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ನಗರ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

BENGALURU
CITY UNIVERSITY

Office of the Registrar, Central College Campus, Dr. B.R. Ambedkar Veedhi, Bengaluru – 560 001.
PhNo.080-22131385, E-mail: registrarbcu@gmail.com

No.BCU/BoS/Syllabus-PG/Science/ 991 /2025-26 Date: 23.09.2025

NOTIFICATION

Sub: Syllabus for the Post Graduate Courses in the Faculty of Science–reg

Ref: 1. Recommendations of the Boards of Studies in the Faculty of Science
2. Academic Council resolution No.04 dated.22.09.2025
3. Orders of Vice-Chancellor dated. 23.09.2025

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The Academic Council in its meeting held on 22.09.2025 has approved the syllabus prepared by different Board of Studies for the Post Graduate Courses in the Faculty of Science. Accordingly, the following CBCS Syllabus for the Semester PG Courses of Science Faculty are hereby notified for implementation effective from the academic year 2025-26.

Sl. No.	Programmes
1.	M.Sc. Chemistry – I & II Semester
2.	M.Sc. Biochemistry – I to IV Semester
3.	M.Sc. Physics – I & II Semester
4.	M.Sc. Mathematics – I to IV Semester
5.	M.Sc. Psychology– I to IV Semester
6.	M.Sc. Counselling Psychology – I to IV Semester
7.	M.Sc. Fashion & Apparel Design – I to IV Semester
8.	M.Sc. Zoology – I & II Semester
9.	M.Sc. Botany – I to IV Semester
10.	M.Sc. Computer Science – I & II Semester
11.	M.Sc. Speech Language Pathology – I to IV Semester
12.	Master of Computer Applications – I & II Semester

The detailed Syllabi for above subjects are notified in the University Website: www.bcu.ac.in for information of the concerned.

REGISTRAR

Copy to;

1. The Registrar(Evaluation), Bengaluru City University
2. The Dean, Faculty of Science, BCU.
3. The Principals of the concerned affiliated Colleges of BCU- through email.
4. The P.S. to Vice-Chancellor/Registrar/Registrar (Evaluation), BCU.
5. Office copy / Guard file / University Website: www.bcu.ac.in

BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

Syllabus for I & II Semesters
M.Sc. Physics 2025-26

BENGALURU CITY UNIVERSITY
CENTRAL COLLEGE CAMPUS
BENGALURU

Board of Studies in Physics (PG) Members

Dr. B. Eraiah , Professor, Department of Physics, Bangalore University, Bengaluru-56	Chairman
Dr. H Nagabhushan, Professor, Department of Physics, Tumkur University, Tumakuru	Member
Dr, Krishnaveni, Professor, PG Department of Physics, University of Mysore, Mysuru	Member
Dr. M.N.Kalasad, Professor, Department of Physics, Davangere University, Davangere	Member
Dr. C.G.Renuka, Department of Physics, Bangalore University, Bengaluru-56	Member
Dr. Basavaraj Angadi, Department of Physics, Bangalore University, Bengaluru-56	Member
Dr. Kamsali Nagaraj, Department of Physics, Bangalore University, Bengaluru-56	Member

Course Details:
I Semester : 4Theory+ 1Theory (softcore) + 4Labs = 26 credits

Paper code	**Paper Title**	Contact hours	**Exam Max. marks**	**Internal Assessment marks**	**Total**	**Credits**
P101	Classical Mechanics	4	70	30	100	4
P102	Electronics and circuit device	4	70	30	100	4
P103	Quantum Mechanics- I	4	70	30	100	4
P104	Mathematical Methods of Physics- I	4	70	30	100	4
P105	Renewable energy sources	3	70	30	100	2
P106	General Physics Lab-1	4	35	15	50	2
P106	Optics Lab-1	4	35	15	50	2
P107	Electronics Lab-I	4	35	15	50	2
P108	Electronics Lab-1I	4	35	15	50	2
				Total marks	**700**	**26**

II Semester : 4Theory+ 1Theory (softcore) + 4Labs = 26 credits

Paper code	**Paper Title**	Contact hours	**Exam Max. marks**	**Internal Assessment marks**	**Total**	**Credits**
P201	Statistical Mechanics	4	70	30	100	4
P202	Electrodynamics	4	70	30	100	4
P203	Quantum Mechanics- II	4	70	30	100	4
P204	Atomic and Molecular Physics	4	70	30	100	4
P205	Experimental Techniques in Physics	3	70	30	100	2
P206	General Physics Lab-2	4	35	15	50	2
P207	Optics Lab -2	4	35	15	50	2
P208	Computer Lab-1	4	35	15	50	2
P209	Computer Lab-2	4	35	15	50	2
				Total marks	**700**	**26**

M.Sc. I Semester

P 101: Classical Mechanics

Unit-I

System of particles: Center of mass, total angular momentum and total kinetic energies of a system of particles, conservation of linear momentum, energy and angular momentum

Lagrangian Formulation: Constraints and their classification, degrees of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle, Lagrange's equations of motion of the second kind, uniqueness of the Lagrangian, Simple applications of the Lagrangian formulation: 1) Single free particle in a) Cartesian and b) plane polar coordinates; 2) Atwood's machine; 3) bead sliding on a uniformly rotating wire in a force free space; 4) Motion of block attached to a spring; 5) Simple pendulum

Symmetries of space time: Cyclic coordinate, Conservation of linear momentum, angular momentum and energy. (14 Hours)

Unit- II

Central forces: Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of orbits, conditions for closed orbits, the Kepler problem (inverse square law force).

