Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Empowered Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the M.Sc.

Program: M. Sc. PHYSICS

Program Code: RJSPGPHY

National Education Policy (NEP 2020)

Level 6.0

(CBCS 2025-2026)

Preamble

The new education policy empowers students to acquire knowledge at their pace. In the two-year PG program, the student has one exit option with a PG Diploma. Under the One-year PG Diploma program and two-year master's Degree program the student must complete on the job training /internship of 4 credits after completion of the second semester of the first year. Research methodology course is mandatory. Research projects are compulsory in both the semesters in second year. Reentry to complete the PG degree after taking the exit option will be permissible up to 05 years from the date of admission to the PG programs.

Why MSc Physics at R JC

The Department of Physics at Ramniranjan Jhunjhunwala college was established in 1963 providing undergraduate education to students in the subject of Botany. In 2018 the MSc program in Physics was started and in 2017 it was recognized as a research center to guide students for their PhD.

The Post graduate program in Physics at Ramniranjan Jhunjhunwala college provides a rigorous training to the student to face the real challenges. The department is well equipped with advanced experimental set-ups, an ever expanding library and several computers. Students carry out long projects as a part of their curriculum often in collaboration with the Institutes in the city and several electives are offered giving students a wide exposure to different branches of the subject.

PROGRAM OUTCOMES FOR POST GRADUATE DEGREE PROGRAMS IN PHYSICS

The Post graduate program in Physics has been designed to train students in problem solving skills along with a conceptual understanding. This has been found to help students in being better prepared for competitive examinations leading to better future prospects.

The program aims to prepare students to become better researchers in theoretical as well as experimental studies in the subject as well as in inter/ multidisciplinary areas.

The program also aims to impart pedagogical skills among the students.

The rigorous training is expected to hone analytical skills and critical thinking skills preparing students for any challenges they might face in their chosen field.

PROGRAMME M SC PHYSICS
PROGRAMME SPECIFIC OUTCOMES (PSOs) FOR M.Sc. PHYSICS

Sr. No.	A student Specific completing M.Sc. Physics will be able to:
PSO1	Understand, analyze and apply difficult concepts from Physics.
PSO2	Plan and carry out an experiment, and interpret the result.
PSO3	Use the knowledge of Physics to solve problems facing the society.
PSO4	develop technology using modern principles of Physics
PSO5	To develop the required acumen for quality research, innovate and communicate

Credit Structure for M Sc Semester I as per NEP 2020 Implemented from the academic year 2024-2025

Papers	Number of Papers	Credits	Total Credits
Major Subject theory	4	4*4 = 16	16
Major Subject Practical	1	2	2
Research Methodology	1	4	4
Total Credits		22	22

Credit Structure for M Sc Semester II as per NEP 2020 Implemented from the academic year 2024-2025

Papers	Number of Papers	Credits	Total Credits
Major subject theory	4	4*4 = 16	16
Major subject Practical	1	2	2
OJT		4	4
Total Credits		22	22

M.Sc. Semester I Physics Syllabus

Course Code	Paper Title	Credits	L/Week
RJSPGPHY101	Mathematical Methods	4	4
RJSPGPHY102	Classical Mechanics	4	4
RJSPGPHY103	Quantum Mechanics I	4	4
RJSPGPHY104	Solid State Physics	4	4
RJSPGRM101	Research Methodology	4	4
RJSPGPHYP101	General Laboratory I	2	4

M.Sc. Semester I Physics Syllabus

Course Code	Title	Credits
RJSPGPHY101	Mathematical Methods	4
Unit I: Complex Variables, Limits, Continuity, Derivatives, Cauchy-Riemann Equations, Analytic functions, Harmonic functions, Elementary functions: Exponential and Trigonometric, Taylor and Laurent series, Residues, Residue theorem, Principal part of the functions, Residues at poles, zeroes and poles of order m, Contour Integrals, Evaluation of improper real integrals, improper integrals involving Sines and Cosines, Definite integrals involving sine and cosine functions.		1
Unit II: Matrices, Eigenvalues and Eigenvectors, orthogonal, unitary and hermitian matrices, Diagonalization of Matrices, Applications to Physics problems. Introduction to Tensor Analysis, Addition and Subtraction of Tensors, summation convention, Contraction, Direct Product, Levi-Civita Symbol		1
Unit III: General treatment of second order linear differential equations with non-constant coefficients, Power series solutions, Frobenius method, Legendre, Hermite and Laguerre polynomials, Bessel equations, Nonhomogeneous equation – Green's function, Sturm-Liouville theory.		1
Unit IV: Integral transforms: three dimensional fourier transforms and its applications to PDEs (Green function of Poisson's PDE), convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations.		1

Main references:

1. S. D. Joglekar, Mathematical Physics: The Basics, Universities Press 2005
2. S. D. Joglekar, Mathematical Physics: Advanced Topics, CRC Press 2007
3. M.L. Boas, Mathematical methods in the Physical Sciences, Wiley India 2006
4. G. Arfken and H. J. Weber: Mathematical Methods for Physicists, Academic Press 2005

Additional references:

