ST ALOYSIUS COLLEGE (AUTONOMOUS)
MANGALURU

Re-accredited by NAAC "A++" Grade
Course Structure and Syllabus of

M.Sc Physics

Learning Outcomes-based Curriculum Framework
for
Postgraduate Physics

(2023-2024 BATCH ONWARDS)

Preamble

Physics is the study of nature through theoretical models and experimental means. There are research and educational institutions, both in public and private sectors, which aim to meet these requirements. The main objective of our postgraduate programme in Physics is to imbibe and impart scientific knowledge which will help the students to enter the field of scientific research, teaching and industry.

A rigorous training through classroom lectures, tutorials and practical training through laboratory modules will be given for the all-round development of the students. Innovative methods like student seminars, projects, student-faculty programme are introduced to develop the skills of students which will be useful for teaching and research. Apart from the curriculum, students are trained to enhance the vocational skills and leadership qualities which forge them into good human beings.

The two-year Master of Scince (M.Sc.) Physics program in the college offers 15 theory courses in Physics, two open electives, seven laboratory courses and a project over a period of four semesters.

1. Introduction

The learning outcomes based curriculum framework (LOCF) for the postgraduate program in Physics is intended to provide a broad framework within which the programhelps to create an academic base that responds to the need of the students to understand the basics of Physics and its ever evolving nature of applications in explaining all the observed natural phenomenon as well as predicting the future applications to the new phenomenon with a global perspective. The curriculum framework is designed and formulated in order to acquire and maintain standards of achievement in terms of knowledge, understanding and skills in Physics and their applications to the natural phenomenon as well as the development of scientific attitude and values appropriate for rational reasoning, critical thinking and developing skills for problem-solving and initiating research which are competitive globally and are on par in excellence with the standard Higher Education Institutions (HEI) in the advanced countries of America, Asia and Europe.

The learning outcome based curriculum framework in Physics should also allow for the flexibility and innovation in the program design of the PG education, and its syllabi development, teaching learning process and the assessment procedures of the learning outcomes. The process of learning is defined by the following steps which should form the basis of final assessment of the achievement at the end of theprogram.

- The accumulation of facts of nature and the ability to link the facts to observe and discover the laws of nature i.e., to develop an understanding and knowledge of basic Physics.
- The ability to use this knowledge to analyze new situations and learn skills and tools like mathematics, engineering and technology to find the solution, interpret the results and make predictions for the futuredevelopments.
- The ability to synthesize the acquired knowledge, understanding and experience for a better and improved comprehension of the physical problems in nature and to create new skills and tools for their possible solutions.

2. Learning Outcomes-based approach to Curriculum planning Nature and extent of PG program in Physics

The PG program in Physics builds on the basic Physics taught at the UG level in all the colleges in the country. Ideally, the undergraduate education should aim and achieve a sound grounding in understanding the basic of Physics with sufficient content of topics from modern Physics and contemporary areas of exciting developments in physical sciences to ignite the young minds. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Physics should be apparent to the student. This is very critical in developing a scientific temperament and an urge to innovate, create and discover in Physics.

Aims of PG Program in Physics

The aims and objectives of our PG educational program in Physics is structured to

- create the facilities and environment to consolidate the knowledge acquired at undergraduate level and to motivate and inspire the students to create deep interest in Physics, to develop a broad and balanced knowledge and understanding of physical concepts, principles and theories ofPhysics
- learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms

- develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics
- expose the student to the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature spanning from 10^{-15} to 10^{26} m in space and 10^{-10} to 10^{25} eV in energy dimensions
- emphasize the discipline of Physics to be the most important branch of science for pursuing interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinaryareas
- to emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment

3. Attributes of a Postgraduate in Physics

Some of the characteristic attributes of a postgraduate in Physics are

- **Disciplinary knowledge and skills:** Capable of demonstrating

  (i) good knowledge and understanding of major concepts, theoretical principlesand experimental findings in Physics and its different subfields like Astrophysics and Cosmology, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and other related fields of study, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology etc.

  (ii) ability to use modern instrumentation and laboratory techniques to design and perform experiments is highly desirable in almost all the fields of Physics listed above in (i).

- **Research aptitude**: Ability of the student to apply the concepts learned in the program to various research areas in Theoretical as well as applied fields not only in Physics but also in interdisciplinary subjects.
- **Skilled communicator:** Ability to transmit complex technical information relating all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in all the basic areas of Physics.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the

issues and problems in the field of Physics, and planning, executing and reporting the results of a theoretical or experimental investigation.

- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in industry and field-based situations.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.
- **Digitally Efficient*:*** Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data, and employing modern e-library search tools like Inflibnet and other various websites of the renowned Physics labs in countries like the USA, Europe, Japan etc. to locate, retrieve, and evaluate Physics information.
- **Ethical awareness/reasoning*:*** The graduate should be capable of demonstrating ability to think and analyze rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsificationor misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.
- **National and international perspective*:*** The graduate should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing towards the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

4. Qualification descriptors for a PG program in Physics

The qualification descriptors for a M.Sc. Physics Program may include the following. The postgraduates should be able to

- Demonstrate
  (i) a systematic, extensive and coherent knowledge and understanding of the academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories,

principles and concepts, and of a number of advanced and emerging issues in the field of Physics;

(ii) procedural knowledge that creates different types of professionals related to the subject area of Physics, including research and development, teaching and government and public service;

(iii) skills in areas related to one's specialization area and current developments in the academic field of Physics, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.

- Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to various subfields in Physics, and techniques and skills required for identifying Physics problems and issues in their area of specialization in Physics.
- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources from the Physics labs around the world, analysis and interpretation of data using methodologies as appropriate to the subject of Physics in the area of his/her specialization.
- Use knowledge, understanding and skills in Physics for critical assessment of a wide range of ideas and complex problems and issues relating to the various subfields of Physics.
- Communicate the results of studies undertaken in the academic field of Physics accurately in a range of different contexts using the main concepts, constructs and techniques of the subject of Physics;
- Address one's own learning needs relating to current and emerging areas of study relating to Physics, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge in Physics.
- Apply one's knowledge and understandings relating to Physics and skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstrate subject-related and transferable skills that are relevant to some of the Physics related jobs and employment opportunities.

5. Programme learning outcomes relating to M.Sc. in Physics

The student graduating with the degree M.Sc. in Physics should be able to

- Acquire

  (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Quantum Mechanics, Astrophysics, Materials Science, Nuclear and Particle Physics, Condensed Matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical Dynamics, Space Sciences, and its relevance with related disciplinary areas/subjects like Chemistry, Mathematics, Life Sciences, Environmental Sciences, Atmospheric Physics, Computer Sciences, Information Technology;

  (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in researchand development, teaching and government/public service;

  (iii) skills in areas related to one's specialization area within the disciplinary/subject area and the current and emerging developments in the field of Physics.

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems, and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
- Recognize the importance of mathematical modeling, simulation and computing, and the role of approximation and mathematical approaches to describe the physical world.
- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.
- Demonstrate relevant generic skills and global competencies such as

  (i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;

  (ii) investigative skills, including skills of independent investigation of Physics-related issues and problems;

  (iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;

(v) ICT skills;

(vi) personal skills such as the ability to work both independently and in a group.

- Demonstrate professional behavior such as

  (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

  (ii) the ability to identify the potential ethical issues in work-relatedsituations;

  (iii) appreciation of intellectual property, environmental and sustainability issues and

  (iv) promoting safe learning and working environment.

Programme Learning Outcomes

Hard Core courses

Sl. No.		PH 571.1	PH 572.1	PH 573.1	PH 574.1	PH 571.2	PH 572.2	PH 573.2	PH 571.3	PH 572.3	PH 573.3	PH 571.4	PH 572.4	PH 573.4P
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basicPhysicsconcepts	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages withrelated disciplines	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related field of specialization	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to usein Physicsproblem	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X	X	X	X	X	X	X	X	X	X
8	Skills in performing analysis andinterpretationof data	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Develop investigative Skills	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Skills inproblem solving inPhysics andrelated discipline	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop technical communication skills	-	-	-	X	-	-	X	-	-	-	-	-	X
12	Developing analytical skills and popular communication	-	-	-	-	-	-	-	-	_	_	-	-	X
13	Developing ICT skills	-	-	-	X	-	-	X	_	-	-	-	-	X
14	Demonstrate professional behaviour with respect to attributes like objectivity,ethical values, self reading, etc.	X	X	X	X	X	X	X	X	X	X	X	X	X

Soft core courses

Sl. No.		PS 575.1 P	PS 576.1 P	PS 574.2	PS 575.2 P	PS 576.2 P	PS 574.3	PS 575.3	PS 576.3 P	PS 577.3 P	PS 574.4	PS 575.4	PS 576.4	PS 577.4	PS 578.4 P
1	Fundamentalunder standing of the field	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basicPhysics concepts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with relateddisciplines	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Proceduralknowledge for professionalsubjects	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills inrelated fieldofspecialization	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to useinPhysicsproblem	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematicalmodeling	-	-	-	--	-	-	-	-	X	-	-	-	-	-
8	Skills inperforming analysis and interpretation ofdata	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Develop investigativeSkills	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Skills in problem solving in Physics andrelated discipline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop Technical Communication skills	X	X	X	X	X	-	-	X	X	-	-	-	-	-
12	Developing analytical skills and popular communication	-	-		-	-	-	-	-	-	_	-	-	-	-
13	Developing ICT skills	-	-		-	-	-	-	-	-	_	-	-	-	-
14	Demonstrate Professional behaviour withrespect to attribute like objectivity,ethical values, self reading, etc	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Open Electives

Sl. No.		PO 577.2	PO 578.3
1	Fundamental understanding of the field	X	X
2	Application of basic Physics concepts	X	X
3	Linkages with related disciplines	X	X
4	Procedural knowledge for professional subjects	X	X
5	Skills in related field of specialization	X	X
6	Ability to use in Physics problem	X	X
7	Skills in Mathematical modeling	X	X
8	Skills in performing analysis and interpretation of data	X	X
9	Develop investigative Skills	X	X
10	Skills in problem solving in Physics and related discipline	X	X
11	Develop Technical Communication skills	X	X
12	Developing analytical skills and popular communication	X	X
13	Developing ICT skills	X	X
14	Demonstrate Professional behavior with respect to attribute like objectivity, ethical values, self reading, etc	X	X

6. Structure of Postgraduate Program in Physics

The M.Sc. (Physics) Program shall comprise "Core" and "Open Elective" courses. The "Core" courses shall further consist of "Hard core" and "Soft core" courses. Hard core courses shall have 4 credits; soft core courses shall have 3 credits. A candidate must choose between the two options (A) or for soft core courses. Open electives shall have 3 credits. Total credit for the programme shall be 95 including open electives.

Core courses are related to the discipline of the M. Sc (Physics) programme. Hard core courses are compulsorily studied by a student as a core requirement to complete the programme of M.Sc (Physics). Soft core courses are electives but are related to the discipline of the programme. Two open elective courses of 3 credits each shall be offered in the II and III semester by the department. Open elective will be chosen from an unrelated programme within the faculty.

Total credit for the M.Sc (Physics) programme is 95. Out of the total 95 credits of the programme, the hard core (HC) shall make up 54.73 % of the total credits; soft core (SC) is 38.94 % while the open electives (OE) 6.31% will have a fixed 6 credits (3 credits - 2 papers).

Theory courses

Topics in each theory course are equally distributed in four units for Hard core courses and three units for soft core courses as well as for open electives. Solving and practising certain typical problems shall be exercised in the class-rooms.

Lab Courses

1. General Physics: A course of general Physics experiments are prescribed for all semesters. A rigorous study of theory of the concerned experiment is made along with the development of experimental skills.
2. Electronics: First two semesters consist of a course of electronics experiments, one in each semester. The design of electronic circuits is a part of the experiments.
3. Computational Physics: One course of Computational Physics has been introduced for the third semester. This will help to solve typical problems in Physics by simulation and using programming language.

Project

There shall be a project in the fourth semester. Evaluation of the project is done by two examiners (one external and one internal). The project will be evaluated for 100 marks out of which 70 marks is assigned for report/dissertation and the remaining 30 marks for internal assessment.

Seminars

A module of seminars has been included in the curriculum to improve presentation skills of the students. Each student has to give a set of two seminars in a semester. The topics for the seminars will be assigned and will be guided.

C/C++ programming

C/C++ programming is offered to the students during second semester as an add-on certificate course

Semester	**Compulsory Hard Core Courses (HC) each with 04 credits (Total no. of Courses 12)**	**Soft core courses (SC) each with 03 credits. Select any 01 course in III semester and any 02 courses in IV semester(one from each group)**	**Open Electivecourses for students of other discipline/program of 03 credits each**	**CompulsarySkill Enhancement Course (SEC) 07 credits each in the first three semesters and 08 credits in the fourth semester**	**Total Credits**
I	PH 571.1 PH 572.1 PH 573.1 PH 574.1	-	-	PS 575.1 P PS 576.1 P PS 577.1 S	23
II	PH 571.2 PH 572.2 PH 573.2	PS574.2	PO 577.2	PS 575.2 P PS 576.2 P PS 578.2 S	25
III	PH 571.3 PH 572.3 PH 573.3	PS 574.3 PS 575.3	PO 578.3	PS 576.3 P PS 577.3 P PS 579.3 S	25
IV	PH 571.4 PH 572.4	**<u>Group I</u>** PS 574.4 PS 575.4 **<u>Group II</u>** PS 576.4 PS 577.4	-	PH 573.4 P PS 578.4 P PS 579.4 S	22
Total Credits	48	12	06	29	95

Course Learning Objectives

Semester I

PH 571.1 Mathematical Physics I

1. **Course learning outcome**: By the end of the course, students will be able to
   - To review the knowledge of vectors and scalar quantities.
   - To learn the concepts of vector calculus such as divergence, curl, line integrals, surface integrals, volume integrals.
   - To study fundamental theorems like The Green's theorem, Stokes' theorem and their applications in Physics.
   - To learn the concepts of curvilinear coordinates and to learn the concepts of vector calculus in curvilinear coordinates.
   - To learn the basic properties of matrices and to study the properties of special types of matrices like Hermitian, Unitary and Orthogonal matrices.
   - To study similarity and unitary transformations, concept of eigenvalues and eigenfunctions, Cayley-Hamilton's Theorem and Diagonalization of matrices.
   - To learn basic definitions of tensors and transformation laws of coordinates. Different types of tensors and algebra of tensors including quotient law.
   - To learn about first and second order partial differential equations, their classification.
   - To solve special equations like Heat equation, Laplace's equation, Poisson's equation.
   - To learn to solve a differential equation using the method of power seires.
   - To learn different special functions like Legendre polynomials, Bessel's function, Laguerre polynomials and Hermite's polynomials and to study orthogonality conditions and different recurrence relations of these functions.

2. **Broad contents of the course:**
   - Vector calculus
   - Curvilinear coordinates
   - Matrices
   - Eigenvalues and eigenfunctions
   - Tensors and transormations
   - Partial differential equations
   - Power series method
   - Special functions

3. **Skills to be acquired:**
   - Solving mathematical problems in calculus and in linear algebra will give students to apply the knowledge to real physical problems.
   - To create a mathematical model of a physical system and solve it.

