

Raja Mahendra Pratap Singh University, Aligarh



Syllabus

**B.Sc. (Honour's) in Physics, B.Sc. (Honour's With Research) in
Physics and M.Sc. in Physics**

**(For both University Campus and Affiliated Colleges of the
University)**

(As per Guidelines of University Grants Commission)

(w.e.f. the session 2025-26)

U.G Physics Syllabus

Fourth Year

Bachelor (Honours)/(Honours with Research) in Physics

Year	Sem.	Code	PAPER TITLE	Theory/Prac ticle/Resear ch Project	credit	Total	
4 th Year	VII	RB010701T	Mathematical Physics	Theory	4	20/20 OR 16/20	
		RB010702T	Atomic and Molecular Physics	Theory	4		
		Choose both theory papers for U.G. (Honours) and any one for U.G. (Honours with Research)					
		RB010703T	Classical Mechanics	Theory	4		
		RB010704T	Statistical Physics	Theory	4		
		RB010705P	Practical	Practical	4		
		RB010706R	Research Project (Allocation) only for U.G. (Honours with Research)				
	VIII	RB010801T	Advanced Mathematical Physics	Theory	4	20/24 OR 24/24	
		RB010802T	Electrodynamics	Theory	4		
		Choose both theory papers for U.G. (Honours) and any one for U.G. (Honours with Research)					
		RB010803T	Nano - Science	Theory	4		
		RB010804T	X-Rays and Laser Physics	Theory	4		
		RB010805P	Practical	Practical	4		
		RB010806R	Research Project (Submission and Evaluation) only for UG (Honours with Research)	Research project	8		

Raja Mahendra Pratap Singh University, Aligarh
Programme Specific Outcomes (PSOs)
M.Sc. Physics

After successful completion of the M.Sc. Physics programme, the students will be able to:

PSO-1: Advanced Knowledge of Physics

Demonstrate comprehensive and in-depth understanding of advanced concepts in core areas of Physics such as Mathematical Physics, Classical Mechanics, Quantum Mechanics, Electrodynamics, Statistical Mechanics, Atomic and Molecular Physics, Nuclear Physics, Condensed Matter Physics, Electronics, and Materials Science.

PSO-2: Analytical and Problem-Solving Skills

Apply mathematical techniques, analytical methods, and physical principles to formulate, analyze, and solve complex problems encountered in theoretical and applied Physics.

PSO-3: Experimental and Instrumentation Skills

Design, perform, and analyze advanced experiments using modern laboratory instruments, electronic devices, and computational tools while maintaining precision, accuracy, and safety standards.

PSO-4: Computational and Digital Competence

Utilize scientific computing, programming languages, numerical techniques, simulation tools, and data analysis software for modeling, interpretation, and solution of physical problems.

PSO-5: Research Aptitude and Innovation

Develop the ability to identify research problems, review scientific literature, design and execute research projects, interpret results, and communicate findings effectively through reports, presentations, and publications.

PSO-6: Interdisciplinary and Emerging Areas Competence

Acquire knowledge and skills in interdisciplinary and emerging areas such as Nanoscience, Materials Science, Photonics, Electronics, Artificial Intelligence applications in Physics, and Renewable Energy technologies.

PSO-7: Professional, Ethical, and Societal Responsibility

Demonstrate scientific temper, ethical values, environmental awareness, and social responsibility while contributing to sustainable technological development and societal welfare.

PSO-8: Higher Studies and Employability

Acquire the necessary competence for pursuing doctoral research, qualifying national competitive examinations (UGC-NET, CSIR-NET, GATE, JAM, etc.), and securing employment in academia, research laboratories, industries, and scientific organizations.

PSO-9: Communication and Teamwork

Communicate scientific ideas effectively through oral presentations, technical writing, and collaborative teamwork in multidisciplinary environments.

PSO-10: Lifelong Learning and Entrepreneurship

Develop self-learning abilities, leadership qualities, and entrepreneurial skills necessary for continuous professional growth and innovation in scientific and technological domains.

Bachelor (Honours) in Physics - Paper I
OR
Bachelor (Honours with Research) in Physics – Paper I
Semester VII - MATHEMATICAL PHYSICS

Course Code: PHY-701

Credits: 4

Maximum Marks: 100

(Theory: 75, Internal Assessment: 25)

Course Objectives

The course aims to:

- Develop a strong mathematical foundation required for advanced studies in Physics.
- Introduce students to vector spaces, matrices, differential equations, and special functions used in theoretical physics.
- Familiarize students with analytical and numerical techniques employed in solving physical problems.
- Prepare students for higher studies, research, and competitive examinations such as UGC-NET, GATE, JAM, and JEST.

Total Lectures-60

UNIT I: Vector Analysis, Vector Spaces, Gamma and Beta Functions Lectures -15

- Vector Analysis
- Scalar and vector fields.
- Gradient, divergence and curl.
- Line, surface and volume integrals.
- Gauss divergence theorem, Green's theorem and Stokes' theorem.
- Orthogonal curvilinear coordinates.
- Dirac delta function and its properties.
- Vector Spaces
- Definition and properties of vector spaces.
- Linear independence and dependence.
- Basis and dimension.
- Inner product spaces.
- Orthogonality and orthonormality.
- Gram-Schmidt orthogonalization procedure.
- Linear operators and their properties.
- Gamma and Beta Functions
- Definition and properties of Gamma function.
- Recurrence relations.

- Evaluation of Gamma functions.
- Definition and properties of Beta function.
- Relationship between Beta and Gamma functions.
- Applications in Physics.

UNIT II: Matrices and Eigenvalue Problems

Lectures -15

- Matrices and matrix operations.
- Determinants and rank of a matrix.
- Inverse of a matrix.
- Systems of linear equations and matrix methods.
- Eigenvalues and eigenvectors.
- Characteristic equation.
- Hermitian, unitary, orthogonal and symmetric matrices.
- Diagonalization of matrices.
- Cayley-Hamilton theorem and applications.
- Similarity transformations.
- Applications of matrices in Physics.

UNIT III: Differential Equations and Special Functions

Lectures -15

- Differential Equations
- First and second order ordinary differential equations.
- Power series solutions.
- Partial differential equations of Physics.
- Separation of variables.
- Applications to Laplace, Heat and Wave equations.
- Special Functions
- Legendre differential equation and Legendre polynomials.
- Generating functions and recurrence relations.
- Associated Legendre functions.
- Bessel differential equation and Bessel functions.
- Generating functions and recurrence relations.
- Hermite and Laguerre polynomials.
- Orthogonality properties and physical applications.

UNIT IV: Numerical Methods

Lectures - 15

Errors in numerical computations.

- Solution of algebraic and transcendental equations:
- Bisection method.
- Newton-Raphson method.

Interpolation:

- Newton forward and backward interpolation.
- Lagrange Interpolation.

- Numerical differentiation and Integration:
- Trapezoidal rule.
- Simpson's 1/3 rule.
- Numerical solution of ordinary differential equations:
- Euler method.
- Runge-Kutta methods.

Course Outcomes (COs)

- After successful completion of this course, the students will be able to:
- CO1: Apply vector analysis and vector space concepts to solve physical problems involving fields and operators.
- CO2: Analyze and solve matrix problems including eigenvalue equations relevant to quantum mechanics and other branches of physics.
- CO3: Solve ordinary and partial differential equations and employ special functions encountered in advanced physics.
- CO4: Apply numerical techniques for solving mathematical problems arising in physical systems.
- CO5: Use analytical and computational methods to model and solve complex problems in theoretical and experimental physics.
- CO6: Develop mathematical proficiency required for higher studies, research, and competitive examinations such as UGC-NET and GATE.

Suggested Books

Arfken, G. B., Weber, H. J. & Harris, F. E., Mathematical Methods for Physicists, Elsevier.
 Boas, M. L., Mathematical Methods in the Physical Sciences, Wiley.
 Riley, Hobson & Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press.
 Pipes, L. A. & Harvill, L. R., Applied Mathematics for Engineers and Physicists, McGraw-Hill.
 Mathews, J. H. & Fink, K. D., Numerical Methods Using MATLAB, Pearson.
 Rajaraman, V., Computer Oriented Numerical Methods, PHI.
 Spiegel, M. R., Schaum's Outline of Vector Analysis, McGraw-Hill.
 Churchill, R. V., Complex Variables and Applications, McGraw-Hill.