1. A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics, McMillan
2. A.C. Bajpai, L.R. Mustoe and D. Walker, Advanced Engineering Mathematics, John Wiley
3. E. Butkov, Mathematical Methods, Addison‑Wesley
4. J. Mathews and R.L. Walker, Mathematical Methods of physics
5. P. Dennery and A. Krzywicki , Mathematics for physicists
6. T. Das and S.K. Sharma, Mathematical methods in Classical and Quantum Mechanics
7. R. V. Churchill and J.W. Brown, Complex variables and applications, V Ed. Mc Graw. Hill
8. A. W.Joshi, Matrices and Tensors in Physics, Wiley India

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT
TITLE OF THE SUBJECT/COURSE	:	MATHEMATICAL METHODS
COURSE CODE	:	RJSPGPHY101
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	This course is expected to equip the students with different mathematical methods used in solving problems in Physics.
2	By extensive problem solving, students would be comfortable in selecting and using any mathematical method learnt.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	deal with complex functions and carry out integrations of functions of complex variables. They would also be able to use the methods of complex analysis to solve integrals involving functions of real variables.	1	BT Level III, IV Apply draw conclusions
CO2	learn different advanced matrix operations, their properties and classifications. They would also learn the concept of tensors and be able to carry out algebra involving them.	1, 3	BT level III, IV and V
CO3	advance their knowledge about differential equations and learn to solve some second order differential equations with non-constant coefficients and learn different examples and methods to solve them.	1,3	BT level III, IV and V
CO3	Students will be introduced to integral transforms. They will learn Fourier and Laplace transforms in detail with their properties and applications.	1,3	BT level III, IV and V

M.Sc. Semester I Physics Syllabus

Course Code	Title	Credits
RJSPGPHY102	**Classical Mechanics**	**4**
Unit I: Review of Newton's laws, Mechanics of a particle, Mechanics of a system of particles, Frames of references, rotating frames, Centrifugal and Coriolis force, Constraints, D'Alembert's principle and Lagrange's equations, Velocity‑dependent potentials and the dissipation function, Simple applications of the Lagrangian formulation. Hamilton's principle, Calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Lagrange Multipliers and constrained extremization problems, Extension of Hamilton's principle to nonholonomic systems, Advantages of a variational principle formulation		1
Unit II: Conservation theorems and symmetry properties, Energy Function and the conservation of energy. The Two‑Body Central Force Problem**:** Reduction to the equivalent one body problem, The equations of motion and first integrals, The equivalent one‑dimensional problem and classification of orbits, The virial theorem, The differential equation for the orbit and integrable power‑law potentials, The Kepler problem : Inverse square law of force, The motion in time in the Kepler problem, Scattering in a central force field, Transformation of the scattering problem to laboratory coordinates.		1
Unit III: Small Oscillations: Formulation of the problem, The eigenvalue equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, Forced and damped oscillations, Resonance and beats. Legendre transformations and the Hamilton equations of motion, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a variational principle.		1
Unit IV: Canonical Transformations, Examples of canonical transformations, The symplectic approach to canonical transformations, Poisson brackets and other canonical invariants, Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, The angular momentum Poisson bracket relations.		1

Main Reference: Classical Mechanics, H. Goldstein, Poole and Safko, 3rd Edition, Narosa Publication (2001)

Additional References:

1. Classical Mechanics, N. C. Rana and P. S. Joag. Tata McGraw Hill Publication.
2. Classical Mechanics, S. N. Biswas, Allied Publishers (Calcutta).
3. Classical Mechanics, V. B. Bhatia, Narosa Publishing (1997).
4. Mechanics, Landau and Lifshitz, Butterworth, Heinemann.
5. The Action Principle in Physics, R. V. Kamat, New Age Intnl. (1995).
6. Classical Mechanics, Vol I and II, E. A. Deslougue, John Wiley (1982).
7. Theory and Problems of Lagrangian Dynamics, Schaum Series, McGraw (1967).
8. Classical Mechanics of Particles and Rigid Bodies, K. C. Gupta, Wiley Eastern (2001)

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT
TITLE OF THE SUBJECT/COURSE	:	CLASSICAL MECHANICS
COURSE CODE	:	RJSPGPHY102
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	After this course, students are expected to gain knowledge of quantum mechanics in considerable depth.
2	They should be able to apply the methods to any problem needing quantum mechanical treatment.
3	They would be well versed in the mathematical aspects of the course.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	learn mathematical formalism and mathematical interconnections between different concepts of quantum mechanics.	1	BT Level III, IV Apply draw conclusions
CO2	solve different one dimensional problems involving simple potentials by using different mathematical methods.	1, 5	BT level III, IV and V Apply, analyze and evaluate
CO3	consider and solve problems using different coordinate systems.	1,5	BT level III, IV and V Apply, analyze and evaluate
CO4	master different concepts and techniques related to rotational motion.	1,5	BT level III, IV and V Apply, analyze and evaluate

