M.Sc. Physics

(Syllabus: Semester I to IV)

Semester-I

1. **Subject Code: MSPH 101** — **Course Title: Mathematical Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DCC
8. Pre-requisite: NIL
9. Objective: The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Complex analysis & Vector Analysis:** Real and complex numbers; Euclidean space; Function of a complex variable; Analytic functions; Cauchy's theorem; calculus of residues and applications. Advanced vector calculus; multiple integrals, Introduction to tensors.	**12**
2.	**Linear Vector Space:** A brief review of linear vector spaces, Inner product, norm, Schwarz inequality, linear operators, eigenvalue and eigenvector, adjoint of a linear operator, Hermitian or self-adjoint operators and their properties, unitary operators, orthonormal basis –discrete and continuous.	**8**
3.	**Linear Differential Equations & Special Functions:** Series solutions of ordinary differential equations; ordinary, regular and irregular singular points; Gamma function; Special functions (Legendre, Bessel, Laguerre, Hermite); **Partial Differential Equations:** Classification of PDE's and boundary conditions; method of separation of variables; A brief review of Fourier and Laplace transforms, Dirac delta functions;	**14**
4.	**Elements of Group Theory:** Definitions and examples of a group; subgroup, cosets, conjugate classes, invariant subgroups and factor group; isomorphism and homomorphism; Permutation groups; Representations of a group, Reducible and irreducible representations, orthogonality relations; Topological groups and Lie groups, SO(2), SO(3), Lorentz group, Generators of U(n) and SU(n), SU(2), SU(3).	**8**
	Total	**42**

Suggested Books

S. No.	***Name of Books/ Authors***	**Year of publication/ Reprint**
1.	*Mathematical Physics* by V.Balakrishnan	Ane Books Pvt. Ltd.
2.	*Mathematical Methods for Physicists* by Arfken	
3.	*Advanced Engineering Mathematics* by Kreyzig	8th Edition, Wiley India (P.) Ltd.
4.	*Group Theory and its Applications to Physical Problems* by M Hammermash	Dover Publications; Reprint edition (December 1, 1989)
5.	*Vector Analysis and an introduction to Tensor Analysis* by Murray R Spiegel	McGraw-Hill; 1 edition (June 1, 1968)
6.	*Linear Algebra* by Seymour Lipschutz & Marc Lars Lipson	McGraw-Hill Education; 5 edition (16 December 2012)
7.	*Complex Variables with an introduction to Conformal Mapping and its Applications* by Murray R Spiegel, Seymour Lipschutz, John J. Schiller, Dennis Spellman	McGraw-Hill Education; 2 edition (17 May 2009)

1.	**Subject Code: MSPH 103**	**Course Title: Classical Mechanics**
2.	Contact Hours:	L: 3 T: 1 P: 0
3.	Examination Duration (Hrs):	Theory: 3 Practical: 0
4.	Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5.	Credits:	4
6.	Semester:	ODD
7.	Subject area:	DCC
8.	Pre-requisite:	NIL
9.	Objective:	To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics. To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamilton formulation of classical mechanics.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Basic Principles of Classical Dynamics:** Newton's laws and symmetries. Generalized coordinates and types of constraints on dynamical systems, D'Alembert principle and Euler-Lagrange equation of motion, Variational calculus, Lagrangian and Hamiltonian formalisms and equations of motion for central forces, electromagnetic forces, coupled oscillators and other simple systems; Poisson brackets and canonical variables; Jacobi Identity.	**12**
2.	**Transformations:** Canonical Transformations, generator of infinitesimal canonical transformations, Symmetry, invariance and conservation laws, cyclic coordinates; Phase space trajectories, Liouville's theorem, Hamilton-Jacobi theory, Action-angle variables.	**10**
3.	**Center of mass and Laboratory problems and Small Oscillations:** Kepler problem. Perturbation and precessing orbits. The classical scattering problem. Small oscillations (non-diagonal kinetic and potential terms).Small Oscillations, normal coordinates, and its application to chain molecules and other problems, Degrees of freedom for a Rigid Body, Euler angles, Rotating Frame, Coriolis force, Foucault's pendulum, Eulerian Coordinates and equation of motion for a rigid body, motion of the symmetrical top.	**12**
4.	**Special relativity**: Internal frames. Principle and postulate of relativity. Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Four- vector notation. Energy-momentum four-vector for a particle. Relativistic invariance of physical laws.	**8**
	Total	**42**

<u>Suggested Books</u>

S. No.	Name of Books/ Authors
1.	*Mechanics by Landau and Lifshitz*
2.	*Classical Mechanics by Goldstein*
3.	*Classical Mechanics by Rana and Jaog*
4.	*Classical Mechanics by J. W. Muller- Kirsten*
5.	*Classical Mechanics of particles and Rigid Bodies by K.C. Gupta*