PH 572.1 Classical Mechanics

1. **Course learning outcome:** By the end of the course, students will be able to
    - Define and understand the basic concepts related to single particle and a system of particles
    - Describe the motion of a mechanical system using Lagrange and Hamilton formalism.
    - Understand the principles of collisions and learn about the concept of centre of mass and laboratory coordinate system
    - Acquire the basic knowledge of the Phase space and Phase trajectory
    - Learn about the canonical transformation
    - Learn about the concept of two body problem
    - Learn the conservation theorems
    - Acquire the knowledge about equation of the orbit and orbit's classification
    - Learn the Kepler's laws of planetary motion
    - Learn the general description and the concept of Scattering
    - Learn the dynamics of the rigid body
    - Understand the rigid body dynamics
    - Learn the theory of small oscillation

2. Broad contents of the course

- System of particles
- D'Alembert's principle
- Lagrange formalism
- Hamiltonian formalism
- Two body problem
- Variational principle
- Canonical Transformation
- Kepler's laws of motion
- Rutherford's Scattering
- Rigid body Dynamics
- Small oscillation

3. Skills to be learned: By the end of the course, students will be able to develop the skill

- To apply the basics of the kinematics and dynamics to translational and rotational motion of systems of particles.
- To solve the equation of motion of the different mechanical systems using Lagrange's and Hamiltonian equation.
- To apply the concept of two-body system to various two-body problems.
- To apply the theory of small oscillations to various diatomic and triatomic molecules.

PH 573.1 Classical Electrodynamics

1. Course learning outcomes:

- Study the basics of electrostatics with rigorous mathematics
- To learn to apply the fundamentals of electrostatics and boundary conditions to solve various problems
- To learn the fundamentals of magnetostatics and magnetism
- To learn the electromagnetic theory through Maxwell equations and underlying theories
- To get a grip on gauge symmetries and transformations and also on radiation emission of a moving or oscillating charge
- To arrive at the plane wave equation of the electromagnetic fields and studying the plane wave solutions
- Analysis of reflection and transmission of waves: using electromagnetic boundary conditions.
- To learn the theory of waveguides and solve the problem of rectangular waveguide.
- To derive the Lorentz transformation equations and understanding basic relativistic dynamics.
- Lorentz transformation and relativistic dynamics is learnt to be written in four vector (tensor) notation.
- Basic laws of electrodynamics, continuity equation, Maxwell's equations, Gauge transformations and potential theory in tensor notation.

2. Broad content of the course:

- Electrostatics
- Coulomb's law

- Gauss's law
- Scalar potential
- Laplace's and Poisson equation
- Magnetostatics
- Vector potential
- Electrodynamics
- Maxwell's equations
- Gauge transformations
- Radiation
- Dipole radiation
- Retarded potentials
- Electromagnetic waves
- Plane wave solutions
- Normal and oblique incidence
- Wave guides
- Special theory of relativity
- Relativistic electrodynamics

3. Skills to be acquired:

- The student will be able to solve the problems in electrostatics and magnetostatics.
- The students will also be able to understand and apply various problems in electrodynamics to various physics.
- Students will be able to solve the concepts of electromagnetic waves to physics and communications.
- Student will also learn relativistic electrodynamics which can be applied to modern understanding of Quantum field theory and Particle Physics.

PH 574.1 Electronics

1. Course learningoutcome:

After going through the course, the student should be able to

- Understand characteristics of an ideal operational amplifier (Op-amp) and a practical operational amplifier, open loop and closed loop applications of op-amp; use Op-amp for basic mathematical operations like addition, subtraction, multiplication, integration and differentiation applications and a few special applications such as filtering and comparators.

- Learn the use of op-amp for wave form generation applications and the applications of timer IC 555.
- Understand the meaning and types of power amplifiers and their applications. The student willable to learn specialized applications of SCR, signal conditioning and other varieties of transducer circuits.
- Will be able to review basics of digital circuits, few aspects of rigisters and digital data storage, synchronous and asynchronous counter applications, memory devices and basics of a microprocessor.

2. Broad contents of the course:

- Operational Amplifiers
- Waveform generators and Specialized IC applications
- Power Amplifiers, Devices and transducers
- Digital electronics

3. Skills to belearned

- Designing and constructing various types of op-amp circuits and studying their response
- The student must able to appreciate and design digital circuits for various applications.

Semester II

PH 571.2 Mathematical Physics II

1. Course Learning Outcome:

- To review the concepts of complex numbers and functions of complex variables.
- To study calculus of complex functions, Cauchy Riemann conditions and differentiability.
- To learn integration of complex functions, Cauchy integral theorem, concepts of poles, singularities, residues.
- To study integration of complex functions using residue theorem also to get a good hold in the concept of mapping and conformal mapping.
- To review the uncdrstanding in Group theory and study the concept of transformation group and symmetry groups.
- To study representation of groups and understand the concepts of irreducible representations.
- To learn Lie groups and their application in Physics.
- To apply the Green's functions to solve various differential equations.
- Reviewing and understanding the concepts of Fourier series and studying the

concepts of Fourier transform and their applications in Physics and Electronics.

- To study Laplace's transorms and their applications in Physics.
- To learn to interpolate a function using various numerical methods.
- To study the method of solving non linear equations and also differential equations using numerical methods.
- To learn integration of various functions by numerical methods.

2. Broad contents of the course:

- Functions of complex variables
- Cauchy integral theorem
- Residue integration
- Conformal mapping
- Groups, subgroups
- Transformation groups and symmetry groups
- Schur's lemma
- Irreducible representations
- Lie groups
- Green's function
- Fourier series and transform
- Convolution theorem
- Laplace transform
- Numerical methods
- Lagrangian, Newton's forward and backward interpolations
- Runge- Kutta method and Euler's method

3. Skills to be acquired:

- The students will be able to understand the existence of complex nature of physical quantities should be observed by the students and they should be able to apply them in theory as well as in practice.
- The students will be able to use the concepts of symmetries and groups to understand various concepts in condensed matter physics and modern physics.
- Students should be able to apply integral trasformation in various fields in physics.
- Students should be able to solve complicated physical problems by numerical methods and also be able to practically simulate the problems using computer programmes.

PH 572.2 Quantum Mechanics I

1. Course Learning Outcome:

- Review of concepts of wave particle duality and to study the birth of quantum theory through Planck's law.
- To setup the Schrödinger equation and to understand the physical interpretation of a quantum mechanical wave function.
- To study in detail the fundamental postulates of quantum mechanics.
- To understand the concepts of eigenvalues, eigenfunctions and degeneracy being applied to quantum mechanics.
- To study various commutation relations and to understand its meaning.

- To setup the Time Independent Schrödinger equation and to learn the concept of stationary states.
- To solve various problems like potential well, potential barrier and harmonic oscillator and to study the properties of stationary states of these problems.
- To study the concept of angular momentum in quantum mechanics and to arrive at the eigenvalues and eigenfunctions of angular momentum and hence to understand the concept of space quantization.
- To study the applications of angular momentum to spherically symmtric systems and to study parity.
- To solve the problem of Hydrogen like atoms in atomic physics.
- To review the concept of scattering and to study quantum mechanical scattering.
- To understand Partial wave analysis in quantum mechanical scattering and also to apply Born approximation.

2. Broad contents of the course:

- Quantum thoery
- Wave matter duality
- Schrödinger equation
- Wave function
- Fundamental postulates of quantum mechanics
- Eigenvalues and eigenfunctions
- Commuting observables and degeneracy
- Stationary states
- Potential well and barrier
- Harmonic oscillator
- Angular momentum
- Parity
- Hydrogen atom
- Scattering

3. Skills to be acquired:

- The student should learn to apply the quantum mechanical calculations in topics like condensed matter physics, nuclear physics and particle physics.
- The students also should become well versed in the concepts so that they can go further to learn quantization of fields and quantum field theory.
- Students should be able to solve the Schrödinger equation both exactly and numerically so that it can be applied in research.

PH 573.2 Condensed Matter Physics- I

1. Course learning outcome: At the end of the course the student is expected to learn and assimilate the following

- A brief idea about crystalline materials-lattice- unit cell-miller indices-reciprocal latticeetc
- Production and applicatins of X-ray. X-ray diffraction. Point groups and space groups and quasi crystals
- Crystal binding- types of bonds, concept of phonon vibration, phonon

scattering, thermal expansion of solids and lattice thermal conductivity

- Free electron models of metals, quantum free electron theory, F.D Statistics,Electron in aperiodic potential, Bloch theorem, metals, semimetals and semiconductors.
- Semiconductors-types,Impurity atoms, electrical conductivity, quantized Hall Effect, amorphous semiconductors, organic semiconductors.

2. Broad contents of thecourse:

- Crystallography
- Crystal binding and Thermal properties of insulators
- Free electron model of metals
- Semiconductors

3. Skills to be learned

- To identify and to draw various crystal structures, crystal axis, crystal planes, crystal directions and symmetry elements.
- To draw band structure of few crystals and to differentiate between direct and indirect bad gap in semiconductors.

PS 574.2 Research Methodology and Ethics

1. Course Learning Outcome

- To have clear understanding of the meaning and purpose of Research in academics, research philosophy and strategies of Research.
- To acquaint with the knowledge of methodology involved in a scientific Research
- To know writing of a good Research Report.
- To understand the ethical issues and practices in research with an awareness of rights and obligations of research participants.
- Understand the process of Intellectual property Rights and its different forms and implications
- To know how to write research papers and publish research papers.

2. Broad content of the course:

Foundation of Research and Research Ethics

Research – meaning, characteristics, objectives, motivation in research, need and importance of research. Types of Research; Philosophy and Research Philosophy

Ethics – meaning and definition, Ethics Vs moral philosophy, nature of moral judgments and reactions. Rights and obligations of Research Participants. Selective reporting and misinterpretation of data. Best practices/standard setting initiatives and guidelines. Self-plagiarism.

Research Methodology and Interpretation and Report Writing

Research Problem – meaning, selecting the problem, sources of problem, statement of a problem; Review of Literature – meaning and need for literature review, sources of literature review, reporting the review of literature, identification of research gap; Research Questions; Objectives of the study.

Research Report – meaning, features of a good Research Report, elements of Research Report, format of a Research Report, Appendices and References/ Bibliography – styles.

Research design, system of interest- experimental setup-characterization-data acquisition-data analysis-reproducibility-statistical and error analysis-application studies - relevance of research

Intellectual Property Rightsand Publication of Scholarly Papers:

IPR – Concept of IPR, nature and characteristics of IPR, origin and development of IPR, justification and rationale for protecting IPR, IPR and sustainable development, IPR and human rights, IPR issues in physical and biological sciences, Commerce and IPR issues, IPR issues in Social Sciences. Forms of IPR – copyrights, trademarks, patents, industrial designs, trade secrets, geographical indications – meaning, features and application of different forms of IPRs. Filing and Registration process of IPRs.

Publication – Scholarly/research article – meaning and features of scholarly article. Successful scientific writing – process. Reference/ bibliography writing, Plagiarism. Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics – h-index, g-index, i10 index etc.

Skills to be acquired:

Research output with philosophical base and greater relevance to the society

- Quality research with scientific methodology
- Production of good Research Reports
- Original Research following ethical guidelines and practices in conducting the research and publication of papers.
- More awareness on Intellectual property Rights and Patents.

PO 577.2 Physics of the Universe

1. **Course Learning Outcome:**
    - To study various astronomical coordinate systems, time measurements.
    - To study various maeasurement systems in the universe to study the distances, temeperature and size of stars.
    - To understand the life cycle of a galaxies and stars.
    - To give classification of stars according to temperature, size and age.
    - To study various laws governing the evolution of universe.
    - To discuss in detail various models that explain the birth and evolution of the universe.
2. **Broad content of the course:**
    - Astronomy
    - Stars
    - Stellar evolution
    - Galaxies
    - H-R diagram
    - Life cycle of stars
    - Evolution of universe
3. **Skills to be acquired:**
    - The student will able to understand basic astronomy, astrophysical phenomena
    - Students will understand basics of evolution of the universe.

Semester III

PH 571.3 Quantum Mechanics II

1. **Course Learning Outcome:**
    - To review the concepts of linear algebra studied in Mathematical Physics I (PH 571.1) so that it can be applied to quantum mechanical calculations.
    - To learn the method of Dirac's ket and bra notations and to learn about general uncertainty relation and theorems like Schwartz inequality.
    - To learn the Schrödinger, Heisenberg and interaction picture and to derive equations of motion and hence to get a broad idea of the process of

quantization of a system.

- To solve the hamonicoscillator and angular momentum problem by matrix method.
- To study the concept of spin and addition of angular momenta.
- To study various approximation techniques in quantum mechanics like Pertubation theory, WKB approximation and variational technique.
- To study the above techniques with real quantum mechanical examples.
- To setup a relativistic wave equation (Klein-Gordon equation) and to understand the existence of negative probability density.
- To setup the Dirac's equation, to study the properties of the Dirac's matrices and to arrive at the solutions of Dirac's equation and hence to give the concept of anti particles through the negative energy solutions of the Dirac's equations.
- To introduce the concept of quantization of fields by first quantizing a classical field and then for a Schrödinger's field and relativistic fields.

2. Broad content of the course:

- Matrix formalism of quantum mechanics
- Quantum dynamics
- Schrödinger, Heisenberg and Interaction pictures
- Harmonic oscillator, angular momentum
- Perturbation theory
- Variational technique
- WKB approximation
- Relativistic quantum mechanics
- Klein Gordon Equation
- Dirac's equation
- Field quantization

3. Skills to be acquired:

- The student will be able to solve any problem in quantum mechanics using matrix formalism.
- The student should be able to apply the approximation methods to the existing problems in research.
- The student should acquire a clear skill of quantization of the fields to be applied to various topics in quantum field theory and modern day high energy physics.

PH 572.3 Condensed Matter Physics- II

1. Course learning outcome: At the end of the course the student is expected to learn and assimilate the following

- To understand various types of crystal defects and imperfectaons in crystal growth process.
- To familiarise luminescence and related phenomenon.
- To understand thermopdynamics phase transtions, order-disordersness and theories of phase transitions.
- To review magentic properties of materals and theories og magnetism. Appllicatons of magnetic proerties- Magnetometer, NMR, Reosaonce.
- Domain theory of magntic materials.
- To understand dilectricmaterails and their applications.

2. Broad contents of thecourse:

- Crystal Imperfections and Phase Transitions In Solids
- Magnetism
- Magnetic resonance
- Dielectric Properties of Solids

3. Skills to belearned

- To perform experiments related to ESR and nuclear magnetic resonance
- To draw hysteresis curve for ferro magnetic materials and differentiate between hysterics loop of hard and soft magnets
- The knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss

PH 573.3 Thermodynamic and Statistical Physics

1. Course Learning outcomes: By the end of the course, students will be able to

- ➢ To understand the relevant quantities used to describe macroscopic systems and thermodynamic potential
- ➢ Understand the macroscopic and microscopic description of temperature, entropy and free energy
- ➢ Learn the theory of probability
- ➢ Understand the concept ensembles and theory of ensembles
- ➢ Understand macrostates and microstates

- Learn partition functions and their importance
- Learn the various distribution functions and their uses in classical and quantum mechanical non-interacting assemblies of systems
- Describe the transport phenomena and understand the diffusion coefficients
- Learn the concept of fluctuation
- Understand the random walk problem

2. Broad contents of the course

- The concept of Entropy
- Thermodynamic potential
- Internal energy and TdS equations
- Specific heats of matter and its applications
- Ensemble and classifications
- Classical description of ensemble theory
- Application of ensemble theory to ideal gas system
- Quantum description of ensemble theory
- Density matrix
- M-B, B-E and F-D distribution functions
- Application of B-E distribution functions to black body radiation
- Bose-Einstein condensation
- Application of F-D distribution function to electron gas in a metal
- Transport phenomena
- Random walk problem
- Fluctuation

3. Skills to be learned: By the end of the course, students will be able to acquire the skill

- To solve the problems related to the concept of entropy
- To apply the classical and quantum statistics to various ensembles
- To solve the random walk problems

PS 573.3 Relativity and Cosmology

1. Course Learning Outcome:

- To learn the concepts of Special Theory of Relativity in Tensor notations and also to understand the concepts like Momentum transformations.

