Pt. Ravishankar Shukla University Raipur

CURRICULUM & SYLLABI
(Based on CBCS & LOCF)

of

M.Sc. PHYSICS

UNDER

FACULTY OF SCIENCE

Session: 2024-26 & onwards

Approved by Board of Studies in Physics on 10, May 2024

Approved by:	Board of Studies	Academic Council

M. Sc. Physics

Master of Science (M.Sc.) in Physics is a full time 2-year (4-semesters) course. There will be four theory papers in each semester, two laboratory courses in semester I, II, III and one project in semester IV. In each semester, there will be two internal examinations/assessments. This course focuses on fostering employability, skill development and core knowledge of the subject.

Programme outcomes:

Upon successful completion of the M.Sc. in Physics program, students will be able to:

PO-1	**Knowledge:** Demonstrate a deep understanding of advanced concepts, theories, and techniques in various fields of Physics.
PO-2	**Critical Thinking and Reasoning:** Investigate the nature of the universe, analyze, understand it and exhibit advanced critical thinking and reasoning skills by analyzing the given scientific data critically and systematically. Critical reasoning helps to assess the validity of assumptions, plan experiments, and interpret results. Critical reasoning allows critically evaluating existing scientific literature, identifying gaps in knowledge, and building on previous research.
PO-3	**Problem Solving:** Improve problem solving skill by developing potential solutions of different Physics related problems so that the students will be able to qualify competitive examinations like NET/ GATE/ SET/ JEST etc. Physics often involves solving complex problems, in theory, research and experiments.
PO-4	**Advance Analytical and Computational Skills:** Use mathematical techniques and build models to interpret physical behavior. Use the methods to develop computational code and tools.
PO-5	**Effective Communication:** Develop subject expertise, confidence, communication skill and scientific discussions to perform in various National and International platform.
PO-6	**Social/Interdisciplinary Interaction:** Integrate concepts of Physics into interdisciplinary context, collaborating effectively with professionals from other fields to address social/interdisciplinary problems.
PO-7	**Self-directed and Life-long Learning**: Appreciate the importance of current professional development and perpetual learning in the rapidly evolving field of Physics. Exhibit the ability to continue learning independently or in formal educational settings.
PO-8	**Effective Citizenship: Leadership and Innovation:** Lead and innovate in various contexts, contributing to advancements in the field and applying physical insights to emerging challenges.
PO-9	**Ethics:** Dwell upon ethical and responsible conduct in research of Physics, teaching and collaboration, ardently following to professional standards and best practices. Able to understand and adhere to ethical guidelines for data collection, analysis, reporting and publishing.
PO-10	**Further Education or Employment:** Obtain employment in research and development in the scientific labs and industries.
PO-11	**Global Perspective:** Understand global perspective by exposing them to international collaboration, diverse research opportunities, and a broader knowledge as to how physics contributes to addressing global challenges. It can also open doors to a range of international career opportunities, whether in academia, industry, or research institutions.

Programme specific outcome: M.Sc. Physics

At the end of the program, the student will be able to:

PSO1	Understand the basic concepts of Physics i.e. classical mechanics, quantum mechanics, statistical mechanics, electrodynamics and plasma physics, electronics etc. through logical and mathematical reasoning.
PSO2	Apply concepts of physics in other fields such as nuclear and high energy physics, atomic and molecular physics, solid state physics, astrophysics and cosmology.
PSO3	Develop experimental skills in front line areas of Physics such as solid state physics, nano-science, lasers, electronics, astronomy and astrophysics.
PSO4	Acquire expertise by pursuing research in challenging areas of pure and applied physics.
PSO5	Attempt national level tests such as NET/SET/GATE/JEST etc.

M. Sc. Physics

Specification of Course	Semester	No. of Courses	Credits
Core	I-IV	19	81
Elective	III-IV	04	19
	Total	23	100
Additional Courses: Qualifying in nature for students admitted in School of Studies only. (Affiliated colleges are suggested to set up their own Generic Elective/Skill enhancement/value added course based on facilities available there. They can also participate in the additional courses of SoS in Physics & Astrophysics with nominal charges.)			
Indian Knowledge System	I	01	02
Generic Elective	II-III	02	04
Skill Enhancement (Value added courses)	IV	01	02

M. Sc. Physics
PROGRAM STRUCTURE

Semester	Course Nature	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credit	Marks		
							CIA	ESE	Total
Semester-I	Core	PHY 110	Mathematical Physics	T	5	5	30	70	100
	Core	PHY 120	Classical Mechanics	T	5	5	30	70	100
	Core	PHY 130	Electrodynamics & Plasma Physics	T	5	5	30	70	100
	Core	PHY 140	Electronics	T	5	5	30	70	100
	Core	PHY-PR 150	General & Optics	P	4	2	30	70	100
	Core	PHY-PR 160	Electronics	P	4	2	30	70	100
Semester-II	Core	PHY 210	Quantum Mechanics-I	T	5	5	30	70	100
	Core	PHY 220	Statistical Mechanics	T	5	5	30	70	100
	Core	PHY 230	Electronic & Photonic Devices and Optical Modulators	T	5	5	30	70	100
	Core	PHY 240	Computational Physics & Computer Programming	T	5	5	30	70	100
	Core	PHY-PR 300	Numerical Analysis & Computer Programming	P	4	2	30	70	100
	Core	PHY-PR 260	Digital Electronics & Microprocessor	P	4	2	30	70	100
Semester- III	Core	PHY 310	Quantum Mechanics-II	T	5	5	30	70	100
	Core	PHY 320	Atomic & Molecular Physics	T	5	5	30	70	100
	Core	PHY 330	Solid State Physics-I	T	5	5	30	70	100
	Elective (Select any one)	PHY 341 (A)	Astronomy & Astrophysics-I	T	5	5	30	70	100
		PHY 342 (B)	Electronics (Communication)-I	T	5	5	30	70	100
		PHY 343 (C)	Physics of Nano-material-I	T	5	5	30	70	100
		PHY 344 (D)	Space Physics-I	T	5	5	30	70	100
		PHY 345 (E)	Quantum Computing- I	T	5	5	30	70	100
	Core	PHY PR 350	Lab Course - Materials Science & General	P	6	3	30	70	100
	Elective (Select any one)	PHY PR 361(A)	Lab Course - Astronomy & Astrophysics	P	6	3	30	70	100
		PHY PR 362(B)	Lab Course - Electronics (Communication)	P	6	3	30	70	100
		PHY PR 363(C)	Lab Course - Physics of Nano-material	P	6	3	30	70	100
		PHY PR 364(D)	Lab Course - Space Physics	P	6	3	30	70	100
		PHY PR 365 (E)	Lab Course- Quantum Computing	P	6	3	30	70	100
Semester-IV	Core	PHY 410	Nuclear & Particle Physics	T	5	5	30	70	100
	Core	PHY 420	Laser Physics and Applications	T	5	5	30	70	100
	Core	PHY 430	Solid State Physics-II	T	5	5	30	70	100
	Elective	PHY 441 (A)	Astronomy & Astrophysics-II	T	5	5	30	70	100
		PHY 442 (B)	Electronics (Communication)-II	T	5	5	30	70	100
		PHY 443 (C)	Physics of Nano-material-II	T	5	5	30	70	100
		PHY 444 (D)	Space Physics-II	T	5	5	30	70	100
		PHY 445 (E)	Quantum Computing - II	T	5	5	30	70	100
	Elective	PHY PR 450	Project Work/ internship	P	12	6	50	150	200

ESE **CIA**

***Physics of Nano Materials: This paper is run under the DST FIST program awarded to the SoS in Physics and Astrophysics, hence only students of University Teaching Department can opt the special paper. College students are not allowed to opt this special paper because of lack of advance instrumentation facilities.**

In Each Semester

MAXIMUM MARKS TOTAL	PASS PERCENTAGE TH.	PR.
600	36	36

In semester IV, Project work in Solid State Physics/ Astronomy & Astrophysics/ Electronics/ Physics of Nano-materials/ Space Physics will lead to specialization in the respective area. It will be primarily based on research oriented topics. On completion of the project, student will submit project report in the form of dissertation. The project submission will be done within one month after the end of theory exams. The project will be examined by an external examiner. The examination of project work shall consist of (a) Presentation and (b) comprehensive viva-voce.

Marks-distribution for Laboratory Courses and Project Work:

(a) Laboratory courses (Semesters I-III):

Sessional : 25 Marks
Viva : 25 Marks
Experiment : 50 Marks

(b) Project Work (Semester IV):

Report – Dissertation : 100 Marks
Presentation : 30 Marks
Comprehensive viva-voce : 20 Marks
Internal assessment : 50 Marks

Note: Paper IV of both Semesters III and IV is a major elective course. Student has to opt for any one of the courses: (A) or (B) or (C) or (D). The commencement of any one of the major elective paper is subjected to the availability of basic infrastructural facilities viz. expert faculty, laboratory etc.

Note:

1. Students are also suggested to choose papers (optional) from MOOC Courses (Swayam Portal) subject to the following conditions:
   a. The chosen paper will be other than the papers offered in the current course structure.
   b. The paper will be PG level with a minimum of 12 weeks' duration.
   c. The list of courses on SWAYAM keeps changing; the departmental committee will finalize the list of MOOC courses for each semester.
   d. The paper(s) may be chosen from Swayam Portal on the recommendation of Head of the Department.
2. The candidates who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Generic Elective Courses (only qualifying in nature) offered by other departments/SoS in Semester II and Semester III.
3. The candidates, who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Skill Enhancement Course/Value Added Course (only qualifying in nature) in Semester I and Semester II.

Indian Knowledge System:

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
I	PHY 510	Indian Contribution to Physics	T	2	2	30	70	100

Generic Elective Courses: (Offered to PG students of other Departments/ SoS only)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
II	PHY 610	Physics of electronic devices	T	2	2	30	70	100
III	PHY 620	Physics for society	T	2	2	30	70	100

Skill Enhancement/Value Added Courses (Any one):

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
IV	PHY 710	Conventional Turner	P	4	2	30	70	100
IV	PHY 720	Hands on training of sophisticated instruments	P	4	2	30	70	100

Programme Articulation Matrix:

Following matrix depicts the correlation between all the courses of the programme and Programme Outcomes

CourseCode	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
PHY 110	√	√	√	√	√	√	√	√	√	√	√	√	√	X	√	√
PHY 120	√	√	√	X	√	X	X	X	√	√	X	√	√	√	√	√
PHY 130	√	√	√	X	√	X	X	√	√	√	X	√	√	X	√	√
PHY 140	√	√	√	√	√	X	√	√	√	√	√	√	√	√	√	√
PHY-PR 150	√	√	√	√	√	X	√	√	√	√	X	√	√	√	X	√
PHY-PR 160	√	√	√	√	√	X	√	√	√	√	X	√	√	√	X	√
PHY 210	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 220	√	√	√	√	√	√	√	√	√	√	X	√	√	√	√	√
PHY 230	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 240	√	√	√	√	√	X	√	√	√	√	√	√	√	√	√	√
PHY-PR 300	√	√	√	√	√	X	√	√	√	√	X	√	√	√	X	√
PHY-PR 260	√	√	√	√	√	X	√	√	√	√	X	√	√	√	X	√
PHY 310	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 320	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 330	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√
PHY 341 (A)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 342 (B)	√	√	√	√	√	√	√	√	√	√	X	√	√	√	√	√
PHY 343 (C)	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√
PHY 344 (D)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 345 (E)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 350	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 361 (A)	√	√	√	√	X	X	√	√	√	√	√	√	√	√	√	√
PHY PR 362 (B)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 363 (C)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 364 (D)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 365 (E)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 410	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 420	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√
PHY 430	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√
PHY 441 (A)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 442 (B)	√	√	√	√	√	√	√	√	√	√	X	√	√	√	√	√
PHY 443 (C)	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√
PHY 444 (D)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY 445 (E)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PHY PR 450	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
No. of courses mapping the PO/PSO	35	35	35	28	34	26	33	34	35	35	26	35	35	33	31	35

M.Sc. (Physics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Physics	1	I
Course Code	Course Title		Course Type
PHY-110	**Mathematical Physics (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The objective of this course is to understand Quantitative problem-solving, modeling, calculus, algebra, and statistics. Physics: Understanding natural phenomena, laws, concepts, experiments, problem-solving, critical thinking.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand vector spaces, linear independence, bases, and dimensionality. Explore inner products, linear transformations, matrices and inverses, orthogonal and unitary matrices. Learn about eigen values, eigenvectors, diagonalization, and complete orthonormal sets of functions.	Ap
2	Understand Cauchy-Riemann conditions. Learn about analytic functions. Apply Cauchy's theorem and integral formula. Explore Laurent series, singularities, and residue theorem. Master contour integration and definite integral evaluation.	Ap
3	Solve first-order differential equations. Address second-order constant coefficient ODEs. Tackle second-order linear ODEs with variable coefficients. Apply series expansion for solution Master nonhomogeneous ODEs and Green's functions method.	U
4	Understand Legendre, Bessel, Hermite, and Laguerre functions. Explore their physical applications. Study generating functions, orthogonality conditions, and recursion relations.	An
5	Master Fourier integral and transforms, including the inversion theorem and series. Understand discrete Fourier transform. Explore Laplace Transform, derivatives, and the inverse LT.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	**3**	**3**	**3**	-	**1**	-	**3**	**1**	-	-	-	**3**	**1**	-	-	-
CO2	**3**	**3**	**3**	**1**	**1**	**1**	**3**	-	-	-	-	**3**	**2**	-	-	**3**
CO3	**3**	**3**	**3**	**1**	**1**	**1**	**3**	-	-	**2**	-	**3**	**2**	-	-	**2**
CO4	**3**	**3**	**3**	**1**	**1**	**2**	**3**	**1**	-	**2**	**1**	**3**	**2**	-	-	-
CO5	**3**	**3**	**3**	**1**	**1**	-	**2**	-	-	**2**	**2**	**3**	**2**	**3**	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Vector space and Matrices, Linear independence, Bases, dimensionality, Inner product, Linear transformation, matrices, Inverse, Orthogonal and Unitary matrices, Independent element of a matrix, Eigen values and eigen Vectors, Diagonalization , Complete orthonormal sets of functions.	15	1
II	Complex Variables: Cauchy- Riemann condition, analytic functions, Cauchy's theorem, Cauchy integral formula, Laurent series, singularities, residue theorem, contour integration, evaluation of definite integrals, problems.	15	2
III	Differential equations, first order differential equation, second order differential equation with constant coefficients, second order linear ODEs with variable coefficients, Solution by series expansion, nonhomogenous differential equations and solution by the method of Green's functions.	15	3
IV	Special functions, Legendre, Bessel, Hermite and Laguerre functions with their physical applications, generating functions, orthogonality conditions, recursion relations,	15	4
V	Integral transforms, Fourier integral and transforms, inversion theorem, Fourier series; properties and applications, discrete Fourier transform, Fourier transform of derivatives, convolution theorem, Laplace Transform(LT), LT of Derivatives, Inverse LT.	15	5

TEXT AND REFERENCE BOOKS

1. Mathematical Methods for Physics, by G. Arfken.
2. Matrices and Tensors for Physicist, by A. W. Joshi.
3. Advanced Engineering Mathematics, by E. Kroyazig.
4. Special Functions, by E. B. Rainville.
5. Special Functions, by W.W. Bell.
6. Mathematical Method for Physicist and Engineers, by K. F. Relly, M. P. Hobson and S. J. Bence
7. Mathematics for Physicists, By Marry L. Boas.

M.Sc. (Physics) Semester-I

Program	Subject	Year		Semester
M.Sc.	Physics	1		I
Course Code	Course Title			Course Type
PHY-120	**Classical Mechanics**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA		ESE	
100	30		70	

Learning Objectives (LO): The course aims to impart deep knowledge to students about analytical methods in classical mechanics. The main objective is to make students able to understand mechanical problems and solve using mathematical tools and classical analytical methods developed by Newton, Lagrange and Hamilton. Two well known central force problems: classical two body problem and scattering problem are introduced to provide basic understanding of procedures used to tackle mechanical problems. Lastly, rigid body dynamics and small oscillation are discussed to provide basic understanding of similar mechanical problems.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Apply Newtonian mechanics on many particle systems. Understand conservation laws and symmetry properties. Understand and classify the constraints. Define generalized coordinates. State D'Alembert, virtual work and Hamilton's principle. Derive Lagrange's equation of motion using D'Alembert's and Hamilton's principle. Apply and solve simple mechanical problems using Lagrange's equation of motion.	Ap
2	Understand Hamilton's formulation of mechanics, Legendre's transformation. Derive Hamilton's equation using Legendre's transformation and Hamilton's principle. Define cyclic coordinates find out associated generalized momentum. State least action principle. Solve simple mechanical problems using Hamilton's formulations.	Ap
3	Understand canonical transformation and apply it to solve simple harmonic oscillator problem. Define Poisson's Bracket (PB) and state equation of motion, conservation theorems using PB. Understand Hamilton-Jacobi's theory and use to solve harmonic oscillator problem. Define Hamilton's principal function and action angle variables.	Ap
4	Define the central force and discuss properties. Discuss two-body problem and reduce to Equivalent One Body (EOB). Derive equation of motion for EOB problem and determine first integrals. Reduce two-dimensional EOB problem into equivalent one-dimensional problem and classify the orbits. Derive differential equation for the orbits. State closures for the stability of the orbits. Understand Kepler's problem and laws. Discuss Rutherford's scattering.	Ap
5	Define Euler's angle and state Euler's theorem on rigid body motion. Discuss rate of change of a vector in rotating frame and define Coriolis force. Determine/define angular momentum and Kinetic energy of motion about a point. Discuss Euler's equation of motion of rigid body. Understand the small oscillation. Determine Eigen value equation and frequencies of oscillation of free vibration. Define normal modes. Discuss free vibrations of linear triatomic molecule.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create)

CO-PO/PSO Mapping for the course:

PO \ CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	**3**	**1**	**2**	-	**2**	**1**	**2**	**1**	-	**1**	**1**	**3**	**1**	**1**	**1**	**3**
CO2	**3**	**1**	**3**	**1**	**2**	**2**	**2**	**1**	-	**1**	**1**	**3**	**1**	**1**	-	**3**
CO3	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**1**	-	**1**	**1**	**3**	**2**	**1**	-	**2**
CO4	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	-	-	-	**3**	**1**	-	-	**2**
CO5	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	-	-	-	**3**	**1**	-	-	**2**

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No of Lectures	CO No.
I	Preliminaries, Newtonian mechanics of one and many particle systems, Conservation laws, Constraints & their classification, Principle of virtual work, Generalized coordinates, D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and dissipation function, Simple applications of the Lagrangian formulation, Hamilton's principle, Lagrange's equations from Hamilton's principle, Conservation theorems and Symmetry properties, Energy function and the conservation of energy.	**15**	**1**
II	The Hamiltonian formulation of mechanics, Legendre transformations and the Hamilton's equations of motion, Cyclic coordinates and Conservation Theorems, Hamilton's equations from Hamilton's principle, The principle of least action, Simple applications of the Hamiltonian formulation.	**15**	**2**
III	Canonical transformations with examples, The harmonic oscillator, Poisson's brackets, Equations of motion and conservation theorems in the Poisson Bracket formulation. Hamilton-Jacobi (HJ) theory: The HJ equation for Hamilton's principal function, Harmonic oscillator as an example of the HJ method, The HJ equation for Hamilton's characteristic function, The action-angle variables	**15**	**3**
IV	The Central force: Two-body central force problem and its reduction to the equivalent one-body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, The differential equation of the orbit, Closure and stability of orbits, The Kepler problem, Scattering in a central force field: Rutherford scattering.	**15**	**4**
V	Rigid body dynamics, The Euler angles, Euler's theorem on the motion of a rigid body, Rate of change of a vector, The Coriolis force, Angular momentum and Kinetic energy of motion about a point, The Euler equations of motion of rigid bodies. Formulation of the problem of small oscillations, The eigen-value equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, Free vibration of linear triatomic molecule.	**15**	**5**

TEXT AND REFERENCE BOOKS

1. Classical Mechanics, By N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991)
2. Classical Mechanics, by H.Goldstein (Addison Wesley, 1980)
3. Classical Mechanics, by H.Goldstein, C Poole & J Fafko (Pearson Education, Inc, 2002)
4. Mechanics, by A.Sommerfeld, (Academic press, 1952)
5. Introduction to Dynamics by Perceival and D.Richaeds (Cambridge University, press, 1982).

