NEP and Learning Outcome-based Curriculum Framework (LOCF)

For

M.Sc. (Physics) Programme

Academic Session (w.e.f. 2024-2025)

I & II SEMESTERS

DEPARTMENT OF PHYSICS

MAHARAJA SURAJMAL BRIJ UNIVERSITY BHARATPUR

Dr. Farbat Singh
Asstt. Registrar
Acad.I

Dr. Divyanshu Bhatnagar

Dr. Avesh Kumar

Mr. Vishnu Kumar

Scheme of Examination

The examination pattern comprises 30% internal assessment and 70% external assessment.

Internal Assessment

The internal assessment is divided as follows:

1. 10% from two sessional exams
2. 20% from attendance, assignments, demonstrations, and presentations

External Assessment

Theory Papers:

1. Each theory paper in the end-of-semester examination (EoSE) carries 70% marks.
2. The EoSE will be of 3 hours duration.
3. The questions will be designed in alignment with Bloom's Taxonomy.

Part A of the question paper shall contain 10 very short answer type questions covering the entire syllabus. Each question carries equal marks.

Part B of the question paper shall contain 04 descriptive type questions one from each unit with internal choice. Each question carries equal marks.

Value-Added Papers

1. Each theory paper in the end-of-semester examination (EoSE) carries 70% marks.
2. The EoSE will be of 2 hours duration.
3. Question paper shall contain 40 multiple choice questions covering the entire syllabus. Students have to attempt any 35 questions. Each question carries 1 mark.
4. If a student attempts more than 35 questions, only the first 35 attempted questions will be considered.

Practical:

Internal: continuous evaluation (30%).

External: end term practical /written exam (40%) and viva-voce (30%).

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SEMESTER-I

Course Title	Course Code	L	T	P	L	T	P	Total Credits	MARKS				
		(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)													
Classical Mechanics	PPSC-01	4	0	0	4	0	0	4	30	70	0	0	100
Mathematical Physics	PPSC-02	4	0	0	4	0	0	4	30	70	0	0	100
Physics Lab-1	PPLAB-01	0	0	12	0	0	6	6	0	0	45	105	150
Discipline Specific Elective Course(s): Students have to choose Any One													
i) Electronics	PPSE-01	4	0	0	4	0	0	4	30	70	0	0	100
ii) Vacuum Science and Thin Films Technology	PPSE-02	4	0	0	4	0	0	4	30	70	0	0	100
Multidisciplinary Course(s)													
Modern Physics	PMDC-01	2	0	0	2	0	0	2	15	35	0	0	50
Ability Enhancement Course(s)													
Programming using Python	PAEC-01	2	0	0	2	0	0	2	15	35	0	0	50
Value-added Course(s)													
Indian Science History	PPVAC-01	2	0	0	2	0	0	2	15	35	0	0	50

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PPSC-01: CLASSICAL MECHANICS

Course Outcomes:

After successful completion of the course on Classical Mechanics, a student will be able to:

- Demonstrate a basic and advanced knowledge of Lagrangian and Hamiltonian Formulations and solve related problems.
- Identify the cyclic coordinates and understand their importance in Hamiltonian formulation.
- Acquire Poisson and Lagrange Brackets knowledge and establish relationships between their properties.
- Demonstrate the concept of motion of a particle under central force and apply advanced methods to deal with central force problems.
- Develop a deep understanding of how to tackle the problems of small oscillations and the special theory of relativity.

Unit – I

Lagrangian and Hamiltonian Formulations: Types of Constraints on dynamical systems, Generalized Coordinates Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, Principle of Least Action and its applications, Canonical Transformation, Legendre Transformation and Hamilton's equation of motion, Physical significance of the Hamiltonian, Cyclic coordinates, Applications of Lagrangian and Hamiltonian Formulations.

Unit – II

Poisson and Lagrange Brackets: Poisson bracket and its properties, Poisson theorem, Poisson bracket and canonical transformation, Jacobi identity and its derivation, Lagrange bracket and its properties, Relationship between Poisson and Lagrange brackets and its properties, Liouville's theorem and its applications.

Unit – III

Central Force Problem and Hamilton-Jacobi Theory: Two-body central force problem: Reduction to the equivalent one-body problem, Equation of motion and first integrals, Classification of orbits, Virial theorem, Differential equation for the orbit, Integrable power law in time in the Kepler's problem; Hamilton-Jacobi Theory: Hamilton-Jacobi equation, Separation of variables in Hamilton-Jacobi equation. Solution of Harmonic Oscillator Problem and Kepler's Problem by Hamilton-Jacobi Method.

Unit – IV

Small Oscillations and Special Theory of Relativity: Theory of small oscillations: Formulation of the problem, Eigenvalue equation, and the principle axis transformation, Frequencies of free vibrations and Normal coordinates, Free vibrations of a linear triatomic molecule; Special Theory of Relativity: Postulates of Special Theory of Relativity, Lorentz Transformation,

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Length Contraction, Time Dilation, Relativistic addition of velocities, variation of mass with velocity, mass-energy equivalence.