- To study tensor analysis as a prerequisite for the General Theory of relativity and understand the meaning of a metric, geodesic and covariant differentiation.
- To learn the theory of General Relativity starting from the Principle of Equivalence and General Covariance by deriving the Einstein's field equations.
- To solve the Einstein's field equation for a weak metric case and arrive at Schwarzschild solutions and also to learn about the Schwarzschild radius and Black holes.
- To study the various experimental predictions of General Relativity in detail.
- To understand various principles underlying the study of Cosmology.
- To study various cosmological models that explain the birth and evolution of universe.

2. Broad content of the course

- Four vectors
- Lorentz transformations
- Energy momentum four vectors
- Tensor calculus
- Geodesic equation
- Covariant differentiation
- Principle of Equivalence
- Principle of General Covariance
- Einstein Field equations
- Schwarzschild solutions
- Precession of perihelia
- Deflection of light
- Cosmological principle
- Cosmic Microwave Background
- Olber's paradox
- Hubble's law
- Steady State Model

3. Skills to be acquired:

- The student will be able to work out the equations of special relativity in tensor notations and wil be able to apply the same in the fields of Relativistic Quantum Mechanics, Relativistic Electrodynamics, Quantum Field Theory and Particle Physics.
- The student will be able to work out Tensor calculus and apply it to General Relativity which will enable them to apply the knowledge in fields like Cosmology and Gravitational Wave astronomy.

PS 574.3 Optics

1. Course Learning Outcomes:

- To study the various natures of progressive plane waves with relevant solutions to the plane wave equations.
- To learn the Femat's principle and Helmholtz and Lagrangian equations in magnification.
- To study the wave theory by Huygen in detail and to deduce the laws of reflection and refraction using the same.
- To study the phenomena of Interference, Diffraction and Polarization with rigorous mathematics and physical examples.
- To study Electro-optic effect and to learn to draw the index ellipsoid for crystals.
- To study the phenomenon of Acousto-optic effect and to understand Raman-Nath and Bragg diffraction in crystals.

2. Broad content of the course:

- Progressive plane waves
- Fermat's principle
- Magnification
- Helmholtz and Lagrange's equations
- Huygen's principle
- Interference
- Types of interferometers
- Diffraction
- Fresnel and Fraunhoffer diffraction
- Grating
- Resolving power
- Optical instruments
- Polarization
- Methods to achieve polarized light
- Retardation plates
- Analysis of different types of polarized light
- Electro-optic effect

- Index ellipsoid
- Acousto-optic effect
- Raman-Nath diffraction
- Bragg diffraction

3. Skills to be acquired:

- The student will know how to work out the solutions of plane waves to apply to various fields of optics and applied optics like non-linear optics.
- The student will get a clear picture of handling optical instruments like various interferometers in practical sessions as well.
- The student will also get a clear picture of analysing diffraction pattern and polarized lights.
- A clear understanding of the electro-optic effect and acousto-optic effect will be obtained by the student which will help the student to get into research areas in applied fields of physics.

PO 577.3 Experimental Techniques

1. Course Learning outcomes: By the end of the course, students will be able to

- Understand the properties of laser
- Learn about the specific laser and their applications in day today life
- Learn about the theory of nonlinear optics
- Learn about the second and third harmonic generation
- Learn the concept of nonlinear absorption coefficients, nonlinear refractive index and nonlinear susceptibility
- Learn the method of Z-scan technique
- Learn the concept of vacuum and its units
- Learn about the techniques to measure vacuum
- Learn about the working principle of different vacuum pumps
- Understand the working principles of TEM, SEM, XPS etc.

2. Broad contents of the course

- Properties of laser
- Specific lasers: solid state, Ion, dye, chemical and gas lasers
- Theory of nonlinear optics
- Second and third order harmonic generation

- Q-switching
- Z-scan technique
- Concept of vacuum and its units
- Applications of vacuum
- Vacuum gauges
- Vacuum pumps
- TEM, SEM, XPS etc

3. Skills to be learned: By the end of the course, students will be able to acquire the skills

- To choose the specific laser for particular applications
- To apply the knowledge of theory of nonlinear optics to compute nonlinear coefficients of compounds
- To use characterization techniques to analysis various compounds

Semester IV

PH 571.4 Atomic and Molecular Physics

1. Course Learning Outcome:

- To review the Bohr model and Vector model of the atom based on the experiments determining space quantization.
- To understand the structure of the simplest atomic system, the hydrogen atom by studying its various spectra.
- The interactions within the atomic system is studied using the perturbation theory for a detailed understanding of the fine and hyperfine atomic structure.
- Zeeman effect, Stark effect elucidate the influence of an external magnetic and electric field on the atomic system.
- X-ray spectra of the atoms are studied.
- The transition processes by absorption, stimulated and spontaneous emission, when an atom interacts with an electromagnetic field are studied in detail.
- The probability of transitions, rates, selection rules, lifetime of atomic states, spectral line widths, line shapes and broadening are understood.
- Molecular structure is understood for a simple diatomic molecule by studying the spectra.
- Microwave spectroscopy, infrared spectroscopy, ultraviolet-visible spectroscopy techniques of the molecular systems are studied with detailed

theory, instrumentation and application.

- Raman spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, electronic spin resonance (ESR) spectroscopy, Mossbauer spectroscopy are studied with the fundamental theoretical background, instrumentation and applications to specific systems.

2. Broad content of the course:

- Bohr and vector atom model
- Stern-Gerlach experiment
- Spectra of atomic hydrogen-fine and hyperfine structure
- Transition rates for the atomic interactions with the electromagnetic field
- Einstein's coefficients
- Microwave spectroscopy
- Infrared spectroscopy
- Ultraviolet and visible spectroscopy
- Raman spectroscopy
- Nuclear magnetic resonance (NMR) spectroscopy
- Electronic spin resonance (ESR) spectroscopy
- Mossbauer spectroscopy

3. Skills to be acquired:

- The student will understand the atomic and molecular structure in detail.
- The application of the perturbation theory to study the various atomic phenomena is understood.
- Spectroscopy studies enable the student to understand the usefulness in research and applications.

PH 572.4 Nuclear and particle Physics

1. **Course Learning Outcome:**

- The internal properties like mass, charge and size of atomic nuclei
- The external properties like binding energy, spin, electronic and magnetic moment.
- To study in detail the concept of Radioactivity.
- Detailed study on nuclear decays and their selection rules
- To study the radiation energy loss by charged particles, electrons, electromagnetic radiation and the neutrons with matter and their energy loss.
- The radiation detection through gas filled detector, semiconductor detectors and neutron detectors

- Two review the different properties of Nuclear forces like short range, saturation, charge independence, spin dependence.
- To study the ground state of the deuteron problem using square well potential and as a mixture of S and D states and to learn the electric and magnetic quadrupole moments of the Deuteron bound state.
- Yukawa's theory of nuclear forces and to explain the anomalous magnetic moment of nucleus.
- To describe basic models like liquid drop model and shell model of the atomic nucleus.
- Explain processes of nuclear collisions, nuclear reactions and cross section
- To study the classification of fundamental forces and conservation laws
- Classification of elementary particles and the properties of the particles
- Gell-Mann-Nishijima formula and CPT theorem
- Application of symmetry arguments to particle reactions

2. Broad content of the course:

- Properties of nucleus
- Nuclear decay
- Basic interactions
- Energy loss
- Radiation detection
- Nuclear forces
- Dueteron
- Yukawa'stheory
- Nuclear models
- Mass parabola
- Nuclear reaction-Q value of nuclear reaction
- Fundamental forces
- Elementary particles
- Gell-Mann-Nishijima formula
- CPT theorem
- Symmetry

3. Skills to be acquired:

- The student will be able to solve problems on nuclear physics
- The student will have an idea in general, how the nuclear radiation is interacting with matter and how it can be detected.
- In depth knowledge of the atomic nucleus
- The student shall be able to understand different nuclear models.
- The student will also be able to device various simulation to study different problems in Nuclear Physics.
- The course gives the basic insight to do research in nuclear physics

PS 574.4 Communication Theory

1. Course learning outcome: At the end of the course the student is expected to learn and assimilate the following

1. Transmission Lines, types and line parameters such as impedance, reflection coefficient, propagation constant. Line distortion and attenuation. Quarter and half wavelength lines. Impedance matching, quarter wave transformer, stub matching. Smith chart and its applications.
2. Wave guides and antenna: Basic concepts, TE and TM waves, types. Cavity resonators. Directional couplers. Electromagnetic radiation, elementary doublet, current and voltage distribution, resonant and non resonant antennas and their characteristics, grounded and ungrounded antennas. Effect of antenna height. Microwave antennas.
3. Microwave devices -Multicavity klystron, reflex klystron, parametric amplifiers, Gunn diode, Microwave transistors, FETs. Communication subsystems, description of the communication system transponders, spacecraft antennas, frequency reuse antennas, multiple access schemes, FDMA, TDMA, CDMA. Satellite communication.

2. Broad contents of thecourse:

- Transmission Lines
- Wave guides and antenna
- Microwave devices and Satellite communication

3. Skills to be learned

To draw radiation patternsfor different types of antenna and to design them.

To calculate various antenna parameters of communication.

To compare various multiple access schemes related to communication

PS 575.4 Laser, Vacuum Techniques and Nonlinear Optics

1. Course Learning outcomes: By the end of the course, students will be able to

- Understand the properties of laser
- Learn about the specific laser and their applications in day today life
- Learn about the theory of nonlinear optics
- Learn about the second and third harmonic generation
- Learn the concept of nonlinear absorption coefficients, nonlinear refractive index and nonlinear susceptibility
- Learn the method of Z-scan technique
- Learn the concept of vacuum and its units
- Learn about the techniques to measure vacuum
- Learn about the working principle of different vacuum pumps
- Understand the working principles of TEM, SEM, XPS etc techniques

2. Broad contents of the course

- Properties of laser
- Specific lasers: solid state, Ion, dye, chemical and gas lasers
- Theory of nonlinear optics
- Second and third order harmonic generation
- Q-switching
- Z-scan technique
- Concept of vacuum and its units
- Applications of vacuum
- Vacuum gauges
- Vacuum pumps
- TEM, SEM, XPS etc

3. Skills to be learned: By the end of the course, students will be able to acquire the skill

- To choose the specific laser for particular applications
- To apply the knowledge of theory of nonlinear optics to compute nonlinear coefficients of compounds
- To use characterization techniques to analysis various compounds

PS 576.4 Condensed Matter Physics- III

1. Course learning outcome: At the end of the course the student is expected to learn and assimilate the following

1. Different techniques of thin film preparation, thickness measurement techniquesnadtheorry of nucleation, properties and applications.
2. Superconductivity Principle, Types, Thermodynamics of superconductivity, BCS theory. Josephson effect and applications.
3. Smart materials of types, prepartion and properties.
4. Nanostructural materials - synthesis, characterization, organization and application.

2.Broad contents of the course:

- Thin films
- Super conductivity
- Smart materials and Nano Materials

3. Skills to be learned

- To grow thin films by some methods and characterize them
- To prepare nano materials by chemical or Physical techniques and to characterize them.
- To appreciate applications of smart materials in our day today life and identify them.

PS 577.4 Nuclear Structure

1. **Course Learning Outcome:**

- To study Deuteron problem as a mixture of S and D states and to learn the electric and magnetic quadrupole moments of the Deuteron bound state.
- Two review different properties of Nuclear forces like charge independence, spin dependence, tensor character and exchange character.
- To study Meson exchange theory and many body potential that describes the nuclear forces.
- To analyse the n-p and p-p scattering at low energies using partial wave analysis and to usderstand the spin dependence of nuclear forces.
- To learn the effective range theory, coherent scattering and examples for hydrogen in scattering studies.
- To compare the theoretical understandings and predictions with the experimental results of n-p and p-p scattering.

- To study quantitatively the Fermi gas model, Independent particle model, the collective model and the Nilsson model.

2.Broad content of the course:

- Dueteron
- Electric and magnetic quadrupole moments
- Nuclear forces
- Exchange forces
- Meson exchange
- n-p and p-p scattering
- spin dependence
- Effective range theory
- Coherent and incoherent scattering
- Collective model
- Fermi gas model
- Independent particle model
- Nilsson model

3. Skills to be acquired:

- The student will have a knowledge of solving quantum mechanical equations for problems in Nuclear Physics.
- Study of nucleon-nucleon scattering will give a better insight in understanding the form of nuclear potential in research.
- The student shall be able to understand different nuclear models.
- The student will also be able to device various simulation to study different problems in Nuclear Physics.

7. Teaching LearningProcesses

The teaching learning processes play the most important role in achieving the desired aims and objectives of the postgraduate programs in Physics as elaborated in detail in the learning based curriculum framework (LOCF). Physics is basically an experimental science as any ideas and concepts, no matter how simple, complex or far-fetched have to be tested in the laboratory by performing specific experiments designed to test, validate and confirm them before they are accepted as principles of Physics applicable to natural phenomenon. While such ideas and concepts originate in the minds of the genius, anywhere and anytime in the universe, their verifications and confirmations have to be done in the laboratory established in the real world and executed by competent and well trained scientists and engineers. To achieve this goal, the appropriate training of young individuals to become competent scientists and engineers in future have to be accomplished.

- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries equipped with adequate modern and modular furnitures and otherrequirements.
- Modern and updated laboratory equipments needed for the undergraduate laboratories and reference and text books for thelibraries.
- Sufficient infrastructure for ICT and other facilities needed for technology-enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessarysoftwares.
- Sufficient number of teachers in permanent position to do all the class room teaching and perform and supervise the laboratory experiments to be done by thestudents.
- All the teachers should be qualified as per the UGC norms and should have good communicationskills.
- Sufficient number of technical and other support staff to run the laboratories, libraries, equipmentandmaintaintheinfrastructuralfacilitieslikebuildings,electricity,sanitation,cleanliness etc.
- Teachersshouldmakeuseofalltheapproachesforanefficientteaching-learningprocess

  i.e.:

  i). Class room teachings with lectures using traditional as well as electronicboards.

  ii). Use of Smart class rooms for simulation and demonstration for conveying the difficult concepts of Physics in class room teaching andlaboratories.

  iii). Tutorials must be an integral part of all the theory and laboratory courses. Theory courses should have 1-2 tutorials every week depending upon the nature of the course.

  iv). Teaching should be complimented with students seminar to be organized very frequently.

  v). Guest lectures and seminars should be arranged by eminent teachers to be invited by the concerned college/university/HEI.

  vi). Open-ended project work should be given to all students individually or in group to 2-3 students depending upon the nature of thecourse.

vii). Internship of duration varying from one week anytime in the semester and/or 2-6 weeks during semester break and summer breaks should be arranged by the college/universities/HEI for the students to visit other colleges/universities/HEI and industrial organizations in the vicinity. If needed, financial assistance may also be provided for such arrangements to be made for their internship in the National Laboratories in the region of theinstitutions.

viii). Special attempts should be made by the institution to develop problem-solving skills and design of laboratory experiments for demonstration at the PG level. For this purpose a mentor system may be evolved where 3-4 students may be assigned to each facultymember.

ix). Teaching load should be managed such that the teacher has enough time to interact with the students to encourage an interactive/participativelearning.

