Maulana Azad National Urdu University

Two-year M.Sc. Program

Courses

(*Effective from Academic Year 2023-25*)

M. Sc. (Physics) Syllabus under CBCS Scheme

SEMESTER-I					
Course Code	**Course Name**	**L**	**T**	**P**	**C**
MSPH101CCT	Classical Mechanics	3	1	0	4
MSPH102CCT	Mathematical Physics	3	1	0	4
MSPH103CCT	Quantum Mechanics	3	1	0	4
MSPH104CCT	Electronics-I	3	1	0	4
MSPH150CCP	General Physics Laboratory-I	0	0	6	3
MSPH151CCP	Electronics Laboratory-I	0	0	6	3
	Total	**12**	**4**	**12**	**22**

L=Lecture, T=Tutorial, P=Practical, C= Credit

Course Code	Course Name	L	T	P	C
MSPH101CCT	**CLASSICAL MECHANICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover the Newtonian, Lagrangian, and Hamiltonian formulations of mechanics and its applications.
Course Objectives	The objective is to provide concepts and problem-solving approaches related to Lagrangian and Hamiltonian. Students will be exposed to derive Newtonian, Lagrangian, and Hamiltonian equations of motion.
Course Outcomes	The successful students will be able to apply the Newtonian, Lagrange, and Hamilton equations of motion.

Module	Content of Course	Hours
	Classical Mechanics	
1	**Newtonian formalism:** Inertial frames and Galilean transforms-Non-inertial frames- pseudo forces, rotational frames, rotational transforms and conservation theorems. Description of rotations in terms of Euler angles-Euler's equations of motion for a rigid body. Minkowski space, space-time diagrams, world point and world line- relativistic motion and Lorentz transforms as rotations in four-space, four velocity, energy-momentum vectors with few examples.	**15**
2	**Lagrangian formalism:** Constraints, generalized coordinates, Principle of virtual work, Lagrange's equations and applications, D'Alembert's principle, Lagrangian equations of motion for plane and spherical pendulums, L-C circuit; velocity dependent potentials-Lagrangian for a charged particle in electromagnetic field, Euler's equations from Lagrange equations. Hamilton's principle, Lagrange's equations from Hamilton's principle.	**15**
3	**Hamiltonian formalism:** The Principle of Least Action-Applications of Hamilton's equations motion of a particle in a central force field, projectile motion of a body. Cyclic coordinates and conservation theorems, Canonical coordinates and canonical transformations, Conditions for a transformation to be canonical, generating functions, Lagrange and Poisson brackets. Hamilton's equations in Poisson bracket from Hamilton- Jacobi theory.	**15**
4	**Mechanics of continuous systems:** Analysis of the free vibrations of a linear triatomic molecule, Eigen value equation- Principal axis transformation-Frequencies and normal coordinates Lagrangian formulation for continuous systems, Hamiltonian formulation.	**15**

Textbook	H. Goldstein, C. P. Poole and J. Safko, *Classical Mechanics*, 3rd Edition, Pearson (2012).
Ref. Book	L. Landau and E. Lifshitz, *Mechanics*, 3rd edition, Butterworth-Heinemann (1982).

Course Code	Course Name	L	T	P	C
MSPH102CCT	**MATHEMATICAL PHYSICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover linear differential with variable coefficients, vector, Hermite and Laguerre Differential equations, Fourier and Laplace transforms, and matrices and tensors.
Course Objectives	The objective is to familiarize with mathematical methods for solving advanced problems in physics. Students will be exposed to mathematical skills to solve problems in both fundamental and advanced physics.
Course Outcomes	The successful students will be able to apply mathematical skills in designing and solving problems.

Module	Content of Course	Hours
	Mathematical Physics	
1	**Linear differential equations with variable coefficients:** **Legendre's Differential equation:** Power series solution, Legendre functions of the first and second kind, Generating function, Rodrigue's formula, Orthogonal properties, Recurrence relations. **Bessel's Differential Equation:** Power series solution, Bessel functions of first and second kind, Generating function, Orthogonal properties, Recurrence relations. Beta and Gamma functions, properties and their relations.	**15**
2	**Hermite Differential Equation:** Power series solution, Hermite polynomials, Generating Function, Orthogonality, Recurrence relations, Rodrigues formula. **Laguerre Differential equation:** Power series solution, Generating Function, Rodrigue's formula, Recurrence relations, Orthogonal properties, Integral representation of Laguerre differential equations.	**15**
3	**Fourier Transform:** Infinite Fourier sine and cosine transforms, Properties of Fourier transforms, Derivative of Fourier transform, Fourier transform of a derivative, Fourier sine and cosine transform of derivatives, Finite Fourier transforms, Applications of Fourier Transforms. **Laplace Transform:** Properties of Laplace transforms, Derivative of Laplace transform-Laplace transform of a derivative, Laplace transform of periodic functions, Inverse Laplace transform and its properties, Inverse Laplace theorem, Convolution theorem.	**15**
4	**Matrice:** Eigen values, Eigen vectors, Characteristic equation of a matrix, Cayley Hamilton theorem, Types of matrices, symmetric and skew symmetric and Hermitian matrices, Unitary and symmetry transformations **Tensors**: Order and rank of the tensors, transformation laws of covariant, contra-variant and mixed tensors, **Properties of tensors:** Addition, subtraction and multiplication of tensors, Outer and inner products, contraction of tensors and quotient law.	**15**

Textbook	George B. Arfken, Hans J. Weber and Frank E. Harris, *Mathematical Methods for Physicists*, 7th Edition, Academic Press (2012).
Ref. Book	Mary L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Edition, John Wiley & Sons (2005).

Course Code	Course Name	L	T	P	C
MSPH103CCT	**QUANTUM MECHANICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic concepts of quantum mechanics.
Course Objectives	The objective is to introduce the fundamental principles of quantum mechanics. Students will be exposed to 1. formulation and postulates of quantum mechanics. 2. applications of quantum mechanics and spherically symmetric potentials. 3. symmetry in quantum mechanics and identical particles 4. approximation methods, scattering theory and relativistic quantum mechanics.
Course Outcomes	The successful students will be able to know the theoretical concepts of quantum mechanics and to apply its principles to physical problems.