References/Books:

1. Classical Mechanics (3rd ed., 2002), H. Goldstein, C. Poole, and J. Safko, Addison Wesley.

2. Classical Mechanics, J C Upadhyaya, Himalaya Publishing House.

3. Classical Mechanics, G. Aruldhas, PHI Learning Pvt. Ltd., New Delhi.

4. Classical Mechanics, John R. Taylor, University Science Books, USA.

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PPSC-02: MATHEMATICAL PHYSICS

Course Outcomes:

After successful completion of the course on Mathematical Physics, a student will be able to:

- Acquire knowledge about the mathematical concepts used in Physics
- Apply mathematical methods to analyse and describe physical phenomenon
- Develop problem-solving skills by applying mathematical tools to solve complex problems in physics
- Enhance critical thinking abilities through analysis of mathematical models in the context of physical theories
- Explore the interdisciplinary applications of mathematical physics in the fields such as engineering, computational physics, etc.

Unit – I

Vector Algebra and vector calculus -type of vectors, scalar product, vector product, triple scaler product, triple vector product, gradiant, divergence and curl, gauss divergence theorem, stoke curl theorem, matrix-order of matrix, various types of matrix, symmetric, skew symmetric, Hermitian, skew Hermitian, orthogonal matrix, unitary matrix, eigen value and eigen vectors, rank of matrix, calay Hamilton theorem, rotation matrix trace and determinant of matrix.

Unit – II

Integral Transforms: Fourier Transforms: Properties of Fourier Transforms, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, Fourier transforms of Derivatives, Parseval's theorem, Convolution theorem, simple applications of Fourier transformations in wave theory; Laplace Transforms: Transforms of some Elementary Functions, Properties of Laplace transform, Transform of Derivatives, Transform of Integrals, Convolution theorem, and its applications, Solution of Differential Equations by Laplace Transform.

Unit – III

Differential & Partial Differential Equations: First order differential equation- variable separation, homogeneous differential equation, Bernoulli form (reducable to the linear form), exact differential equation, Second-order differential equations. Power series solution of differential equations, ordinary point, Singular points, Frobenius method, Partial differential equations: Method of separation of variables.

Special Functions: Bessel Functions: Bessel functions of the first kind Jn(x), Generating function, Recurrence relations, Expansion of Jn(x) when n is half an odd integer, Orthogonality of Jn(x); Legendre Polynomials Pn(x): Generating function, Recurrence relations, Rodrigue's formula, Orthogonality of Pn(x); Hermite and Laguerre Polynomials: generating function & recurrence relations only.

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Unit – IV

Complex Analysis: Function of complex variable, Analytic function, The Cauchy-Reimann equations, Necessary and sufficient conditions for a function to be analytic, Harmonic functions, Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series, singularities and residues. Cauchy residue theorem, Jordan Lemma, Evaluation of real definite integrals. Evaluation of definite integrals of the type: $\int^{2\pi} f\,(Sin\,\theta, Cos\,\theta)d\theta$; $\int^{+\infty} f(x)\,dx$, $\int^{+\infty} f(x)\,e^{iax}\,dx$ Cauchy's residue theorem.

References/Books:

1. Mathematical Methods for Physicists: George Arfken-New York Academy, 1970.

2. Advanced Mathematical Methods for Engineering and Science Students: George Stephenson and P.M. Radmore-Cambridge Uni Press, 1990.

3. Group Theory and Quantum Mechanics: M. Tinkam, Dover Publications Inc., 2003.

4. Mathematical Physics: H.K. Dass, S. Chand Publications, 5th edition, 2017.

5. Mathematical Physics: Satya Parkash, S. Chand Publications, 6th edition, 2014.

6. Elements of Group Theory for Physicists, A W Joshi, New Age International Publishers, 5th edition, 2018.

7. Applied Mathematics For Engineers And Physicists, L A Pipes, Dover Publications Inc., 3rd edition 2014.

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PPLAB-01: PHYSICS LAB-I

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

- Demonstrate circuits of working of diodes, transistors, and their applications.
- Build a common emitter/base/collector amplifier and measure its voltage gain.
- Understand the use of logic gates for various applications.
- Explore the operation and advantages of operational amplifiers.
- Design up-down counter and 4-bit shift register using JK flip flop.
- Learn and understand about modulation and demodulation circuits.
- Construct an Astable multivibrator using a transistor and determine the frequency of oscillation.
- Understand voltage regulation using zener diode.