BACHELOR (HONOURS) IN PHYSICS – Paper II
OR
BACHELOR (HONOURS WITH RESEARCH) IN PHYSICS –Paper II
Semester VII - Atomic and Molecular Physics

Credits: 4

Maximum Marks: 100

Theory: 75 Marks

Internal Assessment: 25 Marks

Course Objectives

The course aims to:

- Develop a comprehensive understanding of atomic structure and atomic spectra.
- Introduce various interactions affecting atomic energy levels and spectral lines.
- Familiarize students with molecular spectroscopy and molecular energy states.
- Provide knowledge of Raman spectroscopy and its applications in modern science and technology.
- Prepare students for higher studies and competitive examinations such as UGC-NET/CSIR-NET.

Total lectures - 60

UNIT I: Elements of Atomic Spectra

Lectures - 15

- Atomic Structure and Spectra
- Review of Bohr model and its limitations.
- Quantum mechanical description of hydrogen atom.
- Quantum numbers and atomic states.
- Vector atom model.
- Orbital and spin angular momenta.
- Magnetic moment of the atom.
- Coupling schemes: L-S coupling and j-j coupling.
- Term symbols and spectroscopic notation.
- Selection rules for optical transitions.
- Fine Structure
- Fine structure of alkali spectra.
- Spin-orbit interaction.
- Doublet structure of alkali spectra.
- Quantum defects.

UNIT II: Effects on Atomic Spectra

Lectures -15

- External Field Effects
- Zeeman Effect: Normal and Anomalous Zeeman Effect.
- Paschen-Back Effect.
- Stark Effect: Linear and Quadratic Stark Effect.
- Hyperfine structure of spectral lines.

- Isotope shift.
- X-Ray Spectra
- Characteristic X-rays.
- Moseley's law.
- Fine structure of X-ray spectra.
- Auger effect (elementary treatment).
- Line Broadening Mechanisms
- Natural broadening.
- Doppler broadening.
- Pressure broadening.
- Instrumental broadening.

UNIT III: Elements of Molecular Spectroscopy

Lectures- 15

- Molecular Structure
- Born-Oppenheimer approximation.
- Molecular energy levels.
- Rotational, vibrational and electronic spectra.
- Rotational Spectroscopy
- Rigid rotator model.
- Pure rotational spectra of diatomic molecules.
- Selection rules.
- Determination of bond length.
- Vibrational Spectroscopy
- Harmonic oscillator approximation.
- Anharmonicity.
- Vibration-rotation spectra.
- Infrared spectroscopy and selection rules.
- Electronic Spectroscopy
- Electronic transitions in molecules.
- Frank-Condon principle.
- Vibrational structure of electronic bands.

UNIT IV: Elements of Raman Spectroscopy

Lectures -15

- Fundamentals of Raman Effect
- Classical and quantum theory of Raman Effect.
- Rayleigh and Raman scattering.
- Stokes and Anti-Stokes lines.
- Selection rules for Raman transitions.
- Raman Spectroscopy
- Rotational Raman spectra.
- Vibrational Raman spectra.
- Raman instrumentation.

- Laser Raman spectroscopy.
- Advanced Topics and Applications
- Resonance Raman spectroscopy.
- Surface Enhanced Raman Spectroscopy (SERS): Elementary concepts.
- Applications of Raman spectroscopy In:
- Material science.
- Nanotechnology.
- Chemical analysis.
- Biological and medical sciences.
- Environmental monitoring.
- Suggested Practicals (Related Experiments)
- Study of Zeeman effect (demonstration/simulation).
- Determination of Rydberg constant using hydrogen spectrum.
- Analysis of rotational-vibrational spectra using spectroscopic data.
- Determination of isotopic shift from spectral lines.
- Study of Raman spectra of liquids/solids.
- Identification of unknown samples using Raman spectroscopy.
- Computer simulation of atomic and molecular spectra.

Suggested Books

- C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill.
 H.E. White, Introduction to Atomic Spectra, McGraw-Hill.
 B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules, Pearson.
 H. Haken and H.C. Wolf, The Physics of Atoms and Quanta, Springer.
 I.I. Sobelman, Atomic Spectra and Radiative Transitions.
 G. Aruldas, Molecular Structure and Spectroscopy, PHI Learning.
 P.F. Bernath, Spectra of Atoms and Molecules.
 K. Thyagarajan and A.K. Ghatak, Lasers: Fundamentals and Applications.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

- CO1: Explain the origin and classification of atomic spectra using quantum mechanical principles and angular momentum coupling schemes.
- CO2: Analyze the influence of external electric and magnetic fields on atomic spectra and interpret various spectral line broadening mechanisms.
- CO3: Describe rotational, vibrational and electronic spectra of molecules and apply spectroscopic principles to determine molecular parameters.
- CO4: Explain the principles, instrumentation and selection rules of Raman spectroscopy and distinguish Raman spectra from other spectroscopic techniques.

- **CO5: Apply atomic and molecular spectroscopic techniques for qualitative and quantitative analysis in physics, chemistry, material science and interdisciplinary research.**

Bachelor (With Honours) in Physics- Paper III
OR
Bachelor (With Honours with Research) in Physics- Paper III
Semester VII- Classical Mechanics

Credits: 4

Maximum Marks: 100
Theory: 75 Marks
Internal Assessment: 25 Marks

Course Objectives

- To provide a rigorous foundation of analytical mechanics.
- To develop the ability to formulate physical problems using variational principles.
- To understand the dynamics of rigid bodies and systems with constraints.
- To introduce advanced concepts such as Hamiltonian mechanics, canonical transformations, and nonlinear dynamics.
- Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Apply Newtonian, Lagrangian, and Hamiltonian formulations to solve mechanical problems.

CO2: Analyze constrained systems and derive equations of motion using variational principles.

CO3: Explain rigid body dynamics and oscillatory motion in physical systems.

CO4: Utilize Hamiltonian formalism, canonical transformations, and phase-space methods for advanced mechanical systems.

UNIT-I: Lagrangian Formulation and Variational Principles

Total Lectures: 60
Lectures- 15

Review of Newtonian Mechanics.

- Constraints and generalized coordinates
- Degrees of freedom
- Principle of Virtual work
- D'Alembert's principle
- Generalized forces
- Calculus of variations
- Hamilton's principle
- Lagrange's equations of motion
- Applications of Lagrangian formulation
- Conservation laws and cyclic coordinates

Applications:

- Simple pendulum
- Atwood machine

- Motion under central force
- Charged particle in electromagnetic field
- Numerical Problems

UNIT-II: Central Force Motion and Small Oscillations

Lectures-15

- Central Force Motion
- Two-body problem
- Reduction to one-body problem
- Conservation of angular momentum
- Effective potential
- Orbit equation
- Kepler's laws
- Planetary motion
- Scattering in central force fields
- Rutherford scattering
- Small Oscillations
- Equilibrium and stability
- Coupled oscillations
- Normal coordinates
- Normal modes
- Vibrations of linear molecules
- Numerical Problems

UNIT-III: Rigid Body Dynamics

Lectures-15

- Inertia tensor
- Principal axes and principal moments of inertia
- Euler's angles
- Rotating coordinate systems
- Coriolis and centrifugal forces
- Euler's equations of motion
- Torque-free motion
- Symmetric top
- Heavy symmetric top
- Gyroscope and precession

Applications:

- Earth rotation effects
- Foucault pendulum
- Numerical Problems

UNIT-IV: Hamiltonian Mechanics and Advanced Topics

Lectures- 15

- Hamiltonian Formulation
- Legendre transformations
- Hamilton's equations of motion

- Poisson brackets and their properties
- Equations of motion in terms of Poisson's bracket
- Language brackets
- Relation between language and Poisson's bracket
- Canonical Transformations
- Generating functions
- Canonical invariance
- Hamilton-Jacobi theory
- Action-angle variables
- Classical foundations of quantum mechanics
- Numerical Problems

Suggested Books

- H. Goldstein, C. Poole and J. Safko, Classical Mechanics.
- N. C. Rana and P. S. Joag, Classical Mechanics.
- J. C. Upadhyaya, Classical Mechanics.
- L. D. Landau and E. M. Lifshitz, Mechanics.
- Kibble and Berkshire, Classical Mechanics.
- Marion and Thornton, Classical Dynamics of Particles and Systems.
- Gupta, Kumar and Sharma, Classical Mechanics.