Module	Content of Course	Hours
	Quantum Mechanics	
1	**Formalism:** Linear vector spaces, Hilbert space, Dimension and basis of a vector space, Square-integrable functions, Dirac notation, Operators, Commutators, Representation in discrete and continuous bases. **Postulates of Quantum Mechanics:** Wave function and its relation to the state vector, Probabilistic interpretation of the wave function and its normalization, Probability current density and continuity equation, Superposition principle, Observables and operators, Expectation values, measurement and uncertainty relations, Time-dependent and Time-independent Schrödinger equations, Acceptable solutions of Schrödinger equation.	**15**
2	**Applications of Quantum Mechanics:** Finite and infinite square well potentials, Tunnelling through a barrier, Linear harmonic oscillator, 3D-box potential, 3D- harmonic oscillator. **Spherically Symmetric Potentials:** Central potential, Orbital angular momentum, Angular momentum algebra, Eigenvalues and eigenfunctions of orbital angular momentum, Spin angular momentum, Stern-Gerlach experiment, Spin algebra, Pauli spin operators and matrices, Addition of angular momenta, Clebsch-Gordon coefficients, Rigid rotator, Hydrogen atom.	**15**
3	**Symmetry in Quantum Mechanics:** Symmetry operations and unitary transformations, Conservation laws; ***Continuous symmetries****:* Space and time translations, rotation; ***Discrete symmetries***: Space inversion, Time reversal and charge conjugation, Symmetry and degeneracy. **Identical particles**: Identicality versus indistinguishability, Identical particles in classical and quantum mechanics, Exchange symmetry and degeneracy, Symmetric and anti-symmetric wave functions, Inclusion/Incorporation of spin, Slater determinants, Symmetrization postulate, Pauli exclusion principle, Bose and Fermi-statistics.	**15**
4	**Approximation methods:** ***Time-independent Approximation Methods***: Time independent (Non-degenerate and degenerate) perturbation theory and its applications, Stark effects, Spin-orbit coupling and fine structure, Zeeman effect, Variational method and its applications, WKB approximation and its applications.	**15**

	Time-dependent Approximation Methods: Time dependent perturbation theory, Fermi's Golden rule, Selection rules, Beta decay, Semi classical theory of interaction of atoms with radiation. **Scattering Theory**: Differential and total scattering cross-sections, Scattering amplitude of spinless particles, Phase shifts, Partial waves analysis (for elastic and inelastic scatterings), Born approximation (for low and high energies). **Relativistic quantum mechanics**: *Lorentz invariance*, Klein-Gordon Equation, Dirac equations, Positive and negative energy states, Significance of negative energy states and antiparticles.	

Textbook	Nouredine Zettili, *Quantum Mechanics Concepts and Applications*, John Wiley & Sons Inc. (2022). B. H. Bransden and C. J. Joachain, *Quantum Mechanics*, Pearson Education (2004).
Reference Book	L. I. Schiff, *Quantum Mechanics*, McGraw Hill McGraw-Hill Book Company (1968). J. J. Sakurai, *Advanced Quantum Mechanics*, Pearson Education (1967).

Course Code	Course Name	L	T	P	C
MSPH104CCT	**Electronics-I**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basics of electronics, electronic devices, and their applications.
Course Objectives	The objective is to build a circuit from individual components. Students will be exposed to designing new circuits using electronic components.
Course Outcomes	The successful students will be able to assemble analog and digital components to make new circuit.

Module	Content of Course	Hours
	ELECTRONICS-I	
1	**Regulated Power Supply**: Basic Principle of regulated power supply: Zener regulator and its working, Transistorized Series regulator, fixed IC voltage regulators using IC 78XX and 79XX, variable IC regulators with LM317 and LM338. **Feedback in Amplifiers**: The concept of feedback, Positive and Negative feedback, feedback gain, Advantages of Negative feedback in amplifiers, Emitter follower, Darlington pair. **Oscillators:** Barkhausen Criterion, RC oscillators: Phase shift Oscillator, Wein Bridge Oscillator, LC Oscillators: Hartley and Colpitts Oscillators, Crystal Oscillator.	**15**
2	**Operational Amplifiers:** Characteristics of Ideal operational Amplifier, Block diagram of an IC operational Amplifier, Emitter coupled differential amplifier and its transfer characteristics. Analysis of inverting amplifier, Non-inverting amplifier, Integrator, Differentiator, summing amplifier, Difference amplifier, Comparator, Logarithmic amplifier and exponential amplifier, Square wave, Rectangular wave and Triangular wave generators. **Timer IC 555:** Working of IC 555, Astable and Mono-stable Multi-vibrator with IC 555.	**15**
3	**Logic Circuits:** Min terms and Max terms simplification of Boolean equations- sum of products and product of sums- Karnaugh Maps (upto 4 variables), Data selector/ Multiplexer, Decoder/ De-multiplexer **Flip-Flops:** RS, D, JK and M/S JK flip flops with their truth tables, timing diagrams. **Registers:** Types of Registers, Serial in Serial out, Serial in Parallel out, Parallel in Serial out and Parallel in Parallel out Registers. **Counters:** Asynchronous and Synchronous Counters, Modulus N Counter, Ripple Counter, Decade Counter using Flip-Flops and IC's 7490, 7493	**15**
4	**Microprocessor:** Introduction to Microprocessors, Architecture of 8085 microprocessor, Instruction set Data transfer instructions, Arithmetic Logic and Branch operations, Interrupts, Simple Assembly language programming: 8-bit addition, 8-bit subtraction, 8-bit multiplication, Ascending and descending arrangement of given numbers.	**15**

Textbook	D. P. Leach, A. P. Malvino and G. Saha, *Digital Principles and Applications*, 8th Edition, McGraw Hill Education (2014). R. S. Gaonkar, *Microprocessor architecture, programming and applications with the 8085*, 6th Edition, Penram International Publishers (2013).
Ref. Book	J. Millman, C. Halkias and C. D. Parikh, *Integrated Electronics* - Analog and Digital Circuit and Systems, 2nd Edition, McGraw Hill Education (2017).