1. **Subject Code: MSPH 105** — **Course Title: Quantum Mechanics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: Odd
7. Subject area: DCC
8. Pre-requisite: NIL
9. Objective: This course aims at providing an elementary introduction to the basic principles of (non-relativistic) Quantum Mechanics, its wave-mechanical and matrix-mechanics formulations, and its applications to simple problems.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Problems with classical physics: double-slit experiment: quantum mechanical wave function and Born interpretation, A brief review of problems involving Schrodinger equation in one dimension (box potential, potential barrier and tunneling, potential well), Hydrogen atom: Schrodinger equation for a particle moving in a central force field, energy levels and eigenvalues, bound states.	**08**
2.	**Linear Vector and Representation Theory**: Linear vector space, Dirac notations of Bra - Ket notation, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schrödinger and Heisenberg pictures.	**10**
3.	**Theory of Angular Momentum and Many-particle Physics:** Quantum theory of angular momentum: Raising and lowering operators, eigenvalues and eigenfunctions, Spin angular momentum, Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations, addition of angular momenta and Clebsch-Gordon coefficients, Pauli spin matrices. Many-particle Schrodinger wave equation; Identical particles: Physical meaning of identity, Principle of indistinguishability and its consequences, Exchange operator, Symmetric and anti-symmetric wave functions, Connection between spin, symmetry and statistics, Pauli exclusion principle and Slater determinant; Application to the electronic system of the helium atom (para- and ortho helium).	**14**
4.	**Approximation Methods:** Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases, Variational method and applications to helium atom and simple cases; WKB approximation and applications to simple cases. Time dependent Perturbation theory, Fermi’s Golden rule, Semi-classical theory of interaction of atoms with radiation.	**10**
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Quantum Mechanics by L. I. Schiff*	McGraw-Hill; 3 Rev Ed edition (1968)
2.	*Modern Quantum Mechanics by J. J. Sakurai*	Pearson Education (LPE), 2017
3.	*Introduction to Quantum Mechanics by C.J. Joachain and B.H. Bransden*	Longman Scientific & Technical / John Wiley & Sons Inc., New York, 1989
4.	*Quantum Mechanics: Concepts and Applications by N. Zettili*	Wiley, 2009
5.	*Introduction of Quantum Mechanics by D.J. Griffiths*	Cambridge University Press, 2016
6.	*Principles of Quantum Mechanics by P.A.M.Dirac*	Oxford University Press ,1958
7	*Principles of Quantum Mechanics, R Shankar*	Springer, 1994
8.	*Lectures on Quantum Mechanics by Ashoke Das*	Hindustan Book Agency, 2003
9.	*Quantum Mechanics by John L. Powell and B. Crasemann*	Published by Addison-Wesley, 1965

1. **Subject Code: MSPH 107** — **Course Title: Applied Optics**
2. Contact Hours: L : 3 T : 1 P : 0
3. Examination Duration (Hrs.): Theory : 3 Practical : 0
4. Relative Weight: CWS : 25 PRS : 0 MTE : 25 ETE : 50 PRE : 0
5. Credits: 4
6. Semester: ODD
7. Subject Area: DCC
8. Pre-requisite: Nil
9. Objective: To provide foundations in the advanced topics of Optics and some applications in Science and Engineering
10. Details of Course:

1st Semester

S. No.	Contents	Contact Hours
1.	E. M. Waves in a medium: Review of Maxwell's equations and propagation of electromagnetic waves, reflection and refraction of electromagnetic waves, total internal reflection and evanescent waves. Various states of polarization and their analysis, Anisotropic media, Plane waves in anisotropic media, Wave refractive index, Uniaxial crystals, some polarization devices.	**12**
2.	Diffraction: Scalar waves, The diffraction integral, Fresnel and and Fraunhofer diffraction, Single-slit, Double Slit, Diffraction grating, Circular aperture, Resolving power, Diffraction of a Gaussian beam	**10**
3.	Fourier Optics: Basics of Fourier transform operation, Definition of spatial frequency and transmittance function, Fourier transform by diffraction and by lens, Spatial frequency filtering, types of filters, Abbe-Porter experiments, phase-contrast microscope. Holography: Principle of holography, On-axis and off-axis hologram recording and reconstruction, Types of hologram and some applications.	**10**
4.	Coherence and Interferometry: Basics of coherence theory, spatial and temporal coherence, fringe visibility, Michelsonstellar interferometer, Optical beats, Multiple beam interference, The Fabry-Perot interferometer, and its application to spectral analysis. Fourier transform spectroscopy, Laser speckles.	**10**
	Total	**42**

Suggested Books

S. No.	Name of Books/Authors	Year of Publication/ Reprint
1.	*Applied Optics and Optical Design by A. E. Conrady*	New edition, (21 February 1992) Dover Publications Inc.
2.	*Fourier Optics: An Introduction by E. G. Steward*	2nd edition (30 July 2004), Dover Publications Inc.;
3.	*Fundamentals of Photonics by by Bahaa E. A. Saleh and Malvin Carl Teich*	2nd edition (13 April 2007), Wiley-Blackwell
4.	*Optics by Ajoy Ghatak*	Sixth edition (1 July 2017), McGraw Hill Education India Private Limited

1. **Subject Code: MSPH 109**	**Course Title: Electronics**	
2. Contact Hours:	L: 3 T: 1 P: 0	
3. Examination Duration (Hrs):	Theory: 3	Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0	
5. Credits:	4	
6. Semester:	ODD	
7. Subject area:	DCC	
8. Pre-requisite:	NIL	
9. Objective:	To make students familiar with basic and advanced analog and digital electronics used in circuit and instrument designing. To provide practical knowledge, electronics based design problems are included.	