Evaluation Scheme

Component Marks (Total 100)

Internal Assessment (Sessional Test, Assignment, Seminar, Viva) - 25

End Semester Examination - 75

Question Paper Pattern (75 Marks) Total: 16 Marks

Section A: Short Answer Questions

10 Questions (Attempt Any 8) , 2 Marks Each

Section B: Medium Answer Questions (Total: 24 Marks)

5 Questions (Attempt Any 3) , 8 Marks Each

Section C: Long Answer Questions (35 marks)

3 Questions (Attempt Any 2) 17.5 Marks Each

UGC-NET Alignment

This syllabus covers the major Classical Mechanics topics prescribed in the UGC-NET Physical Sciences syllabus:

- Newtonian Mechanics
- Variational Principles
- Lagrangian and Hamiltonian Dynamics
- Central Force Problems
- Small Oscillations

- Rigid Body Dynamics
- Canonical Transformations
- Poisson Brackets
- Hamilton–Jacobi Theory
- Nonlinear Dynamics and Chaos

The syllabus is suitable for postgraduate teaching, research preparation, and competitive examinations such as UGC-NET, CSIR-NET, GATE, and JAM.

Bachelor (Honours) in Physics- Paper IV
OR
Bachelor (Honours with Research) in Physics- Paper IV
Semester VII- Statistical Physics

Credits: 4

Maximum Marks: 100
Theory: 75 Marks
Internal Assessment: 25 Marks

Programme Outcomes (POs)

After completion of the M.Sc. Physics Programme, students will be able to:

- PO1: Demonstrate advanced knowledge of fundamental and applied areas of Physics.
- PO2: Apply mathematical, computational, and experimental techniques to solve complex physical problems.
- PO3: Analyze physical phenomena using scientific reasoning and quantitative methods.
- PO4: Design and conduct experiments, interpret data, and draw scientifically valid conclusions.
- PO5: Utilize modern computational tools and emerging technologies in physics research.
- PO6: Communicate scientific ideas effectively through oral presentations, reports, and publications.
- PO7: Develop research aptitude, innovation, and interdisciplinary problem-solving skills.
- PO8: Uphold professional ethics, environmental awareness, and societal responsibilities in scientific endeavors.

Course Objectives

- To introduce the microscopic basis of thermodynamic behavior.
- To develop a statistical description of macroscopic systems.
- To understand classical and quantum statistics and their applications.
- To apply statistical methods to modern problems in condensed matter physics and other branches of science.
- Course Outcomes (COs)

After successful completion of this course, students will be able to:

- CO1: Explain the statistical foundations of thermodynamics and the concept of ensembles.
- CO2: Apply Maxwell-Boltzmann statistics to ideal gases and classical systems.
- CO3: Analyze Bose-Einstein and Fermi-Dirac distributions and their physical consequences.
- CO4: Evaluate phase transitions, critical phenomena, and modern applications of statistical physics.

Total Lectures:60

UNIT-I: Foundations of Statistical Mechanics

Lectures - 15

Review of thermodynamics.

- Macroscopic and microscopic states
- Phase space
- Microstates and macrostates
- Statistical interpretation of thermodynamic quantities
- Probability distributions
- Ensemble concept
- Microcanonical ensemble
- Canonical ensemble
- Grand canonical ensemble
- Partition function and its physical significance
- Thermodynamic functions from partition function
- Entropy and thermodynamic probability
- Gibbs paradox
- Numerical Problems

UNIT-II: Classical Statistical Mechanics

Lectures - 15

- Maxwell-Boltzmann Statistics
- Maxwell-Boltzmann distribution law
- Molecular velocity distribution
- Most probable, average and RMS velocities
- Equipartition theorem
- Specific heat of gases
- Ideal gas in statistical mechanics
- Classical Systems
- Monoatomic and diatomic gases
- Virial expansion
- Real gases and intermolecular interactions
- Brownian motion
- Random walk theory
- Fluctuations
- Numerical Problems

UNIT-III: Quantum Statistical Mechanics

Lectures - 15

Failure of classical statistics.

- Bose-Einstein Statistics
- Bose-Einstein distribution function
- Photon gas
- Blackbody radiation
- Planck radiation law
- Bose-Einstein condensation
- Superfluidity (introductory treatment)

- Fermi-Dirac Statistics
- Fermi-Dirac distribution function
- Degenerate electron gas
- Fermi energy
- Electronic specific heat
- White dwarf stars (introductory concepts)
- Comparison of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.
- Numerical Problems

UNIT-IV: Phase Transitions and Statistical Mechanics

Lectures - 15

- Phase Transitions
- First-order and second-order phase transitions
- Order parameter
- Critical phenomena
- Critical exponents
- Landau theory of phase transitions
- Ising Model
- One-dimensional Ising model (elementary treatment)
- Mean-field approximation
- Fluctuation-dissipation theorem
- Introduction to non-equilibrium statistical mechanics
- Transport phenomena
- Statistical mechanics of magnetic systems
- Numerical Problems

Suggested Books

R. K. Pathria and Paul D. Beale, Statistical Mechanics.
 F. Reif, Fundamentals of Statistical and Thermal Physics.
 Kerson Huang, Statistical Mechanics.
 S. K. Sinha, Statistical Mechanics.
 B. B. Laud, Fundamentals of Statistical Mechanics.
 Landau and Lifshitz, Statistical Physics.
 M. N. Saha and B. N. Srivastava, A Treatise on Heat.

Evaluation Scheme

Component	Marks	(Total 100)p
Internal Assessment (Sessional Test, Assignment, Seminar, Viva, Quiz)	25	
End Semester Examination	75	

Question Paper Pattern (75 Marks)

Section A: Short Answer Questions Total: 16 Marks
 10 Questions (Attempt Any 8) 2 Marks Each

Section B: Medium Answer Questions (Total: 24 Marks)
 5 Questions (Attempt Any 3) ,8 Marks Each

Section C: Long Answer Questions (Total = 75 Marks)
 3 Questions (Attempt Any 2) ,17.5 Marks Each

Mapping with UGC-NET Physical Sciences

The syllabus covers all major UGC-NET Statistical Physics topics:

- Thermodynamics and Statistical Mechanics
- Ensemble Theory
- Partition Functions
- Maxwell-Boltzmann Statistics
- Bose-Einstein Statistics
- Fermi-Dirac Statistics
- Blackbody Radiation
- Degenerate Quantum Gases
- Phase Transitions
- Critical Phenomena
- Ising Model
- Non-Equilibrium Statistical Physics

The syllabus is suitable for postgraduate teaching, research preparation, and competitive examinations such as UGC-NET, CSIR-NET, GATE, and JAM.

Bachelor (With Honour's) in Physics

OR

Bachelor (Honour's with Research) in Physics

Semester VII

List of Practical

1. To determine the value of Planck's constant using photocell.
2. To determine the wavelengths of sodium D_1 and D_2 lines using spectrometer.
3. To study the Balmer lines of the hydrogen spectrum using spectrometer.
4. To study the Iodine spectrum using spectrometer.
5. To analyze the mercury spectrum using spectrometer.
6. To study the Zeeman effect.
7. To analyze the elliptically polarized light by using Babinet compensator.