Scattering in a central force field: general description of scattering, cross-section, impact parameter, Rutherford scattering, center of mass and laboratory coordinate systems, transformations of the scattering angle and cross-sections between them

Motion in non-central reference frames: Motion of a particle in a general non-inertial frame of reference, notion of pseudo forces, equations of motion in a rotating frame of reference, Coriolis force, deviation due east of a falling body, the Foucault pendulum. (14 Hours)

Unit -III

Rigid body dynamics: Degrees of freedom of a free rigid body, angular momentum and kinetic energy of a rigid body, moment of inertia tensor, principal moments of inertia, classification of rigid bodies as spherical, symmetric and asymmetric, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body, notions of spin, precession and nutation of a rigid body.

Small oscillations: Types of equilibria, quadratic forms for kinetic and potential energies of a system in equilibrium, Lagrange's equations of motion, normal modes and normal frequencies, examples of (i) longitudinal vibrations of two coupled harmonic oscillators, (ii) Normal modes and normal frequencies of a linear, symmetric, triatomic molecule, (iii) oscillations of two linearly coupled plane pendula. (14 Hours)

Unit- IV

Hamiltonian formulation: Generalized momenta, canonical coordinates, Legendre transformation and the Hamilton's equations of motion.

Examples of a) the Hamiltonian of a particle in a central force field, b) the simple harmonic oscillator,(c) charged particle moving in an external electromagnetic field. Derivation of Hamilton's equations from variational principle.

Canonical transformation: Generating functions (four basic types), examples of canonical transformations: harmonic oscillator in one dimension. Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets (anti-symmetry, linearity and Jacobi identity), Poisson brackets of angular momentum. The Hamilton-Jacobi equation, harmonic oscillator using Hamilton-Jacobi method

(14 Hours)

References

1. Classical mechanics, H. Goldstein, C. Poole, J. Safco, III Edition, Pearson Education Inc. 2002.
2. Classical mechanics, K. N. Srinivasa Rao, University Press, 2003.
3. Classical mechanics, N. C. Rana and P. S. Joag, Tata McGraw-Hill, 1991.
4. Classical dynamics of particles and systems, J. B. Marian, Academic Press, 1970.
5. Introduction to classical mechanics, Takwale and Puranik, Tata McGraw-Hill, 1983.
6. Classical mechanics, L. D. Landau and E. M. Lifshitz, 4th edition, Pergamon Press, 1985.
7. Classical Mechanics, B A Kagali and T. ShivalingaSwamy, Himalaya Publishing House, 2018
8. Classical Mechanics, John R Taylor, University Science Books, 2005.

P102: Electronic Devices and Circuits

Unit-I

Semiconductor Physics

Physics of junctions: The contact potential; Equilibrium Fermi Levels; Space charge of a junction; Qualitative description of current flow at a Junction; Diode equation (No derivation) – Behaviour under forward and Reverse bias. Metal semiconductor junctions – Schottky barriers, Rectifying contacts, Ohmic contacts; Field Effect Transistors - Transistor operation, The Junction FET, Pinch off saturation, Gate control, Current Voltage characteristics; MOSFET – Basic operation and structure, Depletion and Enhancement mode MOSFET: Principle and working, calculation of threshold voltage; V-I characteristics. (14 Hours)

Unit-II

Operational amplifiers

Transistor based Difference amplifier – dual input and balanced output ac and dc analysis; The operational amplifier – The block diagram; The ideal op-amp; Equivalent circuit of an op amp; Open loop op-amp configurations – Differential, Inverting and Non-Inverting amplifiers; - Limitations of open loop configuration; Operational amplifier as a feedback amplifier, op-amp with negative feedback, closed loop gain, input impedance, output impedance and band width of inverting and non-inverting amplifiers - Voltage follower; Differential amplifier – closed loop gain, input impedance, output impedance. (14 Hours)

Unit -III

Applications of op-amps

Linear applications – Phase and frequency response of low pass, high pass and band pass filters (first order): Inverting and non-inverting configurations; summing amplifier – inverting and non-inverting configurations, subtractor, difference amplifier, ideal and practical differentiator, integrator, peaking amplifier.

Non – linear applications: comparators, positive and negative clippers, positive and negative clampers, small signal half wave rectifiers. (14 Hours)

Unit-IV

Digital Electronics

Digital circuits –Boolean laws and theorems; Sum of products method; Truth table to Karnaugh Map; Simplification using Karnaugh Map technique (4 and 6 variables); Karnaugh simplifications; Product of sums simplification; Flip flops: Latch using NAND and NOR gates- RS flip flop, clocked RS flip flop, JK flip flop, JK slave flip flop - racing –Shift Registers basics - Counters: Ripple/asynchronous counters truth table diagram, Synchronous counters-truth table-timing diagram, Decade counter. (14 Hours)