M.Sc. (Physics) Semester-I

Program	Subject		Year	Semester
M.Sc.	Physics		1	I
Course Code	Course Title			Course Type
PHY-130	**Electrodynamics & Plasma Physics**			Core
Credit	Hours Per Week (L-T-P)			
	L		T	P
5	4		1	0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The course aims to develop a solid understanding of the fundamental principles of electromagnetism, including Maxwell's equations and their applications, the behaviour of charged particles in electric and magnetic fields, including motion, forces, and interactions, explore the properties of plasma.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	To understand the fundamental principles of electromagnetism, learn about vector and scalar potentials, apply gauge transformations to electromagnetism, understand the mathematical properties of space-time. derive the matrix representation of Lorentz transformation.	**Ap**
2	To analyze radiation emitted by moving charges, calculate the total power radiated using Larmor's formula, understand the angular distribution of radiation, investigate radiation from extremely relativistic charges, explore the distribution of radiated energy.	**Ap**
3	Differentiate between Bremsstrahlung and synchrotron radiation. Analyze thermal Bremsstrahlung emission and absorption. Understand the spectrum of synchrotron radiation. Calculate the spectral index for power-law electron distribution. Investigate the transition from Cyclotron to Synchrotron emission.	**U**
4	To understand the definition and properties of plasma, analyze the Debye shielding phenomenon, explore the motion of charged particles in electromagnetic fields. understand electric field drift and gradient B drift, investigate parallel acceleration, magnetic mirror effect, and curvature drift.	**An**
5	To grasp the elementary concepts of plasma kinetic theory, apply the Boltzmann equation to plasma physics, analyze basic plasma phenomena, including plasma oscillations, derive the fundamental equations of magnetohydrodynamics (MHD), investigate hydrodynamic waves, including magnetosonic and Alfven wave	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	2	1	1	1	1	3	3	1	1	3
CO2	3	3	3	1	2	2	2	1	1	1	1	3	3	1	1	3
CO3	3	3	3	1	2	2	2	1	2	2	1	3	3	1	2	3
CO4	3	3	3	1	2	2	2	2	2	2	1	3	3	1	2	3
CO5	3	3	3	1	2	2	2	2	2	2	2	3	3	1	2	3

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Maxwell's equations, vector and scalar potentials and the wave equation, Gauge transformations, Lorenz gauge, Coulomb gauge, Green function for the wave equation, four-vectors, mathematical properties of the space-time in special relativity, matrix representation of Lorentz transformation, covariance of electrodynamics, transformation of electromagnetic fields.	15	1
II	Radiation by moving charges, Lienard-Wiechert potential and fields for a point charge, total power radiated by an accelerated charge-Larmor's formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge, radiation emitted by a charge in arbitrary extremely relativistic motion, distribution in frequency and angle of energy radiated by accelerated charge.	15	2
III	Bremsstralung: emission from single-speed electrons, thermal Bremsstralung emission and absorption, Synchrotron radiation: spectrum of synchrotron radiation, spectral index for power law electron distribution, transition from Cyclotron to Synchrotron emission, Cherenkov radiation	15	3
IV	Plasma: definition, Debye shielding phenomenon and criteria for plasma, motion of charged particles in electromagnetic field; Uniform E & B fields, Electric field drift, Non-uniform magnetostatic field, Gradient B drift, Parallel acceleration and magnetic mirror effect, Curvature drift, adiabatic invariants.	15	4
V	Elementary concepts of plasma kinetic theory, the Boltzmann equation, the basic plasma phenomena, plasma oscillations. Fundamental equations of magneto hydrodynamics (MHD), Hydrodynamics Waves; Magneto sonic and Alfven waves, Magnetic viscosity and magnetic pressure, plasma confinement schemes.	15	5

Reference Books:

1 Jackson, classical electrodynamics.

2 Rybicki & Lightman: Radiative Processess in Astrophysics

2 Panofsky and Phillips: Classical electricity and magnetism.

3 Bittencourt, Plasma physics.

4 Chen: Plasma physics.

M.Sc. (Physics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Physics	1	I
Course Code	Course Title		Course Type
PHY-140	**Electronics**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to equip students with a deep understanding of basic and advanced electronics, solid state devices, basic principle, logic gates for advanced logics, flip flops, integrated circuits and microprocessor.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the basic principles of operational amplifiers. Learn about differential amplifiers and their applications. Analyze the transfer characteristics of differential amplifiers. Understand the concept of offset error voltage and currents. Learn how to measure operational amplifier parameters.	Ap
2	Understand the basic logic gates: OR, AND, NOT, NOR, and NAND. Apply Boolean algebra to solve logic circuits. Learn about De Morgan's theorems and their applications. Understand the characteristics of different logic families.	Ap
3	Understand the concept of flip-flops and their applications. Learn about RS flip-flops and level clocking. Analyze the behavior of edge-triggered flip-flops and D flip-flops. Understand the concept of JK flip-flops and their applications. Learn about J-K master-slave flip-flops. Understand the concept of registers and their applications.	U
4	Understand the basic building concepts of microprocessors. Learn about the different components inside a microprocessor. Analyze the behavior of instruction codes and the instruction register. Understand the concept of the RESET pin and its applications. Learn about on-chip oscillators and their applications.	An
5	Learn how to write assembly language programs for the 8085 microprocessor. Analyze the behavior of examples of assembly language programs of the 8085 microprocessor. Understand the concept of summing two 8-bit numbers.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	1	2	2	2	3	2	2	1	2	2	2	2
CO2	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO3	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO4	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO5	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Operational Amplifier- Basic Op. Amp. Differential amplifier, the emitter coupled Difference Ampl, Transfer characteristics of a Diff. Ampl., an example of an IC Op.-Amp., offset error voltage and currents, measurement of Op.-Amp. Parameters, frequency response of Op-amp. Linear analog systems: Basic Op.-Amp. Applications, Analog integration and differentiation, Electronic analog computation, Non-linear analog systems: Comparators, Waveform generators	15	1
II	Combinational Logic –Basic logic gates: OR, AND and NOT gates, NOR and NAND gates, Boolean algebra, De Morgan's theorems, exclusive OR gate, characteristics of logic families, saturated logic families: RTL, DCTL, nonsaturated logic families: TTL and ECL, Unipolar logic families.	15	2
III	Sequential Logic, Flip-flops: RS Flip-flop, level clocking, Edge triggered Flip Flops, D-Flip flops. JK Flip-flops, J.K. master slave Flip-flops, Registers: buffer, shift and control shift registers, counters: ripple synchronous & ring counters, tri-state registers, Buffer: controlled buffer Register, Bus organized structure, Latch, multiplexer, De-multiplexer, decoder, ALU Memories: RAM, ROM, PROM, EPROM, A/D and D/A converters.	15	3
IV	Microprocessors – Building concept of microprocessors, developing inside of microprocessor, Instruction codes, Instruction Register, Introducing RESET Pin, Introducing on chip oscillator, Interfacing I/O devices, and Introducing Interrupt lines: Stack, Push, Pop operation, delay in servicing interrupts, multiply interrupts, location for interrupts. Introducing slow and fast data transfer, Status of microprocessor, interrupt pins, General purpose Register, flag Register, Increment/decrement register. Features of 8085 microprossor. Pin diagram of 8085, block diagram of 8085. CPU of a microprocessor, timing and control, system timings and interrupt timings of 8085, registers in 8085, interfacing memory and I/O devices- a preliminary idea. Number system, Floating Point notation	15	4
V	Instructions set of 8085, types of instructions- Data transfer group, Arithmetic logic, branch group, stack I/O machine control group, addressing mode of Intel 8085, examples of Assembly language programs of 8085, summing of two 8-bit numbers to result a 16-bit number, summing two 16-bit number, multiplying two 8-bit number to result a 16-bit product, block transfer of data from one memory block to other, BCD to hexadecimal data, finding the largest number in a series..	15	5

Reference Books:

1. Integrated Electronics: J.Millman R.C.C.Halkias.
2. Electronics devices and circuit theory, by Robert Boylested and Louis Nashdaky PHI, New Delhi-110001, 1991.
3. Operational amplifier linear integrated circuits, by Romakanth A. Gayakwad PHI, second edition 1991
4. Digital computer electronics- An introduction to microcomputers-A.P.Malvino
5. Digital finances and applications, by A.P. Malvino and Donald P.Leach, Tata McGraw Hill company, New Delhi 1993.
6. Microprocessor architecture, programming applications with 8085/8086 by Ramesh S.Gaonkar, Willey-Eastern limited 1987.
7. Introduction to microprocessors – A.P.Mathur (Tata McGraw).
8. Microprocessors-Theory and applications- M.Hafiquizzaman (Prentice hall).
9. Microprocessors fundamentals- Schanmi Outling Service Author Pocer L.Tokheim.
10. Integrated circuits : K KBotkar(Khanna publications)
11. Digital Electronics : R P Jain (Tata McGraw Hill)
12. Microprocesss : B Ram
13. 8-bit microprocessor : V.J.Vibhute & P.B. Borole(Tecn-Max Publication, Pune)

M.Sc. (Physics) Semester-I

Program	Subject		Year	Semester
M.Sc.	Physics		1	I
Course Code	Course Title			Course Type
PHY-PR 150	**General & Optics**			Core
Credit	Hours Per Week (L-T-P)			
	L		T	P
2	0		0	4
Maximum Marks	CIA			ESE
100	30			70

Learning objectives (LO):

The objective of this course is to provide experimental skills on general and experiments related to optics.

Course Outcomes:

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Do practically the experiments using laser, optical fiber etc.	Ap
2	The students will also use the optical bench.	Ap
3	Develop small experiments related to these techniques and develop their physical understanding.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	**3**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**3**	**3**	**3**	**2**	**2**
CO2	**3**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**3**	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**3**	**3**	**3**	**2**	**2**

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S. No.	Experiment
1	Determination of band gap of semiconductor by four probe method.
2	Measurement of Hall Coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration.
3	Determination of wavelength of mercury light by constant deviation spectrometer using Hartmann formula.
4	Ultrasonic velocity in a liquid as a function of temperature using ultrasonic interferometer.
5	Experiment on transmission line (A) Determination of characteristics impedance, (B) Study of voltage distribution.
6	Determination of the Curie temperature of ferromagnetic material.
7	Determination of forbidden gap of a diode by plotting reverse saturation current as a function of temperature.
8	Determination of operating voltage and study the characteristics of a GM tube. Determination of operating voltage of a GM tube and determine the linear absorption coefficient.
9	Determination of operating voltage of a GM tube and verify inverse-square law.
10	Determination of short half life of a given source which can be obtained from a mini generator produced with a neutron source by activation.
11	X-ray diffraction by Telexometer.
12	Determination of ionization potential of Lithium/Mercury.
13	Determination of e/m of electron by Normal Zeeman Effect using Febry -Perot Etalon.
14	Determination of Dissociation energy of iodine (I_2) Molecule by photography, the absorption bands of I_2 in the visible region.
15	Measurement of wavelength of He-Ne Laser light using a ruler and thickness of thin wire by the laser.
16	To study Faraday Effect using He-Ne Laser.

M.Sc. (Physics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Physics	1	I
Course Code	Course Title		Course Type
PHY-PR 160	**Electronics-I**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	0	0	4
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The objective of this course is to provide experimental skills on experiments related to Electronics.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	This lab provides the students with the fundaments skills to understand the basics of semiconductors and components like diode transistors, FET, MOSFET, and operational amplifiers.	U, An
2	It will build a mathematical and numerical background for the design of electronic circuits and component values.	U, An
3	Students equipped with the knowledge and training provided in the course will be able to participate in the design, development, and operation of the different areas of electronic systems.	U, An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S. No.	Experiment
1	Study of Differential Amplifier.
2	Basic Logic gates and verification of their Truth- Tables.
3	Combinational logic gates and verification of De-Morgan's Theorem.
4	Study of Op-Amp.-IC-741 is inverting/ Non inverting amplifier and draw frequency response curve.
5	Construction of Schmitt triggers using IC-741 and study of its characteristics.
6	Study of Astable and monostable Multi Vibrator using IC 555.
7	Digital electronics experiments on bread board using IC-7400.
8	Study of R-S, D/T, J-K Flip-Flops.
9	Study of counters: Ripple, Mode 3, Mode 5 counters.
10	Study of Shift Register.
11	Study of R-2R D/A Converter.
12	Study of Random Access Memory (RAM) Read Only Memory. (ROM)
13	Study of A/D Converter.
14	Study of adder/Subtractor.

M.Sc. (Physics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Physics	1	I
Course Code	Course Title		Course Type
PHY-510	**Indian Contribution to Physics**		Qualifying
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	2	2	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

This course provides the knowledge of contribution of Indian Scientist in Physics.

Course Outcome (CO):

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Know a concise account of the development of science in ancient culture.	U
2	Able to understand the great contribution of Indian Physicist towards the growth of science and technology	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	**3**	**3**	**1**	**3**	**1**	**1**	**3**	**2**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**1**
CO2	**3**	**3**	**1**	**3**	**1**	**1**	**3**	**2**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**1**

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus

Unit I	No of Lectures
THE PHYSICAL WORLD: VIEWS AND CONCEPTS Introduction; Universal Conceptions; The Doctrine of Five Elements; Atomism; Attributes of Matter; Motion; AkdSa, Space and Time; Heat and Light; Sound	15

Astronomical Knowledge as revealed in the Samhitas, Brahmanas and Sutras; Late Vedic and Pre-Siddhantic Astronomy; The Period of the Composition of the Astronomical Siddhantas-the Five Siddhantas, the Surya-siddhanta, the Astronomical Works and Commentaries of the Period	
Unit II	
Mathematical Knowledge as revealed in the Samhitas, the Brahmanas, the Vedangas, and Related Literature; Mathematical Contents of the Post-Vedic Period History of Metallurgy, glass and ceramics Contribution of contemporary Indian Physicist towards the growth of science and technology (i) Dr. C V Raman (1888 to 1970), discovery of Raman effect (ii) Satyendra Nath Bose (1894-1974), Bose- Einstein Condensate (iii) Dr. Chandrashekhar (1910-1995), Chandrashekhar limit in Astrology (iv) Dr. Meghnath Saha (1893-1965), Saha on ionization equation (v) Dr. H J Bhabha (1909-1996), (vi) Vikram Sarabhai (1919-1971) (vii) G N Ramachandra (1922-2001) (viii) Jayant Narlikar (1938)	15

Text books and references

1. Textbook on the knowledge system of Bharat by Bhagchand Chauhan
2. History of Science in India, Volume 1, Part I Part II Vol-VIII by Sibaji Raha, et al.,
3. National Academy of Science India and Ramakrishnan Mission Institute of Culture, Kolkata, 2014
4. Pride of India – a Glimpse of India's scientific heritage edited by Pradeep Kohli et al. Samskrit Bharati (2006)
5. Vedic Physics by Keshav Dev Verma, Motilal Banarasi Das Publishers (2012)
6. India's Glorious Scientific Tradition by Suresh Soni, Ocean Books Pvt. Ltd. (2010)
7. A concise history of science in India INSA (1971) by D M Bose, S. N. Sen, B V Subbarayappa

M.Sc. (Physics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Physics	I	II
Course Code	**Course Title**		**Course Type**
PHY-201	**Quantum Mechanics-I**		Core
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks	**CIA**		**ESE**
100	30		70

Learning Objective (LO):

The aim of this course is to empower students with a profound understanding of quantum mechanical concepts, particularly Planck's quantum law, Schrödinger equation, dirac-delta function, bra-ket notation, angular momentum, central force problem, perturbation theory and their applications across various quantum mechanical contexts.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the limitations of classical mechanics. Explore Planck's quantum hypothesis and radiation laws. Comprehend the photoelectric effect and De Broglie's theory. Learn the Schrödinger equation and its significance. Study continuity equations, Ehrenfest theorem, and admissible wave functions. Grasp the general formalism of wave mechanics and representation of states. Solve stationary states and one-dimensional problems, including barriers and the harmonic oscillator.	U
2	Understand the superposition principle in quantum mechanics. Explore uncertainty relations and states with minimum uncertainty. Learn commutation relationships and eigenfunction completeness. Grasp Dirac-delta function and Bra-Ket notation. Master matrix representation of operators and solve the harmonic oscillator. Study Heisenberg's equation of motion.	U
3	Comprehend angular momentum in quantum mechanics. Understand commutation relationships and eigenvalues. Explore spin angular momentum and Pauli's matrices. Learn how to add angular momentum. Master the concept of Clebsch-Gordon coefficients.	Ap
4	Analyze central force problems and spherically symmetric potentials in 3D. Separate the wave equation. Explore parity, square-well potentials, and hydrogen atom solutions. Understand energy levels, wave functions, bound states and degeneracy.	An
5	Master time-independent perturbation theory, both non-degenerate and degenerate cases. Understand first and second-order perturbations with practical examples. Explore removal of degeneracy and its applications, such as the Zeeman effect and Stark effect.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	2	-	3	1	-	2	3	3	3	1	1	2
CO2	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO3	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO4	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO5	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Inadequacy of classical mechanics, Plank quantum hypothesis and radiation law, Photoelectric effect, De-Broglie's theory. Schrödinger equation, continuity equation, Ehrenfest theorem, admissible wave functions, general formalism of wave mechanics, representation of states and dynamical variables, stationary states, one-dimensional problems; walls and barriers, Schrödinger equation for harmonic oscillator and its solution.	15	1
II	Superposition principle, uncertainty relations, states with minimum uncertainty product, commutation relationship, completeness and normalization of eigen functions, Dirac-delta function, Bra & Ket notation, matrix representation of an operator, harmonic oscillator and its solution by matrix method, Heisenberg equation of motion.	15	2
III	Angular momentum in quantum mechanics, commutation relationships, eigen values, Spin angular momentum, Pauli's matrices, addition of angular momentum, Clebsch-Gordon coefficients.	15	3
IV	Central force problem, spherically symmetric potentials in three dimensions, separation of wave equation, parity, three-dimensional square-well potential and energy levels, the hydrogen atom; solution of the radial equation, energy levels and stationery state wave functions, discussion of bound states, degeneracy.	15	4
V	Time- independent perturbation theory, non-degenerate case, first order and second perturbations with the example of an oscillator, degenerate cases, removal of degeneracy in second order, Zeeman effect without electron spin, first-order Stark effect in hydrogen, perturbed energy levels, correct eigen function, occurrence of permanent electric dipole moments.	15	5

Reference Books:

1. L.I. Schiff: quantum mechanics (McGraw-Hill).
2. S.Gasiorowicz, Quantum Physics (Wiley).
3. Landau and Lifshitz: Non-relativistic quantum mechanics.
4. B.Craseman and Z.D.Powell: quantum mechanics (Addison Wesley)
5. A.P. Messiah: Quantum Mechanics.
6. J.J. Sakurai: Modern Quantum Mechanics.
7. Mathews and Venkatesa: Quantum Mechanics.