Course Code	Title	Credits
RJSPGPHY103	**Quantum Mechanics I**	**4**
Unit I:Review of concepts: Postulates of quantum mechanics, observables and operators, measurements, state function and expectation values, the time-dependent Schrodinger equation, time development of state functions, solution to the initial value problem. The Superposition principle, commutator relations, their connection to the uncertainty principle, complete set of commuting observables. Time development of expectation values, conservation theorems and parity. 2. Formalism: Linear Vector Spaces and operators, Dirac notation, Hilbert space, Hermitian operators and their properties, Matrix mechanics: Basis and representations, unitary transformations, the energy representation. Schrodinger, Heisenberg and interaction picture.		1
Unit II: **Wave packet:** Gaussian wave packet, Fourier transform. 2. **Schrodinger equation solutions: one dimensional problems:** General properties of one dimensional Schrodinger equation, Particle in a box, Harmonic oscillator by raising and lowering operators and Frobenius method, unbound states, one dimensional barrier problems, finite potential well.		1
Unit III:**Schrodinger equation solutions: Three dimensional problems:** Orbital angular momentum operators in cartesian and spherical polar coordinates, commutation and uncertainty relations, spherical harmonics, two particle problem-coordinates relative to centre of mass, radial equation for a spherically symmetric central potential, hydrogen atom, eigenvalues and radial eigenfunctions, degeneracy, probability distribution.		1
Unit IV: Ladder operators, eigenvalues and eigenfunctions of L^2 and L_z using spherical harmonics, angular momentum and rotations. 1. Total angular momentum J; LS coupling; eigenvalues of J^2 and Jz. 2. Addition of angular momentum, coupled and uncoupled representation of eigenfunctions, Clebsch Gordan coefficient for $j_1 = j_2 = ½$ and $j_1 =1$ and $j_2 = ½$. 3. Angular momentum matrices, Pauli spin matrices, spin eigenfunctions, free particle wave function including spin, addition of two spins.		1

Main references:

1. Richard Liboff, Introductory Quantum Mechanics, 4th edition, Pearson.

2. D J Griffiths, Introduction to Quantum Mechanics 4th edition
3. A Ghatak and S Lokanathan, Quantum Mechanics: Theory and Applications, 5th edition.

4. N Zettili, Quantum Mechanics: Concepts and Applications, 2nd edition, Wiley.

Additional References

1. W Greiner, Quantum Mechanics: An introduction, Springer, 2004
2. R Shankar, Principles of Quantum Mechanics, Springer, 1994
3. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1977).
4. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1994).

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT
TITLE OF THE SUBJECT/COURSE	:	QUNTUM MECHANICS I
COURSE CODE	:	RJSPGPHY103
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	After this course, students are expected to gain knowledge of quantum mechanics in considerable depth.
2	They should be able to apply the methods to any problem needing quantum mechanical treatment.
3	They would be well versed in the mathematical aspects of the course.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	learn mathematical formalism and mathematical interconnections between different concepts of quantum mechanics.	1,5	BT Level I, II, III, IV remember & Understand, Apply draw conclusions
CO2	solve different one dimensional problems involving simple potentials by using different mathematical methods.	1, 5	BT level I, II, III, IV and V remember & understand Apply, analyze and evaluate
CO3	master different concepts and techniques related to rotational motion.	1,5	BT level I, II, III, IV and V remember & understand Apply, analyze and evaluate

M.Sc. Semester I Physics Syllabus

Course Code	Title	Credits
RJSPGPHY104	**Solid State Physics**	**4**
Unit I: Bragg law, Scattered Wave Amplitude – Fourier analysis, Reciprocal Lattice Vectors, Diffraction Conditions, Brillouin Zones, Reciprocal Lattice to SC, BCC and FCC lattice. Interference of Waves, Atomic Form Factor, Elastic Scattering by crystal, Ewald Construction, Structure Factor, Temperature Dependence of the Reflection Lines, Experimental Techniques (Laue Method, Rotating Crystal Method, Powder Method) Scattering from Surfaces, Elastic Scattering by amorphous solids.		1
Unit II: Vibrations of Monoatomic Lattice, normal mode frequencies, dispersion relation. Lattice with two atoms per unit cell, normal mode frequencies, dispersion relation., Quantization of lattice vibrations, phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic Neutron scattering. Anharmonic Crystal Interaction. Thermal conductivity – Lattice Thermal Resistivity, Umklapp Process, Imperfections		1
Unit III: Langevin diamagnetic equation, diamagnetic response, Quantum mechanical formulation, core diamagnetism. Quantum Theory of Paramagnetism, Rare Earth Ions, Hund's Rule, Iron Group ions, Crystal Field Splitting and Quenching of orbital angular momentum; Adiabatic Demagnetisation of a paramagnetic Salt, Paramagnetic susceptibility of conduction electrons;		1
Unit IV: Ferromagnetic order- Exchange Integral, Saturation magnetisation, Magnons, neutron magnetic scattering; Ferrimagnetic order, spinels, Yttrium Iron Garnets, Anti Ferromagnetic order. Ferromagnetic Domains – Anisotropy energy, origin of domains, transition region between domains, Bloch wall, Coercive force and hysteresis.		1

Main References:-

1. Charles Kittel "Introduction to Solid State Physics", 7th edition John Wiley & sons.
2. J.RichardChristman "Fundamentals of Solid State Physics" John Wiley & sons
3. M.A.Wahab "Solid State Physics –Structure and properties of Materials" Narosa Publications 1999.
4. M. Ali Omar "Elementary Solid State Physics" Addison Wesley (LPE)
5. H.Ibach and H.Luth 3rd edition "Solid State Physics – An Introduction to Principles of Materials Science" Springer International Edition (2004)

