lie groups and Lie algebras.
2.5 Adjoint representation. Cartan-Weyl representation

2.6 of commutation relations
2.7 A brief introduction to Dynkin diagrams.
2.8 Lie derivatives and Killing vectors.

**Key Words:** Lie groups, Lie algebra, Dykin diagrams, Killing vectors

**Reference**


1 Linear Algebra and Group Theory for Physicists, K. N. Srinivasa Rao, Hindustan Book Agency, 2006
2 Mathematical methods for physicists, Arfken G.B. and Weber H.J., Academic Press, 5th. Edn., New York, 2001.
3 Classical groups for physicists, B G Wyborne, John Wiley, New York, 1974.


## SECOND YEAR - SEMESTER – III

| Course Title | **Analytical techniques in Theoretical Physics 1** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practical | | Total Hours | 80 | Hours/Week | 05 | Credits | 03 |
| Course Code | CP330 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 Marks | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | evaluate calculations on various theoretical concepts. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | evaluate problems on various concepts in theoretical Physics | PSO-4<br>PSO-5 | Create |

## Course Outline

**Any five of the following**

1 Calculation of Christoffel symbols.
2 Geodesics and curvature calculations.
3 Exterior Schwarzschild metric calculations.
4 Robertson-Walker metric calculations.
5 Lagrangian and Hamiltonian, Euler Lagrange equations for Schrödinger field.
6 Lagrangian for Maxwell's field and The field equations.
7 Symmetries of the Lagrangian and Constants of motion.
8 Relativistic kinematics-1: Relations between center of momentum and laboratory frames.
9 Relativistic kinematics-2: Non-relativistic limit of relativistic kinematics.

## SECOND YEAR - SEMESTER – IV

<table>
<tr><td>Course Title</td><td colspan="8">Experiments in Solids State Physics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Practicals</td><td>Total Hours</td><td>112</td><td>Hours/Week</td><td>07</td><td>Credits</td><td>04</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">CP210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>04Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | setup and demonstrate experiments that are selected from areas such as magnetic properties, semiconductor physics and X-ray crystallography. |
| CO-2 | observe the behaviours of matter in a lab environment. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyse the given x-ray diffraction data | PSO-3 | Analyze |
| CLO-2 | determine the type of semiconducting materials and their properties. | PSO-5 | Create |

## Course Outline

**Any eight of the following Experiments:**

1 Determination of temperature coefficient of resistance of a thermistor.
2 Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
3 Determination of thermionic work function of a metal (Richardson-Dushmann formula).

4 Verification of Langmuir-Child's law.
5 Magnetic hysteresis.
6 Indexing X-ray powder diffractogram (graphical method).
7 Indexing X-ray powder diffractogram. (mathematical method)
8 Energy gap of an intrinsic semiconductor.
9 Determination of e/kB using the given p-n junction diode.
10 Energy gap of material of photovoltaic cell.
11 Energy gap of material of photoconductive cell.
12 Optical rotatory dispersion of a uniaxial crystal.

## SECOND YEAR - SEMESTER – IV

| Course Title | **Experiments in Nuclear Physics** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Hard Core- Practicals | | Total Hours | 112 | Hours/Week | 07 | Credits | 04 |
| Course Code | CP220 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics. |
| CO-2 | verify some of the concepts learnt in the theory course of Nuclear and Particle Physics. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | perform advanced nuclear electronics experiments independently. | PSO-3 PSO-5 | Create |
| CLO-2 | perform and analyse experiments using gamma ray spectrometer. | PSO-3 PSO-5 | Analyze |

**Course Outline**

**Any eight of the following Experiments:**

1 Dead time of GM counter by two source method.
2 Randomocity of radioactive decay.
3 Beta absorption coefficient measurement.
4 Gamma ray spectrometer.
5 Gamma-ray absorption coefficient measurement.
6 Schmitt trigger.
7 Coincidence circuit.
8 FET common source amplifier.
9 Astable multivibrator using timer IC 555.
10 Clippers and clampers.
11 Op-amp inverting amplifier-frequency response.

## SECOND YEAR - SEMESTER – IV

<table>
<tr><td>Course Title</td><td colspan="9">Project Work</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core</td><td>Total Hours</td><td>80</td><td>Hours/Week</td><td>05</td><td>Credits</td><td>05</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">DP410</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

The aim of project work is to enable the students to communicate physics concepts effectively both orally and in writing and to inculcate learning spirit and research aptitude among students. It exposes the students to the principles, procedures and techniques of implementing a research project. The students learn the elementary scientific methods and acquire the skills of designing and execution of experiments, analysis and reporting of experimental data.
Students may choose one of the following areas for carrying out Minor Project: Liquid crystals
X-ray crystallography
Radiation physics
Nanomaterials
Nanomagnetism
Any other area in Condensed Matter Physics / Nuclear Physics/Theoretical Physics
Project work may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc. A student opting for this course will be attached to one teacher of the department (Project Supervisor) before the end of the 3rd semester. This load (contact duration: 5 hours per week) will be counted towards the normal teaching load of the teacher. Topic(s) for the project may be selected in consultation with the project supervisor. Reference/Text books will be recommended by the project supervisor. The guided project is normally executed in the department laboratory, making use of the existing facilities. A few students may be allowed to take up projects in reputed research institutes depending on their performance, commitment and interesting the field of research.
A report of about 20-30 pages about the work done in the project (typed on both the sides of the

paper and properly bound) will be submitted by a date to be announced by the department. Assessment of the work done under the project will be carried out by an external evaluator and project supervisor on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc.

