COURSE SCHEME

FOR

M.Sc. Physics

2023 Batch

Department of Applied Physics
M.Sc. Physics

1st Semester **Contact hours:**

Course Code	Course Name	Load Allocated			Credits	Type of Course
		L	T	P		
MPH-23101	Mathematical Physics-I	4	1	0	5	Theory
MPH-23102	Classical Mechanics	4	1	0	5	Theory
MPH-23103	Statistical Mechanics	4	1	0	5	Theory
MPH-23104	Semiconductors and Electronic Devices	4	1	0	5	Theory
MPH-23105	Quantum Mechanics-I	4	1	0	5	Theory
MPH-23106	Physics Lab.-I	0	0	6	3	Practical
	Total	**20**	**5**	**6**	**28**	

2nd Semester **Contact hours:**

Course Code	Course Name	Load Allocated			Credits	Type of Course
		L	T	P		
MPH-23201	Mathematical Physics-II	4	1	0	5	Theory
MPH-23202	Condensed Matter Physics-I	4	1	0	5	Theory
MPH-23203	Atomic & Molecular Physics	4	1	0	5	Theory
MPH-23204	Digital Electronics	4	1	0	5	Theory
MPH-23205	Numerical Analysis and Computer Programming	4	0	4	6	Practical
MPH-23206	Physics Lab.-II	0	0	6	3	Practical
	Total	**20**	**5**	**6**	**28**	

3rd Semester **Contact hours:**

Course Code	Course Name	Load Allocated			Credits	Type of Course
		L	T	P		
MPH-23301	Quantum Mechanics-II	4	1	0	5	Theory
MPH-23302	Condensed Matter Physics –II	4	1	0	5	Theory
MPH-23303	Nuclear Physics	4	1	0	5	Theory
MPH-23304	Classical Electrodynamics	4	1	0	5	Theory
MPH-23305	Physics Lab.-III	0	0	6	3	Practical
	Total	**16**	**4**	**6**	**23**	

4th Semester **Contact hours:**

Course Code	Course Name	Load Allocated			Credits	Type of Course
		L	T	P		
MPH-23401	Physics of Nanomaterials	4	1	0	5	Theory
MPH-23402	Synthesis and Characterization of Materials	4	1	0	5	Theory
MPH-23403	Physics Lab.-IV	0	0	6	3	Practical
MPH-23404	Dissertation*	0	0	5	10#	
	Total	**16**	**4**	**6**	**23**	

***Students will be assigned supervisor for dissertation work at the end of 2nd semester, so that during summer break/3rd semester, student can have overview of the particular research problem.**

 # the teaching load for dissertation work will be counted as 2 hours.

NOTE: Marks distribution:
Theory Exam: Internal-50 Marks, External-100 Marks
Practical Exam: Internal-100 Marks, External-50 Marks

MPH-23101
MATHEMATICAL PHYSICS-I

L	T	P	C
4	1	0	5

Course Objectives: The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists. The course will develop understanding of the basic concepts underlying complex analysis and complex integration. This course will aim at introducing the concepts of special functions, linear partial differential equations by separation of variable method.

1. **Elements of complex analysis** **(15)**
   Introduction to function of complex variables, Analytic function, Cauchy-Riemann conditions, Tailor and Laurent series expansion, singularity, Cauchy Integral theorem and formula, poles, residues, residue theorem, application of residues to evaluate real and definite integrals.

2. **Differential Equations** **(15)**
   Linear differential equations with constant coefficients, Cauchy's homogeneous linear equation, Use of Partial differential equations in physics problems, Separation of variables.

3. **Special Functions** **(15)**
   Dirac delta function, Gamma function, Beta function. Bessel function of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, Associated parity, Hermite functions, Laguerre functions.

Course Outcomes (COs): Understand and use, advanced mathematical methods and theories on various mathematical and physical problems. Identify different special mathematical functions. Students will be able to: Think critically about the theories of physics. Think critically about the contribution of various scientists in the mathematical world.

Suggested Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, San Diego).
2. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi).
3. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (Mac. Millan,India, Delhi).
4. Mathematical Methods in the Physical Sciences – M.L. Boas (Wiley, New York).
5. Special Functions: E.D. Rainville (Mac Millan, New York).
6. Mathematical Methods for Physics and Engineering : K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge).
7. Advanced Mathematical Physics by Erwin Kreyszig

MPH-23102
CLASSICAL MECHANICS

L	T	P	C
4	1	0	5

Course Objectives: Students will learn concepts of Lagrangian Formulation and Hamiltonian for different systems and will learn to apply these and understand canonical transformation, rigid body motion and concept of small oscillations.

1. **Lagrangian Formulation** **(10)**
Mechanics of a system of particles; constraints of motion, generalized coordinates, D'Alembert's Principle and Lagrange's velocity- dependent forces and the dissipation function, Applications of Lagrangian formulation.

2. **Hamilton's Principles** **(7)**
Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, symmetry properties of space and time and conservation theorems.

3. **Rigid Body Motion** **(10)**
Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top.

4. **Small Oscillations** **(5)**
Eigen value equation, Free vibrations, Normal Coordinates, Vibrations of a triatomic molecule.

5. **Hamilton's Equations** **(5)**
Legendre Transformation, Hamilton's equations of motion, Cyclic-co-ordinates, Hamilton's equations from variation principle, Principle of least action.

6. **Canonical Transformation and Hamilton-Jacobi Theory** **(8)**
Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton-Jacobi equations for principal and characteristic functions.