8. AssessmentMethods

In the postgraduate program of Physics leading to the M.Sc. with Physics degree, the assessment and evaluation methods focus on testing the conceptual understanding of the basic ideas, development of mathematical skills and experimental techniques retention and ability to apply the knowledge acquired to explain with analysis and reason what has been learnt and to solve new problems and communicate the results and findings effectively. Since the Learning Objectives are defined clearly for each course in detail, it is easier to design methods to monitor the progress in achieving the learning Objectives during the course and test the level of achievement at the end of the course.

- A. Summative assessment for the theory papers, is a combinationofthefollowing i)Internal / classtests ii)assignmentsiii)Oral Presentations of Seminar iv) Viva -Voce Examinationv) Individual/Team Project through research vi) End Semester examination in the patternofShortAnswerand LongAnswer
- B. Laboratory Experiments / Field work / Projects / Case Study / Dissertation can be assessed for Formative Assessment through i) Regular evaluation of Lab. experiments regarding. a) written report of each experiment b) Viva-Voce on each experiment ii) Test through setting experiments by assembling components iii) Internal/ End semester examination

Theory Question Papers Pattern

Hard Core Paper

Each question paper has two parts **Part A** and **Part B**.

Part A of a hard core paper contains 8 questions with internal choice, selecting 1 question from each unit carrying 15 marks each.

Part B of hard core paper contains 4 questions out of which the candi-date has to answer 2 questions of 5 marks each.

The question paper pattern is as follows:

St Aloysius College (Autonomous), Mangaluru
End Semester Examination - M. Sc. Physics Hard Core Paper

Time: 3 hours Max marks: 70

Part A

Answer all questions choosing one from each unit. $[15 \times 4 = 60]$

Unit I

1. a

b [15 marks]

OR

2. a

b [15 marks]

Unit II

3. a

b [15 marks]

OR

4. a

b [15 marks]

Unit III

5. a

   b [15 marks]

OR

6. a

   b [15 marks]

Unit IV

7. a

   b [15 marks]

OR

8. a

   b [15 marks]

Part B

9. Answer any two questions $[5 \times 2 = 10]$

   a

   b

   c

   d

****

Soft core/Open elective paper

Each question paper consists of two parts A and B.

Part A of a soft core/open elective paper contains 6 questions with internal choice, selecting 1 question from each unit carrying 18 marks each.

Part B of soft core/open elective paper contains 6 questions out of which the candidate has to answer 4 questions of 4 marks each.

St Aloysius College (Autonomous), Mangaluru
End Semester Examination - M. Sc. Physics Soft core/Open Elective Paper

Time: 3 hours Max marks: 70

Part A

Answer all questions choosing one from each unit. $[18 \times 3 = 54]$

Unit I

1.a

b [18 marks]

OR

2.a

b [18 marks]

Unit II

3.a

b [18 marks]

OR

4.a

b [18 marks]

Unit III

5.a

b [18 marks]

OR

6.a

b [18 marks]

Part B

7. Answer any four questions $[4 \times 4 = 16]$

a

b

c

d

e

f

****

Internal Assessment

1	Two internal tests	25
2	Surprise tests, Quiz etc.	12
3	Assignment, report writing	10
4	Class participation	03
Total		50*

*From the above, the internal marks are converted into 30.

Practicals

1. One experiment of 4 hour duration will be conducted, with maximum 100 marks for each practical paper. Marks obtained by a candidate out of 100 are given a weightage of 0.7 so that the candidate is assessed out of 70 marks per paper.

2. Maximum marks for internal assessment is 30 per paper, which is awarded conducting an internal practical examination.

Course Details

Semester I					
Code	Title	Lecture/Lab	Tutorial	Nature	Credits
PH 571.1	Mathematical Physics I	4	1	HC	4
PH 572.1	Classical Mechanics	4	1	HC	4
PH 573.1	Classical Electrodynamics	4	1	HC	4
PH 574.1	Electronics	4	1	HC	4
PS 575.1P	General Physics Experiments - I	6 (Lab)		SC	3
PS 576.1P	Electronics Experiments - I	6 (Lab)		SC	3
	Seminar	2		SC Total	1 23
Semester II					
PH 571.2	Mathematical Physics II	4	1	HC	4
PH 572.2	Quantum Mechanics I	4	1	HC	4
PH 573.2	Condensed Matter Physics I	4	1	HC	4
PS 574.2	Research Methodology and Ethics	3	1	SC	3
PS 575.2P	General Physics Experiments - II	6 (Lab)		SC	3
PS 576.2P	Electronics Experiments - II	6 (Lab)		SC	3
PO 577.2	Physics of the Universe	3	1	OE	3
	Seminar	2		SC Total	1 25

Semester III					
PH 571.3	Quantum Mechanics II	4	1	HC	4
PH 572.3	Condensed Matter Physics II	4	1	HC	4
PH 573.3	Thermodynamics and Statistical Physics	4	1	HC	4
PS 574.3	Relativity and Cosmology	3	1	SC	
PS 575.3	Optics	3	1	SC	3
PS 576.3P	General Physics Experiments - III	6 (Lab)		SC	3
PS 577.3P	Computational Physics Practicals	6 (Lab)		SC	3
PO 578.3	Experimental Techniques	3	1	OE	3
	Seminar	2		SC Total	1 25
Semester IV					
PH 571.4	Atomic and Molecular Physics	4	1	HC	4
PH 572.4	Nuclear and Particle Physics	4	1	HC	4
PH 573.4P	Project	8 (Lab)		HC	4
PS 574.4	Communication Theory	3	1	SC	
PS 575.4	Lasers, Vacuum Techniques and Nonlinear Optics	3	1	SC	3
PS 576.4	Condensed Matter Physics III	3	1	SC	
PS 577.4	Nuclear Structure	3	1	SC	3
PS 578.4P	General Physics Experiments IV	6 (Lab)		SC	3
	Seminar	2		SC Total	1 22

Semester I

PH 571.1 Mathematical Physics – I

Unit I: Vector analysis and curvilinear coordinates [13 hours]
Integration of vector function - line integral, surface integral and volume integrals - vector theorems Gauss, Green's theorem and Stoke's theorem (without proof) and their applications in Physics.

Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Di-vergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylin-drical and spherical polar coordinates.

Unit II: Matrices and Tensors [13 hours]
Matrices: Review of Basic properties of matrices, Orthogonal matrices, Hermitian and Unitary matrices, Similarity and Unitary transformations, Diagonalization of matrices, Cayley - Hamilton Theorem. Eigen values and eigenvectors.

Tensors: Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contravariant, covariant and mixed tensors - First rank tensor, higher rank tensors, symmetric and antisymmetric tensors. Tensor algebra - outer product - contraction - inner product - quotient law.

Unit III: Partial Differential equations [13 hours]
First order partial differential equations for a function of two variables. Linear second order partial differential equations - classification into elliptic, parabolic and hyperbolic types. Laplace, wave and heat equations in two and three dimensions (Cartesian, cylindrical and spherical polar coordinates). Separation of variables and Singular points.

Unit IV: Special functions [13 hours]
Review of power series method for ordinary differential equations - description of beta and gamma functions.

Bessel's functions: solution of Bessel's equation-Neuman and Hankel functions - generating function and recursive relations, orthogonality of Bessel's functions - Spherical Bessel's functions.

Legendre polynomials: solution of Legendre equation - Neumann and Hankel functions, Generating function and Recurrence relation, Orthogonality property of Legendre polynomials, Associated Legendre polynomials, Associated legendre Polynomials and spherical harmonics.Laguerre Polynomials: Solution of Laguerre equation, Laguerre and associated Laguerre polynomials.

Hermite polynomials - solution of Hermite equations, generating functions and recurrence relations.

Reference books:

1. Arfken G B, Weber H J, Harris F E, 'Mathematical Methods for Physicists', (VII Edn. Academic Press, 2013)
2. Harper C, 'Introduction to Mathematical Physics', (PHI, 1976)

3. Mary L Boas, 'Mathematical Methods in the Physical Sciences', (John Wiley, 1983)
4. Kreyszig E, 'Advanced Engineering Mathematics', (X Edn. Wiley Eastern, 2011)
5. Spigel M R, 'Vector Analysis - Schaum series', (II Edn. McGraw Hill. 2009)
6. Joshi A W, 'Matrices and Tensors in Physics', (Wiley Eastern, 1995)
7. Ghatak A K , Goyal I C, Chua S J,'Mathematical Physics, Differential Equations and Transform Theory', (MacMilan Publisher India Ltd, 1985)
8. Chattopadyaya P K, 'Mathematical Physics', (Wiley Eastern, 1990)

PH 572.1 Classical Mechanics

Unit I: System of particles and Lagrangian formalism [13 hours]

Mechanics of a system of particles. Conservation of linear momentum, energy and angular momentum. Constraints. Degrees of freedom, generalised coordinates. D'Alembert's Principle, Lagrange's equations of motion. Simple applications of Lagrangian formalism. Calculus of variation, Variational principle, Euler - Lagrange equations. Advantages of variational method. Phase space, Phase trajectories. Applications to systems with one and two degrees of freedom.

Unit II: Hamiltonian formalism and Canonical transformations [13 hours]

Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion: The Hamiltonian of a particle in a central force field. Principle of least action: derivation of equation of motion, variation and end points.
Canonical transformations, Generating functions, Examples of canonical trans-formations, Infinitesimal canonical transformations. Poisson brackets. Hamilton Jacobi theory, the simple harmonic oscillator as an example. Action-angle variables.

Unit III: Central Force problem [13 hours]

Definition and characteristics. Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of the orbits, conditions for closed orbits, Virial theorem, Kepler's laws of planetary motion. Newton's law of gravitation.
Scattering in Central Force Field: general description of scattering, cross-section, impact parameter, Rutherford scattering, centre of mass and laboratory co-ordinate systems.

Unit IV: Rigid body dynamics [13 hours]

Degrees of freedom of a rigid body, angular momentum and kinetic energies of a rigid body, moment of Inertia tensor, principal moment of inertia, Euler angles, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation. Small oscillations: types of equilibriums, Quadratics forms for kinetic and Potential energies of a system in equilibrium, Lagrange's equations of motion

Reference Books:

1. Goldstein H, Poole P.C, Safko J ‘Classical mechanics’, (III Edn, Pearson 2011)
2. Landau L D, Lifshitz E M, ‘Mechanics - A course on theoretical Physics - Volume I’, (Elsevier, 2007)
3. Calkin M G, ‘Lagrangian and Hamiltonian dynamics’, (World scientific, 1998)
4. Percival I., Richards D., ‘Introduction to Dynamics’, (Cambridge Uni-versity Press, 1987)
5. Takwale R G, Puranik P S, ‘Introduction to Classical Mechanics’, (Tata McGraw Hill, 1979)
6. Greiner W, ‘Classical Mechanics: Systems of Particles and Hamiltonian Dynamics’, (Springer, 2004)
7. Rana N C, Joag P S, ‘Classical Mechanics’, (Tata McGraw Hill, 2011)
8. Upadhyaya J C, ‘Classical Mechanics’, (Himalaya Publishing House, 2012)

PH 573.1 Classical Electrodynamics

Unit I: Electrostatics and magnetostatics [13 hours]

Electrostatics - Review of scalar and vector fields. Poisson’s and Laplace’s equations. Laplace’s equation in one, two and three dimensional problems (Cartesian coordinates). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole eld, Field inside a dielectric.

Magnetostatics - vector potential. Boundary conditions. Multipole expansion of vector potential. Magnetisation. Magnetic field inside matter.

Unit II: Electromagnetic theory [13 hours]

Maxwell’s equations. Scalar and vector potentials. Gauge transformations. Coulomb gauge and Lorentz gauge. Energy and momentum in electrodynamics. Poynting theorem. Retarded potentials. Electric and magnetic dipole radiation. Lienard - Wiechert potentials. Fields of a point charge in motion, slowly moving. Power radiated by a point charge oscillation.

Unit III: Electromagnetic waves [13 hours]

Propagation of plane waves in free space, dielectrics and conducting media.

Reection and refraction of electromagnetic waves.

Wave Guides: Modes in rectangular and cylindrical wave guides. Resonant cavities. Evanescent waves. Energy dissipation. Q of a cavity.

Unit IV: Electrodynamics and Relativity [13 hours]

Special Relativity: Principle and postulate of relativity. Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Four - vector notation.

Relativistic electrodynamics: Magnetism as a relativistic phenomenon, Trans-formation of the field, Electric field of a uniformly moving point charge, Electromagnetic field tensor, Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics. Maxwell's Equations in Four Vector Notations

Reference Books:

1. Griffiths D J, 'Introduction to Electrodynamics', (III Edn. PHI, 2009)
2. Jackson J D, 'Classical Electrodynamics', (III Edn. John Wiley,1999)
3. Reitz J R, Milord F J, Christy R W, 'Foundations of ElectromagneticTheory', (III Edn. Narosa Publishing House, 1990)
4. Lorrain P and Corson D, 'Electromagnetic fields and waves', (CBS Publishers and Distributers, 1986)
5. Panofsky W K H, Phillips M, 'Classical electricity and Magnetism', (II Edn., Dover, 2005)
6. Chirgwin B H, Plumpten C, Kilmister C W, 'Elementary Electromagnetic Theory', Vols.1,2 and 3', (Pergamon Press, 1972)
7. Resnick R, 'Introduction to Special Relativity', (Wiley 2007)
8. Rindler D., 'Special Theory of Relativity', (Oxford University Press, 1982)

PH 574.1 Electronics

Unit I: Operational amplifiers [13 hours]
Opamp with negative feedback. Voltage/current feedback amplifiers. Practical opamps-output offset voltage, frequency response. Applications: sum-ming, scaling and averaging amplifoers, instrumentation ampliers, integrator, differentiator, active filters, comparators, Schmitt trigger.

Unit II: Waveform generators and Specialized IC applications [13 hours]
Sine wave, square wave, triangular wave, saw tooth wave generators, voltage-controlled oscillators, unijunction oscillators.
555 - timer - monostable and astable multivibrators - applications. Phase locked loop - phase detector. Low pass filter. Voltage controlled oscillator, frequency multipliers.

Unit III: Power Ampliers, Devices and transducers [13 hours]
Class A, B and AB amplifiers, amplifier distortion, heat sinking. SCR- Characteristics and applications. Solar cells, IR emitters. Transducers- temperature, pressure, vacuum, magnetic elds, vibration, optical and particle detectors. Signal conditioning, and shielding, Shielding and grounding, Lock in detector, Boxcar integrator, High frequency devices - Klystron, Gunn diode.

Unit IV: Digital electronics [13 hours]
The Karnaugh map - Boolean expression simplification, decoders, encoders, MUX and DeMUX.Introduction to flip-flops - RS, JK, Master and slave. Counters - synchronous and asynchronous. Shift registers, semiconductor memory RAM, ROM,PROM, EPROM, EEPROM, ash memory, CCD memory, Comparators, A/D, D/A, Microprocessor and Microcontroller basics.