## SECOND YEAR - SEMESTER – IV

<table>
<tr><td>Course Title</td><td colspan="8">Biomolecular Structure and Molecular Motors</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Theory</td><td>Total Hours</td><td>32</td><td>Hours/Week</td><td>02</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">D1510</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

### Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | explain the stucture of biomolecules |
| CO-2 | elucidate the ligand binding |

<table>
<tr><th colspan="4">Mapping of CLOs with PSOs & CDLs</th></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>understand biomolecular interactions and forces responsible for protein folding</td><td>PSO-2</td><td>Understand</td></tr>
<tr><td>CLO-2</td><td>understand the dynamics of molecular motors</td><td>PSO-2</td><td>Understand</td></tr>
<tr><td>CLO-3</td><td>undestand the Ligand-receptor binding</td><td>PSO-2</td><td>Understand</td></tr>
</table>

***Offered to post-graduate students of Physics, Mathematics and Biochemistry***

### Course Outline

| | | |
|---|---|---|
| **Module-1** | **Electrostatistics and Genome Packing** | **16hrs** |
| 1.1 | Biomolecular interactions : Covalent, Coulomb, Dipolar and van der Waals interactions, Hydrophilic and hydrophobic interactions, Protein folding and Protein folding | |
| 1.2 | Brief review of electrostatics | |
| 1.3 | Role of geometry | |
| 1.4 | Charged line, Charged plane | |
| 1.5 | The membrane as a parallel plate capacitor | |
| 1.6 | Charged wall in different limits | |
| 1.7 | The line charge density of DNA | |
| 1.8 | DNA packing in $\phi-29$ bacteriophage | |
| 1.9 | Electrostatistics of viral capsid assembly | |

**Key Words:** Biomolecular interactions, DNA, Genome Packing

| | | |
|---|---|---|
| **Module-2** | **Molecular Motors** | **16hrs** |
| 2.1 | Classification | |
| 2.2 | One-state model | |
| 2.3 | Two-state model | |
| 2.4 | Master equation approach for motor ensembles : with and without load | |
| 2.5 | Biochemical reaction networks | |
| 2.6 | Law of mass action | |
| 2.7 | Cooperative binding | |
| 2.8 | Ligand-receptor binding | |

**Key Words:** Molecular motors, master equations, reaction networks

**Reference**


1 Introduction to Biomolecular Structure and Biophysics, G.Misra, Springer
2 Molecular and Cellular Biophysics, A. Jack Tuszynski, CRC Press
3 Molecular Biology of the cell, B. Alberts, A. Johnson, J. Lewis , New york Garland Sciences, 4th edition. 2002.
4 Introduction to modeling Biological Cellular control Systems, Weijiu Liu, Springer
5 Motor proteins and Molecular Motors, Anatoly B. Kolomeisky, Taylor and Francis Group


## SECOND YEAR - SEMESTER – IV

| Course Title | **Ceramics and Polymers** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 | |
| Course Code | D1520 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand the importance of various phases of materials in deciding the applications of materials |
| CO-2 | prepare and process polymer materials |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the importance of phase transformations and the phase diagrams | PSO-4 | Understand |
| CLO-2 | synthesize and fabricate polymer materials. | PSO-5 | Analyze |

***Offered to post-graduate students of Physics and Chemistry***

**Course Outline**

**Module-1 Ceramics and Composite Materials** **16hrs**

1.1 Ceramics

1.1.1 Introduction, Classification

1.1.2 Structure: Cesium Chloride, Rock salt, Zinc blende, spinel, fluorite

1.1.3 Properties of ceramic phases: Mechanical, electrical, thermal

1.2 Fabrication, Processing and Applications of Ceramics

1.2.1 Fabrication and processing of i) glass ceramics and ii) clay products, Powder Pressing, Tape Casting

1.2.2 Applications of Glasses, glass-ceramics, clay products, abrasives, cements, advanced cements

1.3 Composite Materials

1.3.1 Introduction, Classification: Agglomerated, reinforced, laminates, surface coatings

**Key words:** Ceramics, composite materials

**Module-2 Polymers** **16 hrs**

2.1 Introduction, chemistry of polymer molecule, size

2.2 Mechanisms of polymerization: Addition polymerization, copolymerization, condensation polymerization, Addition of ploymers

2.3 Structure versus properties of polymers: linear and frame work structures, branched chained structures, cross-linked structures, crystalline structures.