Course Outcomes (COs): Students will understand Classical Mechanics in depth and will be able to apply concepts learned efficiently.The Students will have understanding of Langrangian and its applications in all cases. The difference between classical and quantum physics.Hamiltonian and its applications in all cases.

Suggested Books:
1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi).
2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi).
3. Analytical Mechanics : L.N. Hand and J.D. Finch (Cambridge University Press, Cambridge)
4. Mechanics: L.D. Landau and E.M. Lifshitz (Pergamon, Oxford).
5. Classical Mechanics: N.C. Rana and P.J. Joag (Tata McGraw Hill, New Delhi).

MPH-23103
STATISTICAL MECHANICS

L	T	P	C
4	1	0	5

Course Objectives: Students will get acquainted with the concept of Statistical mechanics and Ensemble theory . They will also learn about quantum statistics. Students will understand various applications of these concepts.

1. **Review of Thermodynamics** **(7)**
   Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potentials, Phase equilibrium.
2. **The Statistical Basis of Thermodynamics** **(8)**
   The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.
3. **Ensemble Theory** **(15)**
   Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations.
4. **Quantum Statistics** **(15)**
   Quantum-mechanical ensemble theory: Density matrix, simple applications of density matrix. Symmetric and Antisymmetric Wave functions. Micro-canonical ensemble of ideal Bose, Fermi and Boltzmann gases. Statistics of the occupation numbers.
5. **Ideal Bose and Fermi Systems** **(8)**
   Ideal Bose systems: basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behavior of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism.

Course Outcomes (COs): Students will understand Statistical Mechanics in depth and will be able to apply concepts learned efficiently.. Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. Apply the principles of statistical mechanics to selected problems. Apply techniques from statistical mechanics to a range of situations.

Sugested Books:

1. Statistical Mechanics (2nd edition): R.K. Pathria (Butterworth-Heinemann, Oxford).
2. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi).
3. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi).
4. Elementary Statistical Physics: C. Kittel (Wiley, New York).
5. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi)
6. Statistical Physics by E S Rajagopal.

MPH-23104
SEMICONDUCTORS AND ELECTRONIC DEVICES

L	T	P	C
4	1	0	5

Course Objectives: The major objective of the course is to develop a better understanding of semiconductor physics. To cultivate skills at formulating and solving physics problems. To develop familiarity with the physical concepts and to understand how a circuit works. Provide the student with different practical, intellectual and transferable skills.

1. **Semiconductors and Junction diodes** **(14)**
   Introduction to semiconductors, Drift and diffusion of carriers, Fermi level, Direct and indirect semiconductors, Photoconductors, Capacitance of p-n junctions, Varactors, Tunnel diode, Light emitting diodes, Metal-semiconductor junctions; Ohmic and rectifying contacts, FET as switch and amplifier, MOSFET, Enhancement and depletion mode. Introduction to CMOS, CMOS Capabilities and Limitations and CMOS Transistors as logic gates (*viz*. NOT, NAND and NOR etc.

2. **Circuit Analysis Theorems** **(12)**
   Sources of electrical power, Voltage and Current sources, equivalence between voltage and current source, Thevenin and Norton theorems, maximum power transfer theorem (statement and proof), Delta star (Y) transformations.

3. **Operational Amplifier** **(17)**
   Operational amplifier, open loop op-amp, differential amplifier, inverting amplifier, non- inverting amplifier, voltage follower, difference and common mode gain, common mode rejection ratio. Input bias current, input offset current, input offset voltage, frequency response, slew rate, concept of feedback, Stability of operational amplifier.
   Operational Amplifier as: Summing, integrator and differential, Logarithmic and anti-logarithmic amplifiers, Current-to-voltage and Voltage-to-current converter, Comparators; Schmitt trigger and square wave generator. Sinusoidal Oscillators: Phase Shift, Wein bridge.

4. **Switching circuits and Power electronics** **(12)**
   Construction and Working of Silicon controlled rectifier (SCR) Diac, Triac, Unijunction Transistor (UJT) and their applications, Transistor multivibrators: astable, monostable and bistable multivibrators.

Course Outcomes (COs): Students will have knowledge of Basics of Semiconductor Physics, Basics of Diode, Transistor, Op-Amp. Students will be able to: Think critically about the theories of physics. Think critically about the contribution of various scientists in the electronic world.

Suggested Books:

1. Semiconductor Devices - Physics and Technology by S.M. Sze (Wiley)
2. Integrated Electronics by Millman and Halkias(Tata McGraw Hill)
3. Electronic devices and Circuit theory by Boylestad and Nashelsky (Preutice Hall).
4. OPAMPS and Linear Integrateed circuits by Ramakant A Gayakwad (Prentice Hall).
5. Electronic Principles by A.P. Malvino(Tata McGraw, New Delhi).
6. Electronic Communication Systems : Kennedy and Davis (Tata McGraw Hill).
7. Semiconductor Physics by Maan Singh.
8. Principles of Electronics: V.K. Mehta and Shalu Mehta, S. Chand & Co. Ltd. New Delhi.

MPH-23105
QUANTUM MECHANICS-1

L	T	P	C
4	1	0	5

Course Objectives: The major objective of the course is to develop a better understanding of Quantum Physics of sub atomic particles. To cultivate skills at formulating and solving physics problems. To develop familiarity with the physical concepts and mathematical methods of quantum mechanics.