Reference books:

1. Boylestad R L and Nashelsky L, ‘Electronic Devices & Circuit Theory’, (X Edn. Pearson Education India, 2009)
2. Coughlin R F and Driscoll F F, ‘Operational Amplifiers and Linear integrated circuits’, (VI Edn. Prentice Hall of India, 2009)
3. GayakwadR .A, ‘Opamps and Linear Integrated Circuits’, (Prentice Hall of India,2002)
4. Patranabis D, ‘Sensors and Transducers’, (Prentice Hall of India, 2004)
5. Murthy D. V. S, ‘Transducers and Instrumentation’, (Prentice Hall of India, 2004)
6. Rangan C S, Sarma G R, Mani V S V, ‘Instrumentation: Devices and Systems’, (Tata McGraw Hill, 1983)
7. Tocci R. J, Widemer N.S, Moss G. L , ‘Digital systems: Principles and Applications’, (Prentice Hall of India, 2009)
8. Tokheim R. L, ‘Digital Electronics: Principle and Applications’, (Mc-Graw Hill, 2007)
9. Floyd T L, ‘Digital Fundamentals’, (Pearson Education India, 2006)
10. Morris Mano M, ‘Digital logic and computer Design’, (Pearson Educa-tion India, 2008)
11. Rajaraman V, Radhakrishnan T, ‘An Introduction to Digital Computer Design’, (PHI, 2004)

PS 575.1P General Physics Experiments - I

1. Quarter Wave Plate
2. Modes of Vibration
3. Young’s Modulus by Koenig’s Method
4. Mass attenuation Coefficient using G M counter
5. e/k using Transistor
6. Study of LDR and LED using Constant Deviation Spectrometer
7. Diffraction at a Straight Edge
8. Specific Charge of electron - Thomson’s method
9. Dielectric constant and curie temperature
10. Wavelength of laser using refection grating
11. Diffusivity of Brass
12. Random nature of Radio Activity
    (Additional experiments may be added)

PS 576.1P Electronics Experiments - I

1. Monostable and Astable Multivibrator using IC 555
2. First order low pass and high pass Butter Worth filters
3. OP-AMP based Schmitt trigger
4. Astable Multivibrator using transistor
5. FET characteristics
6. Transistor biasing
7. Logic Gates

8. Amplifiers using OP-AMP
9. Clippers and Clampers
10. C E amplifier
    Additional experiments may be added

Semester II

PH 571.2 Mathematical Physics - II

Unit I: Complex variables [13 hours]

Complex variables - Review of functions of complex variables - Cauchy Reimann conditions, contour integrals, Cauchy integral theorem, Cauchy integral formula. Taylors and Laurent's series. Zero isolated singular points, simple poles, mth order pole. Evaluation of residues. The Cauchy's residue theorem. The Cauchy principle value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma. Dispersion relations. Geometrical representation - conformal mapping. Dirac delta function and its properties.

Unit II: Group Theory and Green's function [13 hours]

Groups - subgroups - classes. Invariant subgroups - factor groups. Homomor-phism and Isomorphism. Group representation - reducible and irreducible representation. Schur's lemmas, orthogonality theorem. Decomposing reducible representation into irreducible ones. Construction of representations. Representation of groups and quantum mechanics. Lie groups and Lie alge-bra. Three dimensional rotation group SO(3), SU(2) and SU(3) groups.
Introduction to Green's function, properties of Greens function, Greens function for r^2 operator, solution for Poisson equation using Green's function techniques.

Unit III: Integral Transforms [13 hours]

Fourier integral and Fourier transform - Definition - special form of Fourier integral and properties. Convolution theorem involving Fourier transform. Applications of Fourier transform. Laplace's transforms. Convolution theorem involving Laplace's transforms. Application of Laplace's transforms.

Unit IV: Numerical methods [13 hours]

Solution of a system of linear simultaneous equations. Gauss Jordan method,
Gauss - Seidel iterative method.
Interpolation - Definition of interpolating polynomial -finite difference operators - Newton's forward and backward interpolation formulas - examples.
Finite difference expression of order one and two for y' and y". Numerical
integration - integration by trapezoid and Simpson's rule, Solution of ordinary differential equations of first order, Runge-Kutta method of order 4.

Reference books:

1. Arfken G B, Weber H J, Harris F E, 'Mathematical Methods for Physicists', (VII Edn. Academic Press, 2013)
2. Harper C, 'Introduction to Mathematical Physics', (PHI, 1978)
3. Mary L Boas, 'Mathematical Methods in the Physical Sciences', (John Wiley, 1983)
4. Kreyszig E, 'Advanced Engineering Mathematics', (X Edn. Wiley Eastern, 2011)
5. Brown J W, Churchill R V, 'Complex Variables and Applications', (V Edn. McGraw Hill, 2004)

6. Joshi A W, ‘Elements of Group Theory for Physicists’, (New Age International, 1997)
7. Sastry S. S, ‘Introductory methods of Numerical Analysis’, (PHI Learning Pvt Limited, 2005)

PH 572.2 Quantum Mechanics-I

Unit I: General formulation of quantum mechanics [13 hours]
Review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle, Schrodinger equation for free particle in 1 and 3 dimensions - equation subject to forces. Probability interpretation of wave function, probability current density - normalization of wave function, box normalization, expectation values and Ehrenfest’s theorem.

Unit II: Fundamental postulates of quantum mechanics [13 hours]
Postulates of quantum mechanics, Representation of states, dynamical vari-able, adjoint of an operator. Eigen value problem, degeneracy, eigen values and eigen functions. The dirac delta function, completeness and normaliza-tion of eigen functions, closure, physical interpretation of eigen values, eigen functions and expansion coefficients, eigen functions and eigen values using commutation relations, momentum eigen functions.

Unit III: Stationary states and eigen value problem [13 hours]
Time independent Schrodinger equation, particle in square well - bound statenormalized state. Potential step and rectangular potential barrier, reflection and transmission coefficients - tunneling of particles. Harmonic oscillator, energy eigen values, energy eigen functions. Properties of stationary states.

Unit IV Angular momentum, parity and scattering [13 hours]
Angular momentum operators, eigen value equation for L^2 and L_z- separation of variables. Admissibility condition on solutions, eigen values, eigen functions. Physical interpretation. Concept of parity, rigid rotator, particle in a central potential, radial equation.
Three dimensional square well. The hydrogen atom - solution of the radial equation - energy levels. Stationary state wave functions - bound states. Theory of scattering - the scattering experiment, differential and total cross section, scattering amplitude, method of partial waves, scattering by a square well potential, Born approximation (qualitative).

Reference books:
1. Mathews P. M., Venkatesan K., ‘A text book of Quantum Mechanics’, (Tata McGraw Hill)
2. Schiff L I, ‘Quantum Mechanics’ (III Edn. McGraw Hill 1968)
3. Griffiths D J, ‘Introduction to Quantum Mechanics’, (II Edn. Pearson,21, 2011)
4. Cohen Tannoudji C, Diu B, Laloe F, ‘Quantum Mechanics (2 volumes)’, (Wiley, 1992)
5. Sakurai J J, ‘Modern Quantum Mechanics’, (II Edn. Pearson, 2011)
6. Ghatak A K, Lokanathan S, ‘Quantum Mechanics: Theory and Application’, (III Edn. Mc Millan India, 1994)
7. Powell J L, Crasemann B, ‘Quantum Mechanics’, (Addison Wesley, 1961)
8. Jain M. C., ‘Quantum Mechanics, A Textbook for Undergraduates’, (III Edn. PHI, 2012)
9. Arul Das G, ‘Quantum Mechanics’, (PHI, 2009)

PH 573.2 Condensed Matter Physics - I

Unit I: Crystallography [13 hours]

Bravais lattice. Primitive vectors. Unit cell. Primitive and conventional unit cell. Wigner - Seitz cell. Reciprocal lattice - SC, FCC, BCC. First Brillouin zone. Lattice directions, planes. Miller indices.

X-ray production and spectra. X-ray filters. X-ray diffraction. Formulation of Bragg and Von Laue condition. Ewalds construction. Experimental methods - Laue and Powder. Geometric structure factor. Atomic form factor. Symmetry operations. Crystal systems. Crystallographic point groups and space groups. Quasi - crystals.

Unit II: Crystal binding and Thermal properties of insulators [13 hours]

Bond length, bond angle, bond energy. Primary and secondary bonds. Co-ordination numbers. Ionic, covalent, molecular, hydrogen bonded crystals. Cohesive energy - Madelung constant.

Normal modes of monoatomic and diatomic lattice vibrations. Phonon momentum. Inelastic scattering of photons and neutrons by phonons. Thermal expansion. Lattice thermal conductivity - Umklapp andnormal processes.

Unit III: Free electron model of metals [13 hours]

Electrical and thermal conductivity. Hall effect. Magnetoresistance. Thermoelectric power. Born von Karman boundary condition. Density of states. Fermi energy, F.D. distribution. Electronic specific heat. Sommerfeld theory of electric conductivity. Inadequacies of free electron theory. Electrons in periodic potential

Bloch theorem. Kronig - Penney model. Brillouin zones. crystal momentum. Effective mass tensor. Concept of holes. Constant energy surface. Metals, semimetals, insulators and semiconductors.

Unit IV: Semiconductors [13 hours]

Intrinsic semiconductors: Band structure. Direct and indirect gap semicon-ductors. Effective mass. Carrier concentration.

Extrinsic semiconductors: Ionization energy of impurity atoms. Population of impurity levels. Fermi energy. Electrical conductivity. Cyclotron resonance. Quantised Hall effect. Degenerate, amorphous and organic semiconductors.

Reference books:

1. Verma A R, Srivastava O N, ‘Crystallography Applied to Solid State Physics’, (II Edn. New Age International, 2008)
2. Kittel C, ‘Introduction to Solid State Physics’, (VIII Edn. Wiley India, 2005)
3. Ashcroft N W, Mermin N D, ‘Solid State Physics’, (Harcourt Asia, 1974)
4. Ibach H, Luth H, ‘Solid State Physics’, (Narosa, 1991)
5. Omar A , ‘Elementary Solid State Physics’, (Pearson India, 1999)
6. Cullity B D, Stock S R, ‘Elements of X-ray Diffraction’, (Prentice Hall, 2001)

7. Podesta M D, ‘Understanding The Properties Of Matter’, (II Edn. Taylor - Francis, 2002)
8. Blakemore J S, ‘Solid State Physics’, (II Edn. Cambridge University Press, 1985)
9. McKelvey J P, ‘Solid State Physics for Engineering and Materials Science’, (Kreiger, 1992)
10. McKelvey J P, ‘Solid State And Semiconductor Physics’, (Kreiger, 1982)
11. Sze S M, Ng K K, ‘Physics Of Semiconductor Devices’, (Wiley India, 2012)
12. Jasprit Singh, ‘Semiconductor Devices: Basic Principles’, (John Wiley, 2007

PS 574.2 Research Methodology and Ethics

Unit1: Foundation of Research and Research Ethics (13 Hours)

Research – meaning, characteristics, objectives, motivation in research, need and importance of research. Types of Research

Ethics – meaning and definition, Ethics Vs moral philosophy, nature of moral judgments and reactions. Rights and obligations of Research Participants. Scientific conduct – ethics with respect to science and research, intellectual honesty and research integrity.

Scientific misconduct – falsification, fabrication and plagiarism. Publication ethics – meaning and importance, conflicts of interest, publication misconduct – meaning, problems that lead to unethical behaviors, types of publication misconduct, identification of publication misconduct, complaints and appeal.

Violation of public ethics, authorship and contributorship. Predatory publishers and journals – software to identify predatory publications journal finder/journal suggestions tools by JANE, Elsevier journal finder, Springer journal suggestions etc,. Selective reporting and misinterpretation of data. Self-plagiarism.

Unit 2: Research Methodology and Interpretation and Report Writing (13 Hours)

Research Problem – meaning, selecting the problem, sources of problem, statement of a problem; Review of Literature – meaning and need for literature review, sources of literature review, reporting the review of literature, identification of research gap; Research Questions; Objectives of the study.

Research Report – meaning, features of a good Research Report, elements of Research Report, format of a Research Report, Appendices and References/ Bibliography – styles.

Research design, system of interest- experimental setup-characterization-data acquisition-data analysis-reproducibility-statistical and error analysis-application studies - relevance of research

Unit 3: Intellectual Property Rights and Publication of Scholarly Papers: (13 Hours)

IPR – Concept of IPR, nature and characteristics of IPR, origin and development of IPR, justification and rationale for protecting IPR, IPR and sustainable development,

IPR and human rights, IPR issues in physical and biological sciences, Commerce and IPR issues, IPR issues in Social Sciences. Forms of IPR – copyrights, trademarks, patents, industrial designs, trade secrets, geographical indications – meaning, features and application of different forms of IPRs. Filing and Registration process of IPRs.
Publication – Scholarly/research article – meaning and features of scholarly article. Successful scientific writing – process. Reference/ bibliography writing, Dissecting research papers. Data base and Research – Data bases – indexing data base, citation data base, Web of science, Scopus etc, Research Metrics – Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics – h-index, g-index, i10 index, Altmetric.

References: (include subject related research reference books)

Indian National Science Academy (INSA). (2019). Ethics in Science Education, Research & Governance

- Barbara H Stanley J Joan E Sieber, Gary B Melton. Research Ethics: A Psychological Approach. University of Nebraska Press
- David I Bainbridge (2012), Intellectual Property Rights. Long man Publication
- Jayashree Watal. Intellectual Property Rights in the WTO and Developing Countries. Oxford University Press
- A K Singh. Tests, Measurements and Research Methods in Behavioral Sciences. Bharathi Bhawan (Publishers & Distributors), New Delhi
- Leedy P D. Practical Research: Planning & Design. Washington: Mc Millan Publishing Co., INC
- Singh Y K. Fundamentals of Research Methodology and Statistics. New International (P) Ltd., New Delhi.
- Wallinman N. Your Research Project: A Step by Step Guide for the first time Researcher. Sage Publications, London
- Kothari C R. Research methodology: Research & Techniques. New Age International Publishers, New Delhi

PS 575.2P General Physics Experiments - II

1. Michelson's Interferometer
2. Diffraction at a single slit
3. Verification of Malu's Law
4. Energy gap of a Semiconductor
5. Determinations of Cauchy's constants
6. Rydberg's Constant using Hydrogen Spectrum
7. Determination of resolving time of a G M counter (two source method)
8. Determination of Brewster's Angle
9. Young's Modulus using cantilever vibration
10. Characteristics of Photodiode using Constant deviation spectrometer
11. Fresnel's law of Reflection
12. Thermocouple

Additional experiments may be added

PS 576.2P Electronics Experiments - II

1. Monostable Multivibrator (Transistor)
2. Bi-stable Multivibrator (Transistor)
3. Two stage CE Amplifier
4. Amplitude Modulation and Demodulation
5. Frequency Modulation and Demodulation
6. Voltage Controlled Oscillator
7. Phase-shift & Wein-bridge Oscillators (Transistor)
8. Voltage regulators
9. Decoders and Encoders
10. Multiplexers and Demultiplexers
11. Phase Locked Loop - IC 565
12. Counters

Additional experiments may be added

PO 577.2 Physics of the Universe

Unit I: Astronomy and Measurement systems [13hours]
Coordinate systems: Horizontal, equatorial, Galactic, supergalactic. Measurement of times: Solar, Sidereal, universal, standard and ephemeris times. Parallax - precession, nutation, aberration. Proper motion -radial and transverse velocities, space velocity. Units of distance - AU, light year and parsec. Magnitude scale - magnitudes and luminosities (apparent and absolute), colour indices, surface temperature. Distance modulus - distances and radii of stars, double stars and the masses of stars.