2.4 Polymers: Structure, shape, Thermoplastic and Thermosetting polymers

2.5 Deformation of polymers: elastic and plastic

2.6 Properties: Mechanical, Thermal, electrical

2.7 Crystallization, melting, glass transition, factors influencing melting and glass transition temperatures

2.8 Synthesis and Processing: Forming techniques for plastics, Fabrication of Elastomers, Fibers and Films

2.9 Polymer types and their applications

**Key words:** Polymers, polymerization

**Reference**

1 Introduction to Ceramics, W.D. Kingery, H. Kent Bowen, D.R. Uhlmann, John Wiley & Sons, 1976.

2 Materials Science and Processes, Hazra Chaudary S. K., Indian Book Distr. Co., 1977.

3 Thin Film Phenomena, Chopra K. L., Robert E K Publishing Company, 1979.

4 Engineering Materials, Budinski K. G. and Budinski M. K., Prentice-Hall of India Pvt. Ltd, 8th Edn., 2004.

5 Materials Science and Engineering. An Introduction, William D. Callister, Wiley, 2006

6 Polymer Science, V R Gowariker, N V Vishwanathan, Jayadev Shreedhar, New age international, 1986.

## SECOND YEAR - SEMESTER – IV

| Course Title | **Condensed Matter Physics - 2** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | | Credits | 02 |
| Course Code | D0310 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

### Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | describe various physical properties of solid materials |
| CO-2 | differentiate materials based on their energy bands |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand and define electrical and thermal properties of materials | PSO-1<br>PSO-2 | Understand |
| CLO-2 | describe the superconducting property of certain materials | PSO-1<br>PSO-2 | Understand |

### Course Outline

**Module-1 Free Electron Theory of Metals** **16 hrs**

1.1 Boltzmann transport equation
1.2 Sommerfeld's theory of electrical conductivity
1.3 Mean free path in metals
1.4 Dependence of resistivity on temperature and impurities, Matthiessen's rule, electron-phonon collisions, thermal conductivity of insulators, Umklapp processes. [Ref.1,3]
1.5 Electrical conductivity of metals at high frequencies, plasma frequency
1.6 Transparency of alkali metals to UV radiation, anomalous skin effect, plasmons, field enhanced emission, Schottky effect
1.7 Hall effect and magnetoresistance in metals, cyclotron frequency. [Ref.2]

**Key words:** Conductivity, skin effect, phonons

**Module-2 Band Theory of Solids and Superconductivity** **16 hrs**

2.1 Band theory of solids
2.1.1 Bloch theorem - Statement and proof, explanation of periodic potentials in solids
2.1.2 Construction of Brillouin zones for one, two and three dimensional lattice
2.1.3 Nearly free electron model and solution at the boundary

| | |
|---|---|
| 2.1.4 | Discussion of energy gap using nearly free electron model |
| 2.1.5 | Tightly bound electron approximation - application to simple cubic, BCC and FCC lattices [Ref.1, 2, 3] |
| 2.2 | Superconductivity |
| 2.2.1 | BCS theory - elementary ideas, explanation of formation of Cooper pairs (Gedanken thought experiment), energy gap |
| 2.2.2 | Meissner effect and flux quantization. Josephson tunnelling, Josephson junction, Josephson – Theory of AC and DC Josephson effect. High Tc superconductors and applications [Ref.4] |

**Key words:** Brillouin zones, band theory, superconductivity, BCS theory

## Reference


1 Solid State Physics, Dekker A.J., Macmillan India Ltd., New Delhi, 2008.
2 Introduction Solid State Physics, Kittel C., John Wiley, 7th Edn., New York, 1996.
3 Solid State and Semiconductor Physics, Mckelvey J.P., Harper and Row, 2ndEdn., USA, 1966.
4 Solid State Physics, Ibach H. and Luth H., Narosa Publishing House,, New Delhi, 1996.
5 Solid State Physics, Wahab M.A., Narosa Publishing House, New Delhi, 1999.


## SECOND YEAR - SEMESTER – IV

| Course Title | **Condensed Matter Physics - 3** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | D0320 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | understand advanced concepts in X-ray crystallography. |
| CO-2 | understand semiconducting material types, their principle of working and applications |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | define aspects of crystal structure including lattice shapes and the 3-dimensional symmetry associated with specific space group elements. | PSO-1 PSO-2 | Understand |
| CLO-2 | understand the physics of semiconductors and design components using semiconducting material. | PSO-1 PSO-2 | Understand |

## Course Outline

| | | |
|---|---|---|
| **Module-I** | **X-ray Crystallography and Imperfections in Crystalline Solids** | **16 hrs** |
| 1.1 | X-ray crystallography | |
| 1.1.1 | Scattering of X-rays by an electron and atom | |
| 1.1.2 | Expressions for atomic scattering factor and structure factor, significance of Fourier analysis, systematic absence reflections and space groups | |
| 1.1.3 | Structure analysis by single crystal X-ray diffraction - intensity data collection, cell parameters and space group determination, intensity data corrections, phase determination (direct methods), refinement (cyclic Fourier refinement), determination of molecular and crystal structure (qualitative discussion) [Ref.1] | |
| 1.2 | Imperfections in crystalline solids | |
| 1.2.1 | Defects in solids – Types of imperfections, expression for concentration of vacancies, Frenkel and Schottky defects | |
| 1.2.2 | Dislocations – Shear strength of single crystals, Burger's Vector and Burger's circuit, expression for strain energy in the case of edge and screw dislocations [Ref.2] | |
| 1.2.3 | Diffusion in solids – Fick's laws, diffusion in metals, Kirkendall effect, diffusion of interstitials, diffusion and ionic conductivity in alkali halides [Ref.2] | |
| 1.2.4 | Colour centers – generation and types of colour centers [Ref.2] | |
| | **Key words:** Structure factor, space groups, imperfections | |
| **Module-2** | **Semiconductors** | **16 hrs** |
| 2.1 | Hall effect in semiconductors | |
| 2.1.1 | Expression for Hall coefficient in terms of mobility of current carriers and carrier densities, Effect of temperature and impurity concentration on Hall coefficient | |
| 2.1.2 | Magneto-resistance phenomenon (qualitative). [Ref.5] | |
| 2.2 | Cyclotron resonance | |
| 2.2.2 | Cyclotron resonance in Si and Ge semiconductors, experimentally observed facts, variation of cyclotron resonance frequency with orientation of the crystal in the magnetic field. [Ref.5] | |
| 2.3 | Excess carriers in semiconductors | |
| 2.3.1 | Generation and recombination rates, excess carriers, continuity equations for excess carriers | |
| 2.3.2 | Einstein equations, expression for the diffusion length of electrons and holes. [Ref.5] | |
| 2.4 | Diodes and transistors | |
| 2.4.1 | Diodes : Theory, formation of space charge region, expressions for barrier potential, barrier thickness and contact field, effect of the applied field on the above junction parameters, transition capacitance associated with the space-charge region, expressions for current densities using continuity equations for excess carriers, depletion capacitance | |
| 2.4.2 | Transistors –a brief discussion on the dc current gain, $\alpha$ and $\beta$ cut-off frequencies [Ref.5] | |
| | **Key words:** Hall effect, cyclotron resonance, diodes, transistors | |