M.Sc. (Physics) Semester-II

Program	Subject	Year		Semester
M.Sc.	Physics	1		II
Course Code	Course Title			Course Type
PHY-220	**Statistical Mechanics**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA		ESE	
100	30		70	

Learning Objectives (LO): The course aims to impart basic knowledge to students about the analytical methods in statistical mechanics. The main objective of the course is to introduce the methods used to derive macroscopic properties of thermodynamic systems in terms of microscopic properties using general principles/theories of Classical/Quantum statistical mechanics.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Define macroscopic and microscopic states. Understand the connection between statistics and thermodynamics. Understand the physical significance of $\Omega(N,V,E)$. Define classical ideal gas. Understand entropy mixing and Gibb's paradox. Define and understand phase space of classical system. State and Derive Liouville's theorem and its consequences. Define Quantum state understand its connection to phase space.	Ap
2	Define three different types of Ensembles and discuss corresponding theories. Define partition functions for different canonical systems. Understand physical significance of statistical quantities. Understand energy, energy-density fluctuations and correspondence of various ensembles.	Ap
3	Understand quantum statistics and quantum mechanical ensemble theory. Define density matrix. Understand statistics of different quantum mechanical ensembles. State and discuss Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions. Define mean occupation number and discuss its statistics.	Ap
4	Define Ideal Bose gas and discuss its thermodynamic behaviour. Define Bose-Einstein (BE) Condensate and discuss BE condensation. Discuss Liquid Helium II and its elementary excitations. Define Ideal Fermi gas and discuss its thermodynamic behaviour. Define and discuss electron gas, non relativistic and relativistic electron gas. Discuss white dwarf theory.	Ap
5	Understand statistical mechanics of interacting systems. Understand methods of cluster expansion. Discuss Virial expansion of the equation of state. Understand the theory of phase transition. Understand and discuss thermodynamic fluctuations. Discuss Brownian motion and Einstein and Smoluchowski theory.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create)

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	3	1	2	2	3	2	2	3	1	3	3	1	2	3
CO2	3	2	3	2	2	2	3	2	1	3	1	3	3	1	2	3
CO3	3	2	3	3	3	3	3	2	1	3	1	3	3	-	2	3
CO4	3	3	3	1	2	2	3	2	1	3	2	3	2	-	2	3
CO5	3	2	1	2	2	1	2	1	-	1	1	2	1	-	1	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No of Lectures	CO No.
I	Foundation of statistical mechanics : macroscopic and microscopic states, contact between statistics and thermodynamics, physical significance of Ω(N,V, E), the classical gas, entropy of mixing and Gibb's paradox, phase space of classical system, Liouville's theorem and its consequences, quantum states and phase space.	15	1
II	Elements of ensemble theory - A system in microcanonical, canonical, and grand canonical ensembles, partition functions, physical significance of statistical quantities, example of classical system, energy and energy-density Fluctuations and mutual correspondence of various ensembles.	15	2
III	Formulation of quantum statistics - Quantum mechanical ensemble theory, density matrix, statistics of various quantum mechanical ensembles, system composed of indistinguishable particles. Theory of simple gases - Ideal gas in various quantum mechanical ensembles, Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac distributions, statistics of occupation number.	15	3
IV	Ideal Bose and Fermi gases - Thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation and, elementary excitations in liquid helium II, Thermodynamic behavior of an ideal Fermi gas, the electron gas, non-relativistic and relativistic degenerate electron gas, theory of white dwarf stars.	15	4
V	Statistical Mechanics of interacting systems – the method of cluster expansion for a classical gas, Virial expansion of the equation of state. Theory of phase transition – general remark on the problem of condensation, Fluctuations: thermodynamic fluctuations, Spatial correlation in a fluid Brownian motion: Einstein Smoluchowski theory of Brownian motion.	15	5

TEXT & REFERENCE BOOKS –

1. R. K. Pathria, Statistical Mechanics (Pergamon Press).
2. L. D. Landau & E. M. Lifshitz (Butter worth and Heinemann Press).
3. Federick Reif, Fundamental of statistical and thermal physics (McGraw-Hill publishers).
4. Kerson Huang, Statistical Mechanics (Wiley Eastern).

M.Sc. (Physics) Semester-II

Program	Subject	Year		Semester
M.Sc.	Physics	I		II
Course Code	Course Title			Course Type
PHY-230	**Electronic & Photonic Devices and Optical Modulators**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA		ESE	
100	30		70	

Learning Objective (LO):

The course aims to provide knowledge about the characteristics and applications of various semiconductor devices, such as JFETs, MOSFETs, and thyristors. Analyze the behaviour of photonic devices, including LEDs, lasers, and photo-detectors. Gain knowledge of optical modulation techniques and display devices.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the structure and operation of thyristors. Learn about the Shockley diode, three-terminal thyristor, Diac, Triac, SCR, and UJT. Analyze the characteristics of field-controlled thyristors.	Ap
2	Understand the structure and operation of JFETs, MESFETs, and MOSFETs. Learn about the small-signal equivalent circuit for microwave performance of MOSFETs. Analyze the characteristics of MIS and MOS diodes. Understand the concept and working principle of charge-coupled devices (CCDs). Learn about the basic device characteristics of MOSFETs and their different types.	Ap
3	Understand the structure and operation of tunnel diodes and backward diodes. Learn about the static and dynamic characteristics of IMPATT diodes. Analyze the transferred electron effect and its applications in Gunn diodes.	U
4	Understand the concept of radiative transitions. Learn about the structure and operation of LEDs and visible and infrared SC lasers. Analyze the characteristics of photoconductors and photodiodes. Understand the concept of solar cells and their ideal conversion efficiency. Learn about the structure and operation of p-n junction solar cells and heterojunction solar cells. Analyze the characteristics of interface thin film solar cells.	An
5	Understand the modulation of light using birefringence, optical activity, electro-optic, magneto-optic, and acoustic-optic effects. Learn about the materials exhibiting these properties. Analyze the principles of non-linear optics. Understand the concept and working principle of luminescence, photoluminescence, and electroluminescence. Learn about the characteristics of liquid crystal displays and numeric displays.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	3	1	-	-	-	3	1	-	-	-
CO2	3	3	3	1	1	1	3	-	-	-	-	3	2	-	-	3
CO3	3	3	3	1	1	1	3	-	-	2	-	3	2	-	-	2
CO4	3	3	3	1	1	2	3	1	-	2	1	3	2	-	-	-
CO5	3	3	3	1	1	-	2	-	-	2	2	3	2	3	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Special Bipolar devices: Thyristors- the four-layer diodes and their basic characteristics, Shockley diode, three terminal Thyristor, Diac & Triac, SCR, UJT, Field controlled Thyristors.	15	1
II	Unipolar Devices : JFET, MESFET and MOSFET, basic structure, working and device I-V characteristics, small signal equivalent circuit for Microwave performance Introduction to MIS and MOS diodes, charge coupled devices (CCDs), basic structure and working principle , MOSFET-basic device characteristics, types of MOSFET.	15	2
III	Special Microwave Devices: Tunnel diode and backward diode- basic device characteristics, IMPATT diodes and their static and dynamic characteristics, Transfer electron devices- transferred electron effect, Gunn diodes.	15	3
IV	Photonic Devices : Radiative transitions, LEDs, Visible and infrared SC lasers; Photo detectors; Photo conductor, & Photodiode, Solar cells, Solar radiation and ideal conversion efficiency, p-n junction solar cells, Hetero junction. Interface thin film solar cells.	15	4
V	Optical Modulators and Display Devices :Modulation of light-Birefringence, Optical activity, Electro-optic, Magneto-optic and Acoustic- optic effects, Materials exhibiting these properties, Non-linear optics. Display devices: Luminescence, Photo-luminescence, Electro-luminescence, Liquid crystal displays, Numeric displays.	15	5

Reference Books:

1. Semiconductor Devices – Physics and Technology, by S M Sze ,Wiley (1985)
2. Introduction to semiconductor device, M.S. Tyasi, John Wiley and sons
3. Measurement, Instrumentation and experimental design in physics and engineering by M.Sayer and A.Mansingh, Prentice Hall India 2000
4. Optical electronics by Ajay Ghatak and K.Thyagarajah, Cam.Univ. Press.
5. Opto electronics – An introduction: J.Wilson and JFB Hawkes (Eastern Economy Edition).
6. Optical Communications: J.H. Franz and V.K. Jain (Narosa).

M.Sc. (Physics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Physics	1	II
Course Code	**Course Title**		**Course Type**
PHY-240	**Computational Physics and Computer Programming**		Core
Credit	**Hours Per Week (L-T-P)**		
	L	T	P
5	4	1	0
Maximum Marks	**CIA**		**ESE**
100	30		70

Learning Objective (LO):

The course aims to probe numerical methods for solving algebraic equations, differential equations, and data interpolation. Understand the fundamental concepts of computer programming using PYTHON. Gain proficiency in PYTHON programming language syntax and constructs.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Solve linear and nonlinear algebraic equations using numerical methods. Analyze the convergence of solutions to numerical methods. Understand the principles of Gaussian elimination and pivoting. Apply iterative methods to solve linear systems. Learn about matrix inversion techniques.	Ap
2	Apply finite differences to interpolate data points. Use interpolation methods with equally spaced and unevenly spaced points. Fit polynomial curves to data using least squares methods. Implement cubic spline fitting for smooth interpolation. Perform numerical differentiation and integration using Newton-Cotes formulae. Analyze error estimates in numerical differentiation and integration. Apply Gauss method for efficient numerical integration.	Ap
3	Solve ordinary differential equations using Euler's method. Implement Runge-Kutta methods for higher-order accuracy. Apply predictor-corrector methods for improved stability. Understand the fundamental concepts of partial differential equations.	U
4	This course covers two aspects of programming i.e. solving the problem using different techniques like algorithm, flowchart and decision table and then writing the programs using the syntax of Python language to obtain the computer solution to the problem.	An
5	Python helps the beginners to scale up to professional programmer. This course will help enhancing the problem solving skills of the student using the python language.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	3	1	-	-	-	3	1	-	-	-
CO2	3	3	3	1	1	1	3	-	-	-	-	3	2	-	-	3
CO3	3	3	3	1	1	1	3	-	-	2	-	3	2	-	-	2
CO4	3	3	3	1	1	2	3	1	-	2	1	3	2	-	-	-
CO5	3	3	3	1	1	-	2	-	-	2	2	3	2	3	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative method, matrix inversion	15	1
II	Finite differences, interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial least squares and cubic spline fitting. Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.	15	2
III	Numerical solution of ordinary differential equations, Euler and RungaKutta methods, predictor-corrector method, elementary ideas of solutions of partial differential equations	15	3
IV	Introduction to Python: Structure of a Python Program, Elements of Python, Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, Identifiers and keywords, Literals, Strings and Operators. Conditional Statements and Looping: Branching, Looping, Conditional Statement, Exit function, Difference between break, continue and pass. String Manipulation: Understanding string, Accessing Strings, Basic Operations, String slices, Function and Methods.	15	4
V	List: Introduction to list, Accessing list, list operations, Working with lists, Function and Methods. Tuples: Introduction to tuple, Accessing tuples, Operations, Working, Functions and Methods. Dictionary: Introduction to dictionaries, Accessing values in dictionaries, Working with dictionaries, Properties, Functions. Python Functions: Defining a function, Calling a function, Types of functions, Function Arguments, Anonymous functions, Global and local variables, Organizing python codes using functions.	15	5

Reference Books:

1. Sastry: Introductory Methods of Numerical Analysis
2. Rajaraman: Numerical Analysis
3. Antia: Numerical methods.
4. A. B. Downey, Think Python, 2e: How to Think Like a Computer Scientist, O'Reilly, 2015.
5. Z. Shaw, LEARN PYTHON 3 THE HARD WAY, Addison-Wesley, 2017.
6. Arockia Mary P, Problem Solving and Python Programming, Shanlax Publications, 2021.
7. C. Morris, "https://www.kaggle.com/learn/python," [Online].
8. "https://docs.python.org/3/tutorial/index.html," [Online].
9. https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

M.Sc. (Physics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Physics	I	II
Course Code	Course Title		Course Type
PHY PR-300	**Numerical Analysis & Computer Programming**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	0	0	4
Maximum Marks	CIA		ESE
100	30		70

Leaning Objectives (LO):

The course aims to provide Experimental skills on writing PYTHON code for solving algebraic equations, differential equations, integration, matrix inversion and statistical analysis etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	After going through these experiments students will be able to solve equations using numerical approximation.	U, An
2	They will be able to design methods that will give solutions of physical problems.	U, An
3	The students will be skilled in PYTHON language programming and develop algorithms and programs.	U, An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	3	1	1	2	2	1	2	3	2	2	2	2	1
CO2	3	3	1	3	1	1	2	2	1	2	3	2	2	2	2	1
CO3	3	3	1	3	1	1	2	2	1	2	3	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments

S. No.	Experiment
1	To solve simultaneous Linear equation by Gauss Elimination method.
2	To calculate the root of a transcendental equation by Newton – Raphsons method.
3	Solving the system of linear simultaneous equation by Gauss Serdel method.
4	Numerical Integration by Simpson's 1/3 Rule.
5	Solving simultaneous Linear equation by Gauss-Jordon method.
6	Solution of Differential equation by Euler's Method
7	To invert a given matrix by Gauss-Jordon Method.
8	Solution of Differential equation by Runga Kutte Method.
9	To fit the given data in a straight line by linear regression Method. a) WAP to find the Largest of n number of series. b) To calculate the standard deviation of a given set of data.
10	To write a program to compute the complex roots of a given polynomial of N^{th} degree by Grafffe's Method.
11	To write a program to compute the Eigen values of a given matrix.
12	To integrate a given function by: (a) Trapezoidal method or by (b) Gauss Quadrature.
13	To find solutions of Ist order, ordinary differential equation by Taylor method

M.Sc. (Physics) Semester-II

Program	Subject	Year		Semester
M.Sc.	Physics	I		II
Course Code	Course Title			Course Type
PHY PR-260	**Electronics-II**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
2	0	0		4
Maximum Marks	CIA			ESE
100	30			70

Learning Objectives (LO):

The objective of this course is to provide experimental skills on experiments related to Electronics such as transistors, microprocessor etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	The students will be able to interpret data (both theoretical and experimental) and subsequently learn how the important parameters can be derived from a given set of results.	U, An
2	The students will be able to understand the operational principle of these components while using them for experimental investigations.	U, An
3	The students will learn the physics of different electronic instrumentations and the ways to improve the signal quality from any electronic circuit.	U, An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments

S. No.	Experiment
1	Design & Study of Regulated Power supply.
2	Study of Transistor Amplifiers in CE, CB, and CC modes.
3	Study of Transistor Bias Stability.
4	Study of Astable, Monostable and Bistable Multivibrator.
5	Experiment of Uni – Junction Transistor and its application.
6	Experiment of FET and MOSFET characterization and application as an amplifier.
7	Experiment with Microprocessor:- I (a) Convert BCD in to HEXADECIMPL (b) To transfer group of date blocks from one location to another location.
8	Experiment with microprocessor: - II (a) To write programs for addition of two 1 byte data giving results of 2 bytes. (b) To write programs for multiplication of two 1 byte data giving results of 2 bytes.
9	(a) To add 2 16-BIT numbers stored in locations from x x x x to x x x x + 3 and add them store the results from x x x x + 4 to x x x x+6 memory location (b) To find the largest of n numbers of a series.
10	To arrange N numbers in an ascending orders.
11	Experiments with Microprocessor. (a) Convert BCD in to binary and vice-versa. (b) To transfer group of data blocks from one location to another location. (c) To write programs for addition of two 1byte data giving result of 2byte data (d) To write programs for multiplication of two 1 byte data giving result of 2byte data
12	Logic gate study DTL and RTL.
13	Study of Silicon Controlled Rectifier.

Syllabus of Generic Elective Course

M.Sc. (Physics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Physics	I	II
Course Code	Course Title		Course Type
PHY-610	**Physics of electronic devices**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	2	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

This course provides the basic physics behind the devices used in daily life like Wide Area Network (WAN), Local Area Network (LAN), Wireless- Fidelity (Wi-Fi), Bluetooth, Basic understanding of mobile phone communication, Electrocardiogram (ECG), Blood pressure monitor, Pulse Oximeter, Pacemakers etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the principles of electric and magnetic fields. Comprehend electric current, voltage, and their measurement using a multi-meter. Differentiate between conductors and insulators. Explain the characteristics and applications of resistors, capacitors, and inductors. Apply Ohm's law to analyze electrical circuits. Describe domestic electric supply and the concept of grounding. Identify the heating effect of electric current and its applications in daily life devices. Explain the working principles of incandescent lighting devices. Understand the magnetic effects of electric current, electromagnetic induction, and the working principles of DC motors and AC dynamos.	**Ap**
2	Differentiate between intrinsic and extrinsic semiconductors. Understand N-type and P-type semiconductors. Explain the functioning of PN-junction diodes and LEDs. Analyze the operation and applications of transistors. Describe the working principles of solar cells. Understand the applications of phototransistors and photodiodes in electronic systems. Comprehend the role of semiconductors in electronic devices.	**An**
3	Understand electromagnetic waves (EMWs) and wireless communication. Differentiate between types of modulation and demodulation techniques. Identify essential components of wireless communication systems. Explain the basics of wireless networks, including WAN, LAN, Wi-Fi, and Bluetooth. Gain a basic understanding of mobile phone communication.	**Ap**
4	Identify different types of electromagnetic radiations. Differentiate between ionizing and non-ionizing radiations. Understand medical imaging techniques such as X-Ray imaging, CT scans, MRI, and ultrasound. Comprehend the functioning of medical devices like ECG, blood pressure monitors, pulse oximeters, and pacemakers.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create)

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO2	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO3	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO4	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1

"3" – Strong; "2" -- Moderate; "1"- Low; "-" No Correlation

Detail Syllabus

Unit 1: Electricity and Magnetism Fundamentals

Electric and magnetic fields, Electric current and voltage and measuring device: Ammeter, Voltmeter and Multi-meter, Alternating and Direct Currents (AC & DC), Conductors and insulators, Resistors, Capacitors, Inductor, Ohm's law, Domestic electric supply and concept of grounding, Heating effect of electric current and its application in daily life devices- stoves, electric iron; Magnetic effects of electric current, Electromagnetic induction, Working-principle of DC motors and AC Dynamo.