1. **Introduction to Wave Mechanics and Quantum Behaviour (10)**
   Wave equation and its general solution, Quantization in wave mechanics and bound waves, the two-slit diffraction experiment, Particle/wave duality, The classical/quantum description of the state of a particle, the wave function and its interpretation, The cordinate and momentum representation of the quantum state, Fourier series and Fourier Transform, The wave equation in momentum space, The uncertainty principle
2. **General Formalism of Quantum Theory (10)**
   The principle of superposition, Formation of wave-packet, Fourier analysis of wave-packet and its group velocity, Gaussian wave packet, probability current density, equation of continuity, Basic postulates of Quantum Mechanics, Probabilities in momentum and coordinate space, operator representation of dynamical variables, Hermitian operators and properties of eigen values and eigenfunctions of hermitian operators, expectation values and indeterminacies, Ehrenfest's theorem, Eigen value equation, Eigen value and eigen function, Ket Bra notation and Dirac delta function.
3. **Schrodinger equation and its applications (5)**
   Hamiltonian operator and energy eigen value equation, Time independent and time dependent Schrödinger equation, particle in one dimensional box, the one dimensional simple harmonic oscillator, the hydrogen atom**.**
4. **Angular Momentum in Quantum Mechanics (10)**
   Compatible and incompatible variables, commuting observables and simultaneous measurements, The angular momentum operators, commutation relations of angular momentum operators, Orbital angular momentum eigen functions and eigen values, the parity operator, The ladder operator method for the angular momentum spectrum, Electron spin, Pauli's spin matrices and their properties, Addition of two angular Momenta.
5. **Matrix Formulation (10)**
   Alternative to Schrödinger's wave mechanics, the representation of the state of a particle in a discrete basis, the matrix representation for dynamical variables, eigen value equations in the matrix formulation, a spin half particle in a magnetic field.

Course Outcomes (COs): Students will be able to think critically about the theories of physics, Think critically about the contribution of various scientists in the quantum world. Identify the process of how spin of individual electron plays a crucial role in understanding the world of microscopic bodies.

Suggested Books:

1 E. Merzbacher, Quantum Mechanics
2 R.P. Feynman, Feynman Lectures on Physics
3 Sara M. McMurry, Quantum Mechanics
4 L.I. Schiff, QuantumMechanics
5 J J. Sakurai,Modern Quantum Mechanics

MPH-23106

PHYSICS LAB-1

L	T	P	C
0	0	6	3

Course Objectives: The aim and objective of the courses on Physics Laboratory is to expose the students of M.Sc. to the experimental techniques in general Physics, analog electronics, and semiconductor devices so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.This course aims to impart practical knowledge to students related to electronics.

Note : Students are expected to perform at least 8 experiments in one semester

1. To trace I-V characteristic curves of diodes and transistors on a CRO, and learn their uses in electronic circuits.
2. Study of Zener regulator as voltage regulator.
3. To plot the input and output characteristics of CE configuration.
4. To Study the D C characteristics and applications of DIAC.
5. To study the D C characteristics and applications of SCR.
6. To study the D C characteristics and applications of TRIAC.
7. Investigation of the D C characteristics and applications of UJT.
8. Investigation of the D C characteristics of MOSFET.
9. Study of bi-stable, mono-stable and astable multivibrators.
10. Study of Op-Amps and their applications such as an amplifier (inverting, non-inverting), scalar, summer, differentiator and integrator.

Course Outcomes (COs): Students will have knowledge of electronic components like, Basics of Diode, Transistor, Op-Amp. Students will be able to know about the working of electronic instruments.

MPH-23201
MATHEMATICAL PHYSICS-II

L	T	P	C
4	1	0	5

Course Objectives: The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists. The course will develop understanding of the basic concepts underlying Fourier, Laplace analysis and group theory.

1. **Fourier Analysis** **(15)**
   Fourier series of periodic functions, even and odd functions, half range expansions and different wave forms, complex form of Fourier series and practical harmonic analysis. Fourier transforms of various standard functions.
2. **Laplace Analysis & Inverse Laplace Analysis** **(10)**
   Laplace transforms of various standard functions, properties of Laplace transforms and inverse Laplace transforms.
3. **Group theory** **(10)**
   Definition of a group, multiplication table, conjugate elements and classes of groups, direct product Isomorphism, homomorphism, permutation group, definition of the three dimensional rotation groups.
4. **Elementary Statistics** **(10)**
   Introduction to probability theory, random variables, Binomial, Poisson and Normal distributions, Central limit theorem

Course Outcomes (COs): Understand and use theories on various mathematical and physical problems. Identify different special mathematical functions. Students will be able to: Think critically about the theories of physics.

Suggested Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Acad. Press, San Diego).
2. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi).
3. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (Mac Millan, India, Delhi).
4. Mathematical Methods in the Physical Sciences M.L. Boas (Wiley, New York).
5. Special Functions: E.D. Rainville (MacMillan, New York).
6. Mathematical Methods for Physics and Engineering : K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge).
7. Mathematical Physics: Satya Prakash (S. Chand & Sons)

MPH-23202
CONDENSED MATTER PHYSICS -1

L	T	P	C
4	1	0	5

Course Objectives: This course aims to establish fundamental concepts in condensed matter physics, and applies the physics you have learned previously (in particular quantum mechanics, classical mechanics, electromagnetism and statistical mechanics) to these real-world materials. The structure and properties of solids including thermal and electrical properties are described in detail.

1. **Crystal Structure** **(10)**
Crystals, Bravais lattice, symmetry operations and classification of Bravais lattices, Common crystal structures, Determination of crystal structure: X-ray diffraction, Bragg's law, qualitative idea of electron and neutron diffraction. Elastic strain and stress component. Elastic compliance and stiffness constants. Elastic constants of cubic crystals. Elastic waves in cubic crystals.