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Basics of Semiconductor Electronics:** Intrinsic and extrinsic semiconductors, charge densities in p and n type semiconductors, conduction by charge drift and diffusion, the pn-junction, energy level diagrams of pn-junction under forward and reverse bias conditions, derivation of pn-diode equation, Zener and avalanche breakdowns, The bipolar junction transistor basic working principle, configurations and characteristics, Transistor hybrid model, h parameters, Analysis of a Transistor amplifier circuit using h parameters, Hybrid π model, Ebers-Moll model.	12
2.	**Field Effect Transistor:** Field-Effect Transistors (FET) Structure, Working, Construction and characteristics of JFET, transfer characteristic, The FET small signal model, Measurement of gm and rd, JFET fixed bias, Self-bias and voltage divider configurations, JFET source follower (Common-Drain) configuration, JFET Common-Gate configuration.	10
3.	**Operational Amplifier Basic and Applications:** OP Amp, ideal characteristics, op amp as inverting amplifier, effect of finite open loop gain, generalized basic equation of op amp with impedances, integrator and differentiator, inverting and non-inverting summer, voltage follower. Op Amp parameters, offset voltage and current, slew rate, full wave BW, CMRR. OP AMP as voltage regulator, fixed and variable 3 pin regulator, switching regulator.	10
4.	**Digital Electronics and its Application:** Multiplexer, Demultiplexer, Decoder, Encoder, Latches, Flip flops-SR, JK, D, T, and Master Slave –characteristics table and equation-clock timing Diagrams, Edge Triggering-Level Triggering-Realization of one flip Flop using other Flip flops. Shift register, Buffer Registers, Controlled Buffer Registers, Bidirectional shift registers, serial and parallel configuration. Shift register Counters - Ring counter, Johnson counter, Asynchronous ripple or serial counter- Asynchronous Up/Down counter - Presettable Counter, Synchronous counters- Synchronous Up/Down Counter - Decade Counter, Programmable counters.	10
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Electronic Devices and Circuits by Milman and Halkins*	
2.	*Solid State Electronic Devices by Ben G. Streetman*	Seventh Edition, 2015
3.	*Electronics Devices and Circuit theory by Boylested and Nashelsky*	
4.	*Op- Amp and Linear Integrated Circuit by Ramakant A. Gayakwad*	
5.	*Digital Principles and Implementation by A.P. Malvino and D.P. Leach*	

PHYSICS LAB-1: MSPH 111

List of Experiments:

1. To build a Flip- Flop Circuits using elementary gates. (RS, Clocked RS, D-type).
2. To study and verify the operation of 3 to 8-line decoder and 4 to 1-line multiplexer (74138, 74153).
3. Design and set up the BJT CE amplifier using voltage divider bias with and without feedback and determine the gain bandwidth product from its frequency response.
4. Designing of a differentiator using op-amp for a given specification and study its frequency response.
5. To measure the spot size and divergence of a laser beam.
6. To determine the resolving power of a plane transmission grating.
7. To determine the dimensions of a rectangular aperture by its Fraunhofer diffraction pattern.
8. To determine the wavelength of laser source using Michelson's interferometer.
9. Study of Cs-137 spectrum and calculation of FWHM & resolution of given scintillation detector.
10. Study of Co-60 spectrum and calculation of resolution of detector in term of energy.
11. Spectrum analysis of Cs-137 & Co-60 and to explain some of the features of Compton edge and backscatter peak.
12. Measurement of Half value thickness and evaluation of Mass absorption coefficient.