Students assigned the electronic laboratory work will perform at least 8 experiments of the following sections:

1. To study the frequency response of low-pass, high-pass and band-pass filters.
2. To study rectifier and filter circuits and draw wave shapes.
3. To design a JK Flip flop and realize an up-down counter using it.
4. Uni-junction Transistor and its application.
5. To study the common emitter transistor using NPN transistors.
6. To design circuits for OR, AND, NOT, NAND and NOR logic gates and verify their truth tables.
7. To measure (a) phase difference, (b) deflection sensitivity and (c) frequency of an unknown ac signal using CRO.
8. To design an astable and monostable Multivibrator using a 555 timer.
9. To study Zener diodes as a voltage regulator.
10. Application of op-amp as an integrator/differentiator amplifier.
11. To determine various parameters of a p-n junction diode.
12. To study the modulation and demodulation circuits.
13. Working of Half & Full Subtractors.
14. Working of Half & Full Adders.

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Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments.

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PPSE-01: ELECTRONICS

Course Outcomes:

After successful completion of the course on Electronics, a student will be able to:

- Understand the fabrication process for devices and ICs like crystal growth, Oxidation, pattern transfer, diffusion, etching, ion-implantation and epitaxial growth.
- Gain Knowledge of inter-connection, packaging and the processing of compound semiconductor.
- Obtain a fair understanding of the steps involved in the fabrication of electronic devices like BJT, MOSFET, FET, Schottky diodes IC diodes capacitors and resistors.
- Gain a fair understanding of the operation and application of decoders, multiplexers, encoders and flip-flops.
- Comprehend the operation and application of D/A and A/D Converters.
- Explain operation and important adders, shift resistor and Counters.

Unit – I

Bipolar Junction Transistor and Field Effect Transistor: Semiconductor: intrinsic and extrinsic semiconductor, charge densities in p and n type semiconductor, conduction by charge drift and diffusion, p-n junction and energy level diagram under forward and reverse bias conditions, Zener and Avalanche breakdown, PNP and NPN transistors, basic transistor action, gain, input and output characteristics of CB, CE and CC configurations and their applications.

Unit – II

Semiconductor Devices and Fabrication of ICs: Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion), Interface States and Their Effects, Construction of JFET, MOSFET, Idea of channel formation, pinch off and saturation voltage, current voltage output characteristics, Fabrication of ICs, monolithic Integrated Circuit Technology, planar process.

Unit – III

Operational Amplifier: Block Diagram of Op-Amp, Input offset voltage, Input bias current, Feedback, Slew Rate, Frequency Response, and Compensation, common mode rejection ratio, Inverting and non-inverting amplifiers, Linear application of op-amp: summing, difference, Integration, differentiator, Non-Linear application of op-amp: Comparator, Zero crossing detector, Schmitt trigger, Clipping and clamping circuits.

Unit – IV

Digital Circuits and Systems: Binary Adders, full adder, and half adder, serial and parallel adders, binary subtractor, Digital comparator, BCD to decimal Decoder, multiplexer,

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Demultiplexer, Flip-Flops: SR, JK, Master Slave, D Type, T Type, Shift register, Asynchronous counter, Up-Down counter, Divided by N counter.

References/Books:

1. Integrated Electronics by Jacob Millman and Christos C Halkias, Mcgraw Hill Higher Education, (1 January 2002)

2. Gayakwad: OP-AMPS and Linear Integrated Circuits, 4th Edition, Prentice Hall / Pearson.

3. Jacob Millman and Arvin Grabel: Microelectronics, McGraw Hill Education; 2nd edition (1 July 2017) 5.

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PPSE-02: VACUUM SCIENCE AND THIN FILM TECHNOLOGY

Course Outcomes:

After successful completion of the course on Vacuum Science and Thin Film Technology, a student will be able to:

- Understand the fundamentals of vacuum techniques.
- Demonstrate various vacuum pumps and leak detection.
- Get familiar about the concept and basics of thin films.
- Explain various methods of thin films deposition.

UNIT–I

Vacuum Fundamentals and Its Production: Kinetic theory of gases, Mean free path, Mass flow, Pumping speed, Importance of Vacuum, Design, Principles, Construction, Operational Characteristics and the uses of Rotary pump, Roots pump, Turbomolecular pump, Diffusion pumps, Cryogenic-pump, Sputter-ion pump.

UNIT-II

Vacuum Measurement and Detection: Importance of measurement of Pressure, Concept of different gauges: McLeod gauge, thermal conductivity gauges, spin rotor gauge, Ionization gauges, hot cathode, cold cathode gauges; Pirani, Penning and pressure control, Flow Meters and Residual Gas Analyzer, Leak Detection.

UNIT-III

Introduction and preparation of thin film: Environment for Thin Film Deposition, Evolution of Thin Film: Absorption (Physisorption), Surface Diffusion, Chemical Bond Formation (Chemisorption), Nucleation, Microstructure Formation, Deposition Parameters and their effects on Film Growth, Epitaxy–homo, hetero and coherent epilayers, lattice misfit and imperfections.