2. **Thermal properties of Crystal lattices** **(10)**
Specific heat, lattices heat capacity, classical, Einstein and Debye theories of specific heat, Born's modification of the Debye theory, Thermal expansion.

3. **Free Electron Theory of metals** **(10)**
Free electron gas model, Electrical conductivity of metals, Drift velocity and relaxation time, the Boltzmann transport equation. Drude and Lorentz theory, The Somerfield theory of conductivity, thermal conductivity, Widemann-Franz law, Hall effect.

4. **Magnetism** **(15)**
Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of Para magnetism, Quantum theory of Para magnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons, Ferromagnetism, the Weiss molecular field, the interaction of the Weiss field, Ferromagnetic domains, Antiferro, Ferrimagnetism: The two sub lattice model, exchange interaction, Neel's theory of ferrimagnetisms
Superconductivity: Critical field, Meissner effect, Types of superconductors, specific heat, London equations, penetration depth, BCS Theory, Tunneling phenomena, Josephson effect, Introduction to high temperature superconductors.

Course Outcomes (COs): Students will have a basic knowledge of lattice specific heat and elastic constants. Understand the concept of point defects and be able to use it as a tool. Know the significance of grain boundaries. know the fundamental principles of mean free path in metals and qualitative discussion of the features of resistivity. know basic models of dipole theory and thermodynamics of ferroelectric ttransitions.

Suggested Books:
1. C. Kittel, Introduction to Solid State Physics.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics.
3. J.M. Ziman, Principles of the Theory of Solids.
4. A.J. Dekker, Solid State Physics.
5. G. Burns, Solid State Physics.
6. M.P. Marder, Condensed Matter Physics.
7. B. D. Cullity, Elements of X-Ray Diffraction
8. L V Azaroff, Introduction to Solids R
9. R. L Sighal, Solid State Physics.

MPH-23203
ATOMIC AND MOLECULAR PHYSICS

L	**T**	**P**	**C**
4	1	0	5

Course Objectives: Atoms and molecules are the fundamental units for all matters in the Universe. Whatever state of matter it is made of atoms. All the properties of matter are governed by the electronic structure of atoms and molecules. This course enlightens the knowledge of structure of atoms and molecules with various spectroscopic techniques.

1. **One Electron Atom** **(9)**
   Vector model of a one electron atom, Quantum states of an electron in an atom, Hydrogen atom spectrum, Spin-orbit coupling, Relativistic correction, Hydrogen fine structure, Spectroscopic terms and Hyperfine structure.

2. **Two valance Electron Atom** **(8)**
   Vector model for two valance electrons atom, LS coupling, Pauli exclusion principle, Interaction energy for LS coupling, Lande interval rule, jj coupling, and interaction energy for jj coupling.

3. **Atom in Magnetic Field** **(8)**
   Zeeman effect, Magnetic moment of a bound electron, Magnetic interaction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strong field.

4. **Atom in Electric Field:** Stark effect, First order Stark effect in hydrogen. **(5)**

5. **Molecular Spectroscopy** **(10)**
   Rotational and vibrational spectra of diatomic molecule, Raman Spectra, Electronic spectra, Born-Oppenheimer approximation, Vibrational coarse structure, Franck-Condon principle, Rotational fine structure of electronic-vibration transitions.

6. **Spin Resonance Spectroscopy** **(5)**
   Electrons spin resonance and nuclear magnetic resonance spectroscopy.

Course Outcomes (COs): Students will learn About the structure of atom and molecules with various theoretical and experimental observations. Understand and explain basic concepts of different spectroscopic techniques to explore the physical and chemical properties of matter.

Suggested Books:

1. White H. E., Introduction to Atomic Spectra, McGraw Hill (1934).
2. Banwell C. N. and McCash E. M., Fundamentals of molecular spectroscopy, Tata McGraw Hill (1994).

MPH-23204
DIGITAL ELECTRONICS

L	T	P	C
4	1	0	5

Course Objectives: Use concept of Digital Principles for electronic conversions and ddemonstrate application of sequential circuits.

1. **Number System and Binary Code** **(8)**
   Binary, Octal and Hexadecimal Number System (Conversion, Addition & Subtractions). Signed and unsigned numbers, Binary Subtractions using 1's and 2's compliment, ASCII code, Excess 3 code, Grey code, BCD code and BCD additions. Parity, Error Detection codes, Hammings Error correction code.
2. **Minimization of logic function** **(10)**
   OR, AND, NOT, NOR, NAND, EX-OR, EX-NOR, Basic theorem of Boolean Algebra, Sum of Products and Product of Sums, canonical form, Minimization using K-map.
3. **Combinational Circuits** **(12)**
   Combinational circuit design, Encoders, decoders, Adders, Sub tractors and Code converters. Parity checker, seven segment display, Magnitude comparators. Multiplexers, De-multiplexer, Implementation of Combinational circuit using MUX.
4. **Sequential Circuits** **(15)**
   Introduction, flip flops, Clocked flip flops, SR, JK, D, T and edge triggered flip- flops. Excitation tables of Flip flops. Shift Registers, Type of Shift Registers, Counter, Counter types, counter design with state equation and state diagram.

Course Outcomes (COs): Students will have knowledge of number system, logic functions and logic families Basics of combinational and sequential circuits. Students will be able to think critically about the theories of digital physics.

Suggested Books:

1. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
2. Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.