## Reference


1 Crystals, X-rays and Proteins, Sherwood D., Longman, UK, 1976.
2 Solid State Physics, Wahab M.A., Narosa Publishing House, New Delhi, 1999.
3 Introduction to Solid State Physics, Kittel C., John Wiley, 7thEdn., New York, 1996.
4 Solid State Physics, Ibach H. and Luth H., Narosa Publishing House, New Delhi, 1996.
5 Solid State and Semiconductor Physics, Mckelvey J.P., Harper and Row, 2ndEdn., USA, 1966.


## SECOND YEAR - SEMESTER – IV

<table>
<tr><td>Course Title</td><td colspan="8">Experiments in Condensed Matter Physics 1</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Practical</td><td>Total Hours</td><td>80</td><td>Hours/Week</td><td>05</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">DP310</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30 Marks</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>04Hrs</td><td>70 Marks</td></tr>
</table>

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand the practical aspects of Condensed Matter Physics and gain practical experience |
| CO-2 | understand advanced level experiments from areas such as semiconductor physics, X-ray crystallography, and magnetic properties of solids, dielectrics, ferroelectrics and nanoparticles |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyse the given x-ray diffraction data | PSO-3 | Analyze |
| CLO-2 | perform different Solid State Physics experiments using semiconductors | PSO-3 | Apply |

## Course Outline

**Any eight of the following experiments:**

1 Temperature variation of the reverse saturation current in a p-n junction diode.
2 Depletion capacitance of a p-n junction diode.
3 Determination of the energy gap of semiconductors by four-probe method.
4 Calculation of structure factors from powder X-ray diffraction data.
5 Calculation of relative integrated intensities from powder X-ray diffraction data.
6 Paramagnetic susceptibility by Gouy balance method.

7 Determination of Curie temperature of a magnetic material.
8 Dielectric constant and its temperature variation.
9 Synthesis of nanoparticles
10 Measurement of dielectric constant and electronic polarizability of the given non-polar liquid
11 Temperature dependence of the capacitance of a ceramic capacitor and verification of curie-weiss law o
12 Dielectric constant of given non- polar liquids
13 Curie- Weiss law: Temperature dependence of the capacitance of a ceramic and polymer capacitors.

## SECOND YEAR - SEMESTER – IV

| Course Title | **Nuclear Reactor Theory** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | D0330 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | the concepts of nuclear reactor theory |
| CO-2 | the criticallity of reactors and transport equations |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand controlled fission reaction in various types of reactors | PSO-2 PSO-4 | understand |
| CLO-2 | relate the importance of neutrons number in nuclear reactors | PSO-2 PSO-4 | Analyze |

## Course Outline

**Module-1 Reactor Theory-1** **16hrs**

1.1 Nuclear fission, mass-energy distribution of fission fragments, statistical model of fission [Ref.1]
1.2 Neutron and its interaction with matter collision kinematics
1.3 Differential elastic scattering cross sections, isotropic scattering
1.4 The criticality condition for a reactor
1.5 Neutron transport equation using elementary diffusion theory
1.6 One group critical equation
1.7 The critical size on the basis of Fermi age theory [Ref.1]

**Key Words:** Nuclear fission, neutrons, reactors

**Module-2 Reactor Theory-2** **16hrs**

2.1 Reactors - one group theory, spherical and cylindrical homogeneous reactor
2.2 The effective multiplication factor
2.3 Reflector reactors - effects of reflector, one group method of a homogeneous reactor with reflector, reflector savings
2.4 Infinite multiplication factor, critical size and critical mass
2.5 Heterogeneous reactor system - calculation of thermal utilization factor
2.6 Fast breeder reactor, evaluation of buckling using one group model [Ref.2]

**Key Words:** Homogeneous and heterogeneous reactors, multiplication factor

**Reference**


1 Elements of Nuclear Reactor Theory, Glasstone S. and Edlund M.C., D. Van Nostrand Co., USA, 9th print, 1963.
2 Physics of Nuclear Reactors, Garg S., Ahmed F. and Kothari I.S., Tata McGraw-Hill, New Delhi, 1986.
3 Nuclear Physics, Roy R.R. and Nigam B.P., New Age International, New Delhi, 1986.
4 Nuclear Physics - Experimental and Theoretical, Hans H.S., New Age International Publishers, 2001.
5 Nuclear Physics, Ghoshal S.N., S. Chand and Company, Vol. 2., Delhi, 1994.