Course Code	Course Name	L	T	P	C
MSPH150CCP	**General Physics Laboratory-I**	**0**	**0**	**6**	**3**

Expt. No.	List of Experiments
1	Determination of Stefan's constant
2	Characteristics of a Thermistor
3	Specific Heat of Graphite
4	Linear Expansion of the given Material
5	Ultrasonic Velocity of a liquid by Interferometer
6	Ultrasonic Velocity of water/ kerosene by Debye-Sear’s Method
7	Viscosity of Water by oscillating disc method
8	Viscosity of castor oil by oscillating disc method
9	Young's Modulus Y of the material of the spiral spring
10	Rigidity Modulus of the material of the spiral spring
11	Determination of adiabatic compressibility of organic liquids using Ultrasonic interferometer
12	Thermal diffusivity of the given material

Course Code	Course Name	L	T	P	C
MSPH151CCP	**Electronics Laboratory-I (Analog Electronics)**	**0**	**0**	**6**	**3**

Expt. No.	List of Experiments
1	RC-Coupled Amplifier (Single - Stage)
2	Square Wave Generator (IC-741)
3	Wein-Bridge Oscillator (IC-741)
4	Astable Multivibrator (IC-555)
5	Regulated Power Supply (IC-78 XX)
6	Voltage Controlled Oscillator (IC-555)
7	Integrator (IC-741)
8	Schmitt Trigger/Zero Cross Detector
9	RC Phase Shift Oscillator (IC-741)
10	UJT (Relaxation Ocillator)

SEMESTER-II					
Course Code	**Course Name**	**L**	**T**	**P**	**C**
MSPH201CCT	Electromagnetic Theory	3	1	0	4
MSPH202CCT	Statistical Mechanics	3	1	0	4
MSPH203CCT	Solid State Physics	3	1	0	4
MSPH204CCT	Electronics-II	3	1	0	4
MSPH250CCP	General Physics Laboratory-II	0	0	6	3
MSPH251CCP	Electronics Laboratory-II	0	0	6	3
	Total	**12**	**4**	**12**	**22**

Course Code	Course Name	L	T	P	C
MSPH201CCT	**ELECTROMAGNETIC THEORY**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic concepts of electromagnetic theory.
Course Objectives	The objective is to introduce the fundamental principles of electromagnetic theory. Students will be exposed to 1. concepts of fields and forces in electrodynamics and magnetodynamics, 2. basic understanding of electromagnetic waves, guided electromagnetic waves, electromagnetic radiation, and relativistic electrodynamics and their applications.
Course Outcomes	The successful students will be able to explain and solve problems based on classical and relativistic electrodynamics.

Module	Content of Course	Hours
	Electromagnetic Theory	
1	**Electrostatics:** Electric field, Electric potential, Gauss's law and its applications, Electric dipoles, Electric quadrupole and multipoles, Energy density in electrostatic fields. **Electric fields in Matter:** Dielectrics and Conductor, Polarization, Bound charges, Electric displacement, Electrostatic boundary conditions. Linear dielectrics. **Electrostatic Boundary-Value Problems:** Laplace and Poisson equations, Uniqueness Theorem, Green Theorem, Method of Images, Multiple expansions.	**15**
2	**Magnetostatics:** Lorentz force law, Magnetic force on current element, Continuity equation, Biot-Savart law, Ampere's law, Magnetic scalar and vector potentials, multipole expansion of the vector potential. **Magnetic fields in Matter:** Magnetization, Bound currents, Magnetic field intensity, Energy in a magnetostatic field Magnetostatic boundary conditions. Magnetic materials. **Electrodynamics:** Faraday's law of induction, Displacement current, Continuity equation for time-varying fields, Generalized Ampere's law, Maxwell's equations, differential and integral forms, physical significance of Maxwell's equations. Maxwell's equations in free space and linear isotropic media. Boundary conditions on the fields at interfaces. Scalar and vector potentials, Gauge invariance. Lorentz gauge and Coulomb gauge	**15**
3	**Electromagnetic Waves:** Electromagnetic waves in free space, dielectrics, and conductors. Skin depth. Poynting's theorem, electromagnetic energy, momentum, and radiation pressure. Polarization of electromagnetic waves. Coherence. Reflection and refraction at dielectric interfaces. Fresnel's law, Total internal reflection, and Brewster's angle.	**15**
4	**Guided Electromagnetic waves:** Transmission lines, Wave guides, Propagation modes in wave guides, resonant modes in cavities. **Electromagnetic Radiation:** Radiation from a moving point charge and oscillating electric and magnetic dipoles. Retarded potentials. Lienard-Wiechert potential. Dynamics of charged particles in static and uniform electromagnetic field. Dispersion relations in Plasma. **Relativistic Electrodynamics:** Lorentz transformations, four vectors, Transformation of electric and magnetic fields, Invariance of Maxwell's equations	**15**

Textbook	David J. Griffiths, *Introduction to Electrodynamics*, Cambridge University Press (2023)
Ref. Book	J. D. Jackson, *Classical Electrodynamics*, John Wiley (Asia) (1999).

Course Code	Course Name	L	T	P	C
MSPH202CCT	**STATISTICAL MECHANICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic concepts of statistical mechanics.
Course Objectives	The objective is to introduce the fundamental principles of Statistical Mechanics. Students will be exposed to 1. the concept of temperature and how to calculate it. 2. give an exposure to various statistical ensembles and their applications in physics. 3. get familiar with the foundations and applications of quantum statistics.
Course Outcomes	The successful students will be able to explain and solve problems based on classical and relativistic electrodynamics.