Unit II: Stars and Galaxies [13 hours]
Stars: observable properties of a star. Birth and life cycle of a star. Details of death of a star: various stages: proto star, main sequence star, red giant, super giant, white dwarf, stellar explosion, neutron star, black hole. Spectral classification of stars - Hurtzsprung-Russel diagram, Binary stars. The Galaxy - structure, Classification of Galaxies. Active Galactic Nucleii.

Unit III: Evolution and Models of the Universe [13 hours]

Theories and models, stages of evolution, Steady state theory, Big bang model, Cosmic microwave background, Hubble’s law and expanding universe, accelerating universe. Evidences for expansion of universe. Dark matter and dark energy, Observable universe- age, future and end.

References:

1. Baidyanath Basu, chattopadyay T, Biswas S N, ‘Introduction to Astrophysics’ (II Edn, PHI, 2011)
2. Jayant V. Narlikar, 'Introduction to Cosmology', Cambridge University Press (2002), Third Edition.
3. Michael Berry ‘Principles of Cosmology and Gravitation’ (Cambridge University Press, 1976).
4. Abhyankar K D, ‘Astrophysics : Stars and Galaxies’, University Press India Ltd., (2001).
5. Michael Zeilik, Astronomy- The evolving Universe(John Wiley , 1996)

Semester III

PH 571.3 Quantum Mechanics - II

Unit I: Matrix formalism of quantum mechanics [13 hours]

Linear vector spaces - orthogonality and linear independence, bases and dimensions, completeness, Hilbert’s spaces. Hermitian operators. Bra and Ket notations for vectors. Representation theory. Schwartz inequality theorem- proof of Heisenberg uncertainty relation.

Unit II: Quantum dynamics [13 hours]

Equations of motion - Schrodinger and Heisenberg picture - quantum Poisson bracket. Interaction picture. Harmonic oscillator problem solved by matrix method.

Angular momentum - angular momentum operator, commutation relations - raising and lowering operators - eigen values and eigen functions of J^2 and J_z - addition of two angular momentum - Clebsch-Gordan coefficients- the 3-j symbol - Pauli spin matrices.

Unit III: Approximation methods [13 hours]

Perturbation theory for discrete levels - equations in various orders of per-turbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory.

The Variational Method - the hydrogen molecule - exchange interaction. The WKB method.

Unit IV: Relativistic quantum mechanics and elements of field quantization [13 hours]

Klein-Gordan equation for a free particle-Dirac equation- Dirac matrices-Dirac equation for central fields - negative energy solution, spin and magnetic moment of the electron.

Transition from particle to field theory. Second quantisation of the Schrodinger equation. Creation and annihilation operators - commutation and anti - com-mutation relation and their physical implications.

Reference Books:

1. Thankappan V K, ‘Quantum Mechanics’, (Wiley Eastern Ltd., 1993)
2. Merzbacher E, ‘Quantum Mechanics’, (III Edn. John Wiley & Sons, 1998)
3. Shankar R, ‘Principles of Quantum Mechanics’, (Springer, 2013)
4. Griffiths D J, ‘Introduction to Quantum Mechanics’, (II Edn. Pearson 2011)
5. Zettili N, ‘Quantum mechanics Concepts and Applications’, (II Edn. Wiley 2010)
6. Sakurai J J, ‘Modern Quantum Mechanics’, (II Edn. Pearson, 2011)
7. Schiff L I , ‘Quantum Mechanics’, (III Edn. McGraw Hill, 1969)
8. Greiner W, ‘Relativistic Quantum Mechanics: Wave Equations’, (III Edn. Springer, 2000)

PH 572.3 Condensed Matter Physics II

Unit I: Crystal Imperfections and Phase Transitions In Solids [13 hours]
Point defects. Energy of formation. Diffusion. Electrical conductivity of ionic crystals. Color centres. Polarons. Excitons.

Line defects: Dislocations, Burger’s vector. Effect on crystal growth. Crystal Strength.Whiskers.Observation of dislocations. Surface imperfections. Stacking fault.

Luminescence in solids: Fluorescence and phosphorescence. Sulphide and KCl phosphors. Thermoluminescence.

Phase Transitions in Solids: Thermodynamic classiffcation and relations at phase transitions. Order-disorder transitions. Landau theory. Transitions in ferroelectric crystals and Liquid crystals.

Unit II: Magnetism [13 hours]
Dia and paramagnetism: Atoms with completely and partially filled shells.
R-S coupling. Hund’s rules.
Brillouin- Langevin theory of paramagnetism. Rare earth and iron groupions. Pauli paramagnetism.
Magnetic order
Ferromagnetism: Exchange interaction. Heisenberg Hamiltonian.Mean field theory. Spin waves. Dispersion relation for magnons.Bloch $T^{3/2}$ law. Magnetocrystalline anisotropy. Ferromagnetic domains. Hysteresis. Hard and soft magnets. Applications. Neutron diffraction. Antiferromagnetism: Molecular field theory.
Ferrimagnetism: Meanfield theory. Spinels and garnets.

Unit III: Magnetic resonance [13 hours]
Electron spin resonance: Resonance condition, spin lattice relaxation, Line width, Absorption of microwave energy, Crystal field splitting.

Nuclear magnetic resonance: Resonance condition, Spin lattice and spin spin relaxation. Proton NMR spectroscopy. Continuous and FT-NMR. NMR spectrometer. Pulse echo method. Knight shift. Line width. Motional nar-rowing. Chemical shift. Magnetic resonance imaging. Quadrupole effects and resonance. Ferromagnetic resonance.

Unit IV: Dielectric Properties of Solids [13 hours]
Polarization. Dielectric susceptibility. Dielectric constant. Dielectric loss and loss angle.

Local electric field. Polarizability. Claussius - Mossotti relation. Electronic, ionic, dipole polarizability. Dielectric strength.
Freqency dependent dielectric function. Optical properties of ionc crystals. LST equation. Dipole orientation in solids. Langevin function. Dipole re-laxation.

Elastic properties of solids: Analysis of elastic stress and strain. Elastic com-pliance and stiffness constants. Energy density of cubic crystals and isotropic solids. Elastic waves in cubic crystals. Experimental determination of elastic constants.

Reference books:

1. Kittel C, 'Introduction to Solid State Physics', (VIII Edn. Wiley India, 2005)
2. Ashcroft N W, Mermin N D, 'Solid State Physics', (Harcourt Asia, 1976)
3. Ibach H, Luth H, 'Solid State Physics', (Narosa, 1991)
4. Rao C N R, Rao K J, 'Phase transitions in Solids', (McGraw Hill,1978)
5. Mnyukh Y., 'Fundamentals of Solid State Phase Transitions, Ferro-magnetism and Ferroelectricity', (Direct Scienti c Press, 2010)
6. Papon P, Leblond J, Meijer P H E, Schnur S L, 'The Physics of Phase Transitions', (Springer, 2006)
7. Stanley H E, 'Introduction to Phase Transition and Critical Phenom-ena', (Oxford University Press, 1987)
8. Chandrasekhar S, 'Liquid Crystals', (Cambridge University Press, 1992)
9. Coey J M D, 'Magnetism and magnetic materials', (Cambridge, 2010)
10. Jiles D C, 'Introduction to Magnetism and Magnetic Materials', (CRC Press, 1998)
11. Morrish A H, 'Physical Principles of Magnetism', (Wiley, 2001)
12. Keeler J, 'Understanding NMR Spectroscopy', (II Edn. Wiley, 2010)
13. Kaur H, 'Instrumental Methods of Chemical Analysis', (V Edn. Pra-gathiPrakashan, 2009)
14. Bruesch P, 'Phonons: Volume I, II, III', (Spinger series on Solid State Sciences, 2012)

PH 573.3 Thermodynamics and Statistical Physics

Unit I: Thermodynamics [13 hours]

Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy - Helmoltz and Gibb's functions. Maxwell's relations - TdS equations energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Application to specific heats. Probability - thermal equilibrium.

Unit II: Classical statistics [13 hours]

Ensembles: Phase space and ensembles - Liouville's theorem, Microcanonical ensemble, Canonical ensemble, Maxwell - Boltzmann distribution - partition functions - translational partition function. Gibbs' paradox, Sackur - Tetrode equation - vibrational, rotational and electronic partition functions. Boltz-mann equipartition theorems.

Unit III: Quantum statistics [13 hours]
Density operator, Statistics of ensembles - micro,canonical and grand canonical ensembles, Bose - Einstein and Fermi - Dirac distributions, Behaviour of ideal Bose gas - Bose Einstein condensation - Planck's law of black body radiation, Ideal Fermi system - Fermi temperature - Fermi energy - electron gas in metals.

Unit IV: Random motion and fluctuations [13 hours]
Brownian motion - Langevin theory - Einstein relations, Approach to equilibrium - Fokker Planck equation, Fluctuations - fluctuation dissipation theorem power spectrum of fluctuations - persistence and correlation of fluctuation- Wiener-Khinchin theorem, Nyquist theorem.

Reference Books:

1. Zemansky M W, Dittman R H, 'Heat and Thermodynamics', (VIII Edn. McGraw Hill International Edn. 2011)
2. Reif F, 'Fundamentals of Statistical and Thermal Physics', (Levant Books 2010)
3. Pathria R K, 'Statistical Mechanics', (III Edn. Elsevier 2011)
4. Kerson Huang, 'Statistical Mechanics', (II Edn. Willey India, 2010)
5. Daniel V Schroeder, 'An Introduction to Thermal Physics', (Pearson, 2008)
6. Landau L D, Lifshitz E M, 'Statistical Physics', (III Edn. Oxford, 1980)

PS 574.3 Relativity and Cosmology

Unit I: Special Relativity [13 hours]
Review of Lorentz Transformations and its consequences (Length contraction and time dilation). Relativistic Doppler effect and aberration of light. Mass energy equivalence and relativistic energy-momentum relation. Transformation of momentum. Relativistic force and relativistic dynamics.
Lorentz transformation in tensor notation. Four vectors. Scalar products of four vectors. Metric tensor. Invariant interval and spacetime diagrams. Velocity and momentum four vectors. Minkowski force. Lorentz boost.

Unit II: General Relativity [13 hours]
Tensor Calculus: Metric tensor, Affine connection, Covariant differentiation, parallel transport, Riemann-Christoffel curvature tensor, Ricci tensor, Geodesics.
Principle of Equivalence, Gravitational red shift, Principle of General Covariance, Derivation of Einstein field equation.

Schwarzchild solutions, Schwarzchild radius, Schwarzchild singularity. General equations of motion, Deflection of light by sun, Precession of perihelia.

Unit III: Cosmology [13 hours]
The cosmological principle, Robertson-Walker metric, Red-shift. Cosmic microwave radiation background, Early universe, Formation of galaxies. Cosmological models: Olber's paradox, Steady state model, Hubble's law, Expanding Universe, Inflationary model.

Reference Books:

1. Resnick R, ‘Introduction to Special Relativity’, (Wiley India, 2005)
2. Dixon W G, ‘Special Relativity: The Foundation of Macroscopic Physics’, (Cambridge University Press, 1982)
3. Weinberg S, ‘Gravitation and Cosmology: Principles and Applications of The General Theory of Relativity’, (Wiley, 2013)
4. Hartle J B, ‘Gravity: An Introduction to Einstein’s General Relativity’, (Pearson, 2003)
5. Schutz B F, ‘A First Course in General Relativity’, (Cambridge Uni-versity Press, 1985)
6. Narlikar J V, ‘An Introduction to Cosmology’, (Cambridge University Press, 2002)
7. Narlikar J V, ‘An Introduction to Relativity’, (Cambridge University Press, 2010)
8. Weinberg S, ‘Cosmology’, (Oxford University Press, 2008)

PS 575.3 Optics

Unit I: Nature of Light [13 hours]

Waves: Plane progressive wave in 1-D and 3-D. Plane wave and sphericalwave solutions. Dispersion: phase velocity and group velocity. Fermat’sprinciple: Fermat’s principle and its application on plane and curved surfaces. Different types of magnification:Helmholtz and Lagrange’s equations, paraxial approximation, introduction to matrix methods in paraxial optics - simple application. Wave theory of light: Huygen’s principle; deduction of law of reflection and refraction.

Unit II: Physical Optics [13 hours]

Interference: Young’s experiment; spatial and temporal coherence; intensity distribution; Fresnel’s biprism, interference on thin film, Newton’s ring. Michelson’s interferometer. Multiple beam interference- reflected and transmitted pattern. Fabry-Perot interferometer.

Diffraction of light waves: Fresnel and Fraunhofer class, Fresnel’s half period zones; zone plate. Fraunhofer diffraction. Plane diffraction grating (trans-mission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating.

Polarisation: Different states of polarisation; double refraction, Huygen’s construction for uniaxial crystals; polaroids and their uses. Production and analysis of plane, circularly and elliptically polarised light by retardation plates and rotatory polarisation.

Unit III: Applied optics: Electro-optic and Acousto-optic effects [13 hours]

Electro optic effect: Introduction, Electro optic effect in KDP crystals (longi-tudinal and transverse modes), index ellipsoid in the presence of an external electric field

Acousto-optic effect: Introduction, Raman-Nath diffraction, Experimental set up and theory, Bragg diffraction, Bragg diffraction for small angles and large angles.

References

1. Hecht E, "Optics", Pearson Education, 5th edition (2015)
2. Jenkins F. A., White H. E., "Fundamentals of Optics", Tata Mc-Graw Hill Education (2011)
3. Ghatak A. K., "Optics", IV Ed. Tata Mc-Graw Hill Education (2005)
4. Halliday D., Resnick R., Walker J., "Fundamentals of Physics", IX Ed. John Wiley and & Sons (2011)
5. Ghatak A. K., Thyagarajan K., "Optical Electronics", Cambridge Uni-versity Press, (1991)

PS 576.3P General Physics Experiments - III

1. Lorentz number of Copper
2. Magnetic susceptibility - Quincke's method
3. Magnetic susceptibility - Gouy's method ($NiSO_4$, $FeSO_4$, $CoSO_4$)
4. Magnetic Field Mapping around a Circular Coil carrying current
5. Babinet's Compensator
6. U V Spectroscopy
7. Hall effect - Determination of Hall Coefficient
8. Diffraction at a Straight Wire
9. Young's Modulus ByCornu's Method
10. End Point Energy of Beta Particles
11. Energy Gap using Optical Method
12. Photodetector Characteristics

Additional experiments may be added

PS 577.3P Computational Physics Practicals

1. Basic C/C++ programmes to use for, while, do, switch, break, continue instructions.
2. Array, strings, functions, pointer programmes.
3. Programmes on basic Numerical techniques
4. Programmes to solve Schrodinger, heat and wave equations. Additional programmes may be added.

PO 578.3 Experimental Techniques

Unit I: Lasers and Nonlinear optics [13 hours]

Lasers: Introduction - directionality, intensity, monochromaticity, coherence. Some specific laser systems - Ruby laser, Neodymium lasers, He - Ne laser, ion lasers, CO_2 laser, Semiconductor lasers, Q switching.

Nonlinear optics: harmonic generation, second harmonic generation, phase matching, third harmonic generation, Z-scan technique, optical mixing, para-metric generation of light - self focussing of light. Electro optic effect.