Bachelor (Hons.) In Physics Paper- I

OR

Bachelor (Hons. with Research) In Physics Paper-I **Semester VIII -Paper I: ADVANCED MATHEMATICAL PHYSICS**

Course Code: PHY-801

Credits: 4

Maximum Marks: 100
(Theory: 75, Internal Assessment: 25)
Total Lectures - 60

Course Objectives

The course aims to:

- Introduce advanced mathematical techniques widely used in theoretical and modern physics.
- Develop understanding of group theory and its applications in physical systems.
- Familiarize students with Laplace transforms and complex variable techniques for solving physical problems.
- Provide computational and numerical skills for solving mathematical problems encountered in physics.
- Prepare students for higher studies, research, and competitive examinations such as UGC-NET, GATE, JAM, and JEST.

Lectures - 15

UNIT I: Group Theory and Important Theorems

- Group Theory
- Definition and examples of groups.
- Properties of groups.
- Finite and infinite groups.
- Abelian and non-Abelian groups.
- Subgroups and cyclic groups.
- Permutation groups.
- Homomorphism and isomorphism.
- Cosets and Lagrange's theorem.
- Classes and class multiplication.
- Matrix representation of groups.
- Reducible and irreducible representations.
- Orthogonality theorem.
- Character tables and applications.
- Important Theorems
- Cayley's theorem.
- Lagrange's theorem.

- Euler's theorem.
- De Moivre's theorem.
- Binomial theorem.
- Gauss divergence theorem.
- Green's theorem.
- Stokes' theorem and physical significance.

UNIT II: Applications of Laplace Transform

Lectures - 15

- Definition and properties of Laplace transforms.
- Inverse Laplace transform.
- Laplace transforms of elementary functions.
- Shifting theorems.
- Convolution theorem.
- Initial and final value theorems.
- Laplace transform of periodic functions.
- Solution of ordinary differential equations using Laplace transforms.
- Simultaneous differential equations.
- Applications to:
 - Electrical circuits (RLC circuits)
 - Harmonic oscillator
 - Damped and forced oscillations
 - Heat conduction problems

UNIT III: Numerical Methods

Lectures - 15

- Sources and propagation of errors.
- Floating-point arithmetic.
- Numerical solution of nonlinear equations:
 - Bisection method
 - Secant method
 - Newton-Raphson method
- Solution of simultaneous linear equations:
 - Gauss elimination method
 - Gauss-Seidel iteration method
- Interpolation:
 - Newton interpolation
 - Lagrange interpolation
- Numerical integration:
 - Trapezoidal rule
 - Simpson's 1/3 and 3/8 rules
- Numerical differentiation.

- Numerical solution of ordinary differential equations:
- Euler method
- Modified Euler method
- Runge-Kutta methods

Lectures - 15

UNIT IV: Complex Variables

Complex numbers and functions of a complex variable.

Analytic functions.

Cauchy-Riemann equations.

Harmonic functions.

Complex integration.

Cauchy's integral theorem.

Cauchy's integral formula.

Taylor and Laurent series.

Singularities and classification.

Residues and residue theorem.

Evaluation of definite integrals using residue theorem.

Conformal transformations and mappings.

Applications in Physics.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

- CO1: Understand the concepts of group theory and apply symmetry principles to solve problems in physics.
- CO2: Apply important mathematical theorems and group representations in various branches of theoretical physics.
- CO3: Use Laplace transform techniques to solve differential equations arising in physical systems and engineering applications.
- CO4: Employ numerical methods and computational techniques to solve complex mathematical and physical problems.
- CO5: Analyze functions of complex variables and apply contour integration and residue calculus in solving physical problems.
- CO6: Develop advanced analytical and computational skills necessary for research, higher studies, and competitive examinations such as UGC-NET, GATE, JAM, and JEST.

Suggested Books

Arfken, G. B., Weber, H. J. and Harris, F. E., Mathematical Methods for Physicists, Elsevier.

Riley, K. F., Hobson, M. P. and Bence, S. J., Mathematical Methods for Physics and Engineering, Cambridge University Press.

Boas, M. L., Mathematical Methods in the Physical Sciences, Wiley.

Spiegel, M. R., Complex Variables, McGraw-Hill.
Churchill, R. V. and Brown, J. W., Complex Variables and Applications, McGraw-Hill.
Joshi, A. W., Matrices and Tensors in Physics, New Age International.
Rajaraman, V., Computer Oriented Numerical Methods, PHI.
Hamermesh, M., Group Theory and Its Application to Physical Problems, Dover Publications.
Mathews, J. H. and Fink, K. D., Numerical Methods Using MATLAB, Pearson Education

Bachelor (Honours) in Physics- Paper II
OR
Bachelor (Honours with Research) in Physics- Paper III
Semester VIII- Electrodynamics

Credits: 4

Maximum Marks: 100
Theory: 75 Marks
Internal Assessment: 25 Marks

Course Objectives

The course aims to provide an advanced understanding of classical electrodynamics, electromagnetic waves, radiation, relativistic electrodynamics, and their applications. It is designed to strengthen the theoretical foundation required for higher studies, research, and competitive examinations including UGC-NET, GATE, JAM, and CSIR-NET.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Apply vector calculus and Maxwell's equations to solve electrostatic and magnetostatic problems.

CO2: Analyze electromagnetic wave propagation in free space, conductors, and dielectric media.

CO3: Explain electromagnetic radiation, radiation from accelerated charges, and antenna fundamentals.

CO4: Understand relativistic electrodynamics and covariant formulation of Maxwell's equations.

Total Lectures: 60

UNIT- I: Maxwell's Equations and Electromagnetic Waves: Lectures- 15

- Equation of continuity
- Maxwell's Postulate
- Physical interpretation of Maxwell's Postulate
- Maxwell's Equations and their empirical basis
- Derivation of Maxwell's Equations
- Physical significance of Maxwell's equations
- Electromagnetic Energy
- Plane electromagnetic waves in free space
- Plane Electromagnetic waves in isotropic and anisotropic non-conducting medium
- Scalar and Vector Potentials.

- Poynting theorem and Poynting vector
- Reflection and refraction at dielectric interfaces
- Conducting media and skin depth

UNIT-II: Relativistic Electrodynamics:

Lectures- 15

- Lorentz Transformations,
- Four-vectors Transformation of differential operator ,
- Invariance of D' Alembertian Operator,
- Minkowski Force,
- Geometrical interpretation of Lorentz Transformations of Space and Time,
- Lorentz transformation of Electromagnetic potentials,
- Lorentz transformation of Electric and Magnetic Fields,
- Electromagnetic field tensor,
- Covariant form of Maxwell's equations,

UNIT-III: Electrodynamics of a moving and radiating system: Lectures- 15

- Liénard-Wiechert potentials
- The electromagnetic fields from Lienard-Wiechert Potential of a moving charge
- The electromagnetic fields produced by a charge in uniform and accelerated motion.
- Reaction force of radiation
- Radiated Power
- Angular distribution of radiation due to accelerated charge
- Synchrotron radiation (introductory concepts)
- Bremsstrahlung Radiation

UNIT-IV: Applications of Electromagnetic Waves:

Lectures- 15

- Boundary conditions at the surface of discontinuity
- Reflection and refraction of electromagnetic waves at the interface of non-conducting medium
- Fresne's equation
- Verification of Fresnel's equation
- Scattering and it's parameters
- Theory of Scattering of electromagnetic waves, Polarization of Scattered light.

Suggested Books

David J. Griffiths, Introduction to Electrodynamics, 4th Edition.
J. D. Jackson, Classical Electrodynamics, 3rd Edition.
Panofsky and Phillips, Classical Electricity and Magnetism.
Reitz, Milford and Christy, Foundations of Electromagnetic Theory.
Landau and Lifshitz, The Classical Theory of Fields.
Cheng, Field and Wave Electromagnetics.
Feynman Lectures on Physics, Vol. II.

Evaluation Scheme

Component Marks

Total 100

Internal Assessment (Sessional Test, Assignment, Seminar) -25

End Semester Examination -75

Question Paper Pattern (75 Marks):-

- Section A: 10 Short Answer Questions (Attempt Any 8) – 16 Marks
- Section B: 5 Medium Answer Questions (Attempt Any 3) – 24 Marks
- Section C: 3 Long Answer Questions (Attempt Any 2) – 35 Marks

Bachelor (Honours) in Physics- Paper III
OR
Bachelor (With Honours with Research) in Physics- Paper III
Semester VIII- Nano-Science

Credits: 4

Maximum Marks: 100
Theory: 75 Marks
Internal Assessment: 25 Marks

Course Objectives

- To introduce fundamental concepts of nanoscience and nanotechnology.
- To understand size-dependent physical properties of nanomaterials.
- To study synthesis and characterization techniques of nanostructures.
- To explore applications of nanomaterials in electronics, energy, medicine, and emerging technologies.
- Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the fundamental concepts and quantum phenomena governing nanomaterials.