MPH-23205

NUMERICAL ANALYSIS AND COMPUTER PROGRAMMING

L	T	P	C
4	0	4	6

Course Objectives: The major objective of the course is to develop a better understanding of computational methods required to solve many physical problems.

Note: Regarding evaluation and paper setting of Numerical Analysis and Computer Programming

It has been decided that 40% weightage of practical class must be given in the internal awards on the basis of performance of students in the concerned lab and its exam thereof. Similarly, at least 20% weightage of practical class must be given while preparing the question paper for end semester exam i.e. there should be few questions based upon flow chart, how to develop logic and how to write a program etc.

1. **Methods of approximation and errors** **(2)**
   Truncation and round-off errors; Accuracy and precision.
2. **Roots of Equations** **(5)**
   Bisection method, False position method, Iteration methods (Newton Raphson). Systems of linear algebraic equations: inversion and LU decomposition methods. Gauss elimination method.
3. **Curve fitting** **(5)**
   Least squares regression, linear and nonlinear regressions.
4. **Interpolation Methods** **(5)**
   Interpolating polynomials. Newton's divided difference.
5. **Numerical differentiation and integration** **(5)**
   Trapezoidal and Simpson's rules.
6. **Ordinary differential equations** **(8)**
   Euler's method, Runge-Kutta methods. Boundary value and Eigen value problems. Partial differential equations: Numerical solution of Laplace's equation, Few applications.
7. **Fourier approximation** **(5)**
   Introduction, Discrete Fourier and Fast-Fourier Transforms.
8. **Computer Programming** **(10)**
   Some computer programs in suitable languages, based on above topics.

Course Outcomes (COs): Students will be able to: Think critically about the theories of physics. Think critically about the contribution of various scientists in the Physical world.

Suggested Books:

1. Shastry, S.S., "Numerical Methods", Prentice Hall Inc., India, 1998.
2. Richard L. Burden and J. Douglas Faires, Numerical Analysis , Brooks/Cole, Cengage Learning
3. Noble Ben, "Numerical Methods", New York International Publications, New York, 1964.
4. Numerical Analysis with Algorithms and Programming; Santanu Saha, CRC press, 2016
5. Buckingham R.A., "Numerical Methods", Sir Isaac Pitman Sons. Ltd., London, 1957.

6. Uri M. Ascher and Chen Greif, A first Course in Numerical Methods SIAM, 2011.
7. Bakhvalov, N .S., "Numerical Methods", Mir. Pub., Moscow, 1977.
8.Numerical recipes in C++ or Fortran.

MPH-23206
PHYSICS LAB-2

L	T	P	C
0	0	6	3

Course Objectives: The aim and objective of the courses on Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in digital electronics, condensed matter physics and spectroscopy, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note: Students are expected to perform at least 8 experiments in one semester.

I.

1. To study the use of digital to analog and analog to digital converter.
2. To study logic gates and flip flop (JK, RS and D) circuits using on a bread-board. 14. 8085 microprocessor kit – familiarization and introductory programming.
3. Study of Logic Gates: Truth-table verification of OR, AND, NOT, XOR, NAND and NOR gates;
4. Realization of OR, AND, NOT and XOR functions using universal gates.
5. Realization Half Adder / Full Adder using Logic gates.
6. Realization Half Subtractor / Full Subtractor using Logic gates
7. Design 4-Bit Binary-to-Gray & Gray-to-Binary Code Converter.
8. Design 4-Bit magnitude comparator using logic gates.Multiplexer: Truth-table verification and realization of Half adder and Full adder using MUX.
9. Demultiplexer: Truth-table verification and realization of Half subtractor and Full subtractor using DEMUX.
10. Flip Flops: Truth-table verification of RS, JK , D, JK Master Slave Flip Flops.12
11. Design MOD-7 Synchronous up-counter using JK/RS/D Flip Flops.

Course Outcomes (COs): Students will have knowledge of electronic components like gates, flip flop, register, adder, subtractor, counter etc. Students will be able to know about the working of electronic instruments.

Suggested Books:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, 1994, Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4th Edn, 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

MPH-23301
QUANTUM MECHANICS-II

L	T	P	C
4	1	0	5

Course Objectives: Quantum Mechanics-II is a basic continuation course in quantum mechanics that aims at the applications of quantum mechanics. The aim of the course is that the students acquire in-depth knowledge about the foundations of quantum mechanics, as well as skills in applying quantum mechanics in advanced problems.

1. **Perturbation Theory** **(12)**
   Time-independent perturbation theory, First order perturbations, Second order perturbations: anharmonic oscillator, Degenerate perturbation theory: spin-orbit coupling, the time dependent Schrodinger equation, Resonant transition between two energy states, Time dependent perturbation theory, Transition rates and Fermi golden rule.
2. **Relativistic Quantum Mechanics** **(11)**
   Basic notions of relativity and the Lorentz transformations, Klein Gordon equation, Lorentz transformation of spinors and the Dirac equation, The Dirac equation in the presence of an electromagnetic field and the magnetic moment.
3. **Elements of Scattering Theory** **(13)**
   Elastic scattering : elementary considerations on quantum theory of scattering in a given potential method of partial waves, the optical theorem, Born approximation, Low energy scattering and bound states, Scattering in a Coulomb field, scattering of identical particles and scattering of particles with spin, A brief overview of time dependent formulation of scattering. Inelastic collisions and the S matrix : a brief overview.
4. **Systems of Identical Particles** **(9)**
   Classical vs. quantum descriptions, Brief introduction to identical particles in quantum mechanics, Permutation operators and many body wave functions, Application to 2 -electron systems, Pauli exclusion principle, Bose Einstein and Fermi Dirac Statistics.