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT
TITLE OF THE SUBJECT/COURSE	:	SOLID STATE PHYSICS
COURSE CODE	:	RJSPGPHY104
CREDITS	:	04
DURATION	:	60 HOURS

LEARNING OBJECTIVES	
1	The course will further the understanding of the structure of solids, ways to determine it and its effect on the thermal conductivity properties.
2	The course will advance the knowledge about magnetism and gain theoretical understanding of atomic origins of different types of magnetic materials.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	learn advanced concepts like reciprocal lattice and study the phenomenon of scattering from periodic lattice systems. They'll study experimental methods related to x-ray diffraction techniques.	1, 4	BT Level III, IV Apply draw conclusions
CO2	understand different modes of thermal transport in lattice, will study lattice vibrations, phonons etc.	1,4, 5	BT level III, IV and V Apply, analyze and evaluate
CO3	Students will gain theoretical understanding of the atomic origin of diamagnetism, paramagnetism and ferromagnetism.	1,5	BT level III, IV and V Apply, analyze, and evaluate

Course Code	Topic Headings	Credits
RJSPGPHYP101	**General Laboratory 1**	**2**
S.No.		
1	Michelson Interferometer	
2	Analysis of sodium spectrum	
3	h/e by vacuum photocell	
4	Susceptibility measurement by Quincke's method/ Guoy's balance method	
5	Constant current supply using IC 741 and LM 317	
6	Active filter circuits (second order)	
7	Carrier lifetime by pulse reverse method	
8	Resistivity by four probe method	
9	Temperature dependence of avalanche and Zener breakdown diodes	
10	DC Hall effect	
11	Determination of particle size of lycopodium particles by laser diffraction method	
12	Magneto resistance of Bi specimen	
13	Diffraction using helical structure	
14	Waveform Generator using ICs	
Note: Minimum number of experiments to be performed and reported in the journal =06. Some new experiments may be added from time to time.		

SEMESTER	:	I MAJOR (CORE) SUBJECT PRACTICAL
TITLE OF THE SUBJECT/COURSE	:	GENERAL LABORATORY I
COURSE CODE	:	RJSPGPHYP101
CREDITS	:	02
DURATION	:	60HOURS

LEARNING OBJECTIVES	
1	Students will be learn to design experiments and interpret the results
2	Students will carry out some advanced optics experiments
3	Students will carry out experiments to determine some properties of materials

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Design experiments, perform them while minimizing the errors and interpret the results	3, 4,5	BT Level III, IV Apply draw conclusions
CO2	diffraction and interference phenomena in some advanced experiments	3, 4, 5	BT level III, IV and V Apply, analyze and evaluate
CO3	determine some properties of materials	3,4, 5	BT level III, IV and V Apply, analyze and evaluate

Course Code	Title	Credits
RJSPGRM	**Research Methodology**	**4**
Unit I: Research Methodology and Research Problem 1. Meaning of Research; Objectives of Research; Motivation in Research. 2. Types of Research; Research Approaches; Significance of Research 3. Research Methods versus Methodology; Research Process; Criteria of Good Research; Problems Encountered by Researchers in India. 4. What is a Research Problem? Selecting the Problem; Necessity of Defining the Problem; Technique Involved in Defining a Problem		1
Unit II: Research Design and Data Collection - Meaning of Research Design; Need for Research Design; Features of a Good Design; Important Concepts Relating to Research Design. - Different Research Designs; Basic Principles of Experimental Designs; Developing a Research Plan - Collection of Primary Data; Observation Method; Interview Method; Collection of Data through Questionnaires; Collection of Data through Schedules; Other Methods of Data Collection, - Collection of secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method		1
Unit III: Interpretation and Report writing - Meaning of Interpretation, Why Interpretation? - Technique of Interpretation, Precautions in Interpretation, - Significance of Report Writing, Different Steps in Writing Report, - Layout of the Research Report, Types of Reports, Oral Presentation, - Mechanics of Writing a Research Report, Precautions for Writing Research Reports.		1
Unit IV: Research Ethics - Introduction to Research Ethics and Scientific Conduct; Ethics in Writing – Academic Integrity: Research Misconduct/ Fabrication/ Unethical Practices. Academic/Research: Falsification, Manipulation or Tempering of Data. - Literature Review and Proper Use of E-Resources, Scientific Reading, Cite and Write, Style Manuals and Bibliographies. - Understanding Plagiarism and Types of Plagiarism; Publication Misconduct and Publication; Ethics and Ways to avoid Plagiarism; Regulations on Plagiarism in India. - Plagiarism Detection Software; Features and Functionalities of Anti-Plagiarism Software; Plagiarism Policies, Penalties and Consequences		1

References

1. Dawson C (2002) Practical research methods UBS Publishers, New Delhi
2. Kothari C R and G Garg (2019) Research Methodology. New Age International N Delhi.

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I
TITLE OF THE SUBJECT/COURSE	:	RESEARCH METHODOLOGY
COURSE CODE	:	RJSPGRM101
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	Learn the concept of research and different types of research
2	Develop skills for designing experiments and use statistical tools for analysis
3	Learn to analyze ethical aspects of research
4	Formulate a hypothesis test it through experiments and report writing

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Understand the concept of research and different types of research	4	BT Level III, IV Apply draw conclusions
CO2	Design experiments analyze data, present it scientifically in writing do a plagiarism check using software and present it.	4, 5	BT level III, IV and V Apply, analyze and evaluate

Evaluation and Assessment

Evaluation (Theory): Total marks per course - 100.