UNIT-IV

Thin Film Deposition Techniques: Thermal evaporation, Electron beam evaporation, DC and RF Sputtering Technique: Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Chemical Vapour Deposition (CVD), Pulsed Laser Deposition (PLD), Atomic layer deposition (ALD), Spin Coating, Spray pyrolysis, Molecular beam epitaxy.

References/Books:

1. Vacuum Science and Engineering, CM Van Atta, Tata McGraw Hill, New York.
2. Vacuum Technology, Andrew Guthrie, Wiley, New York.
3. Vacuum Technology – An introduction by LG Carpenter
4. Thin Film Phenomenon, K. L. Chopra, McGraw Hill, New York.

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5. Vacuum Physics and Techniques, T. A. Delchar, Chapman & Hall.

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PMDC-01: MODERN PHYSICS

Course Outcomes:

After successful completion of the course on Modern Physics, a student will be able to:

- Understand the quantum theory of light and wave-particle duality.
- Describe Heisenberg uncertainty principle and linear superposition principle.
- Solve the Schrödinger equation for simple systems and interpret wave functions in terms of probabilities and normalization.
- Distinguish between different types of radioactive decays.

Unit-I

Blackbody Radiation (observations and models), Planck's proposition and quantum theory of light, Photoelectric effect, Compton scattering, Pair Production, De Broglie Waves, Davisson-Germer experiment.

Unit-II

Wave description of particles by wave packets. Group and Phase velocities and the relation between them. Two-Slit experiment with electrons, Probability, Wave amplitude and wave functions, Rutherford Model, Hydrogen spectra and Bohr model of atom, Explanation of Hydrogen spectra.

Unit-III

Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

Unit-IV

Solution of Schrodinger equation for one-dimensional problems: One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

References/Books:

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, John R. Taylor, Chris D. Zafiratos, M. A. Dubson,2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, T. A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics Course, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.

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5. Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning.
Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

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PAEC-01: PROGRAMMING IN PYTHON

Course Outcomes:

At the end of this course, students will demonstrate the ability to

• Understand Python syntax and semantics and be fluent in the use of Python flow control and Functions

• Develop, run and manipulate Python programs using Core data structures like Lists, Dictionaries, and use of Strings Handling methods.

• Develop, run and manipulate Python programs using File Operations and searching pattern using regular expressions.

• Interpret the concepts of object-oriented programming using Python

• Determine the need for scraping websites and working with CSV, JSON and other file formats.

UNIT - I

Python Programming Introduction: Variables and assignment statements, data types,

Strings: Slicing, Built in functions (count, find, capitalize, title, lower, upper and swap case, replace, join, isspace (), isdigit(), split(), startswith(), endswith()).

Tuples: creating tuples, Tuple operations: length, concatenation, repetition, membership, maximum, minimum, tuple methods: count, index.

UNIT - II

Dictionary and Sets: creating, accessing values, adding, modifying and deleting items in dictionary, Dictionary methods: len, str, clear, copy, get, update, copy. Difference between list and dictionary, Sets.

Operators: Assignment, Unary, Binary, Arithmetic, Relational, Logical, Bitwise Operator and membership operator

UNIT - III

Control Structures: if-conditional statements, if else condition, if-elif-else condition, nested if-elif-else condition, Iteration (for Loop and while loop), Nested Loops, break and continue statement.

UNIT - IV

Conditional Expressions: Loops, Functions and recursions, File input/output, Object oriented programming, Conditional Expressions, Loops, Functions and recursions, File input/output, Object oriented programming,

References/ Books:

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1. Programming in Python 3: A Complete Introduction to the Python Language (2nd Edition), Mark Summerfield.

2. Python Programming: A Modular Approach by Taneja Sheetal, Kumar Naveen, Eleventh Impression, Pearson India Education Services Pvt. Ltd.

3. Programming Python, 4th Edition by Mark Lutz Released December 2010 Publisher(s): O'Reilly Media, Inc.

4. Python: The Complete Reference by Martin Brown.

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PPVAC-01: INDIAN SCIENCE HISTORY

Course Outcomes:

After successful completion of the course on Indian Science History, a student will be able to:

- Understand the life, work, and scientific achievements of prominent Indian scientists across different eras.
- Analyze the historical development of key scientific institutions and technologies in India.
- Understand the interdisciplinary contributions of Indian scholars in fields such as physics, chemistry, mathematics, and space research.
- Understand the socio-political challenges faced by Indian scientists and their influence on national development.

Unit-I

Bibliography of Indian scientists in the field of Science, Work and life of CV Raman and Bhabha.

Unit-II

History of Indian rocket technology, Indian Missile Man, History of Bose-Einstein Condensation, Evolution of Nuclear power in India, ISRO contributions.

