ESTD : 1880

ST ALOYSIUS

(DEEMED TO BE UNIVERSITY)

MANGALURU 575003 - INDIA

Re-accredited by NAAC "A++" Grade

Course Structure and Syllabus of

M.Sc Physics

Learning Outcomes-based Curriculum Framework for Postgraduate Physics

(2024-2025 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.

Eligibility in MSc in Physics

Candidates who have passed three year B.Sc. degree /four year integrated BSc degree with Physics as a major subject from a recognized University, with minimum 45% aggregate marks or equivalent (40% for SC/ST/Category-I candidates) excluding the languages are eligible* for the programme

*Students pursuing an International curriculum must note that eligibility is according to

Association of Indian Universities stipulations.

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	Fundamentalunderstanding 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 92 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 92. Out of the total 92 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	**Group I** PS 574.4 PS 575.4 **Group II** 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 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 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.

PS 575.1 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.

3. 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.

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 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 573.2 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 574.2 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.

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.

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,clean liness 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

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 selected not more than two questions from each unit. Student has to answer any 5 questions carrying 10 mark each.

Part B of hard core paper contains 6 questions based on applications/numerical problems out of which the candidate has to answer 4 questions of 5 marks each.

The question paper pattern is as follows:

St Aloysius (Deemed to be University)
End Semester Examination - M. Sc. Physics Hard Core Paper

Time: 3 hours		Max marks: 70
	Part A	
Answer any **five** questions		10x5=50
1		
2		
3		
4		
5		
6		
7		
8		
	PART-B	
	Answer any **four** questions	4x5=20 marks
9		
10		
11		
12		
13		
14		
	******	

Soft core/Open elective paper

Each question paper consists of two parts A and B.

The question paper pattern is as follows:

Time: 3 hours		Max marks: 70
	Part A	
Answer any **five** questions		10x5=50
1		
2		
3		
4		
5		
6		
7		
8		
	PART-B	
	Answer any **four** questions	4x5=20 marks
9		
10		
11		
12		
13		
14		

****

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	Quantum Mechanics I	4	1	HC	4
PH 574.1	Electronics	4	1	HC	4
PS 575.1	Research Methodology and Ethics	3	1	SC	3
PS 576.1P	General Physics Experiments - I	6 (Lab)		SC	3
PS 577.1P	Electronics Experiments - I	6 (Lab)		SC	3
PS 578.1S	Seminar	2		SC Total	25
Semester II					
PH 571.2	Mathematical Physics II	4	1	HC	4
PH 572.2	Classical Electrodynamics	4	1	HC	4
PH 573.2	Quantum Mechanics II	4	1	HC	4
PH 574.2	Condensed Matter Physics I	4	1	HC	4
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
PS 578.2S	Seminar	2		SC Total	25

Semester I

PH 571.1 Mathematical Physics – I

Unit I: Vector analysis and curvilinear coordinates [14 hours]

Review of vector analysis. 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, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylindrical and spherical polar coordinates.

Unit II: Matrices and Tensors [14 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 and Green's functions [14 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.
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 IV: Special functions [14 hours]

Review of power series method for ordinary differential equations - Frobenius method - 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 [14 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 [14 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 [14 hours]

Definition and characteristics. Reduction of two particle equations of motion to an 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 coordinate systems.

Unit IV: Rigid body dynamics [14 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 Quantum Mechanics-I

Unit I: General formulation of quantum mechanics [14 hours]

Review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle, Schrödinger 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 [14 hours]

Postulates of quantum mechanics, Representation of states, dynamical variable, adjoint of an operator. Eigen value problem, degeneracy, eigen values and eigen functions. The dirac delta function, completeness and normalization 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 [14 hours]

Time independent Schrödinger equation, particle in square well - bound state, normalized state. One dimensional potential well problem - 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 [14 hours]

Angular momentum operators, eigen value equation for L^2 and L_z- separation of variables. Admissibility condition on solutions, eigen values, eigen functions. Spherical Harmonics Physical interpretation. 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 574.1 Electronics

Unit I: Operational amplifiers [14 hours]
Opamp with negative feedback. Voltage/current feedback amplifiers. Practical opamps-output offset voltage, frequency response. Applications: summing, scaling and averaging amplifiers, instrumentation amplifiers, integrator, differentiator, active filters, comparators, Schmitt trigger.

Unit II: Waveform generators and Specialized IC applications [14 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 [14 hours]
Class A, B and AB amplifiers, amplifier distortion, heat sinking. SCR - Characteristics and applications. Solar cells, IR emitters. Transducers - temperature, pressure, vacuum, magnetic fields, 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 [14 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 575.1 Research Methodology and Ethics

Unit1: Foundation of Research and Research Ethics [14 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 [14 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 [14 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:

1. Ethic in Science Education, Research & Governance, Indian National Science Academy (INSA). (2019).
2. Barbara H Stanley J Joan E Sieber, Gary B Melton. Research Ethics: A Psychological Approach. University of Nebraska Press.
3. David I Bainbridge (2012), Intellectual Property Rights. Long man Publication
4. Jayashree Watal. Intellectual Property Rights in the WTO and Developing Countries. Oxford University Press.
5. A K Singh. Tests, Measurements and Research Methods in Behavioral Sciences. Bharathi Bhawan (Publishers & Distributors), New Delhi.
6. Leedy P D. Practical Research: Planning & Design. Washington: Mc Millan Publishing Co., INC.
7. Singh Y K. Fundamentals of Research Methodology and Statistics. New International (P) Ltd., New Delhi.
8. Wallinman N. Your Research Project: A Step by Step Guide for the first time Researcher. Sage Publications, London.
9. Kothari C R. Research methodology: Research & Techniques. New Age International Publishers, New Delhi.

PS 576.1P 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 577.1P 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 **[14 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, m^{th} order pole. Evaluation of residues. The Cauchy's residue theorem. The Cauchy principle value. Evaluation of different forms of definite integrals. Jordan's lemma. Dispersion relations. Geometrical representation - conformal mapping. Dirac delta function and its properties.

Unit II: Group Theory **[14 hours]**
Groups - subgroups - classes. Invariant subgroups - factor groups. Homomorphism 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 algebra. Three dimensional rotation group SO(3), SU(2) and SU(3) groups.

Unit III: Integral Transforms **[14 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 **[14 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 Classical Electrodynamics

Unit I: Electrostatics and magnetostatics [14 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 field, Field inside a dielectric.

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

Unit II: Electromagnetic theory [14 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 [14 hours]

Propagation of plane waves in free space, dielectrics and conducting media. Reflection and refraction of electromagnetic waves - transverse and oblique incedence cases - Fresnel's equations.

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

Unit IV: Electrodynamics and Relativity [14 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, Transformation 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 tensor 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 573.2 Quantum Mechanics - II

Unit I: Matrix formalism of quantum mechanics [14 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. Change of basis. Coordinate and momentum representation. Proof of Heisenberg uncertainty relation.

Unit II: Quantum dynamics [14 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 [14 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 [14 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.

Basics of Quantum computers.

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 574.2 Condensed Matter Physics - I

Unit I: Crystallography **[14 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 **[14 hours]**

Bond length, bond angle, bond energy. Primary and secondary bonds. Coordination 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 **[14 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 **[14 hours]**

Intrinsic semiconductors: Band structure. Direct and indirect gap semiconductors. 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 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 [14hours]

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 [14 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 [14 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)

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)

****