Unit 2: Semiconductor Devices and Applications

Semiconductors, Intrinsic and extrinsic semiconductors, N-type and P-type semiconductors. PN-junction diodes and Light Emitting Diodes (LEDs), Solar Cell, Transistor and its applications as switch and current amplifier, Phototransistor and its applications in burglar alarming systems and light sensitive switches, Photodiode and its applications in barcode readers and security systems.

Unit 3: Wireless Communication and Networks

Electromagnetic Waves (EMWs), Wireless communication and Types, Modulation and Demodulation, Types of modulation, Essential components of Wireless communication: Transmitter, Receiver, amplifier, Modem, Router, Firewalls Wireless Networks: Wide Area Network (WAN), Local Area Network (LAN), Wireless- Fidelity (Wi-Fi), Bluetooth, Basic understanding of mobile phone communication.

Unit 4: Electromagnetic Radiations and Medical Imaging

Electromagnetic Radiations and types, Ionizing and non-ionizing radiations, Imaging techniques in medical: X-Ray imaging, Computed Tomography (CT scan), Magnetic Imaging Resonance (MRI) and Ultrasound Imaging; Electrocardiogram (ECG), Blood pressure monitor, Pulse Oximeter, Pacemakers.

References:

1. "Principles of Electronics" by V.K. Mehta
2. "Electronic Principles" by Albert Malvino
3. NCERT Physics 12th
4. "Wireless Communication Systems" by Ke-Lin Du & M.N.S. Swamy
5. "Elements of Electromagnetics" by Mathew N.O. Sadiku
6. "Looking Within: How X-Ray, CT, MRI, Ultrasound and other Medical Images are created and How they help Physicians save Lives by Anthony Brinton Wolbarst
7. "Concepts of Physics" by H. C. Verma
8. "The Physics of Everyday Phenomena: A Conceptual Introduction to Physics" by W. Thomas Griffith

M.Sc. (Physics) Semester-III

Program	Subject	Year		Semester
M.Sc.	Physics	2		III
Course Code	Course Title			Course Type
PHY-310	**Quantum Mechanics-II**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The objective of this course is to farm a great ability to understand advanced concepts in quantum mechanics. By the end of this course, students will possess the knowledge and skills required to grasp concept, analyze solutions and apply concept in various applications.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Master the variation method for quantum states. Calculate energy expectation values. Apply to excited states and the helium atom's ground state. Understand quantum phenomena, including zero-point energy and Vander-Waals interactions. Explore W.K.B. approximation, approximate solutions, and asymptotic behavior. Analyze solutions near turning points and connection formulae. Determine energy levels in potential wells and quantization principles.	**Ap**
2	Grasp quantum scattering theory. Calculate differential and total cross sections. Understand wave-mechanical scattering, Green's functions, Born approximation. Analyze partial wave methods, phase shifts, optical theorem. Study scattering by different potentials.	U
3	Master time-dependent perturbation theory. Understand first-order perturbations and harmonic perturbation. Apply Fermi's Golden Rule to ionization and absorption/emission processes. Grasp selection rules. Comprehend wave functions for identical particles, both symmetric and antisymmetric.	**Ap**
4	Understand the principles of relativistic quantum mechanics. Explore the Klein-Gordon equation and its solutions. Analyze the Dirac equation, alpha, beta matrices, and Lorentz covariance. Master free particle solutions and energy spectra. Examine charge and current densities.	U
5	Understand the spin of Dirac particles. Analyze Dirac particles in electromagnetic fields and the concept of negative energy states. Explore Dirac equation for central fields, including spin angular momentum. Study the hydrogen atom, energy level classification, and negative energy states.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	1	2	-	2	1	-	2	1	3	1	2	-	-
CO2	3	3	3	2	2	-	2	1	-	2	1	3	1	2	-	-
CO3	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-
CO4	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-
CO5	3	3	3	1	2	1	2	1	-	3	1	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detail Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Variational method, expectation value of energy, application to excited states, ground state of He-atom, zero-point energy of one-dimensional harmonic oscillator, Vander-Waals interaction, the W.K.B. approximation, approximate solutions, asymptotic nature of the solution, solution near turning point, connection formulae, energy levels of a potential well and quantization rule.	15	1
II	Theory of scattering: differential and total scattering cross section, wave mechanical picture of scattering & the scattering amplitude, Green's functions and formal expression for scattering amplitude, The Born approximation and its validity, Partial wave analysis, asymptomatic behavior of partial waves and phase shifts, optical theorem, scattering by a square well potential, scattering by a hard sphere, scattering by a Coulomb potential.	15	2
III	Time-dependent perturbation theory, first order perturbation, Harmonic perturbation, Fermi's Golden rule, Ionization of a H-atom, absorption and induced emission, Selection rules. Identical particles, symmetric and anti-symmetric wave functions.	15	3
IV	Relativistic quantum mechanics, formulation of relativistic quantum theory, the Klein-Gordon equation; plane wave solutions, charge and current densities, The Dirac equation for a free particle, matrices alpha and beta, Lorentz covariance of the Dirac equation, free particle solutions and the energy spectrum, charge and current densities.	15	4
V	The spin of the Dirac particle, Dirac particle in electromagnetic fields and the significance of the negative energy state, Dirac equation for a central field: Spin angular momentum, approximate reduction, spin–orbit energy, separation of equation, the hydrogen atom, classification of energy levels and negative energy states.	15	5

Reference Books:

1. L.I. Schiff: Quantum Mechanics (McGraw-Hill).
2. S.Gasiorowicz: Quantum Physics (Wiley).
3. Landau and Lifshitz: Quantum Mechanics.
4. B.Craseman and Z.D.Powell : Quantum Mechanics (Addison Wesley)
5. A.P. Messiah: Quantum Mechanics.
6. J.J. Sakurai: Modern Quantum Mechanics.
7. Mathews and Venkatesan: Quantum Mechanics.
8. Bjorken and Drell: Relativstic Quantum Mechanics.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-320	**Atomic and Molecular Physics**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The objective of this course is to understand structure and fundamental components of atom and gain a working knowledge of quantum mechanics and its application to behavior of particles at the atomic and molecular level and students also learn about the fine and hyperfine structure of atoms their energy levels effect of magnetic field in splitting of spectral lines and vibrational rotational and Raman spectra.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand quantum states of one-electron atoms, atomic orbitals, Hydrogen spectrum, spin-orbit interaction, fine structure, alkali spectra, selection and intensity rules.	U
2	Grasp Pauli's exclusion principle, distinguish equivalent and non-equivalent electrons, comprehend ground states, analyse two-electron systems, understand L-S and J-J coupling, explore hyperfine structure, and recognize line broadening mechanisms.	U
3	Understand normal and anomalous Zeeman effects, early discoveries, vector models in weak magnetic fields, bound electron magnetic properties, selection rules, and Stark effects in hydrogen.	**Ap**
4	Study different types of molecules, rotational spectra of diatomic molecules, rigid and non-rigid rotator models, microwave and Raman spectra, and understand the quantum theory of Raman Effect.	U
5	Explore vibrational spectra in diatomic molecules, including simple harmonic and anharmonic models, vibrating rotators, interaction of rotations and vibrations, and analyse IR and Vibrational Raman spectra.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO2	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO3	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO4	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2
CO5	3	3	3	2	1	2	2	2	3	2	2	3	2	2	2	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Quantum states of one electron atoms-atomic orbitals, Hydrogen spectrum, spin orbit (L-S) interaction energy, fine structure of hydrogen spectrum including L-S interaction and relativistic correction, spectra of alkali elements, fine structure in alkali spectra, penetrating and non-penetrating orbits, intensity rules.	15	1
II	Pauli's principle, equivalent and non-equivalent electrons, ground state (basic level of different elements), two electron systems, interaction energy in L-S. and J-J. Coupling, Hyperfine structure, line broadening mechanisms (general ideas).	15	2
III	Normal and anomalous Zeeman effect, early discoveries and developments, vector models of one electron system in a weak magnetic field, magnetic moment of a bound electron, magnetic interaction energy, selection rules, intensity rules, Paschen-Back(PB) effect – principal series effect, Zeeman and PB effects in hydrogen, Stark effect- discovery, Stark effect in Hydrogen, orbital model, weak and strong effect in Hydrogen.	15	3
IV	Types of molecules: linear and diatomic molecules, symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules: rigid rotator model, energy levels, Eigen functions, spectrum, comparison with observed spectrum and non-rigid rotator model, Intensities of spectral lines, microwave spectrometer, Raman spectrum; classical and quantum theory of Raman Effect, pure rotational Raman spectrum	15	4
V	Vibrational spectra of diatomic molecules: simple harmonic model, energy levels and spectrum, comparison with observed spectrum and anharmonic model, Vibrating rotators, Interaction of rotations and vibrations, fine structures and P-Q-R branches, IR spectrometer, Vibrational Raman spectrum, Vibrational rotational Raman spectrum..	15	5

TEXT AND REFERENCE BOOKS:

1. Introduction to atomic spectra - H.E. White (T).
2. Fundamentals of molecular spectroscopy – C.N. Banwell and E.M McCash (T).
3. Spectroscopy vol. I, II and III – Walker and straughner.
4. Introduction to Molecular spectroscopy – G.M. Barrow.
5. Spectra of diatomic molecules – Herzberg.
6. Molecular spectroscopy – Jeanne L.Mc-Hale.
7. Molecular spectroscopy – J.M. Brown.
8. Spectra of atoms and molecules –P.F.Bemath.
9. Modern spection copy, J.M. Holias.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-330	**Solid State Physics-I**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to prob solid state physics and master the fundamental principles of electronic properties of solids, including band theory, Fermi surfaces, phonons, superconductivity, and semiconductors.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the concept of energy bands in solids. Analyze the origin and magnitude of the energy gap. Learn about the Bloch function and Kronig-Penny model. Apply the wave equation to describe electrons in periodic potentials. Understand the significance of the crystal momentum of an electron.	Ap
2	Investigate the effect of temperature on the Fermi-Dirac distribution. Analyze the behavior of the free electron gas in three dimensions. Explore different zone schemes, including reduced and periodic zones. Construct Fermi surfaces and identify their characteristics. Understand the concept of nearly free electrons, holes, and open orbits.	Ap
3	Analyze lattice dynamics in monoatomic and diatomic lattices. Differentiate between optical and acoustic modes. Quantize elastic waves and understand phonon momentum. Investigate the scattering of phonons by neutrons.	U
4	Explore theoretical aspects of superconductivity, including thermodynamics of the superconducting transition, London equation, coherence length, Cooper pairing due to phonons, BCS theory, BCS ground state, to understand the concept and current research scenerio.	An
5	Understand the concept of band gap in semiconductors. Derive the equation of motion for electrons in semiconductors. Analyze the physical interpretation of holes and effective mass. Calculate effective masses of semiconductors like silicon and germanium. Determine intrinsic carrier concentration and intrinsic mobility. effectively.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	3	2	3	3	1	3	2	3	3	3	3	3
CO2	3	3	3	1	3	2	3	3	1	3	2	3	3	3	3	3
CO3	3	3	3	1	3	2	3	3	1	3	2	3	3	3	3	3
CO4	3	3	3	1	3	2	3	3	1	3	2	3	3	3	3	3
CO5	3	3	3	1	3	2	3	3	1	3	2	3	3	3	3	3

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Energy bands: nearly free electron model, origin of energy gap and its magnitude, Bloch function, Kronig-Penny model, Wave equation of electron in periodic potential, restatement of Bloch theorem, crystal moment of an electron, solution of Central equation, Kronig-Penny model in reciprocal space, empty lattice Approximation, approximate solution near zone boundary, Number of orbitals in a band, metals and insulators	15	1
II	Effect of temperature on F-D distribution, free electron gas in three dimension. Different zone schemes, reduced and periodic zones, construction of Fermi surfaces, nearly free electrons, electron, hole, open orbits, Calculation of energy bands, Tight binding, Wigner-Seitz, cohesive energy, pseudo potential methods. Experimental methods in Fermi surface studies, quantization of orbits in a magnetic field, de Haas van Alphen Effect, External orbits, Fermi surface of copper.	15	2
III	Lattice dynamics in monoatomic and diatomic lattice: two atoms per primitive basis, optical and acoustic modes, quantization of elastic waves, phonon momentum, inelastic neutron scattering by phonons, Anharmonic crystal interactions-thermal expansion, thermal conductivity, thermal resistivity of phonon gas, umklapp processes, imperfections.	15	3
IV	Experimental survey: occurrence of superconductivity, Destruction of superconductivity by magnetic field, Meissner effect, heat capacity, energy gap, MW, and IR properties, isotope effect. Theoretical survey : thermodynamics of superconducting transition, London equation, Coherence length, Cooper pairing due to phonons, BCS theory of superconductivity, BCS ground state, flux quantization of superconducting ring, duration of persistent currents, Type II superconductors, Vortex states, estimation of Hc1 and Hc2, single particle and Josephson superconductor tunneling, DC/AC Josephson effect, Macroscopic quantum interference. High temperature superconductors, critical fields and currents, Hall number, fullerenes ring	15	4
V	Band gap, equation of motion, physical derivation of equation of motion, holes, effective mass, physical interpretation of effective mass, effective masses of semiconductors Si and Ge, intrinsic carrier concentration, intrinsic mobility, impurity conductivity, donor and acceptor states, thermal ionization of donors and acceptors, thermo-electric effects.	15	5

Reference Books:

1. C. Kittel: Introduction to Solid State Physics (Wiley and Sons).
2. J.M.Ziman: Principles of theory of solids (Cambridge Univ.Press).
3. Azaroff: X-ray crystallography.
4. Weertman and weertman : Elementary Dislocation Theory.
5. Verma and Srivastava: Crystallography for Solid State Physics.
6. Azeroff and Buerger: The Power Method.
7. Buerger: Crystal Structure Analysis.
8. Thomas: Transmission Electron Microscopy.
9. Omar: Elementary solid state physics.
10. Ashcroft and Mermin: Solid State Physics.
11. Chalking and Lubensky: Principles of Condensed Matter Physics.
12. Madelung: Introduction to solid state theory.
13. Callaway: Quantum theory of solid state physics.
14. Huang: Theoretical Solid State Physics.
15. Kittel: Quantum theory of solids.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-341 (A)	**Astronomy and Astrophysics-I**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to give students a comprehensive understanding of Astronomy and Astrophysics. Starting with basic properties of stars like magnitudes, spectral types, distances, and their position in the HR diagram, the course will give more profound insights into structure, formation, evolution and end states of the stars. Furthermore, this course provides detailed characteristics of the Sun, facilitating the comprehension of other stellar bodies. In addition, it elucidates various observational techniques for astronomical measurements. Ultimately, this course aims to equip students with a fundamental foundation in key astrophysical concepts.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the essential stellar parameters such as magnitudes, colour index and spectral types. Determine stellar distances using various methods. Interpret the Hertzsprung-Russell (HR) diagram. Understand the concept of stellar structure, hydrostatic and thermal equilibrium and energy transport mechanisms.	U/Ap
2	Understand the role of interstellar dust and gas in star formation. Describe the pre-main sequence and post-main sequence evolution of stars. Explain the late stages of stellar evolution and supernova explosion.	U
3	Understand the end states of stars, e.g. white dwarfs, neutron stars and black holes. Derive electron degeneracy pressure and the Chandrasekhar limit. Understand binary stars, their classification, Roche lobes and accretion process. Describe the evolution of semidetached systems, including Algols, cataclysmic variables, and X-ray binaries.	U/Ap
4	Understand the physical characteristics of the Sun. Describe the phenomena in the photosphere, chromosphere and corona. Understand the theory of sunspots, their formation and solar cycle. Gain insights into solar oscillations and helioseismology.	U
5	Understand concepts and techniques in astronomical measurements. Use Kepler's laws to interpret binary stars. Use of Doppler Effect in measuring velocities of galaxies and rotation of Saturn. Estimate the age of the universe using Hubble's Law. Construct an HR diagram and determine cluster distances. Use Period-Luminosity relation for distance measurements. Calculate the period, dispersion, and distances of pulsars.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO2	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO3	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO4	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO5	3	3	3	3	2	2	2	2	1	2	2	3	3	3	3	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Stars-apparent magnitudes, Colour index, Spectral classification, Stellar distances, Absolute magnitude, The H-R diagram of stars. Stellar interiors: The basic equations of stellar structure, Hydrostatic equilibrium, Thermal equilibrium, Virial Theorem, Energy sources, Energy transport by radiation and convection, Equation of state.	15	1
II	Formation and evolution of stars: Inter stellar dust and gas, Formation of protostars, Pre-main sequence evolution, Post main sequence evolution and Evolution on the main sequence for low and high mass stars, Late stages of evolution, Fate of massive stars, Supernovae and its characteristics.	15	2
III	End states of stars, Electron degeneracy pressure, White dwarfs, and Chandrasekhar limit, Neutron stars and Pulsars, Black holes. Binary stars and their classification, close binaries, Roche Lobes, Evolution of semidetached systems: Algols, Cataclysmic variables and X-ray binaries.	15	3
IV	Solar Physics: Physical Characteristics of sun, Photosphere: Limb darkening, Granulation, Faculae, Solar Chromosphere and Corona, Prominences, Solar Cycle and Sunspots, Solar Magnetic Fields, Theory of Sunspots, Solar flares, solar wind, Helioseismology.	15	4
V	Kepler's law and its implication to Binary Stars, Doppler Effect and its use in velocity measurement e.g. rotation of Saturn and its Ring, determination of velocity of galaxies, Hubble's law and Age of the Universe, Star clusters, HR diagram of star clusters, distance and age determination through HR diagram. Variable stars, Cepheid Variables, Period Luminosity relation and Distance measurement. Period, dispersion and distance of the Pulsars. Photometer and photoelectric photometry.	15	5

Text and Reference Books:

1. Astrophysics for Physicists, Arnab Rai Choudhuri, Camb. University Press, 2010.
2. Astrophysics : Stars and Galaxies, K.D. Abhayankar, Universities Press (India) Ltd, 2001.
3. An Introduction to Astrophysics, Baidyanath Basu, PHI, 2010.
4. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wealey, 2007.
5. Introductory Astronomy and Astrophysics, M.Zeilik and S.A. Gregory, Saunders College Publishing, 1998.
6. The Physical Universe: An introduction to astronomy, F.Shu, University Science Books, 1982.
7. Textbook of astronomy and astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publishing House, 2000.
8. The new cosmos, A.Unsold and B. Baschek, Newyork, Springer 2002.
9. A Workbook for Astronomy, Jerry Waxman, Cambridge University Press, 1984.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-342 (B)	**Electronics (Communication)-I**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to master the principles of microwave devices, waveguides, cavities, TEDs, and satellite communication