## SECOND YEAR - SEMESTER – IV

| Course Title | **Two Particle Systems and Nuclear Reactions** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | D0340 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | the n-p, p-p, pion-nucleon, scattering theory |
| CO-2 | various nuclear reaction and theories associated with them |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand the nuclear scattering theories | PSO-2<br>PSO-4 | understand |
| CLO-2 | understand the importance various nuclear reactions | PSO-2<br>PSO-4 | understand |

## Course Outline

| | | |
|---|---|---|
| **Module-1** | **Two Particle Systems and Scattering Theory** | **16hrs** |
| 1.1 | Deuteron | |
| 1.1.1 | SchrÖdinger equation for a two nucleon system, theory of the ground state of the deuteron under central and non-central forces, excited states of the deuteron, Rarita-Schwinger relations, deuteron magnetic and quadrupole moments. | |
| 1.2 | Nucleon-nucleon scattering processes | |
| 1.2.1 | Theory of s-wave scattering of neutrons by free protons and experimental results | |
| 1.2.2 | Wigner's formula for n-p scattering | |
| 1.2.3 | Theory of scattering of slow neutrons by bound protons (ortho and para hydrogen) and experimental results | |
| 1.2.4 | Effective range theory for n- p scattering | |
| 1.2.5 | s-wave theory of proton-proton scattering | |
| 1.2.6 | Mott's modification of Rutherford's formula, pion-nucleon scattering experimental results, (3/2,3/2) resonance. | |

**Key Words:**Deuteron, n-p and p-p scattering, s- wave theory

| | | |
|---|---|---|
| **Module-2** | **Nuclear Reactions** | **16hrs** |
| 2.1 | Nuclear reactions-1 | |
| 2.1.1 | Plane wave theory of direct reactions | |
| 2.1.2 | Born approximation-(plane wave)- Butler's theory | |
| 2.1.3 | Cross section for nuclear scattering and reactions, shadow scattering | |
| 2.1.4 | Breit-Wigner resonance formulae [Ref.3] | |
| 2.2 | Nuclear reactions-2 | |
| 2.2.1 | Bohr's independence hypothesis, the compound nucleus (CN) reactions, decay rates of CN | |
| 2.2.2 | Statistical theory of nuclear reactions, evaporation probability and cross sections for specific reactions [Ref.3] | |

**Key Words:** Direct reactions, cross section, compound nucleus

### Reference


1 Nuclear Physics -Theory and Experiment, Roy R.R. and Nigam B.P., New Age International Ltd., New Delhi, 1986.
2 Nuclear Physics-Experimental and Theoretical, Hans H.S., New Age International Publishers, 2001.
3 Nuclear Reactions, Sachtler G.R., Addison Wesley, New York, 1983.
4 Physics of Nuclei and Particles, Mermier P. and Sheldon E., Academic Press, Vol. 2, USA, 1971.
5 Nuclear Reactions, Jackson D.F., Chapman and Hall, London, 1975.

## SECOND YEAR - SEMESTER – IV

| Course Title | **Experiments in Nuclear Physics 2** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practical | | Total Hours | 80 | Hours/Week | 05 | Credits | 03 |
| Course Code | DP320 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 Marks | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | carrying out precise measurements and handling sensitive equipments in nuclear physics |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | analyse beta spectrum, Bremsstrahlung radiation , and end point energy using different detectors. | PSO-3 PSO-4 | analyze |
| CLO-2 | perform experiments using coincidence circuits. | PSO-3 PSO-4 | create |

## Course Outline

**Any six of the following experiments:**

1 Variable delay line.
2 Pulse recorder.
3 Internal conversion using MCA.
4 Feather analysis: End-point energy of beta rays measurement.
5 Z dependence of external Bremsstrahlung radiation.
6 Fermi-Kurie plot: Determination of the end-point energy of beta rays using a plastic scintillation detector.
7 Determination of source strength by gamma-gamma coincidence.
8 Determination of source strength by beta-gamma coincidence.

## SECOND YEAR - SEMESTER – IV

| Course Title | **Quantum Field Theory** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | D0350 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | the basic ideas of quantum field theory |
| CO-2 | how quantum mechanics and special relativity combine to produce realistic theories of particle creation and annihilation. |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs)<br>On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | apply abstract concepts to real-world situations | PSO-2<br>PSO-5 | Apply |
| CLO-2 | explain canonical momentum and the quantization of fields | PSO-2<br>PSO-5 | Understand |

## Course Outline

**Module-1 Quantum Field Theory** **16hrs**

1.1 Classical and quantum fields: Particles and fields
1.2 Discrete and continuous mechanical systems
1.3 Classical scalar fields
1.4 Maxwell fields
1.5 Quantum Theory of Radiation: Creation, annihilation, and number operators
1.6 Quantized radiation field, Fock states
1.7 Emission and absorption of photons by atoms
1.8 Rayleigh scattering, Thomson scattering, and the Raman effect.