References

1. Solid State Electronic Devices, Ben G Streetman, Sanjay Bannerjee, 7th Edition, 2015, Pearson Education, Asia.
2. Op-Amps and Linear Integrated Circuits, Ramakant A Gayakwad, Fourth Edition, 2004, Eastern Economy Edition.
3. Linear Integrated Circuits, D Roy Choudhury and Shail Jain, 4th Edition 1991, New Age International Limited.
4. Digital Principles and Applications, Donald P Leach and Albert Paul Malvino, 5th Edition, 2002, Tata McGraw Hill.
5. The art of electronics, Paul Horowitz and Winfield Hill, Second Edition, 1992, Foundation Books, New Delhi.
6. Electronic Principles, AP Malvino, Sixth Edition, 1999, Tata McGraw Hill, Delhi.
7. Operational Amplifiers with Linear Integrated Circuits, William Stanley, 1988, CBS Publishers and Distributors.
8. Digital systems, Principles and applications, Ronald J Tocci and Neal S Widmer, Eighth Edition, 2001, Pearson Education.
9. Semiconductor Devices Physics and Technology, S M Sze, Second Edition, 2002, John Wiley and Sons Inc. Asia.

P103: Quantum Mechanics-I

Unit-I

Introductory concepts: Electron diffraction - Wave-particle duality, interpretation of the wave function, wave function for particles having a definite momentum, Schrodinger equation, Gaussian wave Packet, Fourier transform and momentum space wave function, Heisenberg uncertainty principle for position and momentum, conservation of probability, operators and expectation values, Ehrenfest theorem, time-independent Schrodinger equation, stationary states and their properties, energy quantization, properties of energy Eigen functions, general solution of the time dependent Schrodinger equation for a time independent potential. (14 Hours)

Unit-II

One-dimensional problems: Free-particle, box normalization, Eigen values and Eigen functions of particle in a) infinitely deep potential b) finite square well potential, and c) simple harmonic oscillator potential, potential barrier - transmission and reflection coefficients, Delta-function potential. Extension to three dimensional problems: Separation of the Schrodinger equation in Cartesian coordinates, particle in a three dimensional box

(14 Hours)

Unit-III

Formalism: Hilbert space, linear operators,eigenvalues and eigenfunctions of Hermitian operators, degeneracy, expansions in eigenfunctions, observables, Dirac notation, commutation of operators and compatibility, generalized uncertainty principle, simple harmonic oscillator by operator method.

Schrodinger equation for a two body system

Unitary transformations, matrix representation of wave functions and operators, time evolution of a system, evolution operator, time variation of expectation values,the virial theorem, Schrodinger and Heisenbergpictures, Heisenberg equation of motion (14 Hours)

Unit-IV

Angular momentum: Orbital angular momentum commutation relations, orbital angular momentum operators in spherical polar coordinates, eigenvalues and eigenfunctions of L^2 and L_z

Central potential, separation of the Schrodinger equation in spherical polar coordinates, particle on a sphere and rigid rotator, the radial equation, the Hydrogen atom

General operator algebra of angular momentum operators J_x, J_y, J_z. Ladder operators, eigen values and eigenkets of J^2 and J_z, matrix representations of angular momentum operators, Spin angular momentum, spin one half, Pauli matrices, addition of angular momentum, Clebsch-Gordan coefficients in simple cases ($j_1 = j_2=1/2$)

(14 Hours)

References

1. Introduction to Quantum Mechanics – David J. Griffiths, Second Edition, Pearson Prentice Hall 2005.
2. Quantum Mechanics – B.H. Bransden and C.J. Joachain, Second Edition, Pearson Education, 2007.
3. Quantum Mechanics – V.K. Thankappan, Second Edition, Wiley Eastern Limited, 1993.
4. Quantum Mechanics Vol I & II – C. Cohen-Tannoudji, B. Diu and F. Laloe, Second Edition, Wiley Interscience Publication, 1977.
5. Quantum Mechanics- L.I. Schiff, Third Edition, Mc Graw Hill Book Company, 1955.
6. Modern Quantum Mechanics – J.J. Sakurai, Revised Edition, Addison-Wesley, 1995.
7. Principles of Quantum Mechanics - R. Shankar, Second Edition, Springer, 1994.
8. Quantum Mechanics – E. Merzbacher, John Wiley and Sons, 1998.
9. Quantum Physics – S. Gasiorowicz, John Wiley and Sons.
10. Introductory Quantum Mechanics – Richard L Liboff, 4th Edition, Pearson Education, 2007.

P104: Mathematical Methods of Physics and C- Programming (General)

Unit-I

Vector analysis and curvilinear co-ordinates: Vector Integration - Line, surface and volume integrals; Statement of Gauss' and Stokes' theorems, Curvilinear coordinates, tangent and normal vectors, contravariant and covariant components, line element and the metric tensor, Gradient, Curl, divergence and Laplacian in spherical polar and cylindrical polar co-ordinates

Tensors: Definition of tensors, contravariant and covariant components of tensors, raising and lowering of tensor indices, sum, outer, inner products and contraction of tensors, Quotient law, symmetric, antisymmetric tensors. (14 Hours)

Unit-II

Ordinary differential equations and Special Functions: Series solutions of differential equations - Legendre's equation; Legendre polynomials, Rodrigues' formula, Generating function for Legendre polynomials, Orthogonality of Legendre polynomials, normalization of the Legendre polynomials, Associated Legendre differential equation, series solution method, Associated Legendre polynomials, Hermite differential equation – Series solution, Hermite polynomials, Rodrigues' formula, Generating function for Hermite polynomials, Orthogonality of Hermite polynomials, Normalization of Hermite polynomials, Recurrence relations.