CO2: Analyze various synthesis and fabrication techniques for nanostructures.

CO3: Apply advanced characterization techniques for studying nanoscale materials.

CO4: Evaluate the role of nanomaterials in modern technological and industrial applications.

Total Lectures: 60

UNIT-I: Fundamentals of Nanoscience and Nanomaterials Lectures- 15

Introduction to nanoscience and nanotechnology.

- Historical development and emergence of nanotechnology
- Length scales in nanoscience
- Classification of nanomaterials
- Zero-dimensional (Quantum dots)
- One-dimensional (Nanowires, Nanotubes)
- Two-dimensional (Graphene, Thin films)
- Three-dimensional nanostructured materials
- Surface-to-volume ratio and size effects
- Quantum confinement effect
- Density of states in low-dimensional systems

- Electronic, optical, magnetic and thermal properties at nanoscale
- Introduction to quantum wells, quantum wires and quantum dots
- Numerical Problems

UNIT-II: Synthesis and Fabrication of Nanomaterials

Lectures- 15

Top-Down and Bottom-Up approaches.

- Physical Methods
- Ball milling
- Lithography techniques
- Physical vapor deposition (PVD)
- Molecular beam epitaxy (MBE)
- Chemical Methods
- Sol-gel process
- Chemical vapor deposition (CVD)
- Hydrothermal synthesis
- Co-precipitation technique
- Self-assembly methods
- Biological Synthesis
- Green synthesis of nanoparticles
- Biosynthesis using microorganisms and plant extracts
- Nanofabrication Techniques
- Nanopatterning
- Thin film growth mechanisms
- Numerical Problems

UNIT-III: Characterization Techniques of Nanomaterials

Lectures- 15

Structural Characterization:

- X-Ray Diffraction (XRD)
- Scherrer formula and particle size estimation
- Small Angle X-Ray Scattering (SAXS)

Microscopy Techniques:

- Scanning Electron Microscopy (SEM)
- Transmission Electron Microscopy (TEM)
- High Resolution TEM (HRTEM)

Scanning Probe Microscopy:

- Atomic Force Microscopy (AFM)
- Scanning Tunneling Microscopy (STM)
- Spectroscopic Techniques:
- UV-Visible Spectroscopy
- Raman Spectroscopy
- FTIR Spectroscopy

- X-ray Photoelectron Spectroscopy (XPS)
- Magnetic and Electrical Characterization
- Numerical Problems

UNIT-IV: Nanomaterials and Their Applications

Lectures- 15

- Carbon Nanostructures
- Fullerenes
- Carbon nanotubes (CNTs)
- Graphene and graphene derivatives
- Functional Nanomaterials
- Metal nanoparticles
- Semiconductor nanoparticles
- Magnetic nanoparticles
- Nanocomposites
- Applications
- Nanoelectronics and spintronics
- Nanosensors and biosensors
- Solar cells and energy storage devices
- Fuel cells and hydrogen technology
- Drug delivery systems and nanomedicine
- Environmental remediation
- Nanophotonics and optoelectronic devices
- Artificial Intelligence-enabled nanotechnology
- Ethical, societal and environmental aspects of nanotechnology
- Recent Advances in Nanoscience and Nanotechnology
- Numerical Problems

Suggested Books

- C. P. Poole Jr. and F. J. Owens, Introduction to Nanotechnology.
 K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Nanotechnology.
 Bharat Bhushan, Springer Handbook of Nanotechnology.
 Charles P. Poole, Nanotechnology.
 T. Pradeep, Nano: The Essentials.
 Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials.
 M. A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology.

Evaluation Scheme

Component Marks (Total 100)

Internal Assessment (Sessional Test, Assignment, Seminar, Viva) - 25

End Semester Examination - 75

Question Paper Pattern (75 Marks)

Section A (Short Answer Type) Total: 16 Marks

10 Questions (Attempt Any 8) , 2Marks Each

Section B (Medium Answer Type) Total: 24 Marks

5 Questions (Attempt Any 3) , 8 Marks Each

Section C (Long Answer Type) Total: 35 Marks

3 Questions (Attempt Any 2) , 17.5 Marks Each

Mapping with UGC-NET Physical Sciences

The syllabus covers major UGC-NET themes including:

Quantum Mechanics and Low-Dimensional Systems

- Condensed Matter Physics
- Materials Science
- Nanoscience and Nanotechnology
- Characterization Techniques
- Modern Technological Applications
- Computational and Research-Oriented Components

Bachelor (Hons.) in Physics-Paper – IV
OR
Bachelor (Hons.with Research) in Physics-Paper – IV
Semester VIII - X-Rays and Laser Physics

Credits: 4

Maximum Marks: 100
Theory: 75 Marks
Internal Assessment: 25 Marks

Course Objectives

The course aims to:

- Introduce the fundamental principles and production mechanisms of X-rays.
- Develop understanding of X-ray spectroscopy and related analytical techniques.
- Familiarize students with laser spectroscopy and interaction of radiation with matter.
- Provide knowledge of modern spectroscopic techniques and their scientific and technological applications.

Total Lectures - 60
lectures - 15

UNIT I: X-Rays Fundamentals

- Introduction to X-Rays
- Discovery and properties of X-rays.
- Production of X-rays: Coolidge tube.
- Continuous and characteristic X-ray spectra.
- Duane-Hunt law.
- Moseley's law and its significance.
- Absorption of X-rays and absorption edges.
- Soft and hard X-rays.
- X-Ray Diffraction
- Bragg's law and Bragg spectrometer.
- Crystal structure determination using X-rays.
- Laue method and Powder method.
- Reciprocal lattice and Ewald construction (elementary treatment).

lectures – 15

UNIT II: X-Ray Spectroscopy

- Characteristic X-Ray Spectra
- Origin of K, L, M series.
- Fine structure of X-ray spectra.
- Selection rules and transition probabilities.
- Screening constant and Moseley's relation.
- Modern X-Ray Spectroscopic Techniques
- X-ray Fluorescence Spectroscopy (XRF).

- X-ray Photoelectron Spectroscopy (XPS).
- X-ray Absorption Spectroscopy (XAS): EXAFS and XANES (elementary concepts).
- Energy Dispersive X-ray Analysis (EDX/EDS).
- Applications in material characterization, elemental analysis and nanoscience.

UNIT III: Elements of Laser Spectroscopy

lectures - 15

- Fundamentals of Lasers
- Interaction of radiation with matter.
- Spontaneous and stimulated emission.
- Einstein A and B coefficients.
- Population inversion and optical pumping.
- Two-level, three-level and four-level laser systems.
- Laser Systems
- Optical resonator and cavity modes.
- Characteristics of laser beam: coherence, monochromaticity, directionality and brightness.
- Ruby, He-Ne, CO₂ and Semiconductor lasers.
- Q-switching and mode locking (elementary concepts).
- Basic Laser Spectroscopy
- Principle and instrumentation of laser spectroscopy.
- Doppler broadening and Doppler-free spectroscopy.
- Saturation spectroscopy.
- Line width and spectral resolution.

UNIT IV: Applications of Laser Spectroscopy

lectures - 15

- Advanced Spectroscopic Techniques
- Raman spectroscopy.
- Laser-induced fluorescence spectroscopy (LIF).
- Photoacoustic spectroscopy.
- Laser absorption spectroscopy.
- Applications
- Applications in atomic and molecular physics.
- Laser spectroscopy in environmental monitoring.
- Applications in medical diagnostics and biomedical sciences.
- Industrial applications and non-destructive testing.
- Applications in nanotechnology and material science.
- Introduction to ultrafast laser spectroscopy and femtosecond techniques.