Semester-II

1. Subject Code: MSPH 102 — **Course Title: Advance Quantum Mechanics**

2. Contact Hours:	L: 3 T: 1 P: 0
3. Examination Duration (Hrs):	Theory: 3 Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits:	4
6. Semester:	EVEN
7. Subject area:	DCC
8. Pre-requisite:	Knowledge of basic relativistic quantum mechanics.
9. Objective:	The aim of the course is to introduce students to the basics of relativistic quantum mechanics, classical and quantum field theories, and quantum theory of radiation.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Relativistic Quantum Mechanics:** Introduction, Klein-Gordan (KG) equation: Plane wave solution, Probability and current densities, KG equation with electromagnetic potentials; Energy levels in a Coulomb field (Hydrogen atom problem). Difficulties of KG equation, Dirac's relativistic equation: Free particle solutions, Dirac matrices and spinors, Probability and current densities, Dirac equation with electromagnetic potentials, Dirac equation for a central field, Existence of spin angular momentum, spin - orbit energy. Energy levels of Hydrogen atom and their classification (Lamb shift).	**12**
2.	**Field Quantization:** Introduction, Classical and Quantum field equations: Coordinates of the field, Time derivatives, Classical Lagrangian equation, Classical Hamiltonian equations; Quantum equation of the field, Field with more than one component, Complex field, Quantization of the non-relativistic Schrödinger equation (Second quantization): Classical Lagrangian and Hamiltonian equations, Quantum field equations, The N representation, Creation, Destruction and Number operators for Bosons and Fermions, Connection with the many particles Schrödinger equation.	**10**
3.	**Quantization of Relativistic Fields and Feynman Diagrams:** Natural system of units, Quantization of K-G field, Dirac field and Electromagnetic fields (in vacuum); Lagrangian equations, quantum equations, quantized field energy. Interacting fields and Feynman Diagrams: Introduction, Normal product, Dyson and Wick's chronological products, Contraction, Wick's theorem, Electromagnetic Coupling, The Scattering Matrix, Power series expansion of S-matrix, Scattering processes up to second order.	**10**
4.	**Quantum theory of radiation:** Classical radiation field, Transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillators, Creation, Annihilation and Number operators, Photon states, Photon as a quantum mechanical excitations of the radiation field, Fluctuations and the uncertainty relation, Validity of the classical description, Matrix element for emission and absorption, Spontaneous emission in the dipole approximation, Rayleigh scattering, Thomson scattering and Raman effect, Radiation damping and Resonance fluorescence.	**10**
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Quantum Mechanics by L. I. Schiff*	McGraw-Hill; 3 Rev Ed edition (1968)
2.	*Advance Quantum Mechanics by J. J. Sakurai*	Addison-Wesley, 1967
3.	*Principles of Quantum Mechanics by P.A.M.Dirac*	Oxford University Press ,1958
4.	*Quantum Mechanics by V. K. Thankappan*	New Age International, 1993.
5.	*Quantum Mechanics by A. P. Messiah*	Dover Publications, 2017
6.	*Introduction to Quantum Mechanics by C.J. Joachain and B.H. Bransden*	Longman Scientific & Technical / John Wiley & Sons Inc., New York, 1989
7	*Advanced Quantum Mechanics by B. S. Rajput*	Pragati Prakashan, 1994
8.	*An Introduction to Relativistic Quantum Mechanics by Schweber*	Harper & Row, 1961

1. **Subject Code: MSPH 104** **Course Title: Statistical Mechanics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: EVEN
7. Subject area: DCC
8. Pre-requisite: Knowledge of basic quantum mechanics.
9. Objective:

This course is intended to provide a firm foundation to students in a very fundamental subject of Statistical Mechanics which aims to derive the macroscopic behaviour of a system in terms of the mechanics of its microscopic constituents, and finds application in almost all branches of Physics.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Classical Statistical Mechanics:** Foundations of Statistical Mechanics: The macroscopic and microscopic states, Postulate of equal a priori probability, Contact between statistics and thermodynamics; Ensemble theory: Concept of ensemble, Phase space, Density function, Ensemble average, Liouville's theorem, Stationary ensemble; The microcanonical ensemble, Application to the classical ideal gas; The canonical and grand canonical ensembles, Canonical and grand canonical partition functions, Calculation of statistical quantities; Thermodynamics of a system of non-interacting classical harmonic oscillators using canonical ensemble, and of classical ideal gas using grand canonical ensemble, Energy and density fluctuations; Entropy of mixing and the Gibbs paradox, Sackur-Tetrode equation.	**12**
2.	**Quantum Statistical Mechanics:** Quantum-mechanical ensemble theory: Density matrix, Equation of motion for density matrix, Quantum-mechanical ensemble average; Statistics of indistinguishable particles, Two types of quantum statistics- Fermi-Dirac and Bose-Einstein statistics, Fermi-Dirac and Bose-Einstein distribution functions using microcanonical and grand canonical ensembles (ideal gas only), Statistics of occupation numbers; Ideal Bose gas: Internal energy, Equation of state, Bose-Einstein Condensation and its critical conditions; Bose-Einstein condensation in ultra-cold atomic gases: its detection and thermodynamic properties; Ideal Fermi gas: Internal energy, Equation of state, Completely degenerate Fermi gas.	**10**
3.	**Non-Ideal Systems:** Cluster expansion method for a classical gas, Simple cluster integrals, Mayer-Ursell relations, Virial expansion of the equation of state, Van der Waal's equation, Validity of cluster expansion method; Phase transitions: Construction of Ising model, Solution of Ising model in the Bragg-William approximation, Exact solution of the one-dimensional Ising model; Critical exponents, Landau theory of phase transition, Scaling hypothesis.	**10**
4.	**Fluctuations:** Thermodynamic fluctuations and their probability distribution law, Spatial correlations in a fluid, Connection between density fluctuations and spatial correlations; Brownian motion, the Langevin theory of the Brownian motion (derivations of mean square displacement and mean square velocity of Brownian particle), Auto-correlation function and its properties, The fluctuation-dissipation theorem, Diffusion coefficient; the Fokker-Planck equation; Spectral analysis of fluctuations: the Wiener-Khintchine theorem.	**10**
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Statistical Mechanics by R. K. Pathria*	Academic Press; 3 edition, 2011
2.	*Statistical Mechanics by R. K. Pathria and P. D. Beale*	Academic Press; 3 edition, 2011
3.	*Statistical and Thermal Physics by F. Reif*	McGraw-Hill, 1965
4.	*Statistical Mechanics by K. Huang*	Wiley; Second edition, 2008
5.	*Statistical Mechanics by L. D. Landau and I. M. Lifshitz*	Butterworth-Heinemann, 1980
6.	*Statistical Mechanics by R. Kubo*	North-Holland **Publishing** Company, Amsterdam, 1965