Module	Content of Course	Hours
	Statistical Mechanics	
1	**Equilibrium Thermodynamics** Review of Laws of thermodynamics and thermodynamic potentials – Microstates and Macrostates of classical and quantum systems – Phase space – μ-space and Γ-space – Density of states – Expression for density of states in energy space and momentum space – Introduction to Ensembles – Ensemble average – Principle of a priori probability – Thermodynamic probability – Boltzmann entropy relation-Liouville's theorem – Equilibrium solutions.	**15**
2	**Microcanonical and Canonical Ensembles** Introduction – Microcanonical distribution – Microcanonical Average – Entropy (S) – Derivation of S = k log W – Entropy of a Perfect Gas in a Microcanonical Ensemble – Gibbs Paradox – Thermodynamic Quantities in Microcanonical Ensemble. Introduction – Canonical Distribution – Canonical Average – Canonical Ensemble Partition Function – Importance of the Canonical Ensemble Partition Function – Maxwell Velocity Distribution – Maxwell Energy Distribution – Most Probable Velocity – Mean Kinetic Energy – Thermodynamic Function – Classical System in a Canonical Ensembles – Ideal Gas – Microcanonical versus Canonical Ensembles.	**15**
3	**Grand Canonical Ensemble** Introduction – Grand Canonical Distribution – Grand Canonical Average – Grand Canonical Partition Function – Quantum Statistics – Thermodynamic Functions in Grand Canonical Ensemble – Classical System – Ideal Gas in Grand Canonical Ensemble – Density and Energy Fluctuations – Comparison of Various Ensembles.	**15**
4	**Quantum Statistics** Need for Quantum Statistics – Difference between classical and quantum statistics – Identical Particles – Bosons and Fermions – Symmetric and anti-symmetric wave functions – Difference between Bose-Einstein and Fermi-Dirac statistics – Calculating the partition function for Bosons and Fermions – Derivation of Bose-Einstein and Fermi-Dirac distributions – Definition of thermal wavelength – Bose-Einstein Condensation - Applications – Black body radiation (Bose system) – Fermi gas at low temperature – Fermi momentum.	**15**

Textbook	F. Reif, Fundamental of Statistical and Thermal Physics, McGraw-Hill, USA, 1965 K. Huang, Statistical Mechanics, Wiley, India, 2^{nd} Edition, 2011.
Ref. Book	R. K. Pathria and P. D. Beale, Statistical Mechanics, Academic Press, USA, 2011. L. D. Landau and E. M. Lifshitz, Statistical Physics, UK, 3^{rd} Edition, 1980.

Course Code	Course Name	L	T	P	C
MSPH203CCT	SOLID STATE PHYSICS	3	1	0	4

Course Description	The course will cover the principles and techniques of solid state physics.
Course Objectives	The objective is to provide an understanding of structure, thermal, electrical and magnetic properties of matter. Students will be exposed to formulate basic models for electrons and lattice vibrations, the relationship between band structure and the electrical/optical properties of a material.
Course Outcomes	The successful students will be able to explain and solve problems of solid state physics.

Module	Content of Course	Hours
	Solid State Physics	
1	**Crystal Structure** Bravais lattices – primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell, Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; Crystal Structures: basis, crystal class, point group-Space group (information only) – Common crystal structures: NaCl, CsCI, ZnS, and Diamond - Packing density - HCP and CCP; Reciprocal lattice and Brillouin zone; Atomic scattering factor and crystal structure factor of BCC, FCC, Diamond and polyatomic lattices – Explanation of experimental methods for crystal diffraction (Laue, Rotation and Powder)	**15**
2	**Lattice Vibrations and Thermal Properties** Vibration of crystals with monoatomic lattices and diatomic lattices, acoustical and optical modes, long wavelength limits - Derivation of force constants; Quantization of lattice vibrations –Phonon momentum – Inelastic scattering of neutrons by phonons; Normal modes and phonons; Density of modes in one-dimension and three- dimension – Lattice heat capacity – Einstein model – Debye model of the lattice heat capacity – Anharmonic effects in crystals – Thermal conductivity – Thermal Resistivity - Umklapp process.	**15**
3	**Free Electron Theory, Energy Bands and Semiconductor Crystals** Energy levels and density of orbitals – Fermi-Dirac distribution – Free electron gas in three- dimensions - Heat capacity of the electron gas – Electrical conductivity and Ohm’s law - Motion in magnetic fields –Hall effect – Thermal conductivity of metals – Wiedemann-Franz law – Nearly free electron model – Origin of the energy band gap –Bloch functions – Kronig –Penny model; Classification of metal, semiconductor and insulator - Semiconductors – Bandgap – Properties of holes - effective mass in semiconductors - Intrinsic carrier concentration.	**15**
4	**Magnetic Properties of Solids** Origin of magnetism; Langevin theory of diamagnetism and Paramagnetism; Quantum theory of paramagnetism; Weiss theory - Hund’s rules - Quenching of orbital angular momentum; Cooling by adiabatic demagnetization; Pauli paramagnetism; Ferromagnetism: Curie-Weiss law, Temperature dependence of saturation magnetization – Heisenberg’s exchange interaction – Magnons - Ferromagnetic domains – Origin of domains – Coercive force and hysteresis; Ferrimagnetism and antiferromagnetism.	**15**

Textbook	C. Kittel, *Introduction to Solid State Physics*, 8th Edition (Wiley Eastern, New Delhi, 2012)
Ref. Book	A. J. Dekker, *Solid State Physics*, (Macmillan India, 2000).