(14 Hours)

Unit III

Ordinary differential equations and Special Functions (Contd..): Laguerre differential equations – Series solution, Laguerre polynomials, Recurrence relations. Bessel's equation, Series solution, Bessel functions of first and second kind, Orthogonality of Bessel functions, Recurrence relations

Partial differential equations solvable by method of separation of variables – Laplace's, Poisson's and Helmoltz differential equation by separation of variable method and the resulting ordinary differential equations - In Cartesian, cylindrical and spherical coordinates. Spherical harmonics (14 Hours)

Unit IV

C programming: Compiler and interpreter, constants and variables, arithmetic expressions, data types, input and output statements, control statements, switch statements, loop statements, format specifications, arrays, algorithms, flowcharts, functions, simple C programs like i) area of a triangle ii) to check the entered letter is an vowel or consonant using switch iii) computing the sum and average of ten numbers using one dimensional arrays iv) to calculate Fibonacci series using while loop v) sorting numbers in ascending and descending order vi) computing the factorial of a number using for loop vii) addition of two matrices using arrays. (14 Hours)

References

1. Mathematical Methods of Physics, J Mathews and RL Walker, 2ndEdition, Addison-Wesley, 1971.
2. Mathematical Methods for Physicists, GB Arfken and H Weber, 7thEdition, Academic Press, 2012
3. Complex variables, MR Spiegel, Schaum Series, Metric edition, 1981, McGraw Hill.
4. Theory of functions - Part I, K Knopp, Dover Publications New York, 1947.
5. Vector Analysis – an introduction to tensor analysis, Murray R Spiegel, Schaum outlines Series.
6. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series, 4th Edition, 2009.
7. Matrices and Tensors in Physics - AW Joshi, Wiley Eastern Ltd, 3rd edition, 1995.
8. Vector Analysis - MR Spiegel, Schaum Series, Indian Edition, 17th reprint, 2015.
9. Mathematical Methods in the Physical Sciences, Mary L Boas, 3rdEdition, Wiley, New York, 2006.
10. Mathematical Physics with Applications, Problems and Solution, V Balakrishnan, Ane Books, 2017.
11. Programming in ANSI – C, E Balaguruswamy, 2ndEdition, Tata McGraw Hill, 1992
12. Lecture notes at http://www.cplusplus.com/doc/tutorial/
13. Computational Physics Course at http://www.phys.unsw.edu.au/~mcba/phys2020/#numint
14. Introduction to vectors, axial vectors, tensors and spinors, G Ramachandran, MS Vidya and Venkataraya, VijayalakshmiPrakashana, Mysuru, 2017.
15. Let us C, YashavantKanetkar, Infinity Science Press, 2002.

P105: Renewable Energy Sources

(Soft core)

Solar Energy: Solar constant, spectral distribution of extraterrestrial radiation, Terrestrial Solar radiation geometry, empirical equation for estimating solar radiation, Instruments for measuring solar radiation- Pyranometer, sun shine recorder, solar thermal energy collectors- flat plate collectors, liquid heating flat plate collectors, concentrating type collectors. Thermodynamic limits to concentration, solar cookers, types of solar cookers, solar water heater, solar air heaters, solar distillation, Solar water pumping and solar thermal power plant.
Solar photo-voltaic system, photovoltaic effect, efficiency of solar cells, semiconductor materials for solar cells, solar photovoltaic system, applications of solar photo-voltaic devices.

(16hrs)

Unit II

Wind Energy: Origin and classification of winds. Wind turbines, types of rotors, aerodynamics of wind turbines, wind energy extraction, wind characteristics, horizontal axis wind turbine generator. Modes of wind power generation. Advantages and disadvantages of a wind energy system.
Tidal Energy: tidal characteristics, tidal range, tidal energy estimation, energy and power in a double cycle system, yearly power generation from tidal plants, types of tidal power plants, site selection for power plants, advantages and disadvantages of tidal power.

(16 hrs)

Unit III

Biomass Energy: Biomass resources, biofuels, biogas, producer gas, biomass conversion technologies, biochemical conversion, biomass classification. Biogas technology, factors affecting biogas production, biogas plants – floating drum type plant, fixed dome type. Energy recovery from urban waste, power generation from landfill gas. Power generation from liquid waste. Ethanol from biomass.

Fuel Cells: Operation of an acidic fuel cell, technical parameters of a fuel cell, fuel processor, Methanol fuel cell, alkaline fuel cells, polymer electrolyte membrane fuel cells, advantages fuel cell power plants, energy output of a fuel cell, efficiency and emf of a fuel cell, operating characteristics of fuel cells. **(16 hrs)**

Text Books:

1. Renewable energy sources and emerging technologies, **D P Kothari, K C Singal, R Ranjan,** PHI (2018).
2. Non-conventional sources of energy, **G D Rai,** Khanna publications (1979).

References:

1. Renewable energy technologies, **R Ramesh**, Narosa, (1997).
2. Renewable energy systems, **K M Mittal**, Wheeler pub. (1997).
3. Biomass, energy and environment, **Ravindranath N.H.**, Oxford University Press (1995).
4. Solar Energy, **S P Sukhatme and J K Nayak,** Tata McGraw-Hill (2011).
5. Solar Energy, **H P Garg,** TMH (1997).