CIA- 40 marks

Assignment/Presentation/Seminar/written test/problem solving/paper review/Project

Semester End Examination – 60 marks

Question paper covering all units unless otherwise specified

Evaluation (Practicals): Total 50 marks (30 marks for continuous evaluation, 15 marks for viva at the end of the semester and 05 marks for Journal)

PAPER RESEARCH METHDOLOGY (RJSPGRM101)

Evaluation: 100 marks

Continuous evaluation: 40% Presentation and review of classic and recent paper

Semester End Examination : 60% MCQ Test

M.Sc. Semester II Physics Syllabus

Course Code	Paper Title	Credits	L/Week
RJSPGPHY201	Statistical Mechanics	4	4
RJSPGPHY202	Electrodynamics	4	4
RJSPGPHY203	Quantum Mechanics-II	4	4
RJSPGPHY204	Atomic and Molecular Physics	4	4
RJSPGOJT	On Job Training (OJT)	4	4
RJSPGPHYP201	Computer Laboratory I	2	4
	Total	22	32

M.Sc. Semester II Physics Syllabus

Course Code	Title	Credits
RJSPGPHY201	**Statistical Mechanics**	**4**
Unit I: Review of thermodynamics (extensive and intensive variable, concept of equilibrium, internal energy and laws of thermodynamics, specific heat, isothermal and adiabatic processes, thermodynamics potentials, free energy and enthalpy), Thermodynamics of Phase Transitions, Postulates of classical statistical mechanics (ergodicity, Liouville's theorem, equal a priori probability), Microcanonical ensemble, Second law of thermodynamics, examples: ideal gas, Einstein solid, paramagnet.		1
Unit II: Boltzmann statistics, Boltzmann factor, canonical ensemble, Maxwell speed distribution, applications to ideal gas, paramagnet etc, Grand canonical ensemble, Gibbs factor, examples. Fluctuations.		1
Unit III: Bose-Einstein and Fermi-Dirac statistics. Examples: Degenerate Fermi gases, density of states, Sommerfeld Expansion, Blackbody Radiation, Debye theory of solids, Bose-Einstein Condensation		1
Unit IV: Interacting systems, weakly interacting gases, Ising model for Ferromagnets, exact solution in one dimensions, mean field approximations, Monte Carlo simulations.		1

Suggested References:

1. Introduction to Statistical Physics, Kerson Huang , Taylor and Francis 2001.
2. An Introduction to Thermal Physics, Daniel V. Schroeder.
3. Thermal and Statistical Physics, F Reif.
4. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995.
5. Statistical Mechanics - R. K. Pathria& Paul D. Beale (Third Edition), Elsevier 2011 – Chap. 1 to 8
6. Principles of Equilibrium Statistical Mechanics, Debashish Chowdhury and Dietrich Stauffer (Wiley-VCH)

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT THEORY
TITLE OF THE SUBJECT/COURSE	:	**Statistical Mechanics**
COURSE CODE	:	RJSPGPHY201
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	In this course the students will learn the microscopic origin of several laws especially in thermodynamics.
2	The students will learn concepts and techniques to derive governing equations for macroscopic variables from the interactions at the microscopic level.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Understand new concepts of statistical mechanics.	1	BT Level III, IV Apply draw conclusions
CO2	Understand the connection between thermodynamics and statistical mechanics	1, 5	BT level III, IV and V Apply, analyze and evaluate
CO3	Learn different ensembles in detail	1,5	BT level III, IV and V Apply, analyze and evaluate
CO4	Identify and work with systems belonging to different ensembles.	1,5	BT level III, IV and V Apply, analyze and evaluate

M.Sc. Semester II PHYSICS Syllabus

Course Code	Title	Credits
RJSPGPHY202	**Electrodynamics**	**4**
Unit I: Maxwell's equations, The Poynting vector, The Maxwellian stress tensor, Lorentz Transformations, Four Vectors and Four Tensors, The field equations and the field tensor, Maxwell equations in covariant notation.		1
Unit II: Electromagnetic waves in vacuum, Polarization of plane waves. Electromagnetic waves in matter, frequency dependence of conductivity, frequency dependence of polarizability, frequency dependence of refractive index. Wave guides, boundary conditions, classification of fields in wave guides, phase velocity and group velocity, resonant cavities.		1
Unit III:Moving charges in vacuum, gauge transformation, The time dependent Green function, The Lienard‑ Wiechert potentials, Leinard‑ Wiechert fields, application to fields‑radiation from a charged particle, Antennas, Radiation by multipole moments, Electric dipole radiation, Complete fields of a time dependent electric dipole, Magnetic dipole radiation		1
Unit IV: Relativistic covariant Lagrangian formalism: Covariant Lagrangian formalism for relativistic point charges. The energy‑momentum tensor, Conservation laws.		1

Suggested References:

1. W.Greiner, Classical Electrodynamics (Springer‑ Verlag, 2000) (WG).
2. M.A. Heald and J.B. Marion, Classical Electromagnetic Radiation, 3rd edition (Saunders, 1983) (HM)

Additional references:

1. J.D. Jackson, Classical Electrodynamics, 4Th edition, (John Wiley & sons) 2005 (JDJ)
2. W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism,2nd edition, (Addison ‑ Wesley) 1962.
3. D.J. Griffiths, Introduction to Electrodynamics,2nd Ed., Prentice Hall, India,1989.
4. J.R. Reitz ,E.J. Milford and R.W. Christy, Foundation of Electromagnetic Theory, 4th ed., Addison ‑Wesley, 1993

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT THEORY
TITLE OF THE SUBJECT/COURSE	:	**Electrodynamics**
COURSE CODE	:	RJSPGPHY202
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	The purpose of the course is to advance students' knowledge of electrodynamics to a higher level and also to study its applications to practical examples.
2	The students are expected to have appreciated the theoretical consistency of the theory of Maxwell's equations and also its consequences to the real life situations.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Learn advanced concepts involving Maxwell's equations. They will also be introduced to the Poynting theorem and its uses. They will learn about the EM waves from the perspective originating from Maxwell's equations and their propagation through different media and through waveguides.	1	BT Level III, IV Apply draw conclusions
CO2	Learn about moving charges and the radiation emanating from them leading to the theory of antenas. They'll also go on to study the covariant formulation of the Maxwell equations and related concepts.	1, 5	BT level III, IV and V Apply, analyze and evaluate

<table>
<tr><th>Course Code</th><th>Title</th><th>Credits</th></tr>
<tr><td>RJSPGPHY203</td><td><u>Quantum Mechanics‐II</u></td><td>4</td></tr>
<tr><td colspan="2"><u>Unit I :</u> Perturbation Theory:

Time independent perturbation theory: First order and second order corrections to the energy eigenvalues and eigenfunctions. Degenerate perturbation Theory: first order correction to energy.

Time dependent perturbation theory: Harmonic perturbation, Fermi's Golden Rule, sudden and adiabatic approximations, applications.</td><td>1</td></tr>
<tr><td colspan="2"><u>Unit II:</u> Approximation Methods

1. Variation Method: Basic principle, applications to simple potential problems, He-atom.
2. WKB Approximation: WKB approximation, turning points, connection formulas, Quantization conditions, applications.</td><td>1</td></tr>
<tr><td colspan="2"><u>Unit III:</u> scattering Theory

Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude, Partial wave analysis and phase shifts, optical theorem, S-wave scattering from finite spherical attractive and repulsive potential wells, Born approximation.</td><td>1</td></tr>
<tr><td colspan="2"><u>Unit IV:.</u>
1. Identical Particles: Symmetric and antisymmetric wave functions, Bosons and Fermions, Pauli Exclusion Principle, slater determinant.
2. Quantum Computing: Information measure, Turing machine and complexity classes, qubits and quantum logic gates.
3. Relativistic Quantum Mechanics: The Klein Gordon and Dirac equations. Dirac matrices, spinors, positive and negative energy solutions physical interpretation. Nonrelativistic limit of the Dirac equation.</td><td>1</td></tr>
</table>

Suggested References

1. Richard Liboff, Introductory Quantum Mechanics, 4th edition, Pearson.
2. D J Griffiths, Introduction to Quantum Mechanics 4th edition
3. A Ghatak and S Lokanathan, Quantum Mechanics: Theory and Applications, 5th edition.
4. N Zettili, Quantum Mechanics: Concepts and Applications, 2nd edition, Wiley.
5. J. Bjorken and S. Drell, Relativistic Quantum Mechanics, McGraw-Hill (1965).

Additional References

1. W Greiner, Quantum Mechanics: An introduction, Springer, 2004
2. R Shankar, Principles of Quantum Mechanics, Springer, 1994
3. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1977).
4. J.J. Sakurai Modern Quantum Mechanics, Addison-Wesley (1994).

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	I MAJOR (CORE) SUBJECT ELECTIVE THEORY
TITLE OF THE SUBJECT/COURSE	:	**Quantum Mechanics‑II**
COURSE CODE	:	RJSPGPHY203
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	The purpose of this course is to teach advanced concepts of quantum mechanics which will allow them to tackle more complex problems albeit approximately.
2	This course will also introduce the students to further advanced concepts used later in theoretical physics.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Advance their knowledge of quantum mechanics by learning some approximation methods like perturbation theory to calculate the corrections to the energy, variational principle or WKB approximation.	1	BT Level III, IV Apply draw conclusions
CO2	Understand quantum mechanical aspects of scattering theory. They'll also go on to analyse the quantum mechanical reasons behind different behaviors of particles with different spins. Finally, they'll learn relativistic aspects of quantum mechanics.	1, 5	BT level III, IV and V Apply, analyze and evaluate