1. **Subject Code: MSPH 106** **Course Title: Computational Methods**
2. Contact Hours: L : 3 T : 1 P : 0
3. Examination Duration (Hrs.): Theory : 3 Practical : 0
4. Relative Weight: CWS : 25 PRS : 0 MTE : 25 ETE : 50 PRE : 0
5. Credits: 4
6. Semester: EVEN
7. Subject Area: DCC
8. Pre-requisite: Nil
9. Objective: To familiarize the students with the numerical techniques to solve the problems related to science and engineering

10. Details of Course:

S. No.	**Contents**	**Contact Hours**
1.	*Errors in numerical calculations*: Introduction, Number and their accuracy, Errors and their analysis, Absolute, Relative, Percentage and Maximum probable error, Physical significance of errors, General error formula *Solution of numerical algebraic and transcendental equation*: Roots of equations, Direct method and iteration method, Bisection method, Regula Falsi Method or Method of False position, Secant or Chord method, Newton-Raphson method, *Solution of simultaneous linear algebraic equation*: Gauss-elimination method, Gauss-Jordon elimination method, Power method, Jacobi method for finding eigen values, Rotation Matrix, Method of triangularization, Relaxation Method	**12**
2.	*Interpolation:* Introduction, Errors in polynomial Interpolation, Finite differences, Detection of errors by use of difference tables, Differences of a polynomial, Interpolation with equally spaced data points: Newton's forward and backward formulae for interpolation, Central difference: Gauss forward, Gauss Backward, Stirling, Bessels, Everett's formula for interpolation, Interpolation with unequally data points: Lagrange's interpolation formula, Divided differences and their property, Newton Divided differences formula	**12**
3.	*Numerical Differentiation and Integration*: Numerical Differentiation formula to find out derivative using data table, maximum and minimum values of a tabulated data, Numerical integration, Newton-cotes integration formulae, trapezoidal method, Simpson's 1/3-rule, Simpson's 3/8-rule, Boole's and Weddle's Rule, Romberg integration, , Euler-Maclaurin formula, Gaussian integration, Numerical double integration	**10**
4.	*Numerical solution of ordinary differential equations*: Introduction, solution by Taylor's series, Picard's method of successive approximation methods, Euler's method, modified Euler's method, Runge-Kutta method, predictor-corrector method, solution of second order and simultaneous differential equations, Application of optimization and variational methods to problem of interest in applied physics	**08**
	Total	**42**

Suggested Books

S. No.	***Name of Books/Authors***	***Year of Publication/ Reprint***
1	*Numerical Methods for Engineers by Steven C. Chapra and Raymond P Canale*	*1998/ McGraw-Hill International Editions*
2	*An Introduction to Computational Physics by Tao Pang*	*2010/Cambridge University Press*
3	*Numerical Methods for Engineers and Scientists by Amos Gilat*	*2008/John Wiley & Sons*
4	*Applied Numerical Analysis by Gerald and Wheatley*	*2003/Pearson*
5	*Numerical methods for Scientific and Engineering Computation by Jain Iyengar and Jain*	*2009/New Age*

1. **Subject Code: MSPH 108** **Course Title: Electrodynamics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: EVEN
7. Subject area: DCC
8. Pre-requisite: NIL
9. Objective: To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them various practical situations

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Maxwell`s equations and Electromagnetic wave propagation:** Maxwells equations. Continuity Equation. Lorentz force. Poynting theorem. Conservation of energy and momentum. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauge. Fresnel's laws of reflection and refraction, surface impedance of metals, wave propagation in plasmas, electromagnetic waves in wave guides, anomalous dispersion and negative refractive index.	10
2.	**Relativistic formulation of Maxwell's equations:** Review of Special Theory of Relativity (STR) and its application to electromagnetic theory: Conceptual basis of STR. Four-vectors, Tensors. Lorentz transformation as 4-vector transformations. Transformation properties of electric and magnetic fields. E.M. field tensor. Covariance of Maxwell's equations (from tensorial arguments).	12
3.	**Relativistic and Non-Relativistic Charged Particle Dynamics in Electromagnetic Fields:** Motion in uniform static magnetic field, uniform static electric field and crossed electric and magnetic fields. Particle drifts (velocity and curvature) in non-uniform static magnetic fields.	8
4.	**Radiation:** Green function for relativistic wave equation. Radiation from localized oscillating charges. Near and far zone fields. Multipole expansion. Dipole and quadrupole radiation. Centrefed linear antenna. Radiation from an accelerated point charge. Lienard-Wiechert potentials. Power radiated by a point charge: Lienard's formula and its nonrelativistic limit (Larmor's formula).	12
	Total	42