**Key Words:** Classical and quantum fields, Maxwell fields, radiation, scattering

**Module-2 Quantization of the Dirac Field** **16hrs**

2.1 Second quantization
2.2 Positron operators and positron spinors
2.3 Electromagnetic and Yukawa couplings
2.4 Weak interactions and parity non-conservation: Classifi- cation of interactions, parity and hyperon decay,
2.5 The two-component neutrino.
2.6 Pion decay and the CPT theorem.

**Key Words:** Dirac field, particle physics

**Reference**


1 Advanced quantum mechanics, Sakurai J.J., Addison-Wesley, Harlow, England, First ISE Reprint, 1999.
2 Lectures on Quantum Field Theory, Ashok Das, World Scientific, Singapore, 2008.
3 Quantum Field Theory, L H Ryder, Cambridge Univ. Press, Cambridge, 1985.


## SECOND YEAR - SEMESTER – IV

| Course Title | **Angular Momentum and Density Matrix Theory** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | D0360 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will understand: |
|---|---|
| CO-1 | the concepts of angular momentum in quantum physics |
| CO-2 | the fundamentals of density matrix theory and its uses in optics |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | apply angular momentum algebra, angular momentum states and vector spherical harmonics | PSO-2 PSO-5 | apply |
| CLO-2 | outline the basics of Density matrix theory | PSO-2 PSO-5 | analyze |

## Course Outline

**Module 1 Angular Momentum** **16hrs**

1.1 Commutation relations and states
1.2 Transformations under rotations
1.3 Coupling of three and four angular momenta
1.4 Racah coefficients, Wigner 9- j symbols, applications
1.5 Spherical tensors
1.6 Wigner-Eckart theorem. Projection theorem. Evaluation of matrix elements between coupled angular momentum states.
1.7 Vector spherical harmonics. Gradient theorem (Proof not required). Multipole radiation

**Key Words:** Angular momentum, coupling, Wigner-Eckart theorem

| **Module 2** | **Density Matrix Theory** | **16hrs** |
|---|---|---|
| 2.1 | Pure and mixed States, Density matrix and average expectation values | |
| 2.2 | Equation of motion. Spin density matrix. Spin in external magnetic field, Larmor's precession, resonance effects and Rabi oscillations | |
| 2.3 | Spherical tensor parameters and polarization | |
| 2.4 | Transformation properties under rotations | |
| 2.5 | Oriented, non-oriented and aligned systems | |
| 2.6 | Polarization in scattering of spin 1/2 particles, scattering amplitude, asymmetry, double scattering experiments | |

**Key Words:** Pure states, mixed states, density matrix, spherical tensors

**Reference**


1 Modern Quantum Mechanics, J J Sakurai, S F Tuan (Editor), Addison Wesley, India, 1990
2 Advanced Quantum Mechanics, J J Sakurai, Addison Wesley,1999
3 Angular momentum in quantum mechanics, A R Edmonds, Princeton University Press, 1996
4 Quantum theory of angular momentum, L C Biedenharn and D Van Dam, Academic Press Inc, 1966
5 Elementary theory of angular momentum, M E Rose, Dover Science, 1957
7 Density matrix theory and applications, K. Blum, Plenum Press,1981
8 Quantum Electrodynamics, Akhiezer and Berestetsky, Interscience Publishers; Revised Edition edition, 1965


## SECOND YEAR - SEMESTER – IV

| Course Title | **Analytical techniques in Theoretical Physics 2** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Soft Core- Practical | | Total Hours | 80 | Hours/Week | 05 | Credits | 03 |
| Course Code | DP330 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 Marks | 100 |
| | | | External | C3 | Duration | 04Hrs | 70 Marks | |

## Course Objectives (COs)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | evaluate calculations on various theoretical concepts. |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | Evaluate problems on various concepts in theoretical Physics | PSO-4 PSO-5 | Create |

## Course Outline

**Any five of the following**

1 Density matrix description of polarization of light.
2 Double scattering of spin-1/2 particles on spin-zero targets.
3 Second order QED processes (Compton scattering).
4 Evolution of matrix elements between coupled angular momentum states.
5 Dirac matrix representations.
6 Algebra of Dirac matrices.
7 Electron-proton scattering, Rosenbluth formula.
8 Relativistic kinematics-3: Study of decay and production processes.
9 Feynman diagrams and calculations.
10 Energy matrix calculation.

## FIRST/SECOND YEAR - SEMESTER – II/III

| Course Title | **Nanoscience and Nanotechnology** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Type | Open Elective- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 |
| Course Code | B6220/C7190 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | |

## Course Objectives (Cos)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | understand fundamentals of nanoscience |
| CO-2 | understand the properties and applications of nanomaterials |

| **Mapping of CLOs with PSOs & CDLs** | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | describe nanostructured materials, their properties and applications | PSO-1 PSO-2 | Understand |
| CLO-2 | synthesize and characterize nanostructured materials | PSO-1 PSO-2 | Understand |