Course Code	Course Name	L	T	P	C
MSPH202CCT	ELECTRONICS-II	3	1	0	4

Course Description	
Course Objectives	
Course Outcomes	

Module	Content of Course	Hours
	Electronics-II	
1		15
2		15
3		15
4		

Textbook	
Ref. Book	

Course Code	Course Name	L	T	P	C
MSPH250CCP	**General Physics Laboratory-II**	**0**	**0**	**6**	**3**

Expt. No.	List of Experiments
1	Determination of Cauchy's Constants
2	Determination of wavelength of Na light using a diffraction grating
3	Double refraction
4	Banded spectrum
5	Newton's rings - determination of Poisson's ratio
6	Fresnel Biprism - determination of wavelength of Na light
7	Malus law
8	Michelson's interferometer
9	Single slit diffraction
10	Double slit diffraction
11	Determination of wavelength of laser
12	Thickness of thin film using Fresnel biprism or Michelson interferometer
13	Fibre Optics: Characteristics of LED and Phototransistor
14	Fibre optics: determination of numerical aperture

Course Code	Course Name	L	T	P	C
MSPH251CCP	**Electronics Laboratory-II (Digital Electronics)**	**0**	**0**	**6**	**3**

Expt. No.	List of Experiments
1	Construction and Verification of i) Logic Gates/Circuits (Using Nand Gates 7400) ii) AND, OR, NOT, NOR, NAND, EX-OR
2	Half-Adder & Full Adder
3	Flip-Flops: D-Type, T-Type, Jk- Flip Flop (IC-7496)
4	Peaking Amplifier
5	Logarithmic Amplifier
6	Colpitts oscillator

SEMESTER-III					
Course Code	**Course Name**	**L**	**T**	**P**	**C**
MSPH301DCT	Atomic and Molecular Physics	3	1	0	4
MSPH302DCT	Nuclear and Particle Physics	3	1	0	4
MSPH301DET	Computational Physics	3	1	0	4
MSPHXXXXX	Physics of Renewable Energy Systems (GEC-I)	3	1	0	4
MSPH301DEP	Computational Physics Lab	0	0	6	3
MSPH301DCP	Advanced Physics Laboratory-I (Atomic and Nuclear Physics Lab)	0	0	6	3
	Total	**12**	**4**	**12**	**22**

Course Code	Course Name	L	T	P	C
MSPH301DCT	**Atomic and Molecular Physics**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic ideas of atomic and molecular physics.
Course Objectives	The objective is to introduce the fundamental principles of atomic and molecular physics.
Course Outcomes	The successful students will be able to apply quantum mechanics and extract information from one electron and many-electrons atoms and molecules.

Module	Content of Course	Hours
1	**One-electron atoms:** Schrodinger equation for one-electron atoms, Hydrogen atom spectrum. **Interaction of one electron atoms with electromagnetic radiation**: Transition rates, The dipole approximation, The Einstein coefficients, Selection rules and spectrum of one electron atoms, Line intensities and the lifetimes of the excited states, Line shapes and widths.	**15**
2	**One-electron atoms- fine structure and hyperfine structure:** Fine structure of hydrogenic atoms, Relativistic corrections to Kinetic energy, Spin-orbit interaction energy, Darwin term, Lamb shift, Hyperfine structure and isotopic shift. **Interaction of one electron atoms with external electric and magnetic fields:** Zeeman, Paschen-Bach and Stark effects.	**15**
3	**Many electron atoms:** Central field approximation, Thomas-Fermi model of the atom, Hartree- Fock method and the self-consistent field, L-S coupling and j-j coupling, Introduction to the Density functional theory. **Interaction of many electron atoms with electromagnetic radiation and with static electric and magnetic fields**: Many electron atoms in an electromagnetic field, spectra of the alkalis.	**15**
4	**Molecular structure**: Born-Oppenheimer approximation, Electronic structure of diatomic molecule, The rotation and vibration of diatomic molecules, Nuclear spin. **Molecular spectra**: Rotational spectra of diatomic molecules, Vibrational-rotational spectra of diatomic molecules, Electronic spectra of diatomic molecules, Raman spectra of diatomic molecules The Franck-Condon principle. **Applications of atomic and molecular physics:** Electron spin resonance. Nuclear magnetic resonance, and chemical shift.	**15**

Textbook	B.H. Bransden and C.J. Joachain, *Physics of atoms and molecules*, Pearson, 2003. .
Reference Book	Peter Atkins and Ronald Friedman, *Molecular Quantum Mechanics*, Oxford University Press, 2012.

Course Code	Course Name	L	T	P	C
MSPH302DCT	**Nuclear and Particle Physics**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic concepts of nuclear and particle physics.
Course Objectives	The objective is to introduce the fundamental principles of nuclear and particle physics.
Course Outcomes	The successful students will be able to know the theoretical concepts of nuclear forces, models, decay, and reactions and the interaction of high-energy particles.

Module	Content of Course	Hours
1	**Nuclear properties**: Nuclear size, nuclear radius, charge distribution, mass, binding energy, stability and abundance of nuclei, angular momentum (spin), magnetic dipole moment, electric quadrupole moment, parity and isospin. **Nuclear forces**: Deuteron (ground and excited states), spin dependence of nuclear forces, nucleon-nucleon scattering, form of nucleon-nucleon potential, charge symmetry and charge independence of nuclear forces, exchange nature of nuclear forces, Yukawa's theory.	**15**
2	**Nuclear models**: Liquid drop model, semi-empirical mass formula, shell model, magic numbers, and collective model. **Nuclear decay**: Radioactive decay, alpha, beta, and gamma decay, and their selection rules, Gamow theory, Fermi theory, neutrino and antineutrino. **Nuclear Reactions:** Nuclear reactions, reaction mechanism, direct and compound nuclear reaction mechanisms, compound nucleus, nuclear fission and fusion, nuclear reactor.	**15**
3	**Particle Physics**: **Elementary Particle**: Fundamental forces/interaction, Elementary particles and their classifications, **symmetries and conservation laws:** Continuous space time symmetries, conservation laws of momentum, energy, angular momentum, Lorentz invariance, Discrete Symmetries, Parity, Charge conjugation and Time reversal, quantum numbers, Application of symmetry arguments to particle reactions, Gell Mann Nishijima formula.	**15**
4	**The Standard Model:** Parity non-conservation of weak interaction, Wu's experiment, an elementary idea of electroweak unification, Higgs boson and origin of mass, quark model, the concept of color charge, discrete symmetries, properties of quarks and leptons, gauge symmetry in electrodynamics, particle interactions and Feynman diagrams. Relativistic kinematics.	**15**

Textbook	W. E. Burcham and M. Jobes, *Nuclear and particle Physics*, Prentice Hall (1994) .
Reference Book	K.S. Krane, *Introductory Nuclear Physics*, John Wiley (2008) D. J. Griffiths, *Introduction to Elementary Particles*, John Wiley & Sons Inc. (2008)

Course Code	Course Name	L	T	P	C
MSPH301DET	**Computational Physics (SEC-I)**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic ideas of scientific programming, numerical and simulation techniques .
Course Objectives	The objective is to incorporate modern computational skills into the scientific problem solving paradigm.
Course Outcomes	The successful students will become familiar with commonly used computational techniques to solve problems in physics.