Suggested Books

S. No.	*Name of Books/ Authors*	Year of publication/ Reprint
1.	*Classical Electrodynamics* by John David Jackson	3rd Ed.,Wiley, 1998
2.	*Introduction to Electrodynamics* by David Griffiths	3rd Ed.., Benjamin Cummings, 1999
3.	*Principles of Electrodynamics* by Melvin Schwartz.	Dover Publications, 1987
4.	*Classical Electrodynamics by* J. Schwinger, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J. Norton	Westview Press, 1998
5.	*Modern Problems in Classical Electrodynamics* by Charles A. Brau.	Oxford Univ. Press, 2003
6.	*Electrodynamics of Continuous Media* by L. D. Landau and E. M. Lifshitz & L. P. Pitaevskii	Oxford, 2005

1. **Subject Code: MSPH 110**	**Course Title: Solid State Physics**	
2. Contact Hours:	L: 3 T: 1 P: 0	
3. Examination Duration (Hrs):	Theory: 3	Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0	
5. Credits:	4	
6. Semester:	EVEN	
7. Subject area:	DCC	
8. Pre-requisite:	Nil	
9. Objective:	The aim of this course is to familiarise students with basic concepts of solid state physics such as crystal structure, symmetry, lattices, bonding, free electron theory, density of states, magnetism and superconductivity in solids and apply these properties of solids in various scientific and engineering aspects.	

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Crystallography:** Crystalline and amorphous solids, crystal lattice, Basis vectors, Unit cell, Symmetry operations, Point groups and space groups, Three-dimensional crystal systems, Miller indices, Directions and planes in crystals, Inter-planar spacings, Simple Crystal structures, NaCl, CsCl, Diamond, ZnS and HCP structure, Determination of lattice SC, BCC, FCC, construction of reciprocal lattices, diffraction conditions, Laue equations, Miller indices, relation between miller indices of family of planes, X-ray diffraction by crystals. Laue theory. Interpretation of Laue equations. Bragg's law. Reciprocal lattice. Ewald construction. Atomic scattering factor, structure factor of BCC, FCC, diamond and polyatomic lattice, Experimental methods of x-ray diffraction and applications.	**12**
2.	**Bonding and Imperfections in solid:** Types of bonding, ionic, covalent and Metallic bond, cohesive energy of inert gas solids, cohesive energy and bulk modulus of ionic crystals, Medelung constant, types of imperfections, shear strength of crystals, dislocations, illustration of types of dislocation, burger's vector, role of dislocation in crystal growth, low angle grain boundaries, Experimental method of detecting dislocations and stacking faults.	**10**
3.	**Electronic states of solids:** Review of Sommerfeld model, Boltzmann transport equation, thermodynamic properties due to free electrons, band structure, concept of hole and electrons, Bloch's theorem, density of states, nearly free electron approach and pseudopotentials, electron wave equation in periodic crystal potential, solution of zone boundary and near zone boundary, orbitals in bands, semiconductors and insulators, kronig-penny model, Brillion zones.	**10**
4.	**Magnetism and superconductivity**: Origin of magnetism, Magnetic properties of solids, Diamagnetism, Langevin equation, Quantum theory of paramagnetism, Curie law, Paramagnetism in rare earth and iron group ions, Elementary idea of crystal field effects, Ferromagnetism, Curie-Weiss law, Heisenberg exchange interaction, Anti-ferromagnetism, Neel point, occurrence of superconductivity, Meissner effect, London equation, BCS ground state and energy gap, high temperature superconductors.	**10**
	Total	**42**

Suggested Books:

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Introduction to Solid State Physics* by C. Kittle,	8^{th} edition Wiley, 2005
2.	*Elements of Solid State Physics* by J.P. Srivastava,	PHI, 2015
3.	*Solid State Physics* by A.J. Dekker,	Macmillan, 2008
4.	*Solid State Physics* by Ashcroft and Mermin	Cengage Learning, 1976
5.	*Elementary Solid State Physics by* Ali Omar,	4^{th} edition, Addison Wesley, 1994
6.	*Introduction to Material Science and Engineering by* W.J. Callister Junior.	John Wiley &Sons Inc, 2000
7.	Solid State Physics by S.O. Pillai	Wiley Eastern Ltd, 1994

PHYSICS LAB-II: MSPH 112

List of Experiments:

1. To determine the Curie temperature of ferrite core and find out loss in energy.
2. To determine the Hall coefficient, type of charge carrier and carrier concentration of a given semi-conductor.
3. To measure the resistivity of a Ge/Si semiconductor using four probe method at different temperature and find its band gap.
4. To investigate the Lattice dynamic for mono-atomic and diatomic chains.
5. Write a Matlab program to find the roots of the equation by bisection method. Compare the result with the Matlab inbuilt function.
6. Write the Matlab program to solve the second order differential equation for solving the pendulum problem.
7. Write Matlab code to plot the intensity distribution of single-slit, double -slit and N-slit all together. Analyze the result. Show how young’s double slit experiment is different from the double slit diffraction.
8. Write Matlab code to show the propagation of group wave as a function of time.
9. Study the characteristics of a G.M. tube and determination of its operating voltage, plateau length/ slope etc.
10. Estimation of efficiency of the G.M. detector for a) Gamma source 7 b) Beta source.
11. To study the backscattering of Beta particles and gamma rays.
12. Study of energy resolution characteristics of a scintillation spectrometer as a function of applied high voltage and to determine the best operating voltage.