Suggested Books

- B.B. Laud, Lasers and Non-Linear Optics, New Age International.
 K. Thyagarajan and A.K. Ghatak, Lasers: Fundamentals and Applications.
 B.K. Mathur, Introduction to Lasers.

A. Beiser, Concepts of Modern Physics.
C. Kittel, Introduction to Solid State Physics.
B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules.
J. Singh, Modern Physics for Scientists and Engineers.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

- CO1: Explain the generation, properties and diffraction of X-rays and apply Bragg's law to crystal structure studies.
- CO2: Analyze characteristic X-ray spectra and understand modern X-ray spectroscopic techniques used for elemental and structural characterization.
- CO3: Describe the fundamental principles of lasers, optical resonators and various laser systems used in spectroscopy.
- CO4: Apply concepts of laser spectroscopy to investigate atomic, molecular and material properties and understand their interdisciplinary applications.
- CO5: Develop analytical and experimental skills relevant to modern spectroscopic techniques employed in research and industry.

Bachelor (With Honour's) in Physics
OR
Bachelor (Honour's with Research) in Physics

Semester VIII

List of Practical

1. To determine the wavelength of a laser beam using plane diffraction grating.
2. To determine the angular spread of laser beam.
3. To study the B-H curve.
4. Synthesis of nanoparticles by chemical route.
5. To study the first and second order passive filters.
6. To study the first and second order active filters.
7. Analysis of the given XRD pattern of nanostructured substance.

PG Physics Course

Sem	Paper code	Nature	Title	Theory/practical /Research Project	Credit
IX	RB010901T	Compulsory 1	Quantum Physics	Theory	4
	RB010902T	Compulsory 2	Nuclear Physics-1	Theory	4
		Optional	Optional (Specialization)	Theory	-
	RB010903aT	Optional Paper 3a	Advanced Electronics-1		4
	RB010903bT	Optional Paper 3b	Condensed Matter Physics-1		4
	RB010904P	Compulsory 4	Specialization Lab	Practical	4
	RB010905R	Compulsory 5	Research Project (Allocation)	Research Project	-
X	RB011001T	Compulsory 1	Advanced Quantum Physics	Theory	4
	RB011002T	Compulsory 2	Nuclear Physics -II	Theory	4
		Optional	Optional (Specialization)	Theory	-
	RB011003aT	Optional Paper 3a	Advanced Electronics-II		4
	RB011003bT	Optional Paper 3b	Condensed Matter Physics-II		4
	RB011004P	Compulsory 4	Specialization Lab	Practical	4
	RB011005R	Compulsory 5	Research Project (Evaluation)	Research Project	8

10

M.Sc. Physics – Paper 1st
Semester IX – Quantum Physics

UNIT 1

Total Lectures:- 60

Linear operators, Null operator, Identity operator, Singular and Non-singular operator, Eigen functions and Eigen values orthogonal eigen functions, The operator formalism in quantum mechanics, Momentum operator, Hamiltonian operator, commutation in operators, Hermitian operator, Properties of Hermitian operator, Parity operator, Postulates of quantum mechanics, coordinate and momentum representation, superposition of eigen states, continuous spectrum, Equation of motion, Ehrenfest's theorem, simultaneous measurements and commuting operators, Schwartz inequality, Heisenberg uncertainty relation derived from operator, commutator algebra.

UNIT 2

Lectures:- 15

Angular momentum operator, Commutation relation for L_x , L_y and L_z , Ladder operators, Completeness of eigen functions, Dirac-delta function, bra and ket notation, Matrix representation of an operator, Unitary transformation, The Schrodinger equation for spherically symmetric potentials, Degeneracy, Hydrogen atom, Radial equation, Eigen value, Radial Probability.

UNIT 3

Lectures:- 15

Stationary perturbation theory, Non-degenerate case, First order perturbation, second order perturbation, Perturbation of an oscillator, Helium atom, Degenerate case, Removal of degeneracy in first and second order, First order Stark effect in hydrogen, Weak field Zeeman effect, The variational method, Expectation value of the energy, Ground state of Helium, Exchange degeneracy, Heitler-London theory of hydrogen molecule, W K B method and its applications.

UNIT 4

Lectures:- 15

Scattering cross-section, Relation between angles, energies, etc. in laboratory and centre of mass system of co-ordinates, Normalisation of incoming wave, Differential scattering cross-section, Partial waves and phase shifts, Born approximation and its validity condition, Study of scattering from a square well potential.

Lectures:- 15

Text and Reference Books :

1. Quantum Mechanics by Satya Prakash & C.K. Singh
2. Advance Quantum Mechanics by B.S. Rajput
3. Quantum Mechanics by L.I. Schiff

M.Sc. Physics – Paper 2nd
Semester IX – Nuclear Physics I

Total Lectures:- ~~45~~ 60

Unit-I

Theories of nuclear composition: Proton- electron theory, Proton-neutron theory; Nuclear shape and size: charge distribution, mass distribution; Nuclear Instability; Importance of binding energy; Nuclear density; Spin angular momentum; Nuclear spin (total angular momentum); Parity; Nuclear dipole and electric quadrupole moments; Isobaric spin concept.

Lectures:- ~~12~~ 15

Unit-II

Properties and simple theory of deuteron in ground state; Magnetic dipole and quadrupole moments of deuteron; Scattering cross section; Neutron-proton scattering at low energy; S-wave effective range theory; Proton- proton scattering at low energy; Properties of nuclear forces (Spin dependence, Saturation properties, tensor component, charge symmetry and charge dependence); Exchange force model.

Lectures:- ~~12~~ 15

Unit-III

Experimental evidences of Shell structure in nuclei; Extreme single particle shell model; Spin orbit interaction and prediction of magic numbers; Prediction of angular momentum, parity, magnetic moment and electric quadrupole moment; The limitations of the model.

Lectures:- ~~12~~ 15

Unit-IV

Types of reactions and conservation laws; Energetic of nuclear reactions; Reaction cross section; Partial wave method of calculating cross section; Elementary idea of compound and direct reactions.

Lectures:- ~~12~~ 15

Text and Reference Books:

1. Theory of Nuclear Structure by M.K. Pal (Affiliated east-West Press).
2. Introductory Nuclear Physics by Kenneth S. Krane (John Willy & Sons).
3. Nuclear Physics: An Introduction by W.E. Burcham, F. R. S. (Longmans).
4. Nuclear Physics by S. N. Ghoshal (S. Chand & Company LTD.).

RAJA MAHENDRA PRATAP SINGH UNIVERSITY, ALIGARH
M.Sc. Physics Semester – IX
Paper III(a): ADVANCED ELECTRONICS – I

Credits: 4

Maximum Marks: 100

Theory: 75 Marks

Internal Assessment: 25 Marks

Course Objectives

The course aims to:

- Develop an understanding of integrated circuits and analog electronic systems.
- Introduce operational amplifier characteristics and their applications.
- Familiarize students with active filters, signal conditioning and signal translation techniques.
- Develop knowledge of multivibrators and waveform generation circuits.
- Introduce sequential digital circuits including registers and semiconductor memories.

Total lectures - 60

UNIT I : Integrated Circuits and Operational Amplifiers **lectures -15**

- Integrated Circuits
- Classification of ICs: Analog, Digital and Mixed Signal ICs.
- Monolithic and Hybrid ICs.
- Fabrication techniques of monolithic ICs: Epitaxy, Oxidation, Diffusion, Ion Implantation, Photolithography and Metallization.
- Characteristics and limitations of integrated circuits.
- Linear ICs and their applications.
- Operational Amplifiers
- Differential amplifier and basic OP-AMP architecture.
- Ideal and practical OP-AMP characteristics.
- Input offset voltage and currents.
- CMRR, PSRR, Slew Rate, Gain-Bandwidth Product.
- Frequency response and compensation techniques.
- OP-AMP parameters and specifications.
- Numericals based on OP-AMP characteristics.

UNIT II : OP-AMP Applications and Signal Translation

lectures -15

- Linear Applications of OP-AMP
- Inverting and Non-inverting amplifiers.
- Voltage follower and buffer amplifier.
- Summing, scaling and subtractor amplifiers.
- Differential amplifier and Instrumentation amplifier.
- Integrator and Differentiator.