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the principles of microwave devices, including klystrons, magnetrons, and traveling-wave tubes. Analyze the operation of two-cavity klystrons and reflex klystrons. Learn about the principles of magnetrons and helix traveling-wave tubes. Investigate velocity modulation in microwave devices. Apply the basic principles of microwave devices to practical applications.	Ap
2	Understand the propagation of microwaves in waveguides. Solve the wave equation in rectangular and cylindrical coordinates for rectangular and circular waveguides, respectively. Analyze TE, TM, and TEM modes in rectangular and circular waveguides, analyze microwave waveguide components, such as bends, tees, and couplers.	Ap
3	Design and analyze rectangular, circular, and semi-circular cavity resonators. Calculate the Q-factor of cavity resonators. Understand the Gunn effect and its applications in Gunn diodes. Analyze the modes of operation and applications of IMPATT and TRAPATT diodes. Explore the use of TEDs in microwave oscillators and amplifiers.	U
4	Understand the advantages of microwave transmission over other communication methods. Calculate losses in free space propagation of microwaves. Investigate the propagation of microwaves in various environments, such as the troposphere and ionosphere.	An
5	Understand the principles of satellite communication systems. Analyze the orbital parameters of satellites, including geostationary satellites. Design and analyze satellite communication link budgets. investigate the different types of satellite communication systems, such as point-to-point, broadcast, and mobile satellite services.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	3	1	-	-	-	3	1	-	-	-
CO2	3	3	3	1	1	1	3	-	-	-	-	3	2	-	-	3
CO3	3	3	3	1	1	1	3	-	-	2	-	3	2	-	-	2
CO4	3	3	3	1	1	2	3	1	-	2	1	3	2	-	-	-
CO5	3	3	3	1	1	-	2	-	-	2	2	3	2	3	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Klystron, magnetron & traveling wave tubes, velocity modulation, basic principal of two cavity klystrons & relex klystrons, principle of operation of magnetrons, helix traveling wave tubes.	15	1
II	(Wave modes) rectangular wave guides: solution of wave equation in rectangular coordinates, TE modes in rectangular wave guides, TM modes in rectangular wave guides, excitations of modes in rectangular wave guides. Circular wave guides :solutions of wave equation in Cylindrical coordinates, TE modes in Circular wave guides ,TM modes in Circular wave guides , TEM modes in Circular wave guides, excitations of modes in Circular wave guides .	15	2
III	**Microwave cavities**: rectangular cavity resonator, circular –cavity resonator &semi –circular –cavity resonators Q- factor of a cavity resonator. **Transferred Electrons devices (TEDs)** Gunn effect diodes, principle of operation, modes of operations, read diodes, IMPATT diodes, TRAPATT diodes. Microwave communications: advantages of microwave transmission, loss in free space, propagation of microwave, components of antennas used in MW communication system.	15	3
IV	Radar block diagram & operation ,radar frequencies ,pulse consideration, radar range equation ,derivation of radar range equation ,minimum detectable single receiver noise ,signal to noise ratio ,integration of radar pulses ,radar cross sections ,pulse reflections frequency ,antenna ,parameters ,systems losses & propagation losses ,radars transmitters receivers ,antennas displays	15	4
V	Orbital Satellite, geostationary satellite ,orbital patterns ,look angles ,orbital spacing , satellite system ,link modules	15	5

Reference Books:

1) "Microwaves" by K.L. Gupta Wiley Estern Ltd. Delhi.
2) Advanced Electronic communication system by Wayne Tomsi Physics education.
3) Principle of communication of system-by Toub & Schilling: 2nd ed. TMH 1994
4) Communication system: by Siman Haykin, 3rd ed. John wiley & sons inc.1994.
5) Microwave devices & circuits by : Samuel, Y. Liau.
6) Electronic communication: George kennedy

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-343 (C)	**Physics of Nano-Materials- I**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to equip students to develop a comprehensive understanding of various techniques for synthesizing, characterizing, and analyzing nanomaterial's, along with the ability to interpret and apply data obtained through advanced analytical methods for materials science and nanotechnology research.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	comprehensively investigate and understand the properties and applications of nanomaterial's, encompassing metal Nano-clusters, theoretical modeling, electronic structure, semiconductor nanoparticles, magnetic clusters, optical properties, rare gas and molecular clusters, bulk Nano-structured materials, synthesis methods, and unique nanostructured crystals.	Ap
2	Understand about carbon bonds, various carbon allotropes (C60, graphene, CNTs), their diverse types, synthesis techniques (laser vaporization, arc discharge, chemical deposition), purification methods, and explore the multifaceted properties in optics, electronics, mechanics, and thermodynamics.	Ap
3	Explain wide array of synthesis methods for nanomaterial's, including top-down (mechanical milling, attrition) and bottom-up (CVD, PVD, PLD) approaches, as well as chemical routes (precipitation, CBD, sol-gel, thermolysis) to produce diverse nanostructures for various applications.	U
4	Describe a brief overview and analysis of various analytical techniques used in materials science, including X-ray and spectroscopic methods, as well as surface analysis techniques, to aid in understanding material properties and compositions.	An
5	Explore and analyze a diverse array of advanced microscopy and spectroscopy techniques, shedding light on their applications in materials and scientific research for detailed characterization and analysis.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	2	1	-	-	3	1	2	2	-	3	2	1	2	2	2	1
CO2	2	1	-	-	2	1	2	2	-	3	1	1	1	2	2	-
CO3	2	-	-	-	2	1	2	2	1	3	1	-	1	2	2	-
CO4	2	1	1	-	2	2	2	2	1	2	1	-	1	3	3	-
CO5	2	-	-	-	2	2	2	2	1	2	1	-	1	3	3	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Nano Materials** Properties of Nano-Particles: Metal nano-clusters, theoretical modeling of nanoparticles, geometric and electronic structure, magnetic clusters, Semiconductor nanoparticles, optical properties, rare gas and molecular clusters, Bulk nano-structured materials: Solid disordered nanostructures, methods of synthesis, properties, nano-cluster composite glasses, porous silicon, nano structured crystals.	15	1
II	**Carbon Nano Tubes (CNTs)** Nature of carbon bonds, different allotropies of carbon, structure and properties of C_{60}, graphene, carbon nanotubes and its types, laser vaporization techniques, arc discharge method and chemical deposition techniques, purification techniques, Properties of Carbon Nanotubes and Graphene: Optical, electrical, electronic, mechanical, thermal, and vibrational properties.	15	2
III	**Synthesis of Nano- Materials** Top-down & Bottom-up approaches: Formation of nanostructures by mechanical milling (ball milling) and mechanical attrition, Chemical Vapor Deposition (CVD), Physical Vapour Deposition (PVD), thermal and e beam evaporation, Pulsed Laser Ablation(PLD). Chemical Routes for synthesis of Nanomaterials:Chemical precipitation and co- precipitation, chemical bath deposition (CBD), Sol-gel synthesis, Microemulsions or reverse micelles, Solvothermal synthesis, Thermolysis routes and spray pyrolysis.	15	3
IV	**Characterization of Nano-materials (a)** X-ray Diffraction (XRD), powder and single crystal Diffraction, X-ray fluorescence (XRF), X ray photoelectron spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Extended X ray absorption and fluorescence spectroscopy (EXAFS), Dispersive high pressure XRD and Diamond anvil cells (DAC).Nuclear Magnetic Resonance (NMR) and Raman spectroscopy: description and analysis. Surface analysis methods: Secondary ion mass spectroscopy (SIMS), Auger Electron Spectroscopy, ESCA, Deep Level Transient Spectroscopy (DL TS), Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Differential ThermalAnalysis.	15	4

V	**Characterization of Nano-materials (b)** Scanning Tunneling Microscopy (STM), Contact and non-contact Atomic Force Microscopy (AFM), Magnetic Force Microscopy (MFM), Nano indentation. Scanning Electron Microscopy (SEM), Transmission electron microscopy (TEM), High resolution TEM Field emission SEM, Electron Energy Loss Spectroscopy (EELS). Spectrophotometry: UV-Vis spectrophotometers, IR spectrophotometers, Fourier Transform Infrared Radiation (FTIR), Photoluminescence (PL), electroluminesce and thermoluminescence spectroscopy, Near-field Scanning Optical Microscopy (NSOM).	15	5

Text and Reference books:

1. Nano materials: Synthesis properties ,characterization and application: A.S Edelsteinand R.C Cammaratra
2. Introduction to Nanotechnology: Charles P. Poole Jr and Franks J. Qwens
3. Nanotechnology, Kohlr, Michael.
4. Handbook of Analytical instruments, R.S. Khandpur
5. X-ray diffraction procedures, H. P. Klung and L.E.Alexander
6. The Powder Method IV. Azaroff and M. J. Buerger
7. Elements of X-ray diffraction, B. D.Cullity
8. Differential Thermal Analysis, R.C.Mackenzie
9. Thermal Methods of Analysis, W.W.Wendlandt
10. Synthesis, Functionalization and Surface treatment of Nanoparticles :Maric Isbellaand Buraton
11. Encyclopedia of Nanotechnology, H.S. Nalwa
12. Handbook of Nanotechnology: Bhushan (Ed), Springer Verlag, New York (2004).
13. Nanostructures and Nanomaterials- Synthesis properties and Applications by Guozhong Cao (Empirical College Press World Scientific Pub., 2004).
14. Nanocomposite Science and Technology, Ajayan, Schadler and Braun
15. Fullerene & Carbon nanotubes, Dressel Shaus
16. Carbon Nanotubes, Elizer
17. Physical properties of CNT, Saito
18. Carbon nanotechnology, Liming Dai
19. Nanotubes and nanowires, CNR Rao and Govindaraj RCS Publishing.
20. Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh, CRC press, 2007.
21. An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, Michele Mosca
22. The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation by Dirk Bouwmeester, Artur K. Ekert, Anton Zeilinger
23. Problems And Solutions in Quantum Computing And Quantum Information Yorick Hardy Willi-Hans Steeb

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-344 (D)	**Space Physics-I**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

This course aims to give a deep understanding of the fundamentals of space physics. Upon completion of this course, students will have a thorough comprehension of solar physics, planetary systems, celestial mechanics, observational instruments, and space expeditions. Students will acquire the ability to examine and comprehend various phenomena, such as solar activity, planetary structure, coordinate systems, observational instruments, and space research missions. This will allow them to utilize their knowledge in the wider domain of space physics.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the physical properties of the Sun, solar energy generation, and the intricate processes within its layers. Analyse solar phenomena like sunspots, solar flares, and helioseismic activity, as well as understand the dynamic behaviour of our star.	U
2	Understand the solar planetary system, including the major characteristics of planets, atmospheric composition, and planetary magnetism. Understand the magnetic fields, magnetic dipole, planets, asteroids, comets, and magnetic fields of extra-solar planets.	U
3	Understand Solar and Sidereal Time, Julian Date, Right Ascension, Declination, Azimuth, Elevation, galactic coordinates, and the WGS 84 coordinate system. Additionally, learn GPS operation, accuracy, and applications to gather exact time and position information.	U/Ap
4	Understand the electromagnetic bands used in astronomy. Additionally, understand proficiency in the functioning and constraints of diverse telescopes and devices for different astronomical phenomena.	U
5	Understand the planetary exploration, encompassing the early lunar missions, the instruments and experiments of the Apollo program, and the exploration of Mercury, Venus, and Mars. Additionally, they will comprehend the importance of space missions such as Cassini-Huygens and Deep Impact, and delve into scientific pursuits, such as SETI investigations.	U/An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO2	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO3	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO4	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO5	3	3	3	3	2	2	2	2	1	2	2	3	3	3	3	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Physical Characteristics of sun, Source of solar energy, thermonuclear reaction and building up of higher elements, Description of solar internal and external layers, Photosphere: Limb darkening, Granulation, Faculae, Solar Chromosphere and Corona, Heating of the solar chromosphere and corona, Prominences, Solar Cycle and Sunspots, Solar Magnetic Fields, Theory of Sunspots, Solar flares, Solar wind, Coronal mass ejections, Helioseismology	15	1
II	Solar planetary system, Major characteristics of the Planets, Atmospheric Composition, Planetary magnetism, Magnetic fields, Magnetic dipole, Asteroids, Comets, Extra Solar Planets, Magnetic fields of Extra Solar Planets	15	2
III	Time and Coordinate system, Celestial Sphere, Solar Time, Sidereal Time, Julian Date, Right Ascension and Declination, Azimuth and Elevation, galactic coordinates, WGS 84 coordinate system, GPS – operation, accuracy, time and position information.	15	3
IV	Electromagnetic bands of observation: radio, infrared, optical, UV, X-ray and Gamma-ray windows. Ground-based, balloon-borne and satellite-borne telescopes, Resolution of Instruments and Limitations, Optical telescopes, Photometers, Spectrographs, CCDs, Polarimeters. Radio telescopes - interferometry, X-ray and Gamma-ray detectors, Neutrino and Cosmic Ray astronomy, Radar.	15	4
V	Planetary Exploration, Early spacecraft visits to the moon, Unmanned Lunar landers; The Apollo program - man on the moon – instruments and experiments, Lunar structures; Exploration of Mercury, Venus, Mars - the Red Planet – Structure of Mars, Martian atmosphere; ice at the poles, Martian landscapes: linear features, volcanoes, and impact craters; exotic terrains; Study of Planetary moons with space missions, The Cassini- Huygens Mission, The Deep Impact Mission. Search for extra terrestrial life – SETI experiments.	15	5

Text and Reference Books:

1. Solar System Astrophysics, J. C. Brandt and P. W. Hodge
2. Introduction to Experimental Physics, W. B. Fretter.
3. The Magnetic Field of the Earth, Roland T. Merrill, Michael W. McElhinny, Phillip L.
4. Mcfadden,Academic Press
5. Physics of Geomagnetic Phenomena, Vol. I and II, S. Matsushita. and W. H.
6. Campbell, Academic Press
7. Earth's Magnetospheric Process, Ed. B. M. McCormac, D. Reidel Publishers

8. Physics of the Magnetosphere, Eds. R. L. Corovillano, J. T. McCaulley and H.
9. Radosky, D. Reidel Publishers
10. Solar System Plasma Physics, Vol. I, II and III, Eds. C. F. Kennel, L. J. Lanzenrutti
11. and E. N. Parker
12. Dynamics of the Geomagnetically Trapped Radiation (Physics and Chemistry in
13. Space, Vol II)
14. Solar Terrestrial Physics, Ed. E. R. Dyer, D. Reidel Publishers
15. Solar Magneto–Hydrodynamics, E.R. Priest; D Reidel, 1982
16. R.C. Smith, Observational Astrophysics; CUP, 1995.
17. C.R. Kitchin, Astrophysical Techniques; Adam Hilger, 1984.
18. Digital Image Processing, R. C. Gonzales and R. E. Woods, 2nd Ed, Pearson India,
19. 2002
20. Satellite Meteorology, S. Q. Kidder and T. H. Von der Haar, Academic Press, 1995
21. Lecture Notes on Satellite Meteorology, Vol 1 and 2, SAC, Ahmedabad
22. Remote Sensing and Image Interpretation, T. M. Lillesand and R. W. Kieffer, John
23. Wiley, 2002
24. Fundamentals of Space Systems, V. L. Pisacane and R. C. Moore, Oxford University
25. Press, 1994
26. Fundamentals of Remote Sensing, George Joseph, 2003
27. Processing Remote Sensing Data, M. C. Girgard and C. Girgard, Oxford-IBH, 1999
28. Quantitative Remote Sensing of Land Surfaces, Shunlin Liang, Wiley Interscience,
29. 2004
30. Scale in Remote Sensing and GIS, D. A. Quattrachi and M. F. Goodchild
31. Theory of Satellite Orbits in an Atmosphere, King-Hele Desmond, Butterworths,
32. 1964
33. Uncertainty in Remote Sensing and GIS, Ed: G. M. Foddy and P. M. Atkinson
34. Remote Sensing by George Joseph
35. Concepts in Space Sciences Edited by R.R. Daniel
36. Mathematical Principles of Remote Sensing by A.. Milman
37. An Introduction to Ionosphere and Magnetosphere, J. A. Raticliffe
38. Solar System Astrophysics, J. C. Brandft and P. W. Hodge
39. Plasma Diagnostic Techniques, R. H. Huddlestone and S. L. Leonard
40. Introduction to Experimental Physics, W. B. Fretter
41. High Vacuum Techniques, J. Yarwood
42. Plasma Diagnostics, Vol. I, O. Anciello and D. L. Flamn
43. The Earth's Ionosphere: Plasma Physics and Electrodynamics, Michael C. Kelley,
44. AcademicPress
45. Ionospheric Techniques and Phenomena, A. Giraud and M. Petit, D. Reidel Publish.
46. Physics of Geomagnetic Phenomena, Vol. I and II, S. Matsushita and W. H.
47. Campbell, Academic Press
48. Introduction to Ionospheric Physics, H. Risbeth and H. Garriot, Academic Press
49. Space Weather, Physics and Effects by Volker Bothmer and Loannis.A.Depli
50. Springer
51. Aerospace Environment by T Beer
52. Free flight of a rocket By Gantmaker
53. Orbital Mechanics, Ed. Vladimir A, Chobotov, AIAA Edn Series
54. Introduction to Celestial Mechanics, S. W. McCusky, Addison-Wesley
55. Fundamentals of Astrodynamics, R. R. Bates et al, Dover
56. Orbital Motion, A. E. Roy, Adam Hinglar Ltd
57. Orbital Methods in Astrodynamics, P. R. Escobal, John Wiley
58. Fundmentals of Astrodynamics, R. R. Bates et al, Dover
59. Orbital Motion, A. E. Roy, Adam Hinglar Ltd
60. Design of Orbital Flights, J. Johnson et al., McGraw Hill

61. Modern Astrophyiscs, B. W. Carroll and D. A. Ostlie, Addison -Wesley
62. The Physical Universe, F. Shu, University Science Books
63. The Physics of Astrophysics, Vol. I and II, F. Shu, University Science Books
64. Theoretical Astrophysics, Vol. I, II and III, T. Padmanabhan, Cambridge Uni.Press
65. The Physics of Fluids and Plasmas, Arnab Rai Choudhuri, Cambridge Uni.Press
66. Astrophysical Concepts, M. Harwitt, Springer-Verlag
67. Galactic Astronomy, J. Binney and M. Merrifeld, Princeton University Press
68. Galactic Dynamics, J. Binney and S. Tremaine, Princeton University Press
69. Quasars and Active Galactic Nuclei, A. K. Kembhavi and J. V. Narlikar, Cambridge
70. University Press
71. An Introduction to Active Galactic Nucleii, B. M. Peterson

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-345 (E)	**Quantum Computing-I**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The aim of this course is to empower students with a profound understanding of quantum computing concepts , Quantum Cryptography, Quantum Fourier Transform etc.