Semester-III

2. Subject code: **MSPH 201**	Course title**: Atomic and Molecular Physics**
2. Contact Hours:	L: 3 T: 1 P: 0
3. Examination Duration (Hrs):	Theory: 3 Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits:	4
6. Semester:	ODD
7. Subject area:	DCC
8. Pre-requisite:	NIL
9. Objective:	The aim of this course is to introduce students with the concepts of atomic and molecular physics with their applications

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Review of solution of Schrodinger's equation for Coulomb field and Hydrogen atom, Bohr-Sommerfeld theory of Hydrogen Atom, Angular momentum & Parity, Dipole approximation, Magnetic dipole moments, Electron spin and Vector atom model, Spin orbit Interaction, Stern-Gerlach experiment, Hydrogen fine structure, identical particles & Pauli's principle , Spectroscopic Terms and selection rules, Intensities of spectral lines.	**10**
2.	Fine structure of Hydrogen like atoms: Spin-Orbit Interaction, Relativistic Correction, Lamb Shift. Interaction with External Fields- Zeeman Effect, Paschen-Back and Stark effects. Many-electron atoms- LS-coupling approximation, J-J coupling, Hyperfine structures, Lande Interval rule. The idea of Hartree-Fock equations. The central field approximation, Thomas Fermi-potential, Alkali Atom Spectra, Na doublet. X-ray spectra, Fine structure in X-ray Emission Spectra, Electron spin resonance (ESR), Nuclear magnetic resonance (NMR).	**12**
3.	Born-Oppenheimer Approximation, Rotational spectroscopy: Rigid rotor, Rotational spectra of diatomic molecules, Intensities of spectral lines, Isotope effects, Non-Rigid Rotator, Rotation levels of polyatomic molecules: spherical, symmetric, and Asymmetric top molecules. Vibrational spectroscopy: Vibration of diatomic molecules, Harmonic oscillator and Anharmonic oscillator, Vibrational-rotational couplings, Vibration of polyatomic molecules.	**10**
4.	Electronic spectroscopy: Electronic spectra of diatomic molecules, vibrational coarse structure, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of Electronic-Vibration transition, Production of excited state, Radiative processes. Selection rules, Frank-Condon principle, Jablanski diagram and qualitative treatment of small molecule and large molecule limit for nonradiative transitions, Raman Effect. Idea of Symmetry elements and point Groups for diatomic and polyatomic molecules.	**12**
	Total	42

Suggested Books:

S. No.	**Name of Books/ Authors**	**Year of publication/ Reprint**
1.	Introduction to Atomic Spectra, by Harvey Elliott White	McGraw-Hill 1934
2.	Elementary Atomic Structure by G.K. Woodgate	Mc Graw-Hill
3.	Molecular Spectra by G. Herzberg	
4.	*Fundamentals of Molecular Spectroscopy by C.N. Banwell*	
5.	*1.J.R. Lakowicz: Principles of fluorescence spectroscopy*	*Springer, 1983*
6.	*1.K. Shimoda : Introduction to Laser Physics*	

1. Subject code: **MSPH 203** Course title: **Nuclear and Particle Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge of basic properties of nuclei and nuclear structure, nuclear models, nuclear reactions and applications of nuclear physics. Capability of elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement results.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Two Nucleon Systems & Nuclear Forces:** Nuclear Mass & size determination, Mott scattering, nuclear formfactors. Angular momentum, spin, parity, iso-spin and moments of nuclei (Electric and Magnetic),Dipole and quadrupole moments of the deuteron, Central and tensor forces, Evidence for saturation property, Neutron-proton scattering, exchange character, spin dependence (ortho and para-hydrogen), charge independence and charge symmetry. S-wave effective range theory. Proton- proton scattering (qualitative idea only). Evidence for hardcore potential. Meson theory.	**12**
2.	**Nuclear Models & Nuclear Decays and Reactions:** Concept of Liquid drop model, Magic nuclei, nucleon separation energy, Single particle shell model (including Mean filed approach, spin orbit coupling), Physical concepts of the unified model (Collective Model), Selection rules, Fermi theory of beta decay. Kurie plot. Fermi and Gamow-Teller transitions. Logeft value, Parity violation in beta-decay. Gamma decay, selection rules, Introduction to Nuclear Reactions (Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section), Concept of Direct and compound nuclear reaction, Nuclear reactors.	**12**
3.	**Elementary particles:** Relativistic kinematics, Classification: spin and parity determination of pions and strange particles. Gell-Mann Nishijima scheme. Properties of quarks and their classification. Elementary ideas of SU(2) and SU(3) symmetry groups and hadron classification. Introduction to the standard model. Electroweak interaction-W & Z Bosons. .	**10**
4.	**Advance Detectors**: Interaction of radiation with matter (qualitative idea), Basics of Solid state detectors, Scintillation and gas detectors for particle and electromagnetic radiation detection. Idea of Calorimeter, Hybrid detectors and arrays, LIGO and INO..	**8**
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of Publication/
1.	*Introducing Nuclear Physics by K. S. Krane*	Wiley, 2008
2.	*Nuclear Physics – Theory & Experiments by R.R. Roy & B.P. Nigam*	New Age International, 2005
3.	*Nuclear Physics in A Nutshell by C. A. Bertulani*	1st Ed., Princeton University Press, 2007
4.	*Concept of Nuclear Physics by B. L. Cohen*	McGraw – Hill, 2003
5.	*Nuclear Physics by S. N. Ghoshal*	First edition, S. Chand Publication
6.	*Nuclear & Particle Physics : An Introduction by B. Martin*	Wiley, 2006
7	*Introduction to Elementary Particles by D. Griffiths*	Academic Press, 2nd Ed. 2008
8.	*Physics and Engineering of Radiation Detection by Syed Naeem Ahmed*	
9.	*Radiation detection and measurement, G.F. Knoll*	