- Logarithmic and Antilogarithmic amplifiers.
- Voltage-to-Current (V/I) and Current-to-Voltage (I/V) converters.
- Voltage-to-Frequency (V/F) converters.
- Frequency-to-Voltage (F/V) converters.
- Analog multipliers and sample-and-hold circuits.
- Comparators and Schmitt Trigger.
- Analog-to-Digital and Digital-to-Analog Interfacing concepts.

UNIT III : Active Filters and Multivibrators

lectures -15

- Active Filters using OP-AMP
- Passive versus Active filters.
- First-order Low Pass and High Pass filters.
- Second-order Low Pass and High Pass filters.
- Band Pass and Band Reject (Notch) filters.
- All-pass filters.
- Butterworth approximation and frequency response.
- Design considerations of active filters.
- Multivibrators
- Astable, Monostable and Bistable multivibrators.
- OP-AMP based multivibrators.
- IC 555 Timer:
- Monostable operation.
- Astable operation.
- Applications of IC 555.
- Schmitt Trigger as regenerative comparator.
- Design problems and waveform analysis.

UNIT IV : Registers and Semiconductor Memories

lectures -15

- Sequential Logic Circuits
- Review of Flip-Flops (SR, JK, D and T).
- Shift Registers:
- SISO, SIPO, PISO and PIPO registers.
- Bidirectional and Universal Shift Registers.
- Register Transfer Operations.
- Counters: Ripple and Synchronous counters.
- Semiconductor Memories
- Memory organization and hierarchy.
- ROM, PROM, EPROM and EEPROM.
- RAM: Static RAM (SRAM) and Dynamic RAM (DRAM).
- Flash Memory.
- Memory decoding and interfacing concepts.

- Cache memory and associative memory (introductory concepts).
- Introduction to Programmable Logic Devices
- PLA, PAL and FPGA (basic concepts).

Course Outcomes (COs)

After successful completion of this course, students will be able to:

- CO1: Explain the fabrication, characteristics and applications of integrated circuits and operational amplifiers.
- CO2: Analyze and design OP-AMP based linear circuits for amplification, signal conditioning and signal translation.
- CO3: Design and evaluate active filters and multivibrator circuits for waveform generation and signal processing.
- CO4: Understand the operation of sequential logic circuits, registers and semiconductor memory systems used in modern electronic devices.
- CO5: Solve numerical problems related to OP-AMP circuits, filters, timers and digital memory systems.

Suggested Books

Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI.
 D. Roy Choudhury and Shail Jain, Linear Integrated Circuits, New Age International.
 Sergio Franco, Design with Operational Amplifiers and Analog Integrated Circuits, McGraw-Hill.
 Millman and Halkias, Integrated Electronics, McGraw-Hill.
 Morris Mano, Digital Design, Pearson.
 Floyd, Digital Fundamentals, Pearson.
 Sedra and Smith, Microelectronic Circuits, Oxford University Press.
 Taub and Schilling, Digital Integrated Electronics, McGraw-Hill.

Teaching-Learning Methods

Classroom lectures
 Problem-solving sessions
 ICT-enabled teaching
 Simulation using Multisim/LTspice/Proteus
 Seminar and assignment presentations

Scheme of Examination

Component	Marks	Total
End Semester Examination	75	100
Internal Assessment	25	

2

M.Sc. Physics-Paper 3(b)
Semester IX — Condensed Matter Physics-I

Total Lectures: - 60

UNIT 1 — Crystalline solids and Crystal symmetry

Crystalline solids, direct and reciprocal lattice, Bragg's law, x-rays diffraction, X-ray diffraction methods: the Laue, powder and rotating crystal methods. Determination of lattice parameters, Symmetry elements of crystals: rotation, reflection, translation, inversion, roto-inversion, roto-reflection. Point group and space group, symmetry and physical properties of solids.

Lectures: - 15

UNIT 2 — Defects and Imperfections in crystals:

Point defects, line defects, stacking faults, role of dislocations in crystal growth, influence of defects on the physical properties of solids, stress and strain fields, elastic energy of dislocation, dislocation in fcc, bcc, and hcp lattices.

Lectures: - 15

UNIT 3 — Lattice dynamics and optical properties of solids

Dispersion relation of diatomic lattice, optical phonons and dielectric constant, in-elastic neutron scattering, Debye-Waller factor, thermal expansion and thermal conductivity, Interaction of electrons and phonons with photons, polaritons, optical properties of metals, polarons.

Lectures: - 15

UNIT 4 — Electronic and quantum electronic properties of solids

Electrons in a periodic lattice, Bloch theorem, Kronig-Penney Model, Band theory of solids, classification of solids, effective mass, magneto-resistance, metal-insulator transition, Mott-insulator, quantum electronic transport, quantum and integral Hall effect.

Lectures: - 15

Text and Reference Books:

- 1 Introduction to solid state physics by Charles Kittel.
- 2 Solid state physics by S. O. Pillai
- 3 Introduction of Solids by L.V. Azaroff
- 4 Solid State Physics by N.W. Ashcroft and N.D. Mermin.
- 5 Crystallography Applied to Solid State Physics by A.R. Verma and O.N. Srivastava
- 6 Solid State Physics-Structure and Properties of Materials by M.A. Wahab

List of Practical in Advanced Electronics – I

Semester – IX

1. Logic Gates and their combination.
2. Half and Full Adder.
3. Half and Full Subtractor.
4. RS Flip Flop.
5. JK Flip Flop.
6. D – Latch.
7. Study of Op-Amp Characteristics.
8. Schmitt Trigger.

**List of Practical Condensed matter Physics -I
For Semester IX**

1. Measurement of lattice parameters and indexing of powder photographs.
2. Interpretation of transmission Laue photography.
3. Determination of orientation of a crystal by back reflection Laue method.
4. Rotation/oscillation photographs and their interpretation.
5. To study the modulus of rigidity and internal friction in metals as a function of temperature.
6. To measure the cleavage step height of a crystal by multiple Fizeau fringes.
7. To obtain multiple beam Fringes of equal chromatic order.
8. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field.

M.Sc. Physics – Paper 1st
Semester X – Advanced Quantum Physics

Total Lectures:- 65

UNIT 1

Time dependent Perturbation Theory, First order perturbation, Harmonic perturbation Transition probabilities, Fermi Golden rule, Dipole approximation, Second order perturbation,

Lectures:- 15

UNIT 2

Physical meaning of identity, Distinguishability of identical particles, Symmetric and Antisymmetric wave functions, Construction from unsymmetrised function, Connection of spin and statistics, collision of identical particles with spin, Pauli Spin matrices.

Lectures:- 15

UNIT 3

Schrodinger relativistic equation for free particles (Klein-Gordon Equation), Dirac relativistic equation, Free particle equation, Properties of Dirac matrices, Free particles solutions, Electron spin, Magnetic moment, Dirac equation of a central field of force, Spin-Orbit coupling. Solution for hydrogen atom. Negative energy states.

Lectures:- 15

UNIT 4

Formulation in terms of transition probability, Matrix elements of the perturbation, Transition probability for absorption, Transition probability for emission, Einstein coefficients, Einstein transition probability for absorption and emission.

Lectures:- 15

Text and Reference Books :

1. Quantum Mechanics by Satya Prakash & C.K. Singh
2. Advance Quantum Mechanics by B.S. Rajput
3. Quantum Mechanics by L.I. Schiff

M.Sc. Physics – Paper 2nd
Semester X – Nuclear Physics II

Total Lectures:- 60

Unit-I

Basic α - decay process & its systematic, Experimental information on α - decay (dependence of α -decay on mass number, energy-lifetime relationships, long range α - particles, fine structure of α - particles spectra), Theory of α - emission.

Lectures:- 15

Unit-II

Basic β - decay process; Energy released in β - decay; Shape of β - ray spectra; Neutrinos and antineutrinos; Fermi theory of β - decay; Kuri plots and the neutrino mass; Angular momentum and parity selection rule; Comparative half lives and forbidden decays.