Unit-III

Contribution of mathematician Aryabhatta, Contribution made by the Chemists of Ancient India like Nagarjuna and Kanada.

Unit-IV

Shanti Swaroop Bhatnagar - "Father of Research Laboratories" in India, contribution to industrial research and role in establishments of CSIR.

References/Books:

1. Science India, Scientific Magazines by Vijnana Bharati. For details visit: https://scienceindiamag.in.

2. Knowledge Traditions and Practices of India (a text book) 2012, Kapil Kapoor, Michel Danino.

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SEMESTER-II

Course Title	Course Code	L	T	P	L	T	P	Total Credits	MARKS				
		(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)													
Quantum Mechanics	PPSC-03	4	0	0	4	0	0	4	30	70	0	0	100
Nuclear and Particle Physics	PPSC-04	4	0	0	4	0	0	4	30	70	0	0	100
Physics Lab-II	PPLAB-02	0	0	12	0	0	6	6	0	0	45	105	150
Discipline Specific Elective Course(s): Students have to choose Any One													
i) Solid State Physics	PPSE-03	4	0	0	4	0	0	4	30	70	0	0	100
ii) Plasma Physics	PPSE-04	4	0	0	4	0	0	4	30	70	0	0	100
Multidisciplinary Course(s)													
Spectroscopic Techniques	PMDC-02	2	0	0	2	0	0	2	15	35	0	0	50
Ability Enhancement Course(s)													
Electronics Devices	PAEC-02	2	0	0	2	0	0	2	15	35	0	0	50
Value-added Course(s)													
Physics of Nanomaterials	PPVAC-02	2	0	0	2	0	0	2	15	35	0	0	50

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PPSC-03: QUANTUM MECHANICS

Course Outcomes:

After successful completion of the course on Quantum Mechanics-I, a student will be able to:

- Realize basic quantum mechanical view point, learn its wave mechanical matrix formulations, and solve the Schrödinger equation for simple potentials, including harmonic and central potentials.

- Construct matrices for observables and wave functions in different representations, apply matrix theory to linear harmonic oscillator, and describe the time development of a quantum system in Schrödinger, Heisenberg and Interaction pictures.

- Calculate the eigenvalues and eigenfunctions for the orbital and general angular momenta, learn the matrix representation of angular momentum, and perform addition of two angular momenta.

- Grasp the concepts of identity & indistinguishability, understand symmetric and anti-symmetric wave functions, construct spin and total wave functions for a system of two spin ½ particles, and comprehend connection among spin, symmetry statistics.

Unit – I

Schrodinger formulation of Quantum Mechanics: Expectation values, Ehrenfest theorem; Dynamical variables as Hermitian operators, Eigenvalues and Eigenfunctions, Orthonormality of eigenfunctions, Reality of eigenvalues, Closure property, Co-ordinate and momentum representations of wave function, Uncertainty principle for two arbitrary observables, Time independent Schrodinger equation, Infinite and finite square well, Harmonic oscillator problem (analytical solution), Free particle solution, Wave Packet.

Unit – II

Matrix Formulation: Hermitian and unitary matrices; Transformation and diagonalization of matrices, Matrices of infinite rank; Representation of observables and wave functions as matrices, Transformation theory, choice of basis, change of basis, unitary transformations, Hilbert space representation; Dirac's ket and bra notation; Time-development of quantum system.

Unit – III

Quantum theory of Angular Momentum: Schrodinger equation in 3-d, Radial and Angular equations, The Hydrogen atom (reduced mass, radial wave functions and energy eigenvalues), Orbital angular momentum operator L, Commutation relations, Orbital angular momentum and spatial rotations, Eigenvalues and eigenfunctions of L^2 and L_z, Spherical harmonics; General angular momentum J: Eigenvalues and eigenfunctions of J^2 and J_z, Matrix representation of angular momentum operators, Spin angular momentum, Wave function including spin (Spinor); Spin one-half: Spin eigenfunctions, Pauli spin matrices; Addition of two angular momenta, Clebsch-Gordan coefficients and their calculations.

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Unit – IV

Approximation methods and identical particles: Time-independent perturbation theory and applications. Variational method. Identical particles, Pauli exclusion principle, spin-statistics connection. Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation.

References/Books:

1. Quantum Mechanics (3rd edition) by L. I. Schiff.
2. Quantum Mechanics (3rd edition) by D. J Griffith.
3. Quantum Mechanics (3rd edition) by E. Merzbacher.
4. Quantum Mechanics by John L. Powell and B. Crasemann.
5. Quantum Mechanics by A. K. Ghatak and S. Loknathan.
6. Introductory Quantum Mechanics (4rd edition) by Richard L. Liboff.
7. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili.
8. A textbook of quantum mechanics, P. M. Mathew; K. Venkatesan.
9. Principles of quantum mechanics, by Shankar, Ramamurti.