Course Outcomes (COs): Students will Learn about basic non-relativistic quantum mechanics. Study about the approximate methods for solving Schrödinger equations such as perturbation theory, variational method and Born approximations. Gain knowledge about relativistic quantum mechanics . Become familiar with the study of identical particles in quantum mechanics.

Suggested Books:
1. Modern Quantum Mechnics: J.J. Sakurai-Pearson Educaton Pvt. Ltd., New Delhi, 2002.
2. Quantum Mechanics: L I Schiff-Tokyo Mc Graw Hill, 1968.
3. Feynmann lectures in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics: Powel and Craseman-Narosa Pub. New Delhi, 1961.
5. Quantum Mechanics: Merzbacher-John Wiley & Sons, New York, 197

MPH-23302
CONDENSED MATTER PHYSICS-II

L	T	P	C
4	1	0	5

Course Objectives: Provide the student with a broad spectrum of physics courses. Develop the ability of the students to conduct, observe, analyzes and report an experiment. . Develop the ability of the students to deal with physical models and formulas mathematically. Provide the student with different practical, intellectual and transferable skills.

1. **Defects and Diffusion in Solids** **(15)**
   Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Slip, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Diffusion in solids, Classification of diffusion process, Ficks law, Factor affecting diffusion and applications, Kirkendal law interpretation of diffusion in alkali halides.

2. **Dielectric Properties of Solids** **(10)**
   Dielectrics and Ferroelectrics: Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, different contribution to polarization: dipolar, electronic and ionic polarisabilities, General properties of ferroelectric materials. The theories of ferroelectricity.

3. **Electronic Energy bands in Solids** **(10)**
   Wave functions in periodic potential and Bloch theorem, Kronig-Penney Model, E vs. K relations, Motion of electron in one dimension according to band theory, Crystal momentum, Concept of effective mass and hole. Distinction between metals, insulators and semiconductors, Brillouin zones, density of states, overlapping of energy bands.

4. **Optical Properties of Solids** **(10)**
   Dielectric function of electron gas, plasma frequency Plasmons, Excitons, Photoconductivity, influence of traps, Luminescence: excitation and emission, Efficiency of a phosphor, Decay mechanisms, Thermo-luminescence and glow curves, Electroluminescence.

Course Outcomes (COs): Students will: have a basic knowledge of crystal systems and spatial symmetries. Understand the concept of reciprocal space and be able to use it as a tool. know the significance of Brillouin zones. know the fundamental principles of semiconductors, including pn-junctions, and be able to estimate the charge carrier mobility and density.

Suggested Books:
1. C. Kittel, Introduction to Solid State Physics.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics.
3. J.M. Ziman, Principles of the Theory of Solids.
4. A.J. Dekker, Solid State Physics.
5. G. Burns, Solid State Physics.
6. M.P. Marder, Condensed Matter Physics.
7. B. D. Cullity, Elements of X-Ray Diffraction
8. L V Azaroff, Introduction to Solids
9. R.L. Singhal, Solid State Physics.

MPH-23303
NUCLEAR PHYSICS

L	T	P	C
4	1	0	5

Course Objectives: This course introduces students to the fundamental concepts of building up complexity from elementary constituents in the framework of nuclear and sub-nuclear physics. Starting with an overview of the development of nuclear and particle physics, the course builds on previous learning in quantum mechanics and electromagnetism to develop students' understanding of the properties of the strong and weak forces.

1. Properties of Atomic Nucleus **(7)**
Theories of nuclear composition (proton-electron, proton-neutron), Binding Energy, Semi-empirical Mass Formula for nuclear stability, Quantum numbers of nucleons, Quantum properties of nuclear states, nuclear angular momentum, Nuclear Magnetic dipole moment, Electric quadrupole moment, potential well, quantum statistics.

2. Nuclear Interactions **(15)**
Nuclear Forces: Two nuclear system, deuteron problem, proton-proton and proton-neutron scattering experiments at low energy, meson theory of nuclear forces, exchanges forces and tensor forces, effective range theory-spin dependence of nuclear forces-Charge independence and charge symmetry of nuclear forces-Isospin formalisim.

3. Nuclear Models **(15)**
Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic-Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates-magnetic moments and Schmidt lines, Collective model, Nuclear vibrations spectra and rotational spectra, applications.

4. Nuclear Reactions **(8)**
Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, Compound nucleus, scattering matrix, Reciprocity theorem, Breit Winger one level formula, Resonance scattering.

Course Outcomes (COs): Students will be able to Understand the various decay properties of unstable nuclei such as beta decay, gamma decay, and parity violation. .Compare different nuclear reaction mechanisms in relation to cross-sections, excitation functions and angular distributions.

Suggested Books:
1. Roy R.R. & Nigam B.P., Nuclear Physics, New Age International Ltd (2001).
2. Preston M. A. and Bhaduri R. K., Structure of Nucleus Addision-Welsey (2000).
3. Pal, M.K., Theory of Nuclear Structure, East-West Press Delhi (1983).
4. Kaplan Irving Nuclear Physics, Narosa Publishing House (2000).
5. Tayal D. C., Nuclear Physics, Himalaya Publication home (2007)
6. Perkins D.H., Introduction to High Energy Physics, Cambridge University Press (2000).
7. Hughes I.S., Elementary Particles, Cambridge University Press (1991).
8. Close F.E., Introduction to Quarks and Partons, Academic Press (1979).
9. Segre E., Nuclei and Particles, Benjamin-Cummings Pub. Co. (1997).
10. Khanna M.P., Introduction to Particle Physics, Prentice Hall of India Pvt. Ltd (2004).
11. G.N. Ghoshal, Nuclear Physics , S. Chand (2014).