## Course Outline

***Paper to be offered to Non-Physics Postgraduate Students***

**Module-1 Nanoscience** **16hrs**

1.1 Introduction

1.1.1 The nanoscale, origin of nanotechnology, nanomaterials, quantum confinement, surface to volume ratio

| | | |
|---|---|---|
| 1.1.2 | Types of nanomaterials and nanoparticles [Ref.1,2] | |
| 1.2 | Synthesis of nanomaterials : A brief discription on Physical, Chemical and Evaporation techniques | |
| 1.3 | Characterization Techniques : Optical, SEM, TEM, XRD, UV, Visible and IR absorption [Ref.3,4] | |
| | **Key words:** Nanoscale, Nanomaterials, Synthesis, Characterization | |
| **Module-2** | **Nanotechnology** | **16hrs** |
| 2.1 | Applications of nanoscience and nanotechnology,introduction to societal implications of nanoscience and nanotechnology | |
| 2.2 | Nanotechnology goals - knowledge and scientific understanding of nature, industrial manufacturing, materials and products, medicine and the human body | |
| 2.3 | Sustainability - agriculture, water, energy, materials and clean environment, space exploration, national security, moving into the market [Ref.5-7] | |
| | **Key words:** Nanotechnology, Sustainability | |

**Reference**


1 Nanotechnology: Principles and Practices, Kulkarni S. K., Capital Publ. Co., New Delhi, 2007.
2 Nanocrystals: Synthesis, Properties and Applications, Rao C.N.R., John Thomas P. and Kulkarni G.U., Springer series in Materials Science , Springer-Verlag, Berlin, Heidelburg, 2007.
3 Nano: The Essentials: Understanding Nanoscience and Nanotecnology, Pradeep T., Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
4 Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley and Sons, Ltd., UK, 2005.
5 Concept Document ”Nanoscience& Technology Initiative” of DST, GOI, New Delhi, 2002.
6 Societal Implications of Nanotechnology, Winner and Langdon, Testimony to the Committee on Science of the US House of Representatives, 2003.
7 Nanotechnology Regulation and Policy Worldwide , Jeffrey H. Matsuura, Artech House, 2006.


## FIRST/SECOND YEAR - SEMESTER – II/III

| Course Title | **Environmental Physics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Type | Open Elective- Theory | | Total Hours | 32 | Hours/Week | 02 | Credits | 02 | |
| Course Code | B6230/C7200 | Evaluation | Internal | C1+C2 = 15+15 | | | 30 | 100 | |
| | | | External | C3 | Duration | 03Hrs | 70 Marks | | |

### Course Objectives (Cos)

| CO No. | On completion of the course the student will be able to: |
|---|---|
| CO-1 | acquire necessary fundamental knowledge required to describe various environmental processes |
| CO-2 | understand the basic in our environment |

| Mapping of CLOs with PSOs & CDLs | | | |
|---|---|---|---|
| CLOs No. | Course Learning Outcomes (CLOs) On completion of the course the student will learn to: | PSOs Addressed | CLDs |
| CLO-1 | understand how to apply the basic thermodynamics to the human environment | PSO-1 PSO-2 | Understand |
| CLO-2 | understand the basic composition, structure and dynamics of the atmosphere | PSO-1 PSO-2 | Understand |
| CLO-3 | discuss specific environmental problems such as ozone depletion and global warming in the context of an overall understanding of the dynamics of the atmosphere | PSO-1 PSO-2 | Understand |
| CLO-4 | discuss the problems of energy demand and explain the possible contributions of renewable to energy supply | PSO-1 PSO-2 | Understand |

**Course Outline**

***Paper to be offered to Non-Physics Postgraduate Students***

**Module 1 Atmosphere and it's compositions** **16hrs**

1.1 Structure and composition of the atmosphere
1.1.1 Residence time
1.1.2 Photochemical pollution
1.1.3 Atmospheric aerosols
1.2 Atmospheric pressure
1.3 Ozone : Ozone hole, Ozone in polar region
1.4 Terrestrial radiation
1.5 Earth as a black body
1.6 Greenhouse effect, Greenhouse gases, Global warming

**Key words:** Atmospheric composition, Greenhouse effect

**Module 2 Water, Wind and Physics of Soil** **16hrs**

2.1 Physics of Water
2.1.1 Hydrosphere, Hydrologic cycle
2.1.2 Water in the atmosphere
2.1.3 Clouds, Physics of cloud formation
2.1.4 Growing droplets in cloud
2.1.5 Thunderstorms
2.2 Physics of Wind
2.2.1 Measuring the wind, Physics of wind creation
2.2.1 Principal forces acting on air masses: Gravitational force, pressure gradient, Coriolis inertial force, frictional force
2.3 Cyclones and anticyclones
2.4 Global convection
2.5 Global wind patterns
2.6 Soil physics
2.6.1 Soils
2.6.2 Soil and hydrologic cycle

2.6.3 Surface tension and soils, Water flow
2.6.4 Water evaporation, Soil temperature

**Key words:** Hydrosphere, wind, soil

**Reference**


1 Introduction to Environmental Physics: Planet Earth, Life and Climate, Nigel Mason and Peter Hughes,Taylor and Francis, 2001.
2 Principles Of Environmental Physics, John Monteith And Mike Unsworth, Academic Press, 3rd Edn., 2007