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PPSC-04: NUCLEAR AND PARTICLE PHYSICS

Course Outcomes:

After successful completion of the course on Nuclear and Particle Physics, a student will be able to:

- Learn and explain stability of nuclei based on binding energy curve, liquid drop model, magic numbers, shell model.
- Classify and explain types of nuclear decays: alpha decay, beta decay, gamma decay.
- Define and calculate Q value of nuclear reactions.
- Grasp knowledge about quarks and its flavours, and colour quantum number.

UNIT-I

Nuclear Models: Survey of basic nuclear properties, Binding energy curve, Liquid drop model, Semi-classical mass formula, Mass parabola and valley of stability, Magic numbers, Shell model, Spin-orbit coupling, Angular momenta and parity of nuclear ground states, Magnetic moments and Schmidt lines, Nuclear Quadrupole moments, Quadrupole moments of deformed nuclei.

UNIT-II

Nuclear Decays: Beta decay, Fermi theory of beta decay, Angular momentum and parity selection rules, Shape of the beta spectrum, Total decay rate, Comparative half-life, Classification of beta transitions, Selection rules for allowed and forbidden transitions, Detection and properties of neutrino, Gamma decay: Electric and magnetic multipole gamma transitions, Angular momentum and parity selection rules, Alpha decay: Giger-Nuttan law and tunnelling theory, Selection rules for alpha decay.

UNIT-III

Nuclear Interaction: Two Nucleon Problem: Deuteron system, Exchange forces, Yukawa theory of nuclear forces, Nucleon-nucleon scattering, Effective range theory, Spin dependence and charge independence of nuclear forces.

Nuclear Reaction: Kinematics of nuclear reactions in lab and Centre of mass reference frames, Q value calculation, Concept of Cross section, Type of nuclear reactions, Direct and compound nuclear reactions, Inelastic scattering and transfer reactions, Complete and incomplete fusion, Fission: Spontaneous fission mass distributions and elementary model.

UNIT-IV

Classification of particles - fermions and bosons, particles and antiparticles; Basic idea of different fundamental types of interactions with suitable examples; Lepton Classification, Strange particles, Quarks as constituents of Hadrons, Quark model, Gell-Mann Nishijima formula, Charge conjugation, Charge, parity and Time reversal invariance, CPT theorem, Parity non-conservation in β-decay, CP violation.

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References/Books:

1. Physics of Atomic Nuclei, Vladimir Zelevinsky, Wiley-VCH, 2017

2. The Atomic Nucleus, J.M. Reid, Penguin Books, 1972

3. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988

4. R.R. Roy and B.P. Nigam, Nuclear Physics, Wiley-Eastern Ltd., 1983

5. Nuclear Physics, S. B. Patel, New Age publication

6. Basic Ideas and Concepts in Nuclear Physics: K. Heyde, (Overseas Press India) (2005).

7. Nuclear Physics: Experimental and Theoretical: H. S. Hans, (New Academic Science Ltd., Second.

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PPLAB-02: PHYSICS LAB-II

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

- Verify the existence of different harmonics using CRO.
- Determine resistivity of semiconductors using four probe method.
- Study about optical fiber.
- Fourier analysis of complex signals.
- Demonstrate energy quantization using Franck-Hertz Experiment.
- Study the characteristics of Opto-Electronic Device.
- Determine the charge to mass ratio of an electron by using Magnetron and dielectric constant of dielectric material.
- Determine the value of Planck's constant using photocell/LED.
- Study of Hall Effect.

Students assigned the electronic/ general physics laboratory work will perform at least 8 experiments of the following sections:

1. Demonstration of energy quantization using the Franck-Hertz Experiment.
2. To determine the wavelength of laser light using Michelson interferometer experiment.
3. Measurement of resistivity of a semiconductor by four probe method at different temperatures.
4. Measurement of Magneto-resistance of Semiconductors.
5. To determine the value of Planck's constant using photocell/LED.
6. To determine the e/m ratio of an electron using Magnetron.
7. To measure the numerical aperture (NA) of optical fiber.
8. To study Hall Effect and to determine Hall coefficient.
9. Fourier analysis of complex signals.
10. To verify the existence of different harmonics and measure their relative amplitudes in a complex wave using CRO (square, clipped sine wave, triangular wave, etc.).
11. To determine the ionization potential of mercury.
12. Study of Characteristics of Opto-Electronic Device.
13. To determine the half-life of Indium.

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14. Statistics using G. M. Counter.

15. Thickness of Al Sheet using G. M. Counter.

16. Signal to noise ratio using Scintillation detector.

Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments.

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PPSE-03: SOLID STATE PHYSICS

Course Outcomes:

After successful completion of the course on Solid State Physics, a student will be able to:

• Grasp and apply concepts like Bravais lattice, unit cells (primitive, conventional, Wigner-Seitz), and crystal structures with bases and determine crystal structures using X-ray diffraction techniques, including the reciprocal lattice, Brillouin zones, and structure factor.