Module	Content of Course	Hours
1	Computer organization, hardware, software. Scientific programming in FORTRAN and/or C, C++. Introduction to Matlab	**15**
2	**Numerical Techniques I** **Roots of functions**: Bisection method, Newton-Raphson method, Secant method, fixed-point iteration, applications; **Linear equations**: Gauss and Gauss-Jordan elimination methods, Gauss-Seidel iteration method, LU decomposition; **Eigenvalue Problem**: Power method, Inverse power method; **Numerical interpolation, extrapolation and fitting of data:** Polynomial interpolation and extrapolation, cubic spline interpolation, fitting data to a straight line, examples from experimental data fitting.	**15**
3	**Numerical Techniques II** **Numerical differentiation**: forward, backward and centred difference formulae; **Numerical Integration:** Trapezoidal, Simpson and Gaussian quadrature methods**,** **Solutions of ODE**: Initial value problems, Euler's method, second and fourth order Runge-Kutta methods; **Boundary value problems**: finite difference method, applications.	**15**
4	**Simulation Techniques:** Monte Carlo methods, molecular dynamics, density functional theory, simulation methods for the Ising model and atomic fluids, simulation methods for quantum-mechanical problems, time-dependent Schrödinger equation. Langevin dynamics simulation.	**15**

Textbook	K. E. Atkinson, *Numerical Analysis*, John Wiley (Asia) (2004) J.M. Thijssen, *Computational Physics*, Cambridge University Press (2007)
Reference Book	S. S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning (2012)

Course Code	Course Name	L	T	P	C
MSPH30XXXX	Physics of Renewable Energy Systems (GE-I)	3	1	0	4

Course Description	The course will cover the basics of various renewable energy resources and energy generation using different methods.
Course Objectives	The objective is to introduce the fundamentals of renewable energy resources and their applications.
Course Outcomes	The successful students will be able to understand the various types of energy sources and their usage.

Module	Content of Course	Hours
1	**Energy Scenario and Solar Energy:** Global and Indian energy scenario and energy policy, Commercial and noncommercial forms of energy, Fossil Fuels, Renewable sources, Impact of energy systems on environment, Need for use of new and renewable energy sources, Solar thermal and solar photovoltaic energy	**15**
2	**Wind and Geothermal Energy:** **Wind Energy**: Basics- Global circulation, Forces influencing wind-pressure gradient force and Coriolis force, Local and regional wind systems, **Geothermal Energy:** Geothermal tidal and wave energy, Geothermal regions, geothermal sources, Geothermal energy conversion technologies	**15**
3	**Hydrogen Energy and Fuel cells:** **Hydrogen Energy**-production and storage, Production processes: Thermo chemical, Water splitting, Gasification, Pyrolysis methods. Electro-chemical, Electrolysis, Photo electro chemical. General storage methods, Compressed storage, Zeolites, Metal hydride storage, Chemical hydride storage and cryogenic storage. **Fuel cells-** Thermodynamics and performance of fuel Cells, its working, construction, classifications and applications.	**15**
4	**Biomass and Nuclear Energy:** **Biomass Energy**: Biomass energy and application, Techniques for biomass assessment, Thermochemical conversion of biomass, Mini/micro hydro power: classification of hydropower schemes, **Nuclear Energy**: Fission, Fusion, Different type of nuclear reactors, Nuclear waste disposal and environment measures.	**15**

Textbook	J. Twidell and T. Weir, *Renewable Energy Resources*, Taylor and Francis, USA, (2006)
Reference Book	Aldo Vieira da Rosa, *Fundamentals of Renewable Energy Processes*, Elsevier Academic Press, UK (2005)

Course Code	Course Name	L	T	P	C
MSPH301DEP	**COMPUTATIONAL PHYSICS LAB**	**0**	**0**	**6**	**3**

Course Description	The course will cover the applications of computational techniques.
Course Objectives	The objective is to teach computational techniques and apply these methods to solve problems in physics.
Course Outcomes	The successful students will be able to write the numerical algorithms and implementing these algorithms through a computer Programme.

Expt. No.	List of Experiments	Hours
1	Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Euler method.	
2	Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Runge Kutta method.	
3	Write a MATLAB script for the numerical solution of damped pendulum	
4	Write a MATLAB script to simulate the planetary motion of earth around the sun.	
5	Write a MATLAB script to simulate the motion of two coupled harmonic oscillators.	
6	Write a MATLAB script to simulate the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method, and to draw graphs between current and time in each case.	
7	Write MATLAB script to simulate the decay of radioactive nucleus.	
8	Write a MATLAB script to simulate the random walk.	
9	Write a MATLAB script to simulate the Ising model of a ferromagnet.	
10	Write a MATLAB script to solve time dependent Schrodinger equation in 1D for particle in a box problem.	