P106: General Physics Lab-I and P107:Optics Lab-I

List of experiments

1. Evaluation of errors, least square fit (compulsory)
2. Determination of elastic constants of glass (and Perspex) by Cornu's interference method.
3. Laser experiments: (a) Determination of distance between two slits using interference of laser light through double slit. (b) Determination of refractive index of glass and Perspex using total internal reflection. (c) Determination of refractive index of liquids using shift in the diffraction pattern.
4. Determination of the size of the lycopodium particles by diffraction method using a) Spectrometer method and b) Young's method.
5. Statistics of counting of background radiation (using GM counter)
6. Study of intensity distribution of elliptically polarized light
7. Fabry-Perot etalon spacing.
8. Diffraction of laser light by single slit and diffraction grating – determination of wavelength of laser.
9. Babinet's compensator
10. Determination of thickness of mica sheet using Edser-Butler Fringes.
11. Variation of surface tension with temperature.
12. Determining solar rotation period from given data of sunspot motion.
13. Young's modulus of steel by flexural vibrations of a bar.
14. Torsional vibrations and determination of rigidity modulus.
15. Millikan's oil drop experiment.
16. Simulations of physics concepts based on online virtual lab (using MHRD web resource).

P108: Electronics Lab-I and P109: Electronics Lab-II

List of experiments

1. Determination of practical op amp parameters: Input impedance, output impedance, Bandwidth of the open loop configuration.
2. Determination of difference mode gain, common mode gain and slew rate of an op amp.
3. Inverting op amp: Study of frequency response curve (for two different gains), determination of input and output impedance.
4. Non-Inverting op amp: Study of frequency response curve (for two different gains), determination of input and output impedance.
5. Study of frequency response and phase response of a first order op-amp based low pass filter.
6. Study of frequency response and phase response of a first order op-amp based high pass filter.
7. Study of the frequency response of a Band pass and band reject filter. Determination od quality factor.
8. Op amp with more than one input – Inverting and non-inverting configurations.
9. Study of op amp based integrator and differentiator.
10. Phase shift oscillator to determine the input impedance of the circuit.
11. JFET based amplifier.
12. RS and JK flip flop.
13. Implementing a Boolean expression and its simplified form using digital gates.
14. Timer 555 experiments.

M. Sc. II Semester

P201: Statistical Mechanics

Unit-I

Classical statistical description of system of particles: Specification of the state of a classical system, Phase space, Statistical ensemble, Basic postulates, Probability calculations, Behaviour of density of states, Statistical Equilibrium, Liouville theorem, Irreversibility and conditions of equilibrium, Reversible and irreversible processes, Thermal interaction between macroscopic systems, Microcanonical, canonical, grand canonical ensembles.

(14 Hours)

Unit-II

Application of classical statistical mechanics: System in contact with a heat reservoir (Maxwell Boltzmann distribution), Simple applications of the canonical distribution – Paramagnetism, Molecule of an ideal gas in the presence of gravity, Calculation of mean values in the presence of gravity, Connection with thermodynamics, Partition function of ideal gas and their properties, Calculation of thermodynamic quantities of ideal monoatomic gas, Gibbs' paradox, Equipartition theorem.

(14 Hours)

Unit-III

Quantum statistical mechanics: Basic concepts – Quantum ideal gas, Identical particles and symmetry requirements, Quantum distribution functions, Bose - Einstein statistics, Ideal Bose gas, black body radiation, Bose - Einstein condensation, specific heat of Ideal Bose gas, Fermi-Dirac statistics, Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, Quantum statistics in the classical limit.

(14 Hours)

Unit-IV

Irreversible processes and fluctuations: Random walk in one dimension, Brownian motion, Langevin equation, Fluctuation dissipation theorem, Einstein relation, Fourier analysis of random functions, Wiener-Khintchine relations Nyquist's theorem, Fluctuations and Onsager relations.

(14 Hours)

References

1. Fundamentals of Statistical and Thermal Physics, F Reif, First Indian Edition, Levant Books, 2010.
2. Statistical Mechanics, K Huang, Wiley Eastern Limited, New Delhi, 1963.
9. Statistical Mechanics, RK Pathria and PD Beale,3rd Edition, Academic Press (Oxford), 2011.
10. Introduction to Statistical Physics, Silvio R A Salinas, Springer, 2001.
11. Fundamentals of Statistical Mechanics, BB Laud, 5th Edition, New Age International Publication, 2015.
12. An introduction to statistical thermodynamics, Terrel Hill, Courier corporation, 1986.
13. Principles of statistical Mechanics, Richard TollmanClaredon Press, 1979.
14. An introduction to Thermodynamics and Statistical Mechanics, 2dnd Edition, Cambridge Uni Press, 2013.
15. *Statistical mechanics, McQuarrie, Donald A, New York: Harper & Row,* 2nd edition, 2000.

P202: Electrodynamics

Unit-I

Electrostatics: Coulomb's law, Electric field, Gauss's law, applications of Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, Work and energy in electrostatics, Techniques for calculating potentials: Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, Method of Images, Multipole expansion

Magnetostatics: Biot-Savart Law, Divergence and Curl of B, Ampere's law and applications of Ampere's law, Magnetic vector potential, Multipole expansion of the vector potential.

(14 Hours)

Unit-II

Electrodynamics: Faraday's law, Energy in magnetic fields, Maxwell's equations, Maxwell's displacement current, Maxwell's equations and magnetic charge, Maxwell's equations inside matter, boundary conditions.

Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauge; Lorentz force law in potential form, Energy and momentum in electrodynamics, Poynting's theorem Maxwell's stress tensor, Conservation of momentum.

(14 Hours)

Unit –III

Electromagnetic waves: Electromagnetic waves in non-conducting media: Monochromatic plane waves in vacuum, propagation through linear media, Reflection and transmission at interfaces. Fresnel's laws;Electromagnetic waves in conductors: Modified wave equation, monochromatic plane waves in conducting media

Dispersion: Dispersion in non-conductors, free electrons in conductors and plasmas. Guided waves, TE waves in a rectangular wave guide.

(14 Hours)

Unit-IV

Electromagnetic radiation: Retarded potentials, Electric dipole radiation, magnetic dipole radiation, Radiation from a point charge: Lienard-Wiechart potentials, fields of a point charge in motion, power radiated by a point charge

Electrodynamics and Relativity: Review of special theory of relativity, Lorentz transformations, Minkowski four vectors, energy-momentum four vector, covariant formulation of mechanics, Transformation of electric and magnetic fields under Lorentz transformations, field tensor, invariants of electromagnetic field, covariant formulation of electrodynamics.

(14 Hours)

References

1. Introduction to Electrodynamics, David J Griffiths, 2ndEdition, Prentice Hall India, 1989.
2. Classical Electrodynamics, JD Jackson, 4thEdition, John Wiley & Sons, 2005.
3. Classical Electromagnetic Radiation, MA Heald and JB Marion, Saunders, 1983.
4. Electrodynamics, Gupta,Kumar, Singh, Pragathiprakashan,18th edition, 2010.

P203: Quantum Mechanics –II

Unit-I

Approximation Methods - I

*Time independent perturbation theory:*Time independent perturbation theoryfor (i) non degenerate and (ii) degenerate energy levels. Applications: (1) one dimensional harmonic oscillator subjected to a perturbing potential in x and x^2 (2) the fine structure of the hydrogen atom (3) Zeeman effect

Variational Method: Theory, Applications: (1) ground state energy of the one dimensional harmonic oscillator (2) ground state energy of the delta function potential (3)ground state of Helium, *WKB approximation:*the "classical region", tunnelling, Gamow's theory of alpha decay, connection formulae

(14 Hours)

Unit –II

Approximation Methods - II

*Time dependent perturbation theory:*General features, time independent or constant perturbation, sinusoidal perturbation, transition to a continuum, the Fermi golden rule

Quantum Collision Theory: The scattering experiment, relation between differential scattering cross section, total scattering cross section and scattering amplitude. Integral equation of potential scattering, Born approximation, scattering by a spherically symmetric potential, cross-section for scattering in a screened coulomb potential**,** Partial wave analysis, scattering by a central potential, optical theorem. (14 Hours)

Unit-III

Approximation Methods – III

*Time dependent perturbation theory (Contd..): Sudden approximation, Adiabatic approximation:*Statement and proof.

Symmetry Principles and Conservation Laws

Continuous symmetries: Spatial translation symmetry and conservation of linear momentum, time translation symmetry and conservation in energy, Rotations in Space: Conservation of angular momentum,

Discrete symmetries: Parity, Time reversal, Permutation symmetry, symmetric and antisymmetric wave functions, Slater determinant, spin -1/2 particles in a box – The Fermi gas,Ortho and para helium. (14 Hours)

Unit-IV

Relativistic quantum mechanics

Klein-Gordon equation for a free relativistic particle, plane wave solutions, probability density and probability current density.

Dirac Hamiltonian for a free relativistic particle, properties of alpha and beta matrices, probability density and probability current, positive and negative energy solutions, orthogonality and completeness of the solutions, intrinsic spin of the Dirac particle, negativeenergy sea, non-relativistic approximation of Dirac equation in the presence of central potential and spin-orbit energy, Dirac particle in an external magnetic field, magnetic moment. (14 Hours)

References

1. Introduction to Quantum Mechanics – David J. Griffiths, Second Edition, Pearson Prentice Hall 2005.
2. Quantum Mechanics – V.K. Thankappan, Second Edition, Wiley Eastern Limited, 1993.
3. Quantum Mechanics Vol I & II – C. Cohen-Tannoudji, B. Diu and F. Laloe, Second Edition, Wiley Interscience Publication, 1977.
4. Quantum Mechanics- L.I. Schiff, Third Edition, Mc Graw Hill Book Company, 1955
5. Quantum Mechanics – B.H. Bransden and C.J. Joachain, Second Edition, Pearson Education, 2007.
6. Modern Quantum Mechanics – J.J. Sakurai, Revised Edition, Addison-Wesley, 1995.
7. Principles of Quantum Mechanics - R. Shankar, Second Edition, Springer, 1994.
8. Quantum Mechanics – E. Merzbacher, John Wiley and Sons, 1998.
9. Quantum Physics – S. Gasiorowicz, John Wiley and Sons.
10. Introductory Quantum Mechanics – Richard L. Liboff, 4th Edition, Pearson Education, 2007.
11. A text book of Quantum Mechanics – P. M. Mathews and K. Venkatesan, McGraw Hill Book Company, 2nd Edition, 2010