Course Outcomes:

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand history of quantum computation and quantum information, Need of Quantum Computing, Global perspective, future directions, Principle of linear super-position and parallel process, quantum bits (qubits), Hadamard Transformation, Bell states, entanglement, quantum teleportation, quantum logic	U
2	Understand single qubit operations-controlled operations, measurements, universal quantum gates, summary of the quantum circuit model of computation, simulation of quantum system.	U
3	Understand Private key cryptography, private amplification and information reconciliation, quantum key distribution, privacy and coherent information, security. Basic information of Quantum Programming, the quantum search algorithm.	U
4	Understand the quantum Fourier transform, phase estimation, application in order finding and factoring, general application of quantum Fourier transform in period finding, discrete algorithm, hidden subgroup problem.	U
5	Understand the Physical realization of Quantum Computers: guideline principle, conditions for quantum computation, harmonic oscillator quantum computer, optical photon quantum computer, optical cavity quantum electrodynamics, ion traps, nuclear magnetic resonance, quantum logic gates, other implementation technique.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	2	-	3	1	-	2	3	3	3	1	1	2
CO2	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO3	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO4	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO5	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	A. Historical Perspective: History of quantum computation and quantum information, Need of Quantum Computing, Global perspective, future directions, B. Quantum Mechanical concepts: Principle of linear super-position and parallel process, quantum bits (qubits), Hadamard Transformation, Bell states, entanglement, quantum teleportation, quantum logic	15	1
II	Quantum Gates and circuits; Quantum Algorithm: single qubit operations-controlled operations, measurements, universal quantum gates, summary of the quantum circuit model of computation, simulation of quantum system.	15	2
III	A. Quantum Cryptography and Superdense Coding: Private key cryptography, private amplification and information reconciliation, quantum key distribution, privacy and coherent information, security. B. Quantum programming: Basic information, the quantum search algorithm.	15	3
IV	Quantum Fourier Transform and its application: the quantum Fourier transform, phase estimation, application in order finding and factoring, general application of quantum Fourier transform in period finding, discrete algorithm, hidden subgroup problem.	15	4
V	Physical realization of Quantum Computers: guideline principle, conditions for quantum computation, harmonic oscillator quantum computer, optical photon quantum computer, optical cavity quantum electrodynamics, ion traps, nuclear magnetic resonance, quantum logic gates, other implementation technique.	15	5

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-PR 350	**Material Science and General**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	0	0	6
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The objective of this course is to provide experimental skills in the field of materials science.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	After completing this course students will be able to know what things are made up of and why they behave as they do.	U, An
2	It will enable students to observe, measure, and analyze various phenomena of solid samples and substances using photoluminescence, thermoluminescence, mechanoluminescence, etc. as well as maintain a safe and sterile working environment.	U, An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	1	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	To determine activation energy of ionic/superionic solid by Temperature depended conductivity measurement.
2	To study Electron Spin(ESR) Resonance in DPPH (Diphenyl Pricyl Hydrazy) sample
3	To study I-V characteristics of photovoltaic solar cell and find the efficiency.
4	To study the decay of photoconductivity of given sample and find out trap depth.
5	Study of decay of photoluminescence of a given sample.
6	Measurement of electrical conductivity using Impedance Spectroscopy technique.
7	To determine drift velocities of Ag+ ion in AgI from temperature dependence of ionic transference number study.
8	Electrical conductivity of Ball milled/Mechano-chemical synthesized materials.
9	Determination of strength of a given radioactive source.
10	Study of complete spectra of radioactive sources, and study of photo peak efficiency of NaI(Tl) crystal for different energy gamma rays.
11	Structural analysis of powder sample by XRD and particle size determination using Scherrer's formula.
12	FTIR studies of solid samples.
13	Mechanoluminescence of sucrose crystals.
14	Thermoluminescence of irradiated samples.
15	Study of Opto- Electronics Devices.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-PR 361 (A)	**Astronomy and Astrophysics**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	0	0	6
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The main objective of this course is to provide students with practical, hands-on experience in observational astronomy and astrophysics. Through a series of experiments and simulations, the course aims to cultivate skills in data analysis, distance determination, and fundamental astrophysical principles. Students engage in activities ranging from verifying Hubble's law to analyzing the dynamics of celestial objects like pulsars and Saturn.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Gain proficiency in using observational data and simulation programs to analyze astronomical phenomena. Understand fundamental concepts such as Kepler's Law, Hubble's Law, Period-Luminosity relation, and Doppler effect. Apply mathematical and analytical skills to determine crucial parameters like Hubble's constant, distances to celestial objects, and the age of the universe.	U/An
2	Develop practical skills in performing photometry, spectroscopy, and analyzing light curves. Learn techniques for measuring properties like brightness, velocity, and period from observational data. Apply observational techniques to determine the characteristics and distances of various astronomical objects such as star clusters, galaxies, and pulsars.	U/An
3	Understand the application of physical laws, including Newton's laws of motion and gravitation, in celestial mechanics. Analyze the motion of celestial objects such as planets, stars, and binary systems. Gain insights into the dynamics of rotating bodies like Saturn and the orbital dynamics of binary stars, while deducing their masses and properties.	U/Ap
4	Use computational tools and packages for analysis and plotting, such as Gnuplot, Python-matplotlib, Jupyter Note Book etc.	U/An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO4	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	Study of Hubble's law and expansion of the Universe using the spectra of different galaxy cluster fields. Determine the Hubble's constant and age of the Universe. (Make use of CLEA program, Plot Hubble Diagram using GNUPLOT and fit a straight line). This is a simulated observatory programme where students perform experiment to prove the Hubble's law (V is prop to D). They will find the V from the spectra of different Galaxies and distance from their Luminosity/magnitude.
2	Perform photoelectric photometry (in B and V filters) of Pleiades star cluster in order to construct HR Diagram and determine the distance using Main Sequence Fit method. (Make use of CLEA program, Plot HR Diagram using GNUPLOT and fit the data for Main Sequence). This is a simulated observatory programme where students perform photometry i.e. measure the brightness in B and V filters, and Construct an HR diagram, and finally calculate the distance.
3	Study of light curves of Cepheid Variable stars and determine the distance of Small Magellanic Cloud (SMC) using Cepheid Variables' Period Luminosity Relation. (Plot and fit Period Luminosity relation using GNUPLOT). Students will measure the apparent magnitude 'm' and period of variation 'P' from the given light curves of Cepheid variable stars in SMC. From that they will find the distance of SMC using PL relation.
4	Determine the period of Pulsars from their pulse profile in different radio frequencies. Find the dispersion by measuring delay in arrival time of pulses at two frequency bands and hence determine distances of the Pulsars. Students will find the period of different pulsars from their recorded pulse profiles. Their dispersion in different Frequencies and hence distance.
5	Study of Quasar 3C 273 and determine its red-shift, recessional velocity, distance, apparent magnitude, absolute magnitude and size of the emitting region. Find that it is very compact yet very luminous object. Students will find the red-shift (z) from the spectra of Qusar 3C 273, and from the red-shift they will find the distance using Hubble's law, they will extract apparent magnitude from the given image and the absolute magnitude from the calculated distance, and finally size of the source.
6	Determine the rotational velocity and mass of the Saturn. Study the differential motion of ring particles to check that ring particles follow the Keplerian orbit, hence determine the mass of Saturn. Students will use the spectra of Saturn to find Doppler shift (blue shift and red shift). From this they will estimate rotational velocity of Saturn, its inner ring and outer ring. They will also find out the mass of Saturn using the Velocity of ring applying Newton's law of Force F=GMm/r2 = mv2/r.
7	Study of proper motion of 61 Cygni. Find the proper motion of 61 Cygni star over the duration of nearly 100 years from two recorded observations with this given time gap. Students will find the proper motion of 61 Cygni star over the duration of nearly 100 years from two recorded observations with this given time gap.
8	Study of orbit of a visual binary star Kruger 60. Construct an orbit diagram in order to verify that this binary system follows Kepler's law of motion (verify 1st and 2nd law). Use Kepler's 3rd law to determine the mass of Kruger 60 binary system. Students will make an orbit diagram from the recorded observations. This orbit will form an elliptical path. From this they will prove the Keplar's law of motion and deduce the mass of Binary system from the 3rd law.
9	Develop Python (Jupyter) Notebook for (a) HR diagram of Star cluster (b) Hubble's Law (c) Period-Luminosity Relation (d) Kepler's Law (Make use of data from experiments 1, 2, 3 and for Keplers law use Planetary data from reference books in the syllabus) Students will use Python-matplotlib to create diagrams and available modules in Python to fit the curves. Experiments will be explained in details using Jupyter Notebook.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-PR 362 (B)	**Electronics**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	0	0	6
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The objective of this course is to provide experimental skills on experiments related to Electronics such as transistors, microprocessor etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Interpret data and learn how the important parameters can be derived from a given set of results.	U, An
2	Understand the operational principle of these components while using them for experimental investigations.	U, An
3	Learn the physics of different electronic instrumentations and the ways to improve the signal quality from any electronic circuit.	U, An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

P O / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	Experiments with microprocessor. (a)Convert BCD in to binary & vice versa. (b) To transfer group of data blocks from one location to another location. (c) To write programme for addition & subtraction. (d) To write programme for multiplication & division.
2	Logic gate study DTL & RTL.
3	To study& verify the Demorgon's Theorem.
4	Study of Adder/ Subtractor.
5	Study of Encoder & Decoder.
6	Study of Multiplexer & Demultiplexer
7	Study of digital to analog converter.
8	Study of analog to digital converter.
9	Study of 4-bit Counter/ ripple Counter.
10	Study of left/right shift register.
11	Study of read only memory.
12	Study of Random Access Memory.
13	Study of Phase locked loop.
14	Study of BCD to seven segment Decoder.
15	Study of modulation & demodulation.
16	Optical fiber based experiment.
17	Microwave characterization and measurements.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-PR 363 (C)	**Physics of Nano-materials**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	0	0	6
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The course aims to equip students to develop a comprehensive understanding of various techniques for synthesizing, characterizing, and analyzing nanomaterial's, along with the ability to interpret and apply data obtained through advanced analytical methods for materials science and nanotechnology research.

Course Outcomes:

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the concept of synthesis of nano-materials by different synthesis methods and analyze their band gap energies.	Ap
2	Analyze the structural properties and various lattice parameters by x-ray diffraction techniques and predict their crystal structure.	An
3.	To understand the nano behavior of materials in terms of electrical, thermal and optical properties.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs 1	2	3	4	5	6	7	8	9	10	11	PSO 1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	Synthesis of II-IV semiconductor nanoparticles by wet chemical method.
2	Synthesis of nanoparticles (ZrO_2) by Combustion method.
3	Synthesis of nanoparticles by Sol-gel method.
4	Synthesis of nanoparticles by Ball milling method.
5	Synthesis of Quantum cells structures using vacuum coating unit.
6	Synthesis of nanoparticles using Solid state reaction method.
7	Measurement of band gap energy and size of the nano particle of II-IV semiconductor using absorption spectrophotometer.
8	To make the peak analysis of IR transmission spectra of nanoparticle using FTIR spectrometer.
9	Study of effect of capping agent on the size of the nanoparticle during synthesis.
10	To determine the average particle size of nano materials by XRD using Sherer's formula.
11	To determine the Hall coefficient and carrier type for a semiconducting nanoparticles.
12	To determine the Band gap of a given semiconductor using Four probe method from room temperature to 100°C.
13	To determine the average size of naonparticles using Zetasizer.
14	To measure the change of dielectric constant and dielectric loss of nanoparticle with the change of signal frequency by impedance analyzer.
15	To characterize the mechanical properties by tensile testing.
16	To estimate the particle size by SEM.
17	To perform electron diffraction analysis from TEM image.
18	To do roughness analysis of nanostructured sample using AFM.

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-PR 364 (D)	**Space Physics**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	0	0	6
Maximum Marks	CIA		ESE
100	30		70

Learning Objectives (LO):

The objective of this course is to provide experimental skills in the field of Space Physics.

Course Outcomes:

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Gain a deeper understanding of our space and the fundamental principles governing it.	
2	Develop observational and experimental skills, enhancing precision in measurements.	

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO2	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1
CO3	3	3	2	2	1	1	2	2	1	1	1	2	2	2	2	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	The flow of energy out of the Sun.
2	Study of Sun-spot.
3	Astrometry of asteroids.
4	Study of expansion of the universe and calculate the age of the Universe.
5	Identification of element from Fraunhoffer spectrum of the sun.
6	The transit of Venus and Mercury.
7	Jupiter's Moon and speed of light.
8	Determination of Pulsar period and distance.
9	Photo-electric photometry of Pleiades star cluster.
10	The large scale structure of the Universe.

M.Sc. (Physics) Semester-III

Program	Subject	Year		Semester
M.Sc.	Physics	2		III
Course Code	Course Title			Course Type
PHY-PR 365 (E)	**Quantum Computing**			Elective
Credit	Hours Per Week (L-T-P)			
	L	T		P
3	0	0		6
Maximum Marks	CIA			ESE
100	30			70

Learning Objectives (LO):

The objective of this course is to provide experimental skills in the field of Quantum Computing.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Demonstrate a comprehensive understanding of the fundamental principles of quantum mechanics as they apply to quantum computing, including superposition, entanglement, and quantum measurement.	U, Ap
2	To design quantum algorithms for various computational problems.	U, Ap
3	To analyze factoring, database search, and optimization, using techniques such as quantum circuit construction and quantum gate operations.	U, Ap
4	Develop a solid grasp of quantum information theory.	U, Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	1	2	-	2	1	-	2	1	3	1	2	-	-
CO2	3	3	3	2	2	-	2	1	-	2	1	3	1	2	-	-
CO3	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-
CO4	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

List of Experiments:

S.no.	Experiments
1	Quantum States and Gates: verification of gates.
2	Quantum Superposition: Prepare the qubits in a superposition state using the Hadamard gate.
3	Quantum Entanglement: Create an entangled pair of qubits (Bell state) using quantum gates.
4	Quantum Teleportation: Prepare and verify an arbitrary qubit and an entangled pair of qubits.
5	Grover's Search Algorithm: Simulation of Grover's algorithm to search for a marked item in an unsorted list using a quantum circuit.
6	Quantum Error Correction: Simulate a simple quantum error-correcting code and compare the fidelity of corrected vs. uncorrected qubits.
7	Simulation of the behavior of a simple quantum system (e.g., a two-level quantum system) on a quantum computer.
8	Quantum Variational Algorithms: implementation of Variational Quantum Eigen solver (VQE) to find the ground state energy of a small molecule and Compare the VQE result with classical methods.

Generic Elective Course

M.Sc. (Physics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Physics	2	III
Course Code	Course Title		Course Type
PHY-620	**Physics for society**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	2	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The objective of this course is to understand the basic physics principle which is applicable in the activities which is prevalent in society such as sports, use of house hold devices, optical devices etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Understand the concepts of motion and its various types. Explain mass, inertia, force, and linear momentum. Comprehend torque, angular momentum, and Newton's laws of motion. Analyze work and energy, distinguishing between kinetic and potential energy. Explore the conservation law of angular momentum and its applications in gymnastics. Understand the effects of gravity and the concept of center of mass in sports like high jump, diving, and gymnastics. Differentiate between static and dynamic equilibrium and their roles in weightlifting, gymnastics, running, and sprinting. Analyze projectile motion in sports like javelin throw and shot put, as well as the Magnus effect in baseball, soccer, and cricket.	**Ap**
2	Understand heat, temperature, entropy, pressure, heat capacity, and specific heat. Explain the laws of thermodynamics and the Celsius temperature scale. Comprehend thermocouples and their applications. Explore the Seebeck and Peltier effects. Understand phases of matter, phase transitions, and working principles of heat engines and refrigerators. Analyze the functioning of air conditioners (ACs).	**An**
3	Understand the behavior of fluids, including gases and liquids. Differentiate between steady flow, laminar flow, and turbulent flow. Explain Bernoulli's principle and its applications in aircraft flight and wind turbines. Analyze the continuity equation and its implications in pipe flow. Understand the design and applications of nozzles and diffusers. Explore Pascal's law and its applications in hydraulic systems like presses, lifts, and brakes.	**An**
4	Understand optical phenomena, including reflection, refraction, interference, polarization, diffraction, and dispersion. Identify and describe types of mirrors and their applications. Identify and describe types of optical lenses and their applications. Analyze the principles and applications of telephoto lenses and polarizers. Understand the functioning of optical devices such as microscopes and telescopes. Explore the biological optical device – the eye, and understand conditions like short-sightedness, far-sightedness, and their treatments.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO2	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO3	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO4	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detail Syllabus

Unit 1: Mechanics and Dynamics in Sports

Motion and its types, Mass, Inertia, Force and linear momentum, Torque and angular momentum, Newton's law of motion, Work, Energy: kinetic and potential Energy; Conservation law of angular momentum and its role in gymnastics, Gravity, Center of mass and its role in various sports- High jump, diving and gymnastics; Equilibrium: static and dynamic equilibrium and its role various sports- Weightlifting, gymnastic, running; Projectile motion: Javelin throw and Shot put, Magnus effect: in relevance to baseball, soccer and cricket.

Unit 2: Thermodynamics and Heat Applications

Heat, Temperature, Entropy, Pressure, Heat capacity and specific heat, Laws of thermodynamic, Celsius temperature scale, Thermocouple and its applications, Seebeck and Peltier effects, Phases of matter and phase transition, Working principles of Heat engines and Refrigerators, Air conditioners (ACs).

Unit 3: Fluid Mechanics and Applications

Fluids: Gases and Liquids, steady flow, laminar flow and turbulent flow, Bernoulli's principle and its application in aircraft flight and wind turbines, continuity equation and its implication in pipe flow, Nozzle and diffuser designing, Pascal's law, Hydraulic Press machine, hydraulic lifts, hydraulic brakes.

Unit 4: Optics and Optical Devices

Light, Optical phenomena: reflection, refraction, interference, polarization, diffraction, dispersion, Types of Mirror and applications, Types of optical lenses and applications, telephoto lens and applications, polarisers, polarised sunglasses, Microscope, telescopes, Biological optical device: Eye, short-sightedness, far-sightedness and their treatments.