MPH-23304
CLASSICAL ELECTRODYNAMICS

L	T	P	C
4	1	0	5

Course Objectives: The major objective of the course is to make the students familiar with the vast implications of Electricity and Magnetism To cultivate skills at formulating and solving physics problems. To develop familiarity with the physical concepts and mathematical methods of electrodynamics

1. **Boundary Value Problems** **(5)**
   Uniqueness Theorem, Dirichlet or Neumann Boundary conditions, Green's Theorem, Formal solution of Electrostatic & Magnetostatic Boundary value problem, Method of images with examples.
2. **Time Varying Fields and Maxwell Equations** **(10)**
   Faraday's Law of induction, Displacement current, Maxwell equations, scalar and vector potentials, Gauge transformation, Lorentz and Coulomb gauges, General Expression for the electromagnetic fields energy, Poynting's Theorem.
3. **Electromagnetic Waves** **(10)**
   Wave equation, Plane waves in free space and isotropic dielectrics, Polarization, Energy transmitted by a plane wave, Waves in conducting media, Skin depth. Reflection and Refraction of electromagnetic waves at plane surface between dielectrics, Fresnel's amplitude relations. Reflection and transmission coefficients, Polarization by reflection and total internal reflection.
4. **Wave Guides** **(10)**
   Field at the surface of and within the conductor, Wave guides, TE, TM and TEM waves, Energy flow and attenuation in wave guides, Cavity resonators and Power loss in cavity and quality factor.
5. **Radiation Systems** **(10)**
   Fields of radiation of a localized oscillating source, Electric & Magnetic dipole fields and electric quadrupole fields, Centre fed linear antenna, Introduction to radiation damping and radiation reaction.

Course Outcomes (COs): Students will uunderstand how a wave propagates in wave guides, understand relativistic formulation of electrodynamics, understand the theory of field of moving charges.

Suggested Books:

1. Jordan E. C. and Balmain K. G., Electromagnetic Wave and radiating systems, Prentice Hall India Ltd. (1997).
2. Griffiths D.J., Introduction to Electrodynamics, Prentice Hall (1998).
3. Jackson J.D., Classical Electrodynamics, Wiley Eastern (1999).
4. Puri S.P., Classical Electrodynamics, Tata McGraw Hill (1999).

MPH-23305
PHYSICS LAB -3

L	T	P	C
0	0	6	3

Objectives: The aim and objective of the courses on Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in condensed matter physics and nuclear physics, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note: Students are expected to perform at least 6 experiments in one semester.

1. To draw the plateau curve for a Geiger Muller counter.
2. To determine the dead time of given G. M Counter.
3. To study the statistical fluctuations of background counts in a G. M. Counter.
4. To find half life period of a given radioactive substance using a G.M. counter.
5. To determine the absorption coefficient of Pb and Fe for gamma rays using G. M. Counter.
6. To determine the energy of a pure beta-emitter using G.M. Counter and Al absorbers.
7. To study the energy resolution of Cs137.
8. To identify the unknown gamma source using energy calibration.
9. To study anisotropy of gamma-ray for 60Co using coincidence set-up
10. To study energy resolution and calibration of a gamma-ray spectrometer using multichannel analyzer.
11. To study time resolution and calibration of a coincidence set-up using a multi-channel analyzer.

Course Outcomes (COs): The student will be able to carry out experimental work using GM counter in the field of radiation shielding and radioactive analysis of various materials. Understand the interaction of beta particles, alpha particles and gamma ray with matter. Students can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments.

MPH-23401
PHYSICS OF NANOMATERIALS

L	T	P	C
4	1	0	5

Course Objectives: The program focuses on the foundation knowledge of the nanoscience and related fields and acquiring an understanding of Nanoscience and Nanotechnology and its applications.

1. Nanostructures (15)

Free electron theory and its features, Idea of band structure - metals, insulators and semiconductors. Density of states for solids, Nanomaterials, Quantum Confinement: How small?, Electron confinement in infinitely deep square well, Surface area to volume ratio, Nanostructures; Quantum well, Quantum wire, Quantum Dots, Density of states for various quantum structures, Interacting quantum dots, Superlattice, Effect of size on energy band gap of semiconductors, excitons, Confining excitons,.

2. Preparation Techniques (7)

Bottom up: Ion implantation technique, Co-precipitation method, Chemical bath deposition; Top down: Ball Milling, Lithography techniques.

3. Carbon Nanotubes and metal nanoparticles (15)

Carbon allotropes, Carbon nanostructures (carbon nanotubes) and its synthesis, mechanism of growth, Properties and applications of Carbon nanotubes, Nanosized metal particles and metal to insulator transition, Optical properties of metal nanoparticles: Surface plasmon resonance (SPR), Interaction of metal nanoparticles with electromagnetic radiation.

4. Size Characterization Techniques (8)

X-ray diffraction, Determination of particle size using XRD, Study of texture and microstructure, Strain and Size effects on XRD peaks, X-ray diffraction peaks for bulk and its nanoparticles.

Course Outcomes (COs): After completing course students will be able to understand the synthesis of nanomaterials and their applications and the impact of nano-materials and will be able to apply their knowledge to develop Nanomaterials.