Course Code	Course Name	L	T	P	C
MSPH301DCP	**ADVANCED PHYSICS LABORATORY-I** (Atomic and Nuclear Physics Laboratory)	**0**	**0**	**6**	**3**

Expt. No.	List of Experiments	Hours
1	Recording of Hydrogen Spectra	
2	Zeeman effect	
3	Gamma Ray Spectrometer (Energy resolved)	
4	Alpha particle spectrometer (Energy resolved)	
5	Radiation Counter for Alpha and Beta Particle (ZnSe for Alpha and Plastic scintillation counter for beta particle)	
6	Radiation Counter for Gamma and Beta Particle	
7	Finding the Plateau region of GM Tube	
8	Alpha particle counter (only for alpha particle)	
9	Compton Scattering	

SEMESTER-IV					
Course Code	**Course Name**	**L**	**T**	**P**	**C**
MSPH40XXXX	Modern Optics	3	1	0	4
MSPH40XXXX	Experimental Techniques in Physics	3	1	0	4
MSPH40XXXX	Environmental Physics (GEC-II)	3	1	0	4
MSPH40XXXX	Seminar and Project	3	0	0	3
MSPH40XXXX	Special Paper	3	1	0	4
MSPH40XXXX	Special Paper Lab	0	0	6	3
	Total	12	0	12	22

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**MODERN OPTICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic concepts of modern optics.
Course Objectives	The objective is to provide comprehensive knowledge of optical science and its applications.
Course Outcomes	The successful students will become familiar with the working principles and applications optics.

Module	Content of Course	Hours
1	**Geometrical Optics**: Fermat's Principle, Ray equation and its solutions, and applications. **Electromagnetic theory of optics**: Maxwell's equations and propagation of electromagnetic waves, reflection and refraction, total internal reflection, and evanescent waves.	**10**
2	**Polarization**: Polarization, various states of polarization and their analysis. Anisotropic media, plane waves in anisotropic media, birefringence, uniaxial crystals, some polarization devices. **Interference:** Concept of Coherence, Interference by division of wavefront and division of amplitude, Stoke's relations, Non-reflecting films, Michelson interferometer; Fabry-Perot interferometer and etalon.	**10**
3	**Diffraction**: Fraunhofer diffraction: Single slit, circular aperture; limit of resolution. Diffraction grating, Resolving power. Fresnel diffraction: Half-period zones and the zone plate. Diffraction of a Gaussian beam. **Fourier Optics**: Basics of Fourier transformation, spatial frequency and transmittance function, Fourier transform by diffraction and by lens, spatial-frequency filtering, and some applications; Holographic principles, on-axis and off-axis holograms, types of holograms and some applications.	**15**
4	**Lasers:** Laser principles, interaction of radiation and matter, Einstein coefficients, condition for amplification. Optical resonators, Condition for laser oscillation. Longitudinal and transverse modes of a laser. Some Laser Systems, and applications **Fiber optics:** Light propagation in optical fibers, fiber communication, attenuation and dispersion, single and multi-mode fibers, fiber amplifiers and lasers, fiber optic sensors.	**15**
5	**Nonlinear Optics**: Nonlinear optical media, second order nonlinear optics, third order nonlinear optics anisotropic nonlinear media, optical parametric amplification and oscillation, optical phase conjugation, dispersive nonlinear media.	**10**

Textbook	Eugene Hecht, *Optics*, Pearson, 2021.
Reference Book	Bahaa E. A. Saleh and Malvin Carl Teich, *Fundamentals of Photonics*, John Wiley & Sons, 2019.

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**EXPERIMENTAL TECHNIQUES IN PHYSICS**	**3**	**1**	**0**	**4**

Course Description	The course will cover the fundamental concepts of experimental techniques utilized in the fields of applied physics.
Course Objectives	The objective is to acquire knowledge about different experimental techniques.
Course Outcomes	The successful students will understand and learn about different experimental facilities.

Module	Content of Course	Hours
1	**Vacuum Generation and Measurement Techniques:** Introduction to vacuum, gas law; Rotary vane pump, Turbomolecular pump, Cryopump; Pirani gauge, Penning gauge. **Fundamentals of Synthesis and Fabrication of Materials:** Classification of powders; Synthesis of powders: Sol-gel, Hydrothermal, Combustion techniques; Synthesis of thin films: Spin coating, Dip coating, Thermal and electron beam evaporation, Pulsed laser deposition; General concept of lithography, Photolithography, Electron beam lithography; Clean room.	**15**
2	**Introduction to Basic Measurements and Characterization Techniques:** ***Study of Crystal Structure****:* X-ray diffraction (XRD), Transmission Electron diffraction (TED), ***Microscopic Techniques****:* Optical Microscopes (Bright field, Confocal, Super-resolution), Scanning Electron Microscope, Transmission Electron Microscope, Scanning Probe Microscopes. ***Spectroscopic Techniques****:* UV-Vis, Fluorescence, IR and FTIR, Photo-Acoustic, Laser Induced Breakdown, Raman, Twyman-Green interferometer as a special case of Michelson Interferometer for testing of optical components, Lateral shearing interferometers and its applications such as testing. Collimation of a lens, laser speckle techniques and its applications.	**20**
3	**Surface and Compositional Analysis Methods**: EDAX, XPS. **Dielectric Characterization**: Complex impedance spectroscopy, Analysis of Nyquist plot, Various RC network schemes, Analysis of CV curves, ac conductivity, Charging-discharging cycle of capacitors	**10**
4	**Electrochemical Measurements**: Different potentiometric /galvanometric techniques. Methods for studying electrical, magnetic, thermal properties. **Low Temperature Methods:** Temperature measurement and control; Cryostats and cooling methods. **Accelerator and Fusion Techniques:** Pelletron, Linear accelerator, Cyclotron, Synchrotron, Tokamac; Applications in High energy physics, Materials science and Particle therapy.	**15**

Textbook	A.Roth, *Vacuum Technology*, Oxford University Press, 1998. M. Ohring, *The material science of thin films*, Academic Press, 1992 Guozhong Cao, *Nanostructures and Nanomaterials - Synthesis, Properties and Applications*, World Scientific, 2004

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**ENVIRONMENTAL PHYSICS (GEC-II)**	**3**	**1**	**0**	**4**

Course Description	The course will cover the fundamental concepts of environmental Physics.
Course Objectives	The objective is to understand the broad scope of problems to which the principles of environmental physics can be applied.
Course Outcomes	The successful students will understand the concepts of energy transformations and microclimatology of radiation and its effect on living beings.