• Calculate the dispersion relation of lattice waves and grasp the knowledge of phonons and utilizing it to determine the lattice heat capacity.

• Explain band theory of solids including Bloch's theorem and solution of wave equation for an electron in a periodic potential; to differentiate between metals, semiconductor and insulator; to calculate energy bands using tight binding.

• Understand the fundamental properties of superconductors, including qualitative insights into the BCS theory; to describe flux quantization in a superconducting ring along with the DC & AC Josephson effects.

Unit – I

Crystal Structure: Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, Conventional and Wigner-Seitz unit cells; Crystal structures and lattices with bases; Symmetry operations and fundamental types of lattices; Index system for crystal planes. Determination of crystal structure by X-ray diffraction: Reciprocal lattice and Brillouin zones (examples of sc, bcc and fcc lattices); Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence; Ewald construction; Brillouin interpretation; Crystal and atomic structure factors; Structure factor of the bcc and fcc lattices; Experimental methods of structure analysis: Types of probe beam, The Laue, rotating crystal and powder methods.

Unit – II

Lattice dynamics and thermal properties: Classical theory of lattice vibration (in harmonic approximation): Vibrations of crystals with monatomic basis-Dispersion relation, First Brillouin zone, Group velocity; Two atoms per primitive basis-dispersion of acoustical and optical modes. Quantization of lattice waves: Phonons, Phonon momentum, Inelastic scattering of neutrons by phonons. Thermal properties: Lattice (phonon) heat capacity; Normal modes; Density of states in one and three dimensions; Models of Debye and Einstein, Debye T3 law; Effects due to anharmonic crystal interactions; Thermal expansion; Thermal conductivity.

Unit – III

Electronic properties of solids: Sommerfeld's free electron gas model, Density of states, Fermi sphere, Fermi and ground-state energy; Difficulties with the free electron gas model; Band theory of solids: Nearly free electron model, Origin and magnitude of the energy gap; Periodic potential and Bloch's theorem; Kronig-Penney model; Wave equation of electron in a periodic potential, Central equation, Crystal momentum of electron, Solution of the central equation,

D. Divyanshu Bhatnagar Dr. Avesh Kumar Dr. Farhat Singh Asstt. Registrar Acad.I Mr. Vishnu Kumar momentum of electron, Solution of the central equation, Approximate solution at and near a zone boundary; Periodic, extended and reduced zone schemes of energy band representation; Number of orbitals in a band; Classification into metals, semiconductors and insulators. Calculation of energy bands: Tight binding method and its application to sc, bcc and fcc structures.

Unit – IV

Superconductivity: Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Isotope effect; Theoretical survey: Thermodynamics of the superconducting transition, London equation, London penetration depth, Coherence length; Microscopic theory: Qualitative features of the BCS theory, BCS ground state wave function; Quantitative predictions of the BCS theory, critical temperature, energy gap, critical field, specific heat; Flux quantization in a superconducting ring, duration of persistent currents; Dc and Ac Josephson effects; High Tc superconductors (introduction only).

References/Books:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel.

2. Solid State Physics by Neil W. Ashcroft and N. David Mermin.

3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth.

4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman.

5. Applied Solid State Physics by Rajnikant.

6. Condensed matter physics by Michael P. Marder,1960.

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PPSE-04: PLASMA PHYSICS

Course Outcomes:

After successful completion of the course on Plasma Physics, a student will be able to:

• Grasp knowledge about plasma and its properties, and motion of charge particles in electromagnetic field.

• Explain electron and ions wave, and calculate their dispersion relations.

• Interpret damping of plasma waves through different interactions in the medium.

• Learn and understand the techniques of plasma production and its confinement.

Unit – I

Introduction to Plasmas and Particle Dynamics: Definition and general properties of plasma, plasma oscillations, Debye shielding and criteria for plasma, Motion of charged particles in electromagnetic field and non-uniform magnetostatic field, electric field drift, gradient B drift, parallel acceleration and magnetic mirror effect, curvature drift, adiabatic invariants.

Unit – II

Waves and Transport Processes in Plasmas: Fluid description of plasmas, continuity and momentum balance equations of fluid mechanics, electron plasma waves, ion acoustic waves, electromagnetic waves in plasma, magneto-sonic and Alfven waves and their dispersion relations and properties, stability of plasmas, ambipolar diffusion, hydromagnetic equilibrium, diffusion of magnetic lines and frozen-in fields, concept of magnetic pressure, plasma confinement schemes.

Unit – III

Nonlinear Effects and Controlled Fusion: Vlasov equation, landau damping, physical mechanism of landau damping, plasma sheath, Bohm sheath criterion, Bohm velocity, presheath region, pondermotive force and applications as self-focusing, wave-wave interaction, $\omega - k$ matching conditions for the decay of an electron plasma wave, stimulated Raman scattering and stimulated Brillouin scattering, nuclear fusion.