Unit II: Vacuum techniques [13 hours]

Units of vacuum, vacuum spectrum (ranges - low, medium, high, ultra high). Applications - freeze drying, vacuum coating, industrial applications. Con-ductance of pipes, pumping speed, throughput, pumpdown time.

Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure), oil diffusion pump - baffle and trap, cryopump, turbomolecular pump.Vacuum gauges - vacuum gauges and the relevant range of vacuum, Pirani gauge, thermocouple gauge, Penning gauge, hot cathode ionisation gauge.

Unit III: Microstructure study techniques [13 hours]

TEM: Principle and components, imaging method. Contrast formation, sample parameters, Application, limitation.

SEM: Principle, components, image contrast, Application , limitation.

Atomic force microscopy: Principles, imaging modes, advantages and disad-vantages.

X-ray Photoelectron spectroscopy: Principles, components. (XPS/ESCA).

Energy dispersion spectroscopy (EDS).

Electron probe micro analysis (EPMA).

Low energy electron diffraction (LEED).

Reference Books:

1. Silfvast W T, ‘Laser Fundamentals’, (Cambridge University Press, 1998)
2. Ghatak A K, Thyagarajan K, ‘Optical Electronics’, (Cambridge Uni-versity Press, 1991)
3. Laud B B, ‘Lasers and Nonlinear Optics’, (Wiley Eastern, 1985)
4. Mills D L, ‘Nonlinear Optics - Basic Concepts’, (Narosa Publishing, 1991)
5. Boyd R W, ‘Non Linear Optics’, (Academic Press, 1992)
6. Shen Y R, ‘The Principles of Non Linear Optics’, (Wiley, 1984)
7. Saxby G, ‘Practical Holography’, (Taylor & Francis, 2003)
8. Roth A, ‘Vacuum Technology’, (III Edn. Elsevier, 2012)
9. Umrath W, ‘Fundamentals of Vacuum Technology Technology’, (Oer-likonLeybold, 2007)
10. Hata D M, ‘Introduction to Vacuum Technology’, (Prentice Hall, 2007)

11. Smallman R E, Ngan A H W, ‘Physics Metallurgy and Advanced Ma-terials’, (Butterworth, 2011)
12. Ray F Egerton, ‘Physical Principles of Electron Microscopy - An Introduction to TEM, SEM and AFM’, (Springer, 2005)
13. Williams D B, Carter C B, ‘Transmission Electron Microscopy: A Textbook of Materials Science (Four Volumes)’, (Springer, 2008)
14. Leng Y, ‘Materials Characterisation’, (Wiley, 2008)
15. Goodhew P, Humphreys J, Beanland R, ‘Electron Microscopy and Analysis’, (Taylor & Francis, 2000)
16. Suryanarayana C, ‘Experimental Techniques in Materials and Mechanics’, (CRC Press, 2011)
17. Zhang S, Li L, ‘Materials Characterization Techniques’, (CRC Press, 2008)

Semester IV

PH 571.4 Atomic and Molecular Physics

Unit I: Atomic Spectra: [13 hours]
Atomic spectra and the Bohr model for hydrogen, Vector atom model, Quantum Numbers, Moseley’s law, The Stern-Gerlach Experiment- Angular momentum and Spin, X-ray spectra. Fine structure, Hyper fine structure, Lamb effect, Zeeman effect , Stark effect, LS Coupling, jj coupling.

Unit II: One electron and many electron atomic systems [13 hours]
Hydrogenic atoms, Schrodinger equation for one-electron atoms, Interaction of Hydrogenic atoms in an electromagnetic field, Transition rates: sponta-neous absorption, stimulated emission, spontaneous emission, dipole approx-imation. Line shape and line width, line broadening mechanisms (qualita-tive). The central field approximation for many electron atoms.

Unit III: Microwave, Infrared and Electronic spectroscopy [13 hours]
Microwave Spectroscopy: Theory of rotational spectra of diatomic molecules - Experimental technique-structural information. Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in chemical analysis. Electronic spectra of diatomic molecules- coarse structure-Frank-Condon principle - rotational fine structure-formation of band head and shading of bands - determination of I, r and band origin.

Unit IV: Raman and Spin Resonance Spectroscopies [13 hours]
Raman Spectroscopy: Light scattering and Raman effect, classical model for scattering, Stokes and anti-Stokes lines, polarizability, instrumentation.

Spin Resonance Spectroscopies: nuclear spin and electron spins, effect of applied external fields, Nuclear Magnetic Resonance (NMR) spectroscopy, Electron Spin Resonance (ESR) spectroscopy, basic principles and examples, instrumentation. Mossbauer Spectroscopy: Principles and Applications, instrumentation.

Reference books:

1. Brandsen B H, Joachaim C J, 'Physics of atoms and molecules', (Long-man, 1983)
2. Eisberg R, Resnick R, 'Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles', (II Edn. John Wiley & Sons, 2010)
3. Sakurai J J, 'Modern Quantum Mechanics', (II Edn. Pearson, 2011)
4. Cohen Tannoudji C, Diu B, Laloe F, 'Quantum Mechanics (2 volumes)', (Wiley)
5. Banwell C N, McCash E M, 'Fundamentals of Molecular Spectroscopy', (IV Edn. Tata McGraw Hill, 1994)
6. Michael Hollas J, 'Modern Spectroscopy', (IV Edn. Wiley India, 2010)
7. Aruldhas G, 'Molecular Structure and Spectroscopy', (Prentice Hall of India, 2002)
8. Herzberg G, 'Molecular Spectra and Molecular Structure, Vol. I, II & III', (Van Nostrand Co., 1966)
9. Max Born, 'Atomic Physics', (VIII Edn. Dover, 1989)
10. Herzberg G, 'Atomic Spectra and Atomic Structure', (Dover, 1944)
11. Ghoshal S N, 'Atomic and Nuclear Physics', Vol I and Vol II (S Chand and Co., 1994)

PH 572.4 Nuclear and Particle Physics

Unit I: General properties of nuclei and nuclear decay [13 hours]

Constituents of nucleus and their properties. Nuclear radius, distribution of nuclear charge, determination of nuclear radius by mirror nuclei method. Mass of the nucleus and abundance of nuclides. Nuclear binding energy- semi empirical mass formula- stability of the nuclei against beta decay-mass parabola. Nuclear electromagnetic moments.

Nuclear decay - Alpha decay - quantum mechanical tunnelling - wave mechanical theory, angularmomentum and parity selection rules

Beta decay - Energy release in beta decay, Fermi theory of beta decay, shape of the beta spectra, Kurie plots, angular momentum and parity selection rules, comparative half lives

Gamma decay –Energetics of gamma decay, angular momentum and parity selection rules, internal conversion(qualitative only).

Unit II: Interaction of radiation with matter and radiation detectors [13 hours]

Energy loss of heavy charged particles and electrons in matter, Bethe - Bloch formula. Range and range straggling. Interaction of gamma rays- interaction mechanisms - photoelectric absorption, Compton scattering, Klein–Nishina formula (qualitative discussion), pair production processes.Attenuation Coefficients: Total Linear Attenuation Coefficients and Mass Attenuation Coefficients. Interaction of neutrons-fast and slow neutron interaction.

Radiation detectors - Gas filled counters, Scintillation detectors, Semiconductor detectors.Neutron detectors.

Unit III: Nuclear forces and nuclear models [13 hours]

Nuclear Forces: General characteristics of Nuclear forces, the ground state of the deuteron,magnetic dipole and electric quadrupole moments of the deuteron. Exchange forces-Meson theory/ Yukawa's theory of nuclear force.

Shell model: Evidence for shell structure in nuclei –square well potential–energy level

scheme– spinorbit potential, reproducibility of magic numbers with the spin orbit splitting of energy levels.
Nuclear reactions-Reaction cross sections. Types of reactions:Direct and compound nuclear-reactions. Energetics of nuclear reactions: reaction Q value and threshold energy for a reaction. Resonance in nuclear reaction.

Unit IV: Particle Physics [13 hours]
Types of interaction in nature-typical strengths and time-scales, elementary particles and their characteristics, conservation laws: conservation of baryon number, lepton number,isospinstrangeness. The Eightfold way, Quarks and quark model.
Gell-Mann-Nishijima formula, C, P and T invariance, CP violation, the CPTtheorem. Applications of symmetry arguments to particle reactions, parity non conservationin weak interactions.

Reference books:

1. Krane K S, ‘Introductory Nuclear Physics’, (John Wiley, 1988)
2. Patel S B, ‘Nuclear Physics - An Introduction’, (Wiley Eastern, 1991)
3. Roy R K, Nigam P P, ‘Nuclear Physics - Theory and Experiment’, (Wiley EasternLtd., 1993)
4. Evans R D, ‘The Atomic Nucleus’, (Kreiger, 2003)
5. Friedlander G, Kennedy J W, Macias E S, Miller J M, ‘Nuclear and Radiochemistry’,(John Wiley, 1981)
6. Knoll G F, ‘Radiation Detection and Measurement’, (II Edn. John Wiley, 1989)
7. Kapoor S S, Ramamurthy V S, ‘Nuclear Radiation Detectors’, (New AgeInternational, 1986)
8. Singru R M, ‘Introduction to Experimental Nuclear Physics’, (Wiley Eastern, 1975)
9. Segre E, ‘Nuclei and Particles’, (W A Benjamin Inc., New York, 1965)
10. Griths D J, ‘Introduction to elementary particles’, (II Rev Edn. Pear-son, 2001)

PH 573.4P Project

Guidelines for the preparation, presentation and evaluation of students research projects in semester IV (Science Faculty)

Preamble

Research based learning has become an integral part of education at higher level. Autonomy provided to the college has created opportunities for introducing innovativeness through effective learning. In this regard, the choice based credit system introduced to postgraduate programmes from the year 2016-17 has introduced the concept of project work in the fourth semester for four credits.

Research projects play an important role in the curriculum, wherein students develop a research culture by going through the published research articles, documents, choosing a relevant problem, preparing and collecting relevant materials/samples, analyzing and characterising them to arrive at their own findings and conclusions. It is a work that a student must do largely under his / her own direction, in the field of the chosen area, however faculty members will extend their help and guidance towards the implementation of the project work.

This guideline describes the procedures to be followed in the due course of implementation of the project. It outlines the general rules and regulations which govern the project, in terms of research work both theoretical and experimental, preparation of thesis and presentation/publication.

Planning the Project Work

The Students are advised to begin choosing relevant area of their interest during the third semester itself. However by the end of third semester he/she should meet the Head of the department with few project plans of his choice in the order of priority.

Allotment of the Project Work

By the end of third semester, the Head of the department in consultation with other members of his/her department, study the feasibility of the student’s proposal in terms of materials(chemicals), facility, space and cost effectiveness, expertise in the relevant area etc. and allot a group of students to a particular project and a supervisor. By and large student’s selected area is allotted without any bias.

The Role of Supervisor

The supervisor will be able to advise the student about all aspects of the project as it unfolds. He/she must be able to foresee the relevance, applicability and its uniqueness. He will constantly monitor the progress and the quality of the work and give appropriate direction as and when it demands through his/her availability in the department/Lab. He/she also should make the student aware of inadequate progress or any other facts which could impede the completion of a successful piece of work.

Responsibilities of the Student

A student should spend a minimum of 8 hours for the project in the library by referring the articles or in laboratory by doing the experimental work in a week throughout the fourth semester. Student should try to keep supervisor informed about the progress and plans in respect of the project. To make appointments with the supervisor on a regular basis, if he/she is facing difficulty in arranging appointments he/she must contact the Head of Department.

Student should submit at least two written progress reports prior to the presentation in the department. Students should accept the constructive criticism of the supervisor in the point of improving the quality of research work of his/her project.

Assessment

Internal (Out of 30):

1. Action plan: Review of literature/ plan of work/ Synopsis: 10 marks
2. Actual work, results, interactions and regular submission of reports: 10 marks
3. Presentation in front of all members of the department before preparing the final thesis; (The faculty members may fine tune or give suggestions to improve the quality of final work at this stage): 10 marks

Plagiarism Requirement

The project report has to be scrutinised through plagiarism check software as per UGC requirement. Only successful projects will be accepted.

External examination

External examination will be conducted in a similar manner to practical examinations. A

group of 10-12 students allotted to a batch. One internal and one external examiner approved by Board of studies of the concern department will conduct viva-voce.
The marks are distributed as follows (out of 70)

Thesis (report) content: 45 marks

(45 marks are split into 40+5; Out of 45 marks, 3 marks are allotted to the student, who present the paper in any conference and the remaining 2 marks are allotted for the student if he/she wins a prize in the paper presentation.)

Presentation in the final examination: 15 marks

Viva-voce: 10 marks

The student should prepare one or two (if demanded by the department) copies of the report which he/she can preserve for themselves after the final viva-voce.

Note: Due to lack of space to keep bound copies of the project reports, the department may instruct the students to submit the department (library) copy of the project report in compact disc (CD) form. However good projects (at least 3 to 5 in a year) which are worth referring can be preserved in the bound copy form in the department. The same can be used to present before committees (NAAC, DST, LIC etc.) at the time of inspection. This can be told to students in their pre-viva presentation (presentation in the department).

Project report format

COVER PAGE (AS PROVIDED)
FRONT PAGE (AS PROVIDED)
CERTIFICATE (AS PROVIDED)
ACKNOWLEDGEMENT
DECLARATION (AS PROVIDED)

CONTENTS

1. INTRODUCTION
2. REVIEW OF LITERATURE
3. AIM AND OBJECTIVE
4. METHODOLOGY / EXPERIMENTATION / MATERALS & METHODS
5. RESULTS and DISCUSSION
6. CONCLUSIONS
7. REFERENCES

Introduction: This includes the background of the work, lacuna if anyin previous work and importance of the present work. The last part of introduction must highlight the objectives. The objectives should give a clear picture of the project.

Review of Literature: Includes the study and experimentation carried out by other workers on the topic which is being studied in the present project. The subheadings may be given at appropriate places for covering the topic under consideration. The subheadings may be appropriately numbered, for example, 2.1, 2.1.1, 2.2, etc. The literature must be cited with suitable references for example (Subbiahetal:; 2005), (RaviandHarish; 2009) etc.

Materials and Methods: The write -up must include the Materialsused for the project work. Brand names of equipments and chemicals need to be specified. The methodology must be described brefly (the main principle involved is sufficient) citing the reference from which it is based. Only if the method is new, give detailed explanation.

RESULTS AND DISCUSSIONS: This chapter must include the results of the project developed. The results must be depicted as figure, tables, graphs etc. Also the results must be explained in words. The comparison of the results, statisitical significance of the results should be discussed in this chapter. The concluding remarks may be included specifying how the project can help the end user.

Conclusions: This includes the end result derived from the project and any further scope of research which can be carried out using the present work.

References: At the end of the report 30 to 50 references relevant to the topic chosen should be given. The style of reference can be chosen according to any good international journal of the concern PG program. It is left to the discretion of the department.

Examples to write the references

1. For references from journals:

Bhaghyesh et. al., "$\gamma\gamma$ and gg decays of χ_{c0} and χ_{c2}", *Archives of Physics Research*, (2010), **1** (4): 200-204.

2. For references from books:

Arfken G B, Weber H J, Harris F E, "Mathematical Methods for Physi-cists’, VII Edn., Academic Press, (2013).