Course Code	Title	Credits
RJSPGPHY204	<u>**Atomic and Molecular Physics**</u>	**4**
<u>Unit I :</u> **Review*** of one-electron eigenfunctions and energy levels of bound states, Probability density, Virial theorem. Fine structure of hydrogenic atoms, Lamb shift. Hyperfine structure and isotope shift. (ER 8-6) Linear and quadratic Stark effect in spherical polar coordinates. Zeeman effect in strong and weak fields, Paschen-Back effect. (BJ, GW) Schrodinger equation for two electron atoms: Identical particles, The Exclusion Principle. Exchange forces and the helium atom (ER), independent particle model, ground and excited states of two electron atoms. (BJ)		1
<u>Unit II:</u> The central field, Thomas-Fermi potential, the gross structure of alkalis (GW). The Hartree theory, ground state of multi-electron atoms and the periodic table (ER), The L-S coupling approximation, allowed terms in LS coupling, fine structure in LS coupling, relative intensities in LS coupling, j-j coupling approximation and other types of coupling (GW)		1
<u>Unit III:</u> Interaction of one electron atoms with electromagnetic radiation: Electromagnetic radiation and its interaction with charged particles, absorption and emission transition rates, dipole approximation. Einstein coefficients, selection rules. Line intensities and life times of excited state, line shapes and line widths. X-ray spectra. (BJ)		1
<u>Unit IV:</u>.Born-Oppenheimer approximation - rotational, vibrational and electronic energy levels of diatomic molecules, Linear combination of atomic orbitals (LCAO)and Valence bond (VB) approximations, comparison of valence bond and molecular orbital theories (GA, IL) **A)** Rotation of molecules: rotational energy levels of rigid and non-rigid diatomic molecules, classification of molecules, linear, spherical, symmetric and asymmetric tops. **B)** Vibration of molecules: vibrational energy levels of diatomic molecules, simple harmonic and anharmonic oscillators, diatomic vibrating rotator and vibrational-rotational spectra. **c)** Electronic spectra of diatomic molecules: vibrational and rotational structure of electronic spectra. (GA, IL) Quantum theory of Raman effect, Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect, Applications General theory of Nuclear Magnetic Resonance (NMR). NMR spectrometer, Principle of Electron spin resonance ESR. ESR spectrometer. (GA, IL) (*Mathematical details can be found in BJ. The students are expected to be acquainted with them but not examined in these.)		1

Suggested References

1. Robert Eisberg and Robert Resnick, Quantum physics of Atoms, Molecules, Solids, Nuclei and Particles, John Wiley & Sons, 2nded, (ER)
2. B.H. Bransden and G. J. Joachain, Physics of atoms and molecules, Pearson Education 2nded, 2004 (BJ)
3. G. K. Woodgate, Elementary Atomic Structure, Oxford university press, 2nded, (GW).
4. G. Aruldhas, Molecular structure and spectroscopy, Prentice Hall of India 2nded, 2002 (GA)
5. Ira N. Levine, Quantum Chemistry, Pearson Education, 5th edition, 2003 (IL)

Additional References

1. Leighton, Principles of Modern Physics, McGraw hill
2. Igor I. Sobelman, Theory of Atomic Spectra, Alpha Science International Ltd. 2006
3. C. N. Banwell, Fundamentals of molecular spectroscopy, Tata McGraw‑Hill, 3rded
4. Wolfgang Demtröder, Atoms, molecules & photons, Springer‑Verlag 2006
5. SuneSvanberg, Atomic and Molecular Spectroscopy Springer, 3rded 2004
6. C.J. Foot, Atomic Physics, Oxford University Press, 2005 (CF)

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	II MAJOR (CORE) SUBJECT ELECTIVE THEORY
TITLE OF THE SUBJECT/COURSE	:	Atomic and Molecular Physics
COURSE CODE	:	RJSPGPHY204
CREDITS	:	04
DURATION	:	60 LECTURES

LEARNING OBJECTIVES	
1	The students will extend their knowledge of quantum mechanics as applied to atoms and molecules.
2	They'll study different aspects of the atomic and molecular spectra and study their origin from quantum mechanics.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	Study different effects and derive them from the Schrodinger equation. They'll also analyse the effect of the coupling between different angular momenta.	1	BT Level III, IV Apply draw conclusions
CO2	Learn the theory of how electromagnetic radiation is absorbed and emitted by an atom. They'll study various aspects of the spectra of atoms as well as molecules.	1, 5	BT level III, IV and V Apply, analyze and evaluate

Course Code	Topic Headings	Credits
RJSPGPHYP201	COMPUTER LAB I	**2**

Course Code	Topic Headings	Credits
RJSPGPHYP201	COMPUTER LAB I	**2**
S.No.		
1	Introduction to Python Programming	
2	Operators in python, Python Flow controls	
3	Python Functions, Python Data Structures	
4	Python Module Numerical Python,	
5	Math module, SciPy	

COURSE OUTCOMES (COs) M. Sc. PHYSICS

SEMESTER	:	II MAJOR (CORE) SUBJECT
TITLE OF THE SUBJECT/COURSE	:	PRACTICAL(COMPUTER LAB I)
COURSE CODE	:	RJSPPHYP201
CREDITS	:	02
DURATION	:	60 HOURS

LEARNING OBJECTIVES	
1	Students will be exposed to advanced programming paradigms
2	Students will be able to solve some Physics problems with the aid of a computer.

COURSE OUTCOME NUMBER	On completing the course, the student will be able to:	PSO Addressed	BLOOMS LEVEL
CO1	write simple programs using Python.	4	BT Level I, II Remember and understand
CO2	use the knowledge of Python to solve more advanced numerical problems.	2, 4, 5	BT level III, IV and V Apply, analyze and evaluate

Teaching Learning Process

The teaching learning process in the learning outcomes based curriculum framework in the subject of Physics is designed to develop the problem solving skills of every learner. The post graduate course offers experimental, computation and theoretical skills required for further studies and professional development. Various techniques of teaching learning processes are adopted in which the teacher and learners are actively involved.