Unit – IV

Plasma Production: Townsend's theory of gas discharge, Paschen's law, Low-pressure cold cathode discharge, Radio-frequency discharge, Plasma diagnostic techniques: Resistivity of plasma Langmuir single probe method, Langmuir double probe method, microwave method of plasma density determination, Plasma Heating, Confinement of plasma, magnetic mirror, stellarator, Tokamak and inertial confinement.

References/Books:

1. Introduction to plasma physics and controlled fusion Chen, Francis F, Springer, 3rd edition, 2016.

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2. The physics of fluids and plasmas: an introduction for astrophysicists. Choudhuri, Arnab Rai. Cambridge University Press, 2015.

3. Principles of Plasma Discharges and Materials Processing, Lieberman and Lichtenberg, Wiley-Inter-science; 2ndedition, 2008.

4. Introduction to dusty plasma physics. Shukla P. K. and Mamun A. A., CRC Press; 2001.

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PMDC-02: SPECTROSCOPIC TECHNIQUES

Course Outcomes:

After successful completion of the course on Spectroscopic Techniques, a student will be able to:

• Understand the fundamental principles and classifications of various spectroscopic techniques.

• Explain the working mechanisms and applications of optical and thermal characterization techniques.

• Analyze the interaction of electron beams with solids and the resulting imaging techniques.

• Apply electron and probe microscopy tools for advanced material analysis and problem-solving in research..

Unit-I

Optical Characterization Techniques: UV-Visible spectroscopy, Infrared spectroscopy, Atomic absorption spectroscopy (AAS), Raman spectroscopy,

Unit-II

Thermal Characterization Techniques: Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC).

Unit-III

Electron Microscopy: Interaction of electrons with solids, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM).

Unit-IV

Probe Microscopy: Scanning Probe Microscope (SPM): Atomic force microscopy (AFM), scanning tunneling microscopy (STM).

References/Books:

1. Fundamentals of molecular spectroscopy, Colin N. Banwell & Elaine M. McCash, Tata McGraw –Hill publishing company limited.

2. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.

3. Introduction to Molecular Spectroscopy by Gordon M Barrow, McGraw-Hill Inc. US.

4. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee, Volumes 49 – 51 (2009).

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PAEC-02: ELECTRONIC DEVICES

Course Objectives:

After successful completion of the course on Electronics, a student will be able to:

- Understand the principles and applications of microwave semiconductor devices.
- Analyze the working of tunnel, Gunn, and avalanche transit-time devices.
- Explain the operation of photonic devices including LEDs, lasers, and display technologies.
- Evaluate different types of photodetectors and solar cells for optoelectronic applications.

Unit – I

Microwave Devices: Overview of microwave frequency range and applications, Basic working principles of microwave semiconductor devices, Introduction to negative resistance and transit-time effects.

Unit – II

Transfer electron devices: Tunnel and Gunn diode, Avalanche Transit time devices (Read, IMPATT diodes, parametric devices).

Unit – III

Photonic Devices: Radiative transition and optical absorption, LED, OLED and LCD; semiconductor lasers, heterostructure and quantum well devices.

Unit – IV

Photodetector, Schottky barrier and p-i-n photodiode, avalanche photodiode, photomultiplier tubes, Solar cells.

References/Books:

1. Physics of Semiconductor Devices, S. M. Sze and K. K. Ng (3rd Ed., Wiley, 2008)
2. Semiconductor devices Physics and Technology, S. M. Sze (2nd Ed., Wiley, 2008)
3. Microwave Devices and Circuits, S. Y. Liao (3rd Ed., Pearson, 2003)
4. Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D.Helfrick (2nd Ed., Phi Learning, 2008)

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PPVAC: PHYSICS OF NANO-MATERIALS

Course Outcomes:

After successful completion of the course on Physics of Nano-Materials, a student will be able to:

- Understand the quantum confinement effect and analyze its consequences through simple models.
- Describe different types of fabrication techniques of nanomaterials like PVD and CVD.
- Demonstrate the physics behind various characterization techniques.

UNIT-I

Nanoscale Systems: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Density of states (1-D,2-D,3-D), Band structure of materials at the nanoscale, Size Effects in nano-systems,

UNIT-II

Quantum confinement and its consequences on optical, electrical and magnetic properties, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

UNIT-III

Overview and Synthesis of Nanomaterials: Metals, Metal Oxides, Carbon-based nanomaterials CNT, C60, graphene, Top-down and bottom-up approach, Ball milling, Co-precipitation, Sol-gel and Hydrothermal synthesis, Annealing and sintering process.

UNIT-IV

Vacuum deposition, Thermal evaporation, Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Photolithography.

References/Books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

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