Module	Content of Course	Hours
I	The Scope of environmental physics, properties of gases and liquids	**10**
II	Transport of heat, mass, and momentum, transport of radiant energy, radiation environment	**15**
III	Microclimatology of Radiation I: Radiative Properties of Natural Materials, Radiation Interception by Solid Structures	**20**
IV	Microclimatology of Radiation II: Interception by Plant Canopies and Animal Coats	**15**

Textbook	John L. Monteith and Mike H. Unsworth, *Principles of Environmental Physics*, Academic Press 2013.
Reference Book	Egbert Boeker and Rienk Van Grondelle, *Environmental Physics*, John Wiley & Sons, 2019.

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**SEMINAR AND PROJECT**	**3**	**0**	**0**	**3**

Course Description	The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.
Course Objectives	The objective is to make students familiar with the approach to conducting literature survey, capable of independent thinking, and learn basic techniques for carrying out research.
Course Outcomes	The successful students will be able to understand the basic of literature review techniques used for performing research, analyze the results and tabulate them in a proper manner and how to write and dissertation, making presentation and viva voce.

Module	Content of Course	Hours
Guidelines	1. Projects would be allotted to students which have to be carried out and completed in M.Sc. (3rd Sem). 2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest. 3. The project will comprise of the following: a. Collection of data, procurement and fabrication of experimental set up and writing of computer programs if needed. b. Writing a dissertation or project report. This will be submitted by the M.Sc. (Final) students in the first week of May. c. Giving a preliminary seminar before the final presentation for the purpose of internal assessment whose weight age would be 25%. 4. The final evaluation of the project work completed will be done by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report. 5. The weight age of the final evaluation would be 75%.	
Evaluation	The evaluation will be done by an external examiner. External examiner will award the grades based on quality of research work done recorded in dissertation and presentation made by student.	

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**MATERIAL SCIENCE**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic ideas of materials and their properties.
Course Objectives	The objective is to give a comprehensive knowledge about the materials.
Course Outcomes	The successful students will understand the various properties and applications of materials.

Module	Content of Course	Hours
1	**Introduction:** Material and its classifications, Electron Energy Bands, and Chemical Bonds. **Materials Processing**: Functionality driven material; Extraction, synthesis, processing, and characterization of materials.	**15**
2	**Structural Materials**: Introduction to Alloys, Ceramics, Polymers and Composites; Preparation, Processing and Applications; Elastic and Plastic deformation, Residual stress, Hardness, Fracture, Fatigue, strengthening and forming, fracture resistance, fatigue life, creep resistance. **Optical Materials**: Introduction to optical materials; Interaction of light with electrons in materials; Applications as dielectric coatings, electro-optical devices, optical recording, optical communications.	**15**
3	**Magnetic Materials**: Properties and processing of magnetic materials; Field, Induction, Magnetization and Hysteresis; Applications as Permanent magnets, Magnetic recording and sensing. **Electronic Materials**: Si as material for microelectronics and photovoltaic, preparation, processing and applications; III-V and II-VI semiconductors and optoelectronic applications; Thermoelectric materials, figure of merit, thermoelectric generators and refrigerators; Superconducting Materials and properties, applications including magnets, magneto-encephalography, Josephson junction, SQUID; Conducting Polymers, synthesis and applications; Ferroelectric materials, piezoelectricity and applications; Shape memory alloys and applications.	**15**
4	**Energy storage materials**: Batteries, principles of electrochemistry; Primary and secondary (rechargeable) batteries and materials; Fuels cells; Ultracapacitors. **Biomaterials:** Requirements like absence of toxicity, corrosion resistance, biocompatibility; Metal, ceramic and polymer biomaterials; bio-resorbable and bio-erodible polymers; Applications as implants, and prosthesis.	**15**

Textbook	Traugott Fischer, *Materials Science for Engineering Students*, Academic Press 2009.
Reference Book	J.W. Morris, Jr., *The Structure and Properties of Materials*, McGraw Hill,2005..

Course Code	Course Name	L	T	P	C
MSPH40XXXX	**GRAVITATION AND COSMOLOGY**	**3**	**1**	**0**	**4**

Course Description	The course will cover the basic principles of gravitation and cosmology.
Course Objectives	The objective is to introduce the concepts of gravitation and cosmology.
Course Outcomes	The Successful students will be able to grasp various physical aspects of gravity and cosmology.

Module	Content of Course	Hours
1	**Preliminary discussions**: Review of special theory of relativity, vector and tensor, particle dynamics, electrodynamics, energy momentum tensor, relativistic hydrodynamics. **Principle of equivalence**: Statement of the principle, gravitational forces, geodesic–affine connection, Newtonian limit.	**15**
2	**Tensor analysis**: Tensor algebra, tensor density, transformation of affine connection, covariant differentiation, gradient, divergence, curl, parallel transport. **Curvature**: curvature tensor, Bianchi identity, Ricci tensor, curvature scalar, Killing vectors and symmetries.	**15**
3	**Einstein's field equation**: Derivation of field equation, Schwarzschild solution, Birkhoff's theorem, geodesic equation in Schwarzschild space time, Precession of perihelion of mercury, bending of light rays, gravitational red shift. **Stellar equilibrium and collapse**: Differential equation for stellar structure, White dwarfs, neutron stars, comoving coordinates, Schwarzschild blackholes, collapse to a blackholes.	**15**
4	**Gravitational radiation**: Propagation, detection, and generation of gravitational waves, energy carried away by gravitational waves. **Universe**: Friedmann-Robertson-Walker solution, our Universe. **Cosmology**: Models of the universe and the cosmological principle, Cosmological metrics, Types of universe, Robertson-Walker universes, Big Bang, Dark energy.	**15**

Textbook	Steven Weinberg, *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*, John Wiley & Sons, 2013.
Reference Book	Bernard Schutz, *A First Course in General Relativity*, Cambridge University Press, 2009.