References:

1. "Concepts of Physics" by H. C. Verma
2. "The Physics of Everyday Phenomena: A Conceptual Introduction to Physics" W. Thomas Griffith
3. "Biomechanics in Sport: Performance Enhancement and Injury Prevention" by Vladimir M. Zatsiorsky.
4. NCERT Physics 11th
5. NCERT Physics 12th

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	2	IV
Course Code	Course Title		Course Type
PHY-410	**Nuclear and Particle Physics**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to give students a comprehensive understanding of nuclear physics and elementary particle physics, covering a wide array of topics, including nuclear interactions, reactions, decay mechanisms, various nuclear models, and the properties of fundamental particles. By exploring these topics, the course provides an understanding of the details of nuclear phenomena, the fundamental constituents of matter, and the principles governing the behaviour of nuclei and elementary particles.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain the fundamental principles governing nucleon-nucleon interactions by analyzing the properties of the ground state of the deuteron and nucleaon-nucleaon scattering. Evaluate the role of spin dependence, charge independence, and charge symmetry in nuclear forces. Interpret the Meson theory of nuclear forces and the Yukawa interaction.	U
2	Calculate reaction energetics and threshold energies using the Q-equation. Determine reaction cross-sections and interpret resonance phenomena. Apply formal reaction theory, including partial wave approach and phase shifts. Analyze direct and compound nuclear reactions. Utilize the reciprocity theorem to understand reaction processes.	U
3	Interpret beta decay processes and analyze the shape of beta spectra. Apply conservation laws and Pauli's neutrino hypothesis to understand beta decay. Calculate total decay rates using Fermi's theory of beta decay. Analyze angular momentum and parity selection rules in nuclear decay. Discuss experimental methods for detecting and studying neutrinos.	U
4	Explain the liquid drop model and Bohr-Wheeler theory of fission. Interpret experimental evidence for shell effects and the single-particle shell model. Analyze spin-orbit interaction and magic numbers in nuclear models. Understand the collective model of Bohr and Mottelson and its application in describing nuclear phenomena.	U
5	Classify elementary particles and understand their fundamental interactions. Analyze the properties of leptons, hadrons, and quarks. Discuss symmetries, groups, and conservation laws in particle physics. Interpret SU(2) and SU(3) multiplets and their significance in particle physics. Explain the quark model and its implications for the structure of hadrons. Describe the standard model of particle physics.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

Program M.Sc Cour

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	2	2	2	1	2	2	3	3	2	2	2
CO2	3	3	3	2	2	2	2	2	1	2	2	3	3	2	2	2
CO3	3	3	3	2	2	2	2	2	1	2	2	3	3	2	2	2
CO4	3	3	3	2	2	2	2	2	1	2	2	3	3	2	2	2
CO5	3	3	3	2	2	2	2	2	1	2	2	3	3	2	2	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Nuclear Interactions** Nucleon-nucleon interaction, Two-nucleon system, The ground state of the deuteron, Tensor forces, Nucleon-nucleon scattering at low energy, Scattering length, Effective range theory, Spin dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Iso-spin formalism, Exchange forces, Meson theory of nuclear forces and the Yukawa interaction.	15	1
II	**Nuclear Reactions** Reaction energetics: Q-equation and threshold energies, Reactions cross sections, Resonance: Breit-Wigner single-level formula, Direct and compound nuclear reactions, Formal reaction theory: Partial wave approach and phase shifts, Scattering matrix, Reciprocity theorem,	15	2
III	**Nuclear Decay** Beta decay, Shape of the beta spectrum and problems in conservation laws, Pauli's neutrino hypothesis, Femi's theory of beta decay, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, Parity violation, Detection and properties of neutrino. Gamma decay, Multiple transitions in nuclei, Angular momentum and Parity selection rules, Internal conversion.	15	3
IV	**Nuclear models** Liquid drop model, Bohr-Wheeler theory of fission, Shell Model, Experimental evidence for shell effects, Single particle shell model, Spin-orbit interaction and magic numbers, Analysis of shell model predictions, Magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.	15	4
V	**Elementary particle Physics** The fundamental interactions, Classification of elementary particles, Leptons and Hadrons, Symmetries, groups and conservation laws, SU(2) and SU(3) multiplets and their properties, Quark model, Properties of Quarks, the standard model.	15	5

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	2	IV
Course Code	Course Title		Course Type
PHY-420	**Laser Physics and Applications**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course objective is to provide students understanding and practical application of LASER, covering their fundamental characteristics, a wide range of laser systems, advanced physics concepts, multi-photon processes, laser spectroscopy, diverse laser applications, and laser communication, fostering expertise in laser technology and its multifaceted uses.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain the fundamental principles of lasers, including spontaneous and stimulated emission, coherence, and population inversion. Explore the components and characteristics of lasers, from pumping mechanisms to cavity losses, to achieve an in-depth knowledge of laser technology.	**Ap**
2	Analyze and apply a wide range of laser systems, including solid-state lasers like ruby and Nd:YAG, semiconductor lasers, gas lasers like He-Ne and CO2, liquid lasers, and chemical lasers, to comprehend their features, applications, and underlying principles in diverse laser technologies.	**An**
3	Explore advanced topics in laser physics, including Q-switching, mode locking, non-linear optics, harmonic generation, phase matching, parametric generation, and self-focusing of light. Gain a deep understanding of cutting-edge laser technologies and their applications.	**Ap**
4	Describe multi-photon processes, including multi-quantum photoelectric effects and various two- and three-photon processes. Understand laser spectroscopy techniques, such as Rayleigh and Raman scattering, stimulated Raman effect, and coherent anti-Stokes Raman scattering.	**Ap**
5	Explore a wide array of laser applications, from precise measurements of Earth's rotation to isotope separation, thermonuclear fusion, and diverse applications in chemistry, biology, astronomy, engineering, and medicine. Additionally, understand laser communication principles, including ranging, fiber optics, and the propagation of light in varying mediums for efficient data transmission.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO2	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO3	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO4	3	3	3	1	2	2	3	3	1	2	2	3	3	3	3	3
CO5	3	3	3	1	2	1	2	3	1	2	2	3	3	3	3	3

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Laser Characteristics –** Spontaneous and stimulated emission, Einstein's quantum theory of radiation, theory of some optical processes, coherence and monochromacity, kinetics of optical absorption, line broadening mechanism, Basic principle of lasers, population inversion, laser pumping, two & three level laser systems, resonator, Q-factor, losses in cavity, threshold condition, quantum yield.	15	1
II	**LASER Systems-** state lasers- the ruby laser, Nd:YAG laser, ND: Glass laser, semiconductor lasers – features of semiconductor lasers, intrinsic semiconductor lasers, Gas laser - neutral atom gas laser, He-Ne laser, molecular gas lasers, CO2 laser, Liquid lasers, dye lasers and chemical laser.	15	2
III	**Advances in laser Physics-** Production of giant pulse -Q-switching, giant pulse dynamics, laser amplifiers, mode locking and pulling, Non-linear optics, Harmonic generation, second harmonic generation, Phase matching, third harmonic generation, optical mixing, parametric generation and self-focusing of light.	15	3
IV	**Multi-photon processes-** multi-quantum photoelectric effect, Theory of two-photon process, three- photon process, second harmonic generation, parametric generation of light, Laser spectroscopy : Rayleigh and Raman scattering, Stimulated Raman effect,Hyper-Raman effect, Coherent anti-stokes Raman Scattering, Photo-acoustic Raman spectroscopy.	15	4
V	**Laser Applications –** ether drift and absolute rotation of the Earth, isotope separation, plasma, thermonuclear fusion, laser applications in chemistry, biology, astronomy, engineering and medicine. Communication by lasers: ranging, fiber Optics Communication, Optical fiber, numerical aperture, propagation of light in a medium with variable index, pulsedispersion.	15	5

Text and reference books:

1. Laud, B.B.: Lasers and nonlinear optics, (New Age Int.Pub.1996).
2. Thyagarajan, K and Ghatak, A.K.: Lasers theory and applications (Plenum press,1981).
3. Ghatak, A.K.and Thyagarajan, K : Optical electronics (Cambridge Univ. Press1999).
4. Seigman, A.E.: Lasers (Oxford Univ. Press 1986)
5. Maitland, A. and Dunn, M.H. : Laser Physics (N.H.Amsterdam, 1969).
6. Hecht, J.The laser Guide book (McGraw Hill, NY, 1986).
7. Demtroder, W. : Laser Spectroscopy (Springe series in chemical physicsvol.5,Springe verlag, Berlin, 1981).
8. Harper, P.G.and Wherrett B.S. (Ed.): Non-linear-optics (Acad.press, 1977).

CO-PO/PSO
PO
CO

M.Sc. (Physics) Semester-IV

Program	Subject	Year		Semester
M.Sc.	Physics	2		IV
Course Code	Course Title			Course Type
PHY-430	**Solid State Physics-II**			Core
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The course aims to understand the fundamental principles of plasmons, polaritons, dielectrics, ferroelectrics, magnetism, and optical processes and provide research based and theoretical knowledge.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the concept of plasmons and their role in plasma optics. Analyze the dispersion relation for electromagnetic waves in plasma. Investigate transverse optical modes in plasma and the transparency of alkali metals in the ultraviolet region. Study longitudinal plasma oscillations and their relation to plasmons. Explore electrostatic screening and the screened Coulomb potential in plasma.	Ap
2	Apply Maxwell's equations to describe polarization and electric fields in dielectrics. Differentiate between local, Lorentz, and cavity fields in dielectrics. Relate dielectric constant and polarizability to electronic polarizability. Investigate structural phase transitions and their impact on dielectrics. Classify ferroelectric crystals and their characteristics.	Ap
3	Grasp the fundamental concepts of diamagnetism and paramagnetism. Apply quantum theory to explain paramagnetism in rare earth ions. Investigate the Hund rule, crystal field splitting, and quenching of orbital angular momentum in iron group ions	U
4	Understand the concept of ferromagnetic order and its relation to the Curie point and exchange integral. Analyze the temperature dependence of saturation magnetization and its behavior at absolute zero. Investigate magnons, the quantization of spin waves, and the thermal excitation of magnons. Study neutron magnetic scattering as a tool for investigating ferromagnets.	An
5	Analyze optical reflectance and its relation to electronic transitions in materials. Understand the concept of excitons and their types, including Frenkel and Mott-Wannier excitons. Investigate excitons in alkali halides and molecular crystals. Study lattice vacancies, Schottky and Frenkel point effects, and color centers.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO2	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO3	3	3	3	1	2	1	3	3	1	2	2	3	3	3	3	3
CO4	3	3	3	1	2	2	3	3	1	2	2	3	3	3	3	3
CO5	3	3	3	1	2	1	2	3	1	2	2	3	3	3	3	3

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Dielectric function of the electron gas, Plasma optics, Dispersion relation for EM wave, Transverse optical modes in Plasma, Transparency of Alkali metals in the ultraviolet, Longitudinal Plasma oscillations, Plasmon, electrostatic screening and screened Coulomb potential, Mott metal-insulator transition, screening and phonons in metals, Polaritons, LST relation .	15	1
II	Maxwell's equations, polarization, macroscopic electric field, depolarization filed, E1;local electric field at an atom, Lorentz filed E2, fields of dipoles inside cavity E3; dielectric constant and polarizability, electronic polarizability; structural phase transition; ferro-electric crystals, classification; displacive transition, soft optical phonons, Landau theory of phase transitions, first and second order transition, antiferro-electricity, ferroelectric domain, piezoelectricity, ferro-elasticity, optical ceramics.	15	2
III	General ideas of dia- and para- magnetisms, quantum theory of paramagnetism, rare earth ions, Hund rule, iron group ions, crystal field splitting, quenching of orbital angular momentum, spectroscopic splitting factor, van vleck temperature dependent paramagnetism, Cooling by isentropic demagnetization, nuclear demagnetization, paramagnetic Susceptibility of conduction electrons.	15	3
IV	Ferromagnetic order, Curie point and exchange integral, temp dependence of saturation magnetization, saturation magnetization at absolute zero; magnons, quantization of spin waves, thermal excitation of magnons; neutron magnetic scattering, Ferrimagnetic order, Curie temp and susceptibility of ferrimagnets, iron garnets. Antiferromagnetic order, susceptibity below neel temp, antiferromagnetic magnons, ferromagnetic domains	15	4
V	Optical reflectance, excitons, Frenkel and Mott-Wannier excitons, Alkali Halides and Molecular crystals Defects: lattice vacancies, Schottkey and Frenkel point effects, colour centers, F and other centres, Line defect. Shear strength of single crystals, dislocations edge and screw dislocations, Burger vectors, Stress fields of dislocations, low angle grain boundaries, dislocation densities, dislocation multiplication and slip, strength of alloys, dislocations and crystal growth, hardness of materials.	15	5

Reference Books:

1. C. Kittel: Introduction to Solid State Physics (Wiley and Sons).
2. J.M.Ziman: Principles of theory of solids (Cambridge univ.press).
3. Azaroff : X-ray crystallography.
4. Weertman and weertman : Elementary Dislocation Theory.
5. Verma and Srivastava: Crystallography for Solid State Physics.
6. Azeroff and Buerger: The Power Method.
7. Buerger: Crystal Structure Analysis.
8. Thomas: Transmission Electron Microscopy.
9. Omar: Elementary solid state physics.
10. Aschroft and Mermin : Solid State Physics.
11. Chalking and Lubensky: Principles of Condensed Matter Physics.
12. Madelung : Introduction to solid state theory.
13. Callaway: Quantum theory of solid state physics.
14. Huang: Theoretical Solid State Physics.
15. Kittel: Quantum theory of solids.

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	2	IV
Course Code	Course Title		Course Type
PHY-441 (A)	**Astronomy and Astrophysics -II**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to provide a more advanced and detailed understanding of Astronomy and Astrophysics by studying the structure, dynamics, and characteristics of different types of galaxies, including the Milky Way and Active Galactic Nuclei (AGNs). It also aims to explore the fascinating phenomena, theories and models related to the origin and evolution of the Universe. Ultimately, the course aims to equip students with valuable knowledge in the field of astronomy and cosmology.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the Milky Way Galaxy's structure and dynamics of spiral arms. Learn about the classification of galaxies. Explore their brightness profiles, distribution of gas and dust and their properties. Understand the intriguing concept of rotation curves, shedding light on the mysterious realm of dark matter.	U/Ap
2	Explore the different types of Active Galactic Nuclei (AGNs). Gain insights into the Unified model of AGNs to understand these complex celestial phenomena.	U/Ap
3	Understand the shortcomings of Newtonian gravity, necessity of General Relativity and its predictions. Gain a comprehensive understanding of various cosmological models.	U
4	Understand the universe's origins and evolution. Explore various phenomena that happened in the early universe step by step.	U
5	Analyze and interpret the observational data and techniques such as redshift-magnitude relation, number counts of extragalactic objects, the variation of angular sizes with distance, age of the universe, and abundance of light nuclei etc. to test the various cosmological models.	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO2	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO3	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO4	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO5	3	3	3	3	2	2	2	2	1	2	2	3	3	3	3	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	The Milkyway Galaxy: Structure of the Milkyway, Oort's theory of galactic rotation, Dynamics of the spiral arms, Distribution of Interstellar matter. Normal Galaxies: Classification of galaxies, Hubble sequence: Elliptical, Lenticulars and Spiral galaxies, and their properties, Brightness profiles, Distribution of gas and dust in galaxies, Rotation curve and dark matter.	15	1
II	Active galaxies: Active Galactic Nuclei (AGNs), Seyfert galaxies, BL Lac Objects, Radio galaxies: General properties, Superluminal motion, Quasars: Properties and Energy requirements, Nature of quasar redshifts, Supermassive black hole model and Unified model of AGNs.	15	2
III	Problem in Newtonian gravity and need of General Relativity. Principle of Equivalence. Concept of curved space, Predictions of General Relativity: precession of perihelion of Mercury, bending of light, gravitational lensing, Gravitational wave and its detection through Laser interferometer. Weyl's Postulate, Cosmological Principle, Friedmann Model, Einstein's model with cosmological constant, Steady State Model.	15	3
IV	Relics of the big bang, The early universe, Thermodynamics of the early universe, Thermal History, Primordial neutrinos, Helium synthesis and other nuclei, Microwave background, The very early universe, The formation of structures in the Universe, Jeans Mass, Growth Rate, Recombination era, Onset of matter dominated era.	15	4
V	Observations of the cosmological significance, Measurement of Hubble`s constant, Anisotropy of local large - scale velocity fields, Age of the universe, Abundance of light nuclei, Dark matter, The redshift-magnitude relation, Number counts of extragalactic objects, The variation of angular sizes with distance.	15	5

Text and Reference Books:

1. Astrophysics for Physicists, Arnab Rai Choudhuri, Camb. University Press, 2010.
2. Astrophysics: Stars and Galaxies, K.D. Abhayankar, Universities Press (India) Ltd, 2001.
3. An Introduction to Astrophysics, Baidyanath Basu, PHI, 2010.
4. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wealey, 2007.
5. Introductory Astronomy and Astrophysics, M.Zeilik and S.A. Gregory, Saunders College Publishing, 1998.
6. Quasars and active galactic neuclei, A.K. Kembhavi and J.V. Narlikar, Cambridge University Press, 1999.
7. Elements of Cosmology, J.V. Narlikar, Universities Press, 1996.
8. Introduction to cosmology, J.V. Narlikar, 3rd edition, Cambridge Uni. Press, 2002.
9. The Physical Universe: An introduction to astronomy, F.Shu, University Science Books 1982.
10. Textbook of astronomy and astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publishing House, 2000.
11. The new cosmos, A.Unsold and B. Baschek, Newyork, Springer 2002.
13. A Workbook for Astronomy, Jerry Waxman, Cambridge University Press, 1984.
15. Galactic Astronomy: Binney and Merrifield, Princeton University Press, 1981.
16. General relativity and Cosmology, J.V. Narlikar, Macmillan Company of India Ltd, New Delhi 1978.

M.Sc. (Physics) Semester-IV

Program	Subject	Year		Semester
M.Sc.	Physics	2		IV
Course Code	Course Title			Course Type
PHY-442 (B)	**Electronics (Communication)-II**			Elective
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The course aims to master the principles learnt in third semester and advanced it for research based applications and master the fundamental principles of digital communications, including pulse modulation, noise, and data transmission

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand pulse modulation systems and the sampling theorem. Analyze low-pass and band-pass signals. Investigate PAM, channel bandwidth for PAM signals, natural sampling, and flat-top sampling. Study signal-through-holding, quantization of signals, and quantization error.	Ap
2	Grasp the principles of PCM, differential PCM, and delta modulation. Analyze adaptive delta modulation (CVSD). Investigate BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, and MSK.	Ap
3	Identify the sources of noise in communication systems. Analyze the frequency-domain representation of noise. Investigate the effect of filtering on the probability density of Gaussian noise. Study the spectral components of noise and the effect of a filter on the power spectral density of noise. Understand superposition of noise, mixing involving noise, and linear filtering.	U
4	Design baseband signal receivers. Calculate the probability of error for optimum filters. Analyze white noise, matched filters, and the probability of error. Investigate coherent reception correlation, PSK, FSK, and non-coherent detection on FSK. Study differential PSK, QASK, and the calculation of error probability for BPSK, BSFK, and QPSK.	An
5	Analyze noise in pulse code and delta modulation systems. Investigate PCM transmission and the calculation of quantization noise in PCM receivers. Study the effect of thermal noise and the output signal-to-noise ratio in PCM.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	3	1	-	-	-	3	1	-	-	-
CO2	3	3	3	1	1	1	3	-	-	-	-	3	2	-	-	3
CO3	3	3	3	1	1	1	3	-	-	2	-	3	2	-	-	2
CO4	3	3	3	1	1	2	3	1	-	2	1	3	2	-	-	-
CO5	3	3	3	1	1	-	2	-	-	2	2	3	2	3	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Pulse modulation systems, Sampling Theorem, Low pass &Band pass signal, PAM- Channel BE for PAM signal, Natural Sampling, Plat-top sampling, Signal through holding, Quantization of signals, quantization error	15	1
II	PCM, Differential PCM, Delta modulation, Adaptive, delta modulation (CVSD). BPSK, DPSK, QPSK, PSK,QASK, BFSK, FSK,MSK	15	2
III	Sources of noise, Frequency domain representation of noise , Effect of filtering on the probability density of Gaussian noise, Spectral component of noise, Effect of a filter on the power spectral density of noise, Superposition of noise, Mixing involving noise, binear filtering, Noise bandwidth, Quadrature component of noise, Power spectral density of nc (t) ns (t) & their time derivatives.	15	3
IV	Base band signal receiver, Probability of error optimum filter, White noise: Matched filter & probability of error, Coherent reception correlation, PSK, FSK, Non-Coherence detection on FSK, Differential PSK, QASK, Calculation of error probability for BPSK,BSFK,QPSK.	15	4
V	Noise in pulse code & delta modulation system, PCM transmission, Calculation of quantization noise output signal power, Effect of thermal noise, output signal to noise ratio in PCM, DM, Quantization noise in DM, output signal power, DM output signal to quantization noise ratio, effect of thermal noise in delta modulation, output signal to niose ratio in DM	15	5

Reference Books:

1) "Microwaves" by K.L. Gupta Wiley Estern Ltd. Delhi.
2) Advanced Electronic communication system by Wayne Tomsi Physics education.
3) Principle of communication of system-by Toub & Schilling: second edition TMH 1994
4) Communication system: by siman Haykin, third edition John wiley & sons inc.1994.
5) Microwave devices & ckts by: Samuel, Y. Liau.
6) Electronic communication: George kennedy.