P204: Atomic and Molecular Physics

Unit - I

Atomic Physics – A: Brief review of early atomic models of Bohr and Sommerfeld: One electron atom; Atomic orbitals, spectrum of Hydrogen atom: Energy levels and selection rules, Rydberg atoms, relativistic correction to the kinetic energy, spin – orbit interaction and fine structure in alkali spectra, Lamb shift. Magnetic dipole hyperfine structure, energy shift, hyperfine transition on Hydrogen, Isotope shifts

(14 Hours)

Unit - II

Atomic Physics – B: Interaction with external fields: (Quantum mechanical treatment) Zeeman effect and Anomalous Zeeman effect – magnetic interaction energy, selection rules, splitting of levels in Hydrogen atom. Linear stark effect order correction to energy and Eigen states: Paschen-Back effect, Two electron atom: ortho and para states, role of Pauli exclusion principle, level schemes of two electron atoms. Many electron atoms: LS and JJ coupling scheme, Lande interval rule

(14 Hours)

Unit – III

Molecular Physics-A: Born-Oppenheimer approximation (qualitative). Classification of molecules: Classical treatment of rotation of molecules and rotational angular momentum, Rotational spectra of diatomic molecules as a rigid rotator, centrifugal distortion and non-rigid rotator, intensity of rotational lines, Rotational spectra of symmetric rotors, Experimental technique of microwave spectroscopy. Raman scattering and polarizability. Rotational Raman spectrum of diatomic and linear polyatomic molecules. Experimental technique. Applications of Raman spectroscopy: Determination of nuclear spin

(14 Hours)

Unit -IV

Molecular Physics-B: Vibrational energy of a diatomic molecule, diatomic molecules as simple harmonic oscillator, anharmonicity, effect of anharmonicity on vibrational terms, energy levels and spectrum, Morse potential energy curve, Hot bands and overtones, Vibrational Raman scattering, The rule of mutual exclusion, Rovibronic spectrum of a diatomic molecule with example. Diatomic molecules in excited vibrational states. Correlation between Raman and IR spectroscopy, Experimental technique of IR spectroscopy: IR spectrometer, Applications of IR spectroscopy: Material characterization and structural elucidation

(14 Hours)

Reference

1. Physics of atoms and molecules, Bransden and Joachain, (2nd Edition) Pearson Education, 2004.
2. Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGraw Hill, 1998.
3. Modern Spectroscopy, J. M. Hollas, John Wiley, 1998.
4. Molecular Spectroscopy, Jeanne L. McHale, Pearson Education, 2008.
5. Molecular Quantum Mechanics, P.W. Atkins and R. S. Friedman, 3rd Edition, Oxford Press (Indian Edition), 2004.
6. Molecular Structure and Spectroscopy: G. Aruldhas, Prentice Hall of India, New Delhi, 2001.
7. Handbook of Molecular Spectroscopy: D.N. Satyanarayana, 2nd Edition, I. K. International Publishing House Pvt. Ltd. 2019.

P205: Experimental Techniques in Physics (Soft core paper)

Duration: 39 Hours **Credits: 2** **No. of Hours per week: 3**

Unit – I

Safety measures in Experimental Physics

Occupational health and safety, chemical substances, radiation safety, general electrical testing standards, General laboratory and workshop practice.

Physical measurement

Measurement, result of a measurement, sources of uncertainty and experimental error, Systematic error, random error, Reliability- chi square test, Analysis of repeated measurement, Precision and accuracy, Elementary data fitting

Instrumentation Electronics

Transducers, Transducer characteristics, selection of a instrumentation transducer, Transducer as an electrical element, modelling external circuit components, circuit calculations, ac and dc bridge measurements.

(14 Hours)

Unit-II

Vacuum techniques

Units of pressure measurement, characteristics of vacuum, applications of vacuum, Vacuum pumps: Rotary, oil diffusion, turbo molecular pumps, Ion pumps. Vacuum gauges: Pirani and Penning gauges. Pumping speed of a vacuum pump.

Thin film techniques

Thin film techniques(overview), film thickness monitors, film thickness measurement.

Measurement of low temperature

Resistance thermometers, thermocouples.

(14 Hours)

Unit-III

Landmark experiments in Physics

Familiarization of certain landmark experiments in Physics through original papers:

1. Mossbauer effect
2. Parity violation experiment of Wu et al.
3. Cosmic microwave background radiation (CMBR) detection
4. Josephson tunnelling
5. Laser cooling of atoms
6. Bose-Einstein Condensation
7. Detection of Gravitational waves and black holes

(14 Hours)

Reference

1. Measurement, Instrumentation and Experimental design in Physics and Engineering Michael Sayer and AbhaiMansingh, Prentice Hall of India 2005
2. Data Reduction and Error Analysis for the Physical Sciences, P.R. Bevington and K.D Robinson, McGraw Hill, 2003
3. Electronic Instrumentation- H.S. Kalsi, TMH Publishing Co. Ltd. 1997
4. Instrumentation Devices and Systems-C.S. Rangan, G.R. Sharma, V.S.V. Mani, 2nd Edition, Tata McGraw Hill, New Delhi, 1997
5. Instrumentation Measurement Analysis-B.C. Nakra, K.K. Chaudhary.
6. Introduction to Modern Astrophysics, Bradley W Carroll and DA Ostlie, Pearson- Addison Wesley, 2007.