Text Books

1. Chow G-M & Gonsalves K.E., Nanotechnology - Molecularly Designed Materials, American Chemical Society.
2. Jain K.P., Physics of Semiconductor Nanostructures, Narosa Publishing House (1997).
3. Cao, G., Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Emperial College Press (2004).

MPH-23402
SYNTHESIS AND CHARACTERIZATION OF MATERIALS

L	T	P	C
4	1	0	5

Course Objectives: The syllabus introduces the basic concepts and principles to understand various synthesis/growth methods of materials of bulk and nano size as well as thin film fabrication methods. The course is also providing basic understanding of characterization techniques to study electrical, optical and structural, electronic and magnetic properties of materials to explore the field in detail.

1. **Synthesis of Materials** **(10)**
Bulk Synthesis: Solid state reaction method, sol gel method, chemical co- precipitation method. Film deposition methods: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, sputtering (RF, DC); pulsed laser deposition (PLD), Spin coating technique.

2. **Microscopic Techniques** **(8)**
Transmission electron microscopy (TEM), Scanning electron microscopy (SEM); scanning tunneling microscopy (STM); Atomic force microscopy (AFM).

3. **Spectroscopic Techniques** **(12)**
Diffraction techniques: X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS). FTIR, UV-Visible spectroscopy.

4. **Electrical and Magnetic Characterization Techniques** **(10)**
Electrical resistivity, Dielectric properties measurements, Magnetic characterization by measuring Magnetization viz. M-H loop, temperature dependent magnetization by Force and Induction method using Vibrating Sample magnetometer(VSM) and introduction to Superconducting Quantum Interference Device (SQUID).

Course Outcomes (COs): After completing course students will be able to understand the methods and basics of instrumentation used in synthesis of materials and thin film fabrication as well as characterization techniques to analyse the various physical properties of materials.

Suggested Books:

1. Thin Film Phenomena: K.L. Chopra-Mc Graw Hill Book, Comp., 1979.
3. Material Science and Engg :W.D. Callister-John Wiley, 2001
4. Elements of X-ray Diffraction (3rd edition) : B.D. Cullity, S.R. Stock-Prentice Hall, 2001.
5. X-ray Fluorescence spectroscopy: R. Jenkins-Wiley Interscience, New York, 1999.
7. The Principles and Practice of Electron Microscopy: Ian M. Watt-Cambridge Uni. Press, 1997
8. Modern techniques for surface science: D.P. Woodruff and T.A. Delchar- Cambridge University Press, 1994.
11. "*Vacuum Technology*", 1983, A. Roth, Pergamon Press (Oxford).
13. "Low-temperature Physics: an introduction for scientists and engineers, "1992, P V E McClintock, D J Meredith and J K Wigmore, Blackie (Glasgow).

MPH-23403
PHYSICS LAB -IV

L	T	P	C
0	0	6	3

Objectives: The aim and objective of the courses on Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in condensed matter physics and nuclear physics, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note: Students are expected to perform at least 6 experiments in one semester.

1. To study the series and parallel characteristics of a photovoltaic cell.
2. To study the spectral characteristics of a photovoltaic cell.
3. Verification of Curie-Wiess law by studying temperature dependence of electrical susceptibility of a ferroelectric material.
4. To determine the energy gap and resistivity of the semiconductor using four probe method.
5. To study temperature dependence of conductivity of a given semiconductor crystal using four-probe method and Vander Paw method.
6. Study of Thermo luminescence of f-centres in Alkali Halide Crystals.
7. To determine crystal structure of different material using x-ray diffraction.
8. To measure dielectric constant of Barium titanate as function of temperature and frequency and hence study its transition.
9. To measure heat capacity of solid at high and low temperatures.
10. The Hall coefficient for given semiconductor and study its temperature dependence.
11. To trace hysteresis loop and calculate retentivity, coercively and saturation magnetization.
12. Detrmination of crystal structure and lattice parameters using X-ray diffraction technique.
13. To determine the magnetic susceptibility of a material using Quink's method.
14. To find the wavelength of monochromatic light using Febry Perot interferometer.
15. To find the wavelength of sodium light using Michelson interferometer.
16. To verify the existence of Bohr's energy levels with Frank-Hertz experiment.

Course Outcomes (COs): The student will be able to carry out experimental work using GM counter in the field of radiation shielding and radioactive analysis of various materials. Understand the interaction of beta particles, alpha particles and gamma ray with matter. Students can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments.

MPH-23404
DISSERTATION

L	T	P	C
0	0	5	10

Course Objectives: Dissertation involves project work with the intention of exposing the student to research /development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

1. Experimental Methodology: Students will learn how to design a problem and write hypothesis, set up and perform experiments, analysis of obtained results, drawing inferences and conclusions, which will be followed by a detailed report of outcomes.

2. Students will be required to perform detailed study on a problem in one of the following fields:

· Experimental Physics

· Theoretical Physics

In all, it will be a collaborative work to perform experimental/theoretical work and to prepare final report, may involve a maximum of 05 students in each group. The final evaluation will comprise of pre-submission seminar for Internal Evaluation and final presentation of results for External Evaluation.

3. The report must have minimum three chapters namely (1) Introduction, (2) the main work including theoretical /experimentation and Results, and (3) Discussion and Conclusion. At the end adequate references must be included. Plagiarism should be avoided by the student.

Course Outcomes (COs):

- Exposure to research methodology
- Picking up skills relevant to dissertation/project
- Development of creative ability and intellectual initiative
- Developing the ability for scientific writing
- Becoming conversant with ethical practices in acknowledging other sources, avoiding.

Suggested Books: As suggested by the student's supervisor pertaining to work assigned.