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	2	IV
Course Code	Course Title		Course Type
PHY-443 (C)	**Physics of Nano-Materials-II**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	4	1	0
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to equip students with a deep understanding of fundamental principles of electrical transport in nanostructures, including band structures, conduction mechanisms, and their applications. Understand the role of carbon nanotubes in various technologies and the potential of polymeric nanofibers in diverse fields. Investigate advanced lithography techniques and their nano-applications. Analyze the environmental and health impacts of nanomaterials, emphasizing corporate responsibility and future implications in sustainable nanotechnology.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain grasp the fundamental principles of crystal bonding, structure, and symmetries, along with in-depth knowledge of electrical transport in nanostructures, encompassing conduction theories, mechanisms, and properties in metals, insulators, and semiconductors, particularly in low-dimensional systems.	Ap
2	Explore and harness the diverse applications of Carbon NanoTubes (CNTs) and functional nanomaterials in clean energy, environmental technologies, healthcare, and advanced electronic displays for enhancing technology and sustainability.	Ap
3	Describe the diverse range of applications for polymeric nanofibers, spanning biomedical uses like medical prostheses and drug delivery, to filtration, protective clothing, and electrical/optical applications, with a focus on advancing nanotechnology's impact in various industries.	U
4	Explain concept of various lithography techniques, from photolithography to advanced methods like electron beam lithography and soft lithography, and to highlight their Nano lithographic applications and current research trends.	An
5	Comprehensively assess the environmental and health implications of nanomaterials, applying principles of industrial ecology, eco-toxicology, and corporate responsibility, to ensure sustainable integration of nanotechnology for a safer future.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	1	2	-	2	2	2	3	1	3	2	-	1	2	2	2
CO2	2	1	-	-	2	2	2	2	1	3	2	-	-	1	2	-
CO3	1	1	-	-	1	1	2	3	-	3	2	-	-	1	2	-
CO4	2	-	-	-	2	1	2	2	-	3	2	-	-	1	1	-
CO5	1	1	-	-	2	1	2	1	1	1	3	-	-	1	1	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Electrical transport in nano-stucture** Crystal bonding, structure, growth and symmetries; Band structure and density of states at nano-sclale; Electrical transport in nano-structure-Electical conduction in metals, classical and quantum theory, Conduction in Insulator and Ionic crystal, electron transport in semiconductors, various conduction mechanism in 3D (bulk) and 2D (thin film) and low dimensional systems, thermoionic emission , Field – enhanced thermoionic emission, Arrhenius type thermally activated conduction, variable range hopping and Polaron conduction.	15	1
II	**Application of CNT** Applications of Carbon NanoTubes (CNTs) in field emission, fuel cells, CNT FETs, Light Emitting Displays (LEDs) and Flat Panel Displays (FPD), hydrogen storage, solar panels. Application of functional nanomaterials: clean energy (Hydrogen Production from Biomass, Catalytic coal hydrogasification), environmental technologies (clean water and air), health care (tissue and bone repairs, bio medical sensors).	15	2
III	**Next Generation Applications for Polymeric Nanofibres** Background, Biomedical Applications, Medical Prostheses, Tissue Engineering Scaffolds, Drug Delivery, Wound Dressing, Cosmetics. Filtration applications, Filter media, Protective Clothing, Material Reinforcement, Electrical Conductors, Optical applications, Sensor devices, Conclusion. Reference: Nanotechnology: Global Strategies, Industry Trends and Applications (Editor: Jurgen Schulte	15	3
IV	**Nano-Lithography** Photolithography Principles; Phase Shifting Optical Lithography; Electron Beam Lithography (EBL); Neutral Atomic Beam Lithography; Ion-Beam Lithography (IBL); X-ray Lithography (XRL); Proximal Probe Lithography, Proximal Probes, STM based Electron-Beam Lithography, Soft Lithography. Nano lithographic applications and current research.	15	4
V	**Sustainable Nanotechnology and Human Health** Application of industrial ecology to nanotechnology, Fate of	15	5

	nanomaterials in environment, environmental life cycle of nano materials, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, environmental reconnaissance and surveillance. Corporate social responsibility for nanotechnology, Nano materials in future - implications.		

Text and Reference Books:

1. Nano materials: Synthesis properties ,characterization and application: A.S Edelsteinand R.C Cammaratra
2. Nanoelectronics and Nanosystems , Karl Goser, Peter Glosekotter, Jan Dienstuhl.,Springer, 2004
3. Nanomaterial Systems Properties and Application, A.S.Eldestein and R.C.Cammarata.
4. Handbook of Nanotechnology: Bhushan (Ed), Springer Verlag, New York (2004).
5. Nanostructures and Nanomaterials- Synthesis properties and Applications byGuozhong Cao (Empirical College Press World Scientific Pub., 2004).
6. Nanocomposite Science and Technology, Ajayan, Schadler and Braun
7. Piezoelectric Sensors: Force, Strain, Pressure, Acceleration and Acoustic EmissionSensors, Materials and Amplifiers, G. Gautschi.
8. Block Copolymers in Nanoscience Massimo Lazzari
9. Supramolecular Chemistry, Jonathan W. Steed, Jerry L. Atwood
10. Nanotechnology: Importance and Application by M.H. Fulekar, IK International,2010.
11. Nanotechnology in Biology and Medicine: Methods, Devices and Application by TuanVo-Dinh, CRC press, 2007.
12. Nanosystem characterization tools in the life sciences by Challa Kumar. Wiley-VCH,2006.
13. Nanolithography M.Gentili et al.(edits),Springer.
14. Environanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z HonglinWang, Rachid Sliman, Ian Wright. Elsevier, 2010.
15. Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.
16. Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.
17. An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, MicheleMosca
18. The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation by Dirk Bouwmeester, Artur K. Ekert, AntonZeilinger

Problems And Solutions in Quantum Computing And Quantum Information YorickHardy Willi-Hans Steeb

CO-PO

M.Sc. (Physics) Semester-IV

Program	Subject		Year	Semester
M.Sc.	Physics		2	IV
Course Code	Course Title			Course Type
PHY-444 (D)	Space Physics -II			Elective
Credit	Hours Per Week (L-T-P)			
	L		T	P
5	4		1	0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The objective of this course is to provide a thorough comprehension of the universe, its evolution, and various cosmological phenomena. Additionally, the objective is to cultivate proficiency in spacecraft and satellite technology, satellite orbits, attitude control, rocket propulsion, and remote sensing applications. Furthermore, offers an overview of solar wind, ionospheric layers, geomagnetic events, and the impact of space weather on communication, power grids, spacecraft, and satellite navigation.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Understand the universe's description, origin, evolution, age, and size. They will learn spectral analysis, element synthesis, and the study of exotic stars like novae, supernovae, pulsars, black holes, and gamma-ray bursts from birth to death. Students will also learn about galaxy structure, starbursts, active galactic nuclei, and current discoveries like dark matter, dark energy, and an accelerating cosmos.	U
2	Understand the satellite motion principles, orbital elements, and satellite attitude control. Understand the various types of orbits and explore concepts related to launch vehicles, spacecraft, and diverse rocket propulsion methods. Additionally, students will gain insights into rocket motor design, flight stability, recovery systems, and overall stability and control systems in the context of space exploration.	U/Ap
3	Comprehend a diverse range of sensors and their attributes, substances, and applications. Understand the the satellite data processing, covering acquisition, communications, and image processing methods and applications of remote sensing.	U/Ap
4	Understand the ionospheric layers and their formation, along with the effects of radiation on Earth's atmosphere and associated photo-chemical processes. Comprehend the fundamental principles of geomagnetism, magnetic coordinates, the measurement of different components of the geomagnetic field, changes, storms, and phenomena such as equatorial and auroral events. Also learn about the solar wind, its interaction with the interplanetary medium and planets, the magnetosphere, storm and sub-storm phenomena, and Van Allen radiation belts.	U
5	Understand the consequences of space weather and its effect on communication systems, power grids, spacecraft hardware, operations, satellite navigation, and the Forecast of Space Weather.	U/An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO2	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO3	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO4	3	3	3	3	2	2	3	2	1	2	2	3	3	3	3	2
CO5	3	3	3	3	2	2	2	2	1	2	2	3	3	3	3	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Universe - description, origin, its evolution, age and size; Stars–birth, life, death, spectral analysis, stellar composition - element synthesis in stars, Exotic stars- novae, supernovae, pulsars, black holes and gamma ray bursts; Galaxies; Starbursts and Active Galactic Nucleus; Evidence for the Big Bang; Cosmic Background Radiation; Expansion Models; Dark Matter and Energy Recent innovations about the concept of Universe: Dark Energy and an accelerating universe	15	1
II	Satellite orbits and attitude: principles of satellite motion, Kepler's laws, orbital elements, satellite attitude and its control, types of orbits, polar and geostationary, earth and sunsynchronous, orbit optimization, viewing geometry, launch vehicles and spacecrafts, rocket propulsion concepts such as solid, hybrid, liquid, nuclear and antimatter. Rocket motors and their design, flight stability and recovery systems, stability and control system.	15	2
III	Sensors and systems: visible, infrared, water vapour and microwave sensors, sensor characteristics, sensor materials, passive and active sensors, scanning radiometers, spectral signatures. Satellite data processing: satellite data acquisition, satellite communications, data collection platforms, earth station, image processing, geometric and radiometric corrections, image navigation, registration, image enhancement techniques, noise removal methods, histogram methods, density slicing, image classification. Applications of remote sensing in earth resources management, agriculture, forestry, water resources and disaster mitigation	15	3
IV	The ionospheric layers D, E, F and their formation, effect of radiation on earth's atmosphere, photochemical processes, Geomagnetic and magnetic coordinates, poles, measurement of geomagnetic field components, micropulsation indices, variations of geomagnetic field, quiet and disturbed variations, geomagnetic storms, equatorial and auroral phenomena. Solar wind, model of solar winds, interaction in the interplanetary medium and with the planets. Magnetosphere: interaction of solar wind with the geomagnetic field and formation of the magnetospheric tail, storm and sub-storm phenomena, Van Allen radiation belts.	15	4
V	Space Weather Effects on Communication, Space Weather Effects on Power Grids, Space Radiation Protection, Effects on Spacecrafts hardware and Operations, Effects on Satellite Navigation, Forecast of Space Weather.	15	5

Text and Reference Books:

Same as mentioned in Semester III, Paper IV (D).

M.Sc. (Physics) Semester-IV

Program	Subject	Year		Semester
M.Sc.	Physics	2		IV
Course Code	Course Title			Course Type
PHY-445 (E)	**Quantum Computing-II**			Elective
Credit	Hours Per Week (L-T-P)			
	L	T		P
5	4	1		0
Maximum Marks	CIA			ESE
100	30			70

Learning Objective (LO):

The aim of this course is to empower students with a profound understanding of quantum Noise and Quantum operation, Quantum Error corrections, Entropy Formation, Quantum Sensing and Metrology etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Develop a solid grasp of quantum information theory	U
2	To understand concepts such as qubits, quantum gates, quantum error correction,	U
3	To understand cryptography, and their applications in quantum computing and communication	Ap
4	Explore and evaluate potential applications of quantum computing across different fields such as chemistry, finance, and machine learning, and assess the advantages and limitations compared to classical computing approaches.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	2	-	3	1	-	2	3	3	3	1	1	2
CO2	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO3	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO4	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2
CO5	3	3	3	-	2	1	2	1	-	2	1	3	3	1	1	2

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	A. Quantum Noise and Quantum operation: classical noise and Markov process, quantum operations: overview, environment, quantum operation, operator – sum representation, Axiomatic approach, Example of Quantum Noise and Quantum operation, Applications of Quantum Noise and Quantum operation, Limitation of Quantum Noise and Quantum operation B. Distance measures for Quantum information: Distance measures for classical information, trace distance, fidelity, relationship between distance measure, wellness of quantum channel	15	1
II	Quantum Error corrections: introduction, The Shor code, theory of Quantum Error corrections, construction of quantum codes, stabilizer code, fault-tolerant quantum computation	15	2
III	Entropy Formation: Shannon entropy, Basic properties of entropy: the binary entropy, relative entropy, conditional entropy, Von Neumann entropy, Strong subadditivity	15	3
IV	Quantum Information Theory: distinguishable quantum states and the accessible information, data compression, classical information over noisy quantum channels, entanglement as a physical resource, quantum cryptography.	15	4
V	Quantum Sensing and Metrology, Quantum Communication: Principle of quantum sensing, quantum limit to measurement precision, Quantum Sensing in Atomic and Optical Systems, Quantum Sensing with Superconducting Circuits, Quantum Sensing with Solid-State Devices, Quantum Interferometry, Quantum Enhanced Metrology, Quantum Metrology with Entangled States, Quantum Clocks and Timekeeping.	15	5

Text and Reference Books:
Same as mentioned in Semester III, Paper IV (E).

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	2	IV
Course Code	Course Title		Course Type
PHY-PR 450	Project Work		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
6	0	0	12
Maximum Marks	CIA		ESE
200	50		150

In semester IV, Project work in Solid State Physics/ Astronomy & Astrophysics/ Electronics/ Physics of Nano-materials/ Space Physics will lead to specialization in the respective area. It will be primarily based on research oriented topics. On completion of the project, student will submit project report in the form of dissertation. The project submission will be done within one month after the end of theory exams. The project will be examined by an external examiner. The examination of project work shall consist of (a) Presentation and (b) comprehensive viva-voce.

Marks-distribution for Project Work:

Report – Dissertation : 100 Marks
Presentation : 30 Marks
Comprehensive viva-voce : 20 Marks
Internal assessment : 50 Marks

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	1	IV
Course Code	Course Title		Course Type
PHY 710	**Conventional Turning**		Qualifying
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	0	0	4
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):
The objective of this course is to understand the working mechanism of Welding Machine, Lathe Machine, Shaping machine etc.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Handle Welding Machine, Lathe Machine, Shaping machine etc.	Ap
2	To make screw, threads etc.	Ap
3	Operate Drilling and Taping machine.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	-	1	1	1	2	2	1	3	2	2	2	3	2	-
CO2	3	3	-	1	1	1	2	2	1	3	2	2	2	3	2	-
CO3	3	3	-	1	1	1	2	2	1	3	2	2	2	3	2	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detail Syllabus

1. **Trade Introduction** - Responsibilities related to tools and machines. Medical facilities.
2. **Occupational safety and first aid** – Importance of occupational safety and health. accidents at work place. Safety precautions while using hand tools. Storage of inflammable materials. First aid five concepts, Personal protective equipments. Power failure. Protection of body.
3. **Measurement and measuring instruments**- Measurement and its types, steel rule, Try Square, Callipers.
4. **Gauge and precision instruments** – Micrometer. Vernier Callipers. Dial test indicator. Vernier depth Gauge. Surface gauges/marking block.
5. **Cutting tools** – Files and Special files, Hacksaw, Chisels.
6. **Striking and holding tools** – Hammer, Vice.
7. **Lathe machine** – Introduction and Working of lathe machine, Types of lathe machines. Constructional features of Lathe machine. Lathe machine accessories. Specification of a Lathe machine, Cutting tools, lathe operations. Alignment of Lathe machine centres. Feed mechanism and Safety precautions to be observed while working on Lathe machine. Cutting fluids and their uses. Mounting and dismounting of chuck and Face plate.
8. **Taper turning** – Taper, Advantages and disadvantages of Taper turning methods as compared to other methods.
9. **Screw threads** – Types of screw threads. Thread cutting ,Change gear train, Screw Thread measurement, Measurement of minor diameter of threads., Measurement of flank angle and form of threads. Production methods of start Thread, Helix angle and its effects on threading tool clearance angle. Left hand thread cutting., Square thread cutting, Setting of tool for thread cutting, feeding of tool for thread cutting.
10. **Gauges and precision instruments** – Gauges and Classification of gauges according to accuracy and use. Plug gauge, Ring gauge, Feeler gauge Angle gauge, Radius or fillet gauge, Slip gauges, Inside micrometer, Sine bar.
11. **Shaping machine** – Classification of shaping machine, Different types of shaping machines, Main parts of shaping machines. Specifications of shaping machines, quick return mechanism. Feed mechanism, Work supporting and holding devices for shaping machines. Cutting speed and cutting time.
12. **Drilling machine** – Drilling machines, Size and specifications of Drilling machines. Drilling machine accessories, Counter sinking and Counter boring, Soot facing, Reamers.
13. **Milling machine** – Classification of milling machine, Specifications of milling machine. Milling cutters, Classification of standard Milling cutters, Milling cutters material. Milling machine attachments, Indexing. Milling operation, Cutting speed, feed and depth of cut.
14. **Screw threads** – Types of screw threads, Screw pitch gauge, Taps. Tap wrenches, Die, Tap drill size, Removal of broken tap, Removal of stud or screw, Blank size for external threading.
15. **Welding machine** – Working on welding machine.

M.Sc. (Physics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Physics	I	IV
Course Code	Course Title		Course Type
PHY 720	**Hands on training of sophisticated instruments**		Qualifying
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	0	0	4
Maximum Marks	CIA		ESE
100	30		70

Learning Objective:
The objective of this course is to understand the working mechanism and details of sophisticated instruments, and to perform experiments/ testing for characterization and important analysis.

Course Outcomes:

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Handle X-Ray diffraction and FTIR instruments.	Ap
2	Perform the Thermal Analysis using TGA and DSC and Electrical analysis by EIS.	An
3	Operate spectro fluorophotometer and TLD reader.	An
4	Perform astronomical observations using Telescope	An

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	Pos											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO2	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO3	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1
CO4	3	3	1	3	1	1	3	2	1	2	3	3	3	3	3	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Unit 01:

Structural Analysis: X-Ray and its interaction with matter, X-Ray diffraction and Bragg's Law, X-Ray beam Production techniques, Methods of structural analysis using X-Ray diffraction: 1) Laue's Method, 2) Rotating crystal method and 3) Powder Method; X-Ray diffractogram of crystalline and amorphous phases, Crystallite size determination using Scherrer's formula, Various components of XRD machines.

Compositional Analysis: Infrared radiation (IR) and its interaction with matter, IR production, Fourier Transform IR: Principle and instrumentations.

Unit 02:

Thermal Analysis: Thermal Gravimetric Analysis (TGA): principle and instrumentation, Differential Scanning Calorimetry (DSC): principle and instrumentation.

Electrical Analysis: Electrochemical Impedance Spectroscopy (EIS): principle and instrumentation, Nyquist Plot and determination of electrical Conductivity.

Unit 03:

Thermoluminescence: Luminescence, classification of luminescence, fluorescence, phosphorescence, phosphors, thermoluminescence, theory and working, instrumentation, TL glow curve, kinetic parameters, methods using for TL study, applications of thermoluminescence.

Photoluminescence: Introduction, types of photoluminescence, spectro fluorophotometer, block diagram, emission and excitation spectra, theory and working mechanism, applications of photoluminescence.

Unit 04:

Telescope: Types of Telescope: Refracting telescope and Reflecting telescope, Astronomical Telescopes: why Reflectors?, Telescope designs: Prime-focus, Newtonian, Cassegrain and Schmidt-Cassegrain. Telescope mounts: Altitude-azimuth mount and Equatorial mount. Celestial sphere and constellations.