P206: General Physics Lab-II and P207: Optics Lab-II

1. Evaluation of errors, least square fit (compulsory)
2. Inverse square dependence of counts (using GM counter)
3. Analysis of binary star system
4. Solar cell characteristic curve and efficiency of solar cell.
5. Thermal conductivity of a material of a rod by Forbe's method
6. Verification of Stefan's Law by electrical method.
7. Determination of Stefan's constant
8. Determination of velocity of ultrasonic waves in liquids
9. Analysis of X-ray diffraction pattern
10. Energy gap of a thermistor.
11. Thermal diffusivity of a material (Angstrom's method)
12. Thermal conductivity of a poor conductor
13. Determination of velocity of ultrasonic waves in liquids using the method of diffraction and comparison with the mechanical method.
14. Thermal and electrical conductivities of copper to determine the Lorentz number
15. Relaxation (thermal) time of a serial light bulb
16. Verification of Curie-Weiss law for a ferroelectric material – T dependence of a ceramic capacitor
17. Thermal expansion - Determination of coefficients of thermal expansion of some materials (Al, Cu, Brass, NaCl, KCl)
18. Zeeman effect
19. Simulations of physics concepts based on online virtual lab (using MHRD web resource).
20. Determination of wavelength of iron arc spectral lines using constant deviation spectrometer.
21. Hartmann's method of spectral calibration using mercury spectrum and characterization of electronic absorption band of $KMnO_4$ based on Hartmann's formula.
22. Determination of wavelength of sodium light by Michelson's interferometer.
23. Determination of wavelength of sodium light and laser light using Fabry-Perot interferometer.
24. Verification of Brewster's law
25. Verification of Fresnel's laws.
26. Verification of Malus' law.
27. Experiments with lasers and reflection grating.
28. Verification of Beer-Lambert law
29. Determination of birefringence of Mica.
30. Optical rotatory dispersion (verification of Biot's law).
31. Rydberg constant using Hydrogen emission lines.
32. Rydberg constant using Hydrogen absorption lines.
33. Analysis of vibrational spectra of PN molecule.
34. Analysis of rotational Raman spectrum.
35. Simulations of physics concepts based on online virtual lab (using MHRD web resource).

P208: Computer Lab – I and P209: Computer Lab – II

Lab-I: Examples to illustrate the fundamental concepts of C-programming (minimum of 20 programs)

Lab-II: C-programs

1. Finding roots using (a) Bisection method and (b) Newton-Raphson method
2. Solving a system of linear equations (Gauss elimination method)
3. Evaluating integrals using Trapezoidal rule and Simpson's rule
4. Solving ordinary differential equations based on Euler and Runge-Kutta methods
5. Fitting data using least square fitting

Scheme of Examination:

A: THEORY QUESTION PAPERPATTERN

- Each hard core theory paper (4 credit course) examination is for 70 marks.
- Each soft core (2 credit course) theory paper examination is for 70 marks.
- Open elective (4 credit course) theory paper examination is for 70 marks.

Question paper pattern for Hard core (70 marks)

Each hard core theory paper syllabus is divided into 4 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows:

- Each question paper will consist of 3 sections: A B and C.
- **Part A: Six** questions of 5 marks each, out of which **four** to be answered (4 x 5 =20 marks). Short answer conceptual/reasoning questions shall be asked in this section to test conceptual understanding of the student.
- **Part B**: **Six** questions of 10 marks each, out of which **four** to be answered (4 x 10 = 40 marks). Descriptive/derivation questions shall be asked in this section.
- **Part C: Four** problems (or questions on physical concepts) of 5 marks each, out of which **two** to be answered (2 x 5 = 10 marks).

Question paper pattern for Soft core (70 marks)

Each soft core theory paper syllabus is divided into 3 units.

- Each question paper will consist of 2 sections: A & B.
- **Part A**: **Nine** questions of 5 marks each, out of which **six** to be answered (6 x 5 = 30 marks),short answer conceptual/reasoning questions shall be asked in this section to test conceptual understanding of the student.
- **Part B**: **Six** questions of 10 marks each, out of which **four** to be answered (4 x 10 = 40 marks). Descriptive/derivation questions shall be asked in this section.

Question paper pattern for Open elective (70 marks)

Each question paper will consist of 3 sections: A, B and C.

- **Part A: Ten** questions of 2 marks each. All questions are compulsory (2 x 10 =20 marks).
- **Part B**: **Six** questions of 5 marks each, out of which **four** to be answered (4 x 5 = 20 marks).
- **Part C: Five** questions of 10 marks each, out of which **three** to be answered (3 x 10 = 30 marks)

B. INTERNAL ASSESSMENT

- Internal Assessment for each theory / practical paper is 30 marks.
- Internal tests shall be conducted for 30 marks in each paper.

  - 5 marks is reserved for attendance.
    Allotment of marks for attendance:
    Attendance greater than95% - 5 marks
    Attendance between 95 – 91% - 4 marks
    Attendance between 90 – 86 % - 3 marks
    Attendance between 85 – 81 % - 2 marks
    Attendance between 80 – 76 % - 1 marks

Important Note: As per UGC guidelines candidates with attendance less than 75% - ineligible to appear for examination

C. PRACTICAL EXAMINATION

Semester end practical examination for each practical course is for **70** marks.
Internal assessment for each practical course is for **30** marks based on conduct of internal tests.