**Question Paper Blueprint**

For 3 and 4 credit Courses

| | | | |
|---|---|---|---|
| **St. Philomena's College (Autonomous), Mysuru** | | | |
| **I/II/III/IV Semester M.Sc. Examination , Month-Year** | | | |
| **Subject:** | | | |
| **Title:** | | | |
| **Time: 3hours** | | | **Max.Marks:70** |
| ***Instruction: Answer any one full question from Section-A, Section-B and Section-C and any four questions from Section-D*** | | | |
| **Section A** | | | |
| 1. | a. | Question to beasked from Module 1 | 18 |
| | b. | Question to beasked from Module 1 | |
| **OR** | | | |
| 2. | a. | Question to beasked from Module 1 | 18 |
| | b. | Question to beasked from Module 1 | |
| **Section B** | | | |
| 3. | a. | Question to be asked from Module 2 | 18 |
| | b. | Question to be asked from Module 2 | |
| OR | | | |
| 4. | a. | Question to be asked from Module 2 | 18 |
| | b. | Question to be asked from Module 2 | |
| **Section C** | | | |
| 5. | a. | Question to be asked from Module 3 | 18 |
| | b. | Question to be asked from Module 3 | |
| OR | | | |
| 6. | a. | Question to be asked from Module 3 | 18 |
| | b. | Question to be asked from Module 3 | |
| **Section D** | | | |
| 7. | Question to be asked from Module-1 | | 04 |
| 8. | Question to be asked from Module-1 | | 04 |
| 9. | Question to be asked from Module-2 | | 04 |
| 10. | Question to be asked from Module-2 | | 04 |
| 11. | Question to be asked from Module-3 | | 04 |
| 12. | Question to be asked from Module-3 | | 04 |

Note: Marks of SectionA, B and C can be any combinations of 18. For example (12+6), (10+8),(9+9),(10+4+4),(8+6+4)etc,.

**Blue print of Question paper for 2 – credit Soft-core courses from I to IV semesters**

| | | |
|---|---|---|
| **St. Philomena's College (Autonomous), Mysuru** | | |
| **I/II/III/IV Semester M.Sc. Examination , Month-Year** | | |
| **Subject:** | | |
| **Title:** | | |
| **Time: 4 hours** | | **Max. Marks :70** |
| ***Instruction: Answer any four full question from Section-A and any of the five questions from Section-B*** | | |
| **Section-A** | | |
| 1. | Question to be asked from Module-1 | 05 |
| 2. | Question to be asked from Module-1 | 05 |
| 3. | Question to be asked from Module- 2 | 05 |
| 4. | Question to be asked from Module-2 | 05 |
| 5. | Question to be asked from Module-3 | 05 |
| 6. | Question to be asked from Module-3 | 05 |
| **Section-B** | | |
| 7. | Question to be asked from Module-1 | 10 |
| 8. | Question to be asked from Module-1 | 10 |
| 9. | Question to be asked from Module- 2 | 10 |
| 10. | Question to be asked from Module-2 | 10 |
| 11. | Question to be asked from Module-3 | 10 |
| 12. | Question to be asked from Module-3 | 10 |

Note: Marks of Section A and B can be any combinations of 05 and 10 respectively. For example in Section - A we may have (3+2), in Section – B we may have (06+04), (05+05) etc.

**Blue print of Question paper for 4 – credit generic elective courses**

| | | |
|---|---|---|
| **St. Philomena's College (Autonomous), Mysuru** | | |
| **II/III Semester M.Sc. Examination , Month-Year** | | |
| **Subject:** | | |
| **Title:** | | |
| **Time: 4 hours** | | **Max. Marks :70** |
| **Instruction: Answer any seven full questions from Section-A, any six full questions from Section-B and any two full questions from Section-C** | | |
| **Section A** | | |
| 1. | Question to be asked from Module-1 | 02 |
| 2. | Question to be asked from Module-1 | 02 |
| 3. | Question to be asked from Module- 2 | 02 |
| 4. | Question to be asked from Module-2 | 02 |
| 5. | Question to be asked from Module-3 | 02 |
| 6. | Question to be asked from Module-3 | 02 |
| 7. | Question to be asked from Module-4 | 02 |
| 8. | Question to be asked from Module-4 | 02 |
| **Section B** | | |
| 9. | Question to be asked from Module-1 | 06 |
| 10. | Question to be asked from Module-1 | 06 |
| 11. | Question to be asked from Module- 2 | 06 |
| 12. | Question to be asked from Module-2 | 06 |
| 13. | Question to be asked from Module-3 | 06 |
| 14. | Question to be asked from Module-3 | 06 |
| 15. | Question to be asked from Module-4 | 06 |
| 16. | Question to be asked from Module-4 | 06 |
| **Section C** | | |
| 17. | Question to be asked from Module-1 | 10 |
| 18. | Question to be asked from Module-2 | 10 |
| 19. | Question to be asked from Module-3 | 10 |
| 20. | Question to be asked from Module-4 | 10 |

Note: Marks of Section B and C can be any combinations of 06 and 10 respectively. For example in Section – B we may have (03+03) and in Section – C we may have (05+05) etc.

## Blue print for Practical Examination

| St. Philomena's College (Autonomous), Mysuru | | |
|---|---|---|
| **I/II/III/IV Semester M.Sc. Physics Practical Examination , Month-Year** | | |
| **Title:** | | |
| **Time: 4 hours** | | **Max. Marks :70** |
| **Sl. No.** | **Description** | **Marks** |
| 1. | Practical work/ performing experiments and obtaining result. | 50 |
| 2. | Record | 10 |
| 3. | Viva | 10 |