Some of the salient teaching learning processes are

- Class lectures
- Presentations
- Peer teaching and learning
- Flipped classroom, project based learning, quiz, seminars, exhibitions, posters
- Practical's experimental design planning, analysis, interpretation, application of knowledge gained
- Technology enabled self learning
- Internships, On job training
- Project work, scientific writing,

The effective teaching strategies would address the requirements of learners to learn at their own pace. The teaching pedagogy adopted to ensure inculcate critical thinking skills in the learner. The teaching learning processes adopted aim at participatory pedagogy.

Mapping of the course to employability/ Entrepreneurship/skill development

Class	Course Name	Course Code	Topic focusing on Employability/ Entrepreneurship/ skill development	Employability/Entrepreneurship/Skill development	Specific activity
M Sc Physics Semester I	Mathematical Methods	RJSPGPHY 101	Fourier Transforms	The topics offer an important mathematical skill to deal with various real world situations.	Problem solving
M Sc Physics Semester I	Classical Mechanics	RJSPGPHY 102	Lagrangian Equations, variational principle, Hamiltonian Dynamics	Employability in the field of teaching and research. Variational principle is used to optimize processes in industry.	Conceptual understanding and problem solving.
M Sc Physics Semester I and II	Quantum Mechanics I, Quantum Mechanics II, Atomic and Molecular Physics	RJSPGPHY 103, RJSPGPHY 203, RJSPGPHY 204	Foundations and Applications of Quantum Mechanics, Quantum Computing.	Skills in dealing with systems and technology at the atomic and molecular level	Conceptual understanding and problem solving.
M Sc Physics Semester I	Solid State Physics	RJSPGPHY 104	Crystal Structure and Magnetism	Basic skills in understanding material and their various properties.	Presentations and problem solving
M Sc Physics Semester II	Statistical Mechanics	RJSPGPHY 201	Thermodynamics and its derivation from microscopic interactions	Skills to understand various engines and also designing new materials	Conceptual understanding and problem solving.
M Sc Physics Semester II	Electrodynamics	RJSPGPHY 202	EM Waves and their reflection and transmission	Employability in the field of teaching and research. Basic skills for understanding waveguides.	Presentations and problem solving
M Sc Physics Semester I	General Laboratory I	RJSPGPHYP 101	Various Experiments	Skills in handling various high end instruments, employability in service and sales of scientific instruments	Experiments
M Sc Physics Semester II	Computer Laboratory I	RJSPGPHYP 201	Python Programming	Employability in software development and Data Science	Practice of programming

Mapping of curriculum with relevance in the local, regional, national and global developmental needs

S.NO.	Topic (Paper/ Unit/Content)	Relevance
1	Quantum Computing	Quantum Computers are expected to be the next generation computers being developed all over the world and its basic understanding starts
2	Python Programming	This training in programming with or without the a knowledge of Physics can be useful in some of the industries in India as well as abroad
3	General Laboratory	The training in design and handling of instruments is useful in the local service industry and sales of such instruments.
4.	All papers	The emphasis on conceptual understanding and problem solving prepares students for a career in research globally as well as in teaching locally in International Schools, Junior and Degree Colleges.

RULES AND REGULATIONS REGARDING ASSESSMENT AND EVALUATION FOR FY PG UNDER NEP FROM A.Y. 2024-2025 ONWARDS-

1. A learner appearing for first year PG examination under NEP will have **maximum of 22 credits per semester** and examinations will be of maximum 550 marks.
2. Courses having **2 credits, 3 credits and 4 credits** will have examinations of **50, 75, 100 marks** respectively.
3. Duration of examinations:
   - An IA exam of 20/25 marks shall be of duration of 30 minutes.
   - An IA exam of 40 marks shall be of duration of 50 minutes. Departments may use different modes of internal evaluation.
   - An SEE exam of 30 marks (offline) shall be of duration of 1 hour.
   - An SEE exam of 50 marks (offline) shall be of duration of 2 hours.
   - An SEE exam of 50 marks (online MCQ) shall be of 60 minutes.
   - An SEE exam of 60 marks (offline) shall be of duration of 2 ½ hours.
4. There shall be **separate passing of Internal Examination and SEE** for each paper with a **minimum passing percentage of 40.**
   a. Minimum marks for passing in internal examination of 40 marks shall be 16.
   b. Minimum marks for passing in SEE of 60 marks shall be 24.
5. **Appearing for SEE** for every paper is **compulsory** irrespective of the performance in the Internals examinations. A student absent in SEE will be thus declared failing in a given subject.
6. There shall be provision for supplementary examination for the benefit of students who miss their SEE on grounds of medical emergency or representing college at the national level event or any other equivalent event with a special permission granted by the Head of the institution.
7. There shall be no Additional Examinations for any of the Semesters except for the Semester III wherein one chance of credit improvement in Semester III shall be given before the Learner appears for the final Semester IV Examination.
8. Irrespective of the performance in Semester I and II, students shall migrate to Sem III. Eligibility for a PG degree is that a learner must complete 22 credits in each semester.
9. All ordinances under UG examinations are applicable to PG examinations as well.