Cover Page

TITLE
(Times New Roman, Font size 20, Capitals, Bold)

A Project Report
Submitted by
(Times New Roman, Font 12)

NAME
(Reg. No.)
(Times New Roman, Font 12, Bold, Capital)

to

ST ALOYSIUS COLLEGE
(AUTONOMOUS)

In partial fulfilment of the requirements for the award of
Master of Science
(Times New Roman, Font 16,)
PHYSICS
(Times New Roman, Font 16,Capital,)

Department of PG Studies and Research in Physics
(Times New Roman, Font 16)

April, 2023
(Times New Roman, Font 16)

Front page

TITLE
(Times New Roman, Font size 20, Capitals, Bold)

A Project Report
Submitted by
(Times New Roman, Font 12)

NAME
(Reg. No.)

Under the guidance of
NAME OF THE SUPERVISOR

to

ST ALOYSIUS COLLEGE
(AUTONOMOUS)

In partial fulfilment of the requirements for the award of
Master of Science
PHYSICS
(Times New Roman, Font 16,)

Department of PG Studies and Research in Physics
(Times New Roman, Font 16)

April, 2023
(Times New Roman, Font 16)

CERTIFICATE

This is to certify that the project report entitled "Title" is a bonafied work carried out by (Name, Reg.No.)under the guidance of (Name of the Guide) in the Department of PG Studies and Research in Physics, St Aloysius College.

The same is being submitted to the Department of Post Graduate Studies and Reserach in Physics, St Aloysius College in partial fulfilment of the requirements for the award of Master of Science- Physics. No part of this thesis has been presented for the award of any other degree.

Name and Signature of HOD   Name and Signature of the Guide

ACKNOWLEDGEMENT

In the "Acknowledgement" page, the writer recognizes his/her indebtedness for guidance and assistance of the different persons and members of the faculty. Courtesy demands that he/she also recognize specific contributions by other persons or institutions such as libraries and research foundations/funding agencies. Acknowledgements should be expressed simply, tastefully, and tactfully.

DECLARATION

I/We, Name hereby declare that the project work entitled "Title" is my/our original work and has been carried out under the guidance of Name of the Guide, PG Department of Physics, St Aloysius College is being submitted to the Department of PG Studies and Research in Physics (Department Name), St Aloysius College in partial fulfillment of the requirements for the award of Master of Science - Physics.

I also hereby declare that this work, in part or full, has not been submitted to any other University/Institution for any Degree/Diploma.

Date of Submission: Signature of the candidate
(NAME)
(Reg. No.)

Signature of the Supervisor
(NAME)

PS 574.4 Communication Theory

Unit I Transmission Lines [13 hours]

Distributed parameters, types of transmission lines, calculation of line parameters. Inductance and capacitance of parallel round conductors, coaxial cables. Voltage, current and impedance relations. Characteristic impedance, reection coefficient, propagation constant. Line distortion and attenuation. Line parameters at high frequencies, Line termination. Standing wave ratio. Quarter and half wavelength lines. Impedance matching, quarter wave transformer, stub matching. Smith chart and its applications.

Unit II Wave guides and antenna [13 hours]

Basic concepts, guided waves between parallel planes. TE and TM waves. Rectangular wave guides. Qualitative treatment of circular wave guides, com-parison with coaxial cable, wave guide coupling. Matching and attenuation, cavity resonators. Directional couplers.

Electromagnetic radiation, elementary doublet, current and voltage distribution, resonant and non resonant antennas, radiation pattern, antenna gain, effective radiated power, antenna resistance, bandwidth, beam width, polarisation, grounded and ungrounded antennas. Effect of antenna height. Microwave antennas.

Unit III Microwave devices and Satellite communication [13 hours]

Multicavity klystron, reflex klystron, parametric amplifiers, Gunn diode, Mi-crowave transistors, FETs.

Communication subsystems, description of the communication system transponders, spacecraft antennas, frequency reuse antennas, multiple access schemes, frequency division multiple access, time division multiple access, code division multiple access. Tracking geostationary satellites. Examples of satellite communication systems - IRS and INSAT series.

Reference Books:

1. Ryder J D, "Networks, Lines and Fields", II Edn. (PHI, 1997)
2. Tomasi Wayne, "Electronic Communication Systems", (Pearson Edu-cation Asia, 2001)
3. Kennedy G., Davis B., "Electronic Communication Systems", IV Edn. (Tata McGraw Hill, 1993)
4. Roddy D., Coolen J., "Electronic Communications", IV Edn. (PHI, 1995)
5. Kraus J D, Fleisch D A, "Electromagnetics with Applications", V Edn. (McGraw Hill, 1999)
6. Ghatak A K, Thyagarajan K, "Optical Electronics’, (Cambridge University Press, 1991)
7. Taub H, Schilling D L, "Principles of Communication System", II Edn. (McGraw Hill, ISE, 1986)
8. Liao S Y, "Microwave Devices and Circuits", III Edn. (PHI)
9. Roddy D, "Satellite Communications", III Edn. (McGraw Hill, 2001)

PS 575.4 Lasers, Vacuum techniques and Nonlinear Optics

Unit I: Lasers and Nonlinear optics [13 hours]
Lasers: Introduction. Some specific laser systems - Neodymium lasers, ion lasers, CO_2 laser, dye lasers, chemical lasers, X-ray lasers, free electron lasers, Q switching, mode locking.

Nonlinear optics: harmonic generation, second harmonic generation, phase matching, third harmonic generation, Z scan technique, optical mixing, para-metric generation of light - self focussing of light. Electro optic effect.

Unit II: Vacuum techniques [13 hours]
Units of vacuum, vacuum spectrum (ranges - low, medium, high, ultra high). Applications-freeze drying, vacuum coating, industrial applications. Con-ductance of pipes, pumping speed, throughput, pumpdown time.

Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure), oil diffusion pump - baffle and trap, cryopump, turbomolecular pump. Vacuum gauges - vacuum gauges and the relevant range of vacuum, Pirani gauge, thermocouple gauge, Penning gauge, hot cathode ionisation gauge.

Unit III: Microstructure study techniques [13 hours]
TEM: Principle and components, imaging method. Contrast formation, sample parameters, Application, limitation.
SEM: Principle, components, image contrast, Application , limitation.
Atomic force microscopy: Principles, imaging modes, advantages and disad-
vantages.
X-ray Photoelectron spectroscopy: Principles, components. (XPS/ESCA).
Energy dispersion spectroscopy (EDS).
Electron probe micro analysis (EPMA).
Low energy electron diffraction (LEED).

Reference Books:

1. Silfvast W T, ‘Laser Fundamentals’, (Cambridge University Press, 1998)
2. Ghatak A K, Thyagarajan K, ‘Optical Electronics’, (Cambridge Uni-versity Press, 1991)
3. Laud B B, ‘Lasers and Nonlinear Optics’, (Wiley Eastern, 1985)
4. Mills D L, ‘Nonlinear Optics- Basic Concepts’, (Narosa Publishing, 1991)
5. Boyd R W, ‘Non Linear Optics’, (Academic Press, 1992)
6. Shen Y R, ‘The Principles of Non Linear Optics’, (Wiley, 1984)
7. Saxby G, ‘Practical Holography’, (Taylor & Francis, 2003)
8. Roth A, ‘Vacuum Technology’, (III Edn. Elsevier, 2012)
9. Umrath W, ‘Fundamentals of Vacuum Technology Technology’, (Oerlikon Leybold, 2007)
10. Hata D M, ‘Introduction to Vacuum Technology’, (Prentice Hall, 2007)
11. Smallman R E, Ngan A H W, ‘Physics Metallurgy and Advanced Materials’, (Butterworth, 2011)
12. Ray F Egerton, ‘Physical Principles of Electron Microscopy - An Introduction to TEM, SEM and AFM’, (Springer, 2005)

13. Williams D B, Carter C B, ‘Transmission Electron Microscopy: A Textbook of Materials Science (Four Volumes)’, (Springer, 2008)
14. Leng Y, ‘Materials Characterisation’, (Wiley, 2008)
15. Goodhew P, Humphreys J, Beanland R, ‘Electron Microscopy and Analysis’, (Taylor & Francis, 2000)
16. Suryanarayana C, ‘Experimental Techniques in Materials and Mechanics’, (CRC Press, 2011)
17. Zhang S, Li L, ‘Materials Characterization Techniques’, (CRC Press, 2008)

PS 576.4 Condensed Matter Physics III

Unit I: Thin films [13 hours]

Preparation techniques. Physical vapour deposition. Knudsen cosine law. Sputtering and chemical methods. Thickness measurement techniques - quartz crystal monitor.

Nucleation and growth, Capillary theory of nucleation. Growth stages and effect of deposition parameters. Electrical and optical properties of thin films. Conduction in thin films - a qualitative description. Reflectance and transmittance of light by thin films. Anti reflection coating, reflection coating and interference filters.

Unit II: Super conductivity [13 hours]

Type I and Type II superconductors. Thermodynamics of superconductivity. London equations. Coherence length. Flux quantization, Cooper pairs. Accomplishments of BCS theory. Basic concept of tunnelling: metal-insulator - metal; metal - insulator - superconductor, superconductor - insulator
superconductor tunnelling. Cooper pair tunnelling. AC and DC Josephson effect. SQUIDS. High T_c superconductors. Applications.

Super fluids.

Unit III: Smart materials and Nano Materials [13 hours]

Piezoelectric materials, smart polymers and gels, shape memory materials - alloys and polymers. Electro - rheostatic and magneto: rheostatic materials, magnetostrictive materials, electrogenic and chromogenic systems, electrochromic, thermochromic, photochromic materials, ferrouids, Photomechanical materials, dielectric elastomers.

Nanostructural materials - metals, semiconductors and ceramics. Synthesis of nano particles - inert gas evaporation, laser pyrolysis - sputtering techniques, plasma techniques, chemical methods.

Functionalized metal nano particles - synthesis, characterization, organization and applications.

Reference books:

1. Goswami A, ‘Thin film fundamentals’, (New Age International, 1996)
2. Ohring M, ‘The Materials Science of Thin films’, (Academic Press, 1992)
3. Wagendristel A, Wang Y, ‘An Introduction to Physics and Technology of Thin Films’, (World Scientific, 1994)
4. Chopra K L, ‘Thin Film Phenomena’, (Kreiger Publ., 1979)
5. Callister W, Rethwisch D G, ‘Materials Science and Engineering’, (John Wiley, 2010)
6. Van Vleck L H, ‘Elements of Materials Science and Engineering’, (Pear-son, 2002)
7. Smith W F, Hashemi J, Raviprakash, ‘Materials Science and Engineering’, (Tata McGraw Hill, 2008)

8. Ashcroft N W, Mermin N D, ‘Solid State Physics’, (Harcourt Asia, 1976)
9. Ibach H, Luth H, ‘Solid state Physics’, (Narosa, 1991)
10. Kittel C, ‘Introduction to Solid State Physics’, (VIII Edn. Wiley India, 2005)
11. Annet J F, Wills H H, ‘Superconductivity, Superuids and Condensates’, (Oxford University Press, 2004)
12. Tinkham M, ‘Introduction to Superconductivity’, (II Edn., Dover, 2012)
13. Schwartz M, ‘Encyclopedia of Smart Materials’, (Wiley Interscience, 2005)
14. Radheshyam Rai, ‘Synthesis, Characterisation and Apllications of Smart Materials’, (Nova Science Publishing, 2012)
15. Culshaw B, ‘Smart Structures and Materials’, (Artech House, 1995)
16. Chattopadhyay K K, Bannerjee, A N, ‘Introduction to Nanoscience and Nanotechnology’, (PHI, 2007)
17. Charles P Poole Jr and Frank J Owens, ‘Introduction to Nanotechnology’, (Wiley Interscience, 2002)
18. Edward L Wolf, ‘Nano Physics and Nanotechnology’, (II Edn. Wiley VCH, 2006)

PS 577.4 Nuclear Structure

Unit I: Deuteron problem and Nuclear Forces [13 hours]
Deuteron as mixture of S and D states - admixture in the deuteron wave function - magnetic and electric quadrupole moment of deuteron from S and D mixture. Ground state wave function of deuteron. Expression for Pd.

Review of nuclear forces - charge, Symmetry, spin-dependence, tensor character, exchange character. Pseudoscalar meson theory. General survey of non-central forces. Two body potential, three body and many body potentials.

Unit II: Nuclear Scattering [13 hours]
Free n-p and p-p scattering: n-p scattering formalism - partial wave analysis - theory of S wave neutron scattering by free protons - scattering length - spin dependence of n-p scattering. Effective range theory of n-p scattering-signicance of sign of scattering length, coherent and incoherent scattering. Coherent scattering from hydrogen molecules and sign of scattering lengths. Cross sections for ortho and para hydrogen - comparison with experiment. The optical theorem. Low energy scattering of protons by protons. Experi-mental results. High energy n-p scattering and experimental results.

Unit III: Nuclear Models [13 hours]
Fermi gas model: kinetic energy for the ground state-asymmetry energy - nuclear evaporation. Independent particle model: motion in mean potential, energy levels according to harmonic oscillator potential and infinite square well potential - effect of spin-orbit interaction.

Collective model: collective vibrations and rotations. Nuclear quadrupole moments. Nilsson model - calculation of energy levels - prediction of ground state spin.

Reference books:
1. Roy R R, Nigam B P, ‘Nuclear Physics-Theory and Experiment’ (Wiley Eastern Ltd., 1993)
2. Emilio Segre, ‘Nuclei and Particles’, II Edn. (Benjamin, 1977)
3. Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. II (S Chand and Company, 1994)
4. Singru R M, ‘Experimental Nuclear Physics’, (Wiley Eastern, 1972)

5. Krane K S, ‘Introductory Nuclear Physics’, (John Wiley, 1986)
6. Evans R D, ‘Atomic Nucleus’, (Tata McGraw Hill, 1972)
7. Kapoor S S, Ramamoorthy V S, ‘Radiation Detectors’, (Wiley Eastern, 1986)

PS 578.4P General Physics Experiments - IV

1. Zeeman effect
2. Verdet’s Constant
3. Freedericksz Transition
4. Temperature Dependence of Hall Coefficient
5. Thermal Expansion of a Crystal using Optical Interferometry
6. Magnetoresistance
7. Hysteresis Loop Tracer
8. Junction capacitance of a p-n diode
9. Fabry - Perot Interferometer
10. Fermi Energy of metal
11. Electron Spin Resonance
12. Gamma ray spectrometer
13. Four probe method

Additional experiments may be added

General Reference:

1. ‘C R C Handbook of Chemistry and Physics’, (94thEdn. C R C Press, Taylor and Francis Group, 2014)
2. Halliday D, Resnick R, Walker J, ‘Fundamentals of Physics’, (Extended IX Edn. Wiley India, 2011)
3. Young H D, Freedman R A, ‘Sears and Zemansky’s University Physics with Modern Physics’, (XIII Edn., Pearson, 2012)
4. Alonso M, Finn E J, ‘Physics’, (Pearson, 2012)
5. Beiser A, ‘Concepts of Modern Physics’, (VI Edn., Tata McGraw Hill, 2003)
6. Krane K, ‘Modern Physics’, (III Edn., Wiley Inc., 2012)
7. Jenkins F A, White H E, ‘Fundamentals of Optics’, (McGraw Hill, 1974)
8. Hecht E, ‘Fundamentals of Optics’, (Addison Wesley, 2002)
9. Weinberg S, ‘First Three Minutes: A Modern View of the Origin of the Universe’, (Basic Books, 1993)

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