Lectures:- 15

Unit-III

Energetic of γ - decay, Classical electromagnetic radiations and their quantum mechanical approach, Angular momentum and parity selection rule, Life times for γ - emission, Zero-zero transition, nuclear isomerism, Internal conversion.

Lectures:- 15

Unit-IV

Fundamental interactions, Classification of elementary particles on the basis of interactions and their quantum numbers; Symmetry and classification of elementary particles, Gellmann-Nishijima formula, CPT invariance, CP violation in K- decay, Quark model, colored quarks and gluons.

Lectures:- 15

Text and Reference Books:

1. Introductory Nuclear Physics by Kenneth S. Krane (John Willy & Sons).
2. Introductory Nuclear Physics by Smauel S. M. Wong (Wily-VCH, Second Edition)
3. Nuclear and Particle Physics: An Introduction by Brian R Maritm (John Willy & Sons).
4. Nuclear Physics by S. N. Ghoshal (S. Chand & Company LTD).

RAJA MAHENDRA PRATAP SINGH UNIVERSITY, ALIGARH

M.Sc. Physics

Semester X

Paper III (a): ADVANCED ELECTRONICS – II

Credits: 4

Max. Marks: 100

Theory: 75 Marks

Internal Assessment: 25 Marks

Course Objectives

The course aims to:

- Develop understanding of analog and digital communication systems.
- Familiarize students with satellite, radar, microwave and antenna technologies.
- Introduce modern modulation and multiplexing techniques.
- Enable students to understand the working principles of contemporary communication systems.

Total lectures - 60

lectures - 15

UNIT I: Analog Communication

- Basics of Communication Systems
- Elements of a communication system.
- Information source, transmitter, channel, receiver and destination.
- Need for modulation.
- Amplitude Modulation (AM)
- Generation and detection of AM waves.
- DSB-SC, SSB and VSB modulation.
- Power relations and efficiency.
- Frequency and Phase Modulation
- FM and PM concepts.
- Generation and detection of FM.
- Comparison of AM, FM and PM.
- Noise in analog communication systems.
- Multiplexing Techniques
- Frequency Division Multiplexing (FDM).
- Time Division Multiplexing (TDM): basic concepts.

UNIT II: Digital Communication

lectures - 15

- Introduction
- Advantages of digital communication.
- Sampling theorem and quantization.
- Pulse Modulation Techniques
- PAM, PWM, PPM.
- Pulse Code Modulation (PCM).

- Delta Modulation (DM) and Adaptive Delta Modulation (ADM).
- Digital Modulation Techniques
- ASK, FSK, PSK and QPSK.
- QAM and DPSK (basic concepts).
- Information Theory
- Entropy and information content.
- Channel capacity theorem.
- Error detection and correction codes.

UNIT III: Satellite and Radar Communication

lectures - 15

- Satellite Communication
- Orbital mechanics and Kepler's laws.
- Types of satellites: GEO, MEO and LEO.
- Satellite subsystems: transponder, telemetry, tracking and command systems.
- Uplink and downlink.
- Link budget concept.
- Applications of communication satellites.
- Radar Communication
- Basic radar principle and radar equation.
- Radar frequencies and range determination.
- CW Radar and Pulsed Radar.
- MTI and Doppler Radar.
- Radar antennas and displays.
- Applications of radar in defense, meteorology and remote sensing.

UNIT IV: Microwave and Antenna Systems

lectures - 15

- Microwave Engineering
- Microwave frequency bands and applications.
- Microwave propagation.
- Waveguides: rectangular waveguide, TE and TM modes.
- Cavity resonators.
- Microwave sources: Klystron, Magnetron and Gunn diode.
- Microwave measurements.
- Antenna Systems
- Antenna parameters: radiation pattern, gain, directivity, beam width, bandwidth and polarization.
- Dipole and monopole antennas.
- Yagi-Uda antenna.
- Horn antenna.
- Parabolic reflector antenna.
- Antenna arrays and phased arrays (basic concepts).

Course Outcomes (COs)

After successful completion of the course, students will be able to:

- CO1: Explain the principles of analog communication systems and analyze various modulation techniques.
- CO2: Apply concepts of digital communication including pulse and digital modulation schemes for signal transmission.
- CO3: Understand the working principles and applications of satellite and radar communication systems.
- CO4: Analyze microwave devices, waveguides and various antenna systems used in modern communication networks.
- CO5: Evaluate the performance characteristics of communication systems and interpret their practical applications in wireless and space communications.

Suggested Books

Simon Haykin, Communication Systems, Wiley.
Kennedy & Davis, Electronic Communication Systems, McGraw-Hill.
Taub and Schilling, Principles of Communication Systems, McGraw-Hill.
Dennis Roddy, Satellite Communications, McGraw-Hill.
Merrill I. Skolnik, Introduction to Radar Systems, McGraw-Hill.
Samuel Y. Liao, Microwave Devices and Circuits, Pearson.
C. A. Balanis, Antenna Theory: Analysis and Design, Wiley.
K. D. Prasad, Antennas and Wave Propagation, Satya Prakashan.

Suggested Pedagogy

Lectures, smart-class demonstrations, simulation using MATLAB/Scilab, communication system experiments, seminar presentations and assignments.

M.Sc. Physics-Paper 3(b)
Semester X — Condensed Matter Physics-II

Total Lectures: - 40

UNIT 1 — Magnetic Properties and superconductivity

Magnetism in materials: Dia, Para and Ferromagnetism, Weiss theory of ferromagnetism: spin waves, magnons, Domain and Bloch wall, Curie-Weiss law, Superconductivity, energy gap, critical temperature, persistent currents, Meissner effect, Cooper pairing due to phonons, BCS theory of Superconductivity, Ginzburg-Landau theory, DC Josephson effect, ac Josephson effect.

Lectures: - 15

UNIT 2 - Electron gas in solids

Electron gas in 1-D and 2-D system, interacting electron gas: Hartree and Hartree-Fock approximations. Correlation energy, Screening, Plasma Oscillations. Strongly-interacting Fermi system. Elementary introduction to Landau's quasi-particle theory of a Fermi liquid.

Lectures: - 15

UNIT 3 - Disordered systems

Point defects: Shallow impurity of states in semiconductors. Localized lattice vibrational states in solids, vacancies, interstitials, and colour centres in ionic crystals. Disorder in condensed matter, substitutional, positional, and topographical disorder, short- and long-range order, atomic correlation function and structural descriptions of glasses and liquids, Anderson model for random systems and electron localization, mobility edge.

Lectures: - 15

UNIT 4 - Thin films

Thin film and ultrathin films, conditions for accurate determination of step height and film thickness (Fizeau fringes), Nucleation and growth of thin films, Film growth models, Electrical conductivity of thin films, comparing the behaviour of thin films from their bulk counterpart, Boltzmann transport equation for a thin film (for diffused scattering), expression for electrical conductivity for thin films.

Lectures: - 15

Text and Reference Books:

1. Introduction to solid state physics by Charles Kittel.
2. Principles of Condensed Matter Physics by P. M. Chaikin and T. C. Lubensky
3. Solid State Physics-Structure and Properties of Materials by M. A. Wahab
4. Physics of Surfaces and Interfaces by Harald Ibach
5. Solid state physics by S. O. Pillai.

List of Practical in Advanced Electronics – II

Semester – X

1. Amplitude Modulation and Demodulation.
2. Frequency Modulation and Demodulation.
3. Study of Analog to Digital Converter.
4. Study of Digital to Analog Converter.
5. Study of ASK, FSK and PSK.
6. Study of V-I Characteristics of Gun Diode.
7. Study of generation of Microwave and klystron tube.
8. Study of Multivibrator.
9. Study of 555 – timer.

22

**List of Practical Condensed matter Physics -II
For Semester X**

1. Conductivity of Germanium in Vander Pauw Geometry.
2. Magneto-resistance of Ge
3. Four-probe method
4. Hall effect
5. Study of Fluorescence materials
6. Study of Ferromagnetic materials.
7. Study of Superconducting materials.
8. Measurement of magnetic susceptibility.