11. Subject Code: **MSPH 207** Course Title: **Fibre and Integrated optics**
12. Contact Hours: L : 3 T : 1 P : 0
13. Examination Duration (Hrs.): Theory : 3 Practical : 0
14. Relative Weight: CWS : 25 PRS : 0 MTE : 25 ETE : 50 PRE : 0
15. Credits: 4
16. Semester: ODD
17. Subject Area: DSE
18. Pre-requisite: Nil
19. Objective: To familiarize the students with the guided wave characteristics of the optical fiber and waveguide.

20. Detail of the course

S. No.	Contents	Contact Hours
1.	Guided wave Optics, Guided Wave Structures, Ray analysis, Modes of planar waveguide, Physical understanding of modes. Electromagnetic mode theory for optical propagation, Modal analysis of planar step index waveguide	**10**
2.	Mode theory for optical fibers: step index fibers; Propagation characteristics of step index fibers, graded index fibers, Single Mode fibers and their characteristics, Fabrication of optical fibers	**10**
3.	Signal degradation on optical fiber due to dispersion and attenuation, Pulse dispersion in graded index optical fibers, Material dispersion, Waveguide dispersion and design considerations Optical Sources: LEDs and Laser diodes, Detectors for optical fiber communication	**10**
4.	Guide wave optical components, Directional coupler: coupled mode theory Integrated Optical devices: optical switches and wavelength filters, modulators, Fabrication and characterization of optical waveguides, prism-coupling technique	**12**
	Total	**42**

Suggested Books

S. No.	Name of Books/Authors	Year of Publication/ Reprint
1	A.K.Ghatak & K.Thyagarajan, "Optical Electronics",	Cambridge University Press (1989)
2	A.K.Ghatak & K.Thyagarajan, "Introduction to Fiber Optics”,	Cambridge University Press (1998).
3	G. Keiser, "Optical Fiber Communications	McGraw-Hill, Inc. (2012)
4	K Okamoto, "Fundamentals of optical waveguides",	Academic Press (2006)
5	A. Yariv and P. Yeh, "Photonics",	Oxford University Press (2007)
6	T. Tamir, “Integrated optics”,	Springer-Verlag
7	J.Gowar , “ Optical communication systems”,	Prentice Hall India

1. Subject code: **MSPH 209** — Course title: **Advanced Condensed Matter Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3+1 (T) Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DSE
8. Pre-requisite: Knowledge of basic solid-state physics
9. Objective: The aim of this course is to prepare students for undertaking somewhat advanced studies in Condensed Matter Physics. It emphasizes on, starting from magnetism to the consequences of going beyond the independent electron approximation and an exposure to the language of second quantization- the language used in condensed matter theory research. Finally, the basics of electronic structure calculation and its application to advanced material design.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Magnetism:** Mean field theory- Curie-Weiss law; Electrostatic origin of magnetic interactions, Magnetic properties of a two-electron system, Singlet-triplet (exchange) splitting in Heitler-London approximation; Spin Hamiltonian and the Heisenberg model; Crystal fields, origin of crystal fields, Exchange interaction, origin of exchange, direct exchange, indirect exchange in ionic solids and in metals, double exchange, Landau theory of ferromagnetism, Heisenberg and Ising models, Spin excitation, Magnons.	**10**
2.	**Second Quantization:** Second quantization for Fermions and Bosons, Review of Bloch's theorem, Metal-Insulator transition, Mott insulators, Hubbard model, spin and charge density waves, electrons in a magnetic field, Landau levels, integer quantum Hall effect.	**10**
3.	**Beyond the independent electron approximation:** The basic Hamiltonian in a solid: Electronic and ionic parts, Born-Oppenheimer Approximation; The Hartree equations, Connection with variational principle; Exchange: The Hartree-Fock approximation, Hartree-Fock theory of free electrons- One electron energy, Band width, DOS, Effective mass, Ground state energy, exchange energy, correlation energy (only concept).	**10**
4.	**Electronic Structure of Materials:** Density functional theory, Local density approximation and beyond LDA, The tight-binding method, APW method, OPW method, Pseudo-potential method, KKR method, LMTO method, The full-potential methods, Electron in disordered solids, Coherent potential approximation (KKR-CPA), Tight-binding molecular dynamics, Car-Parinello methods and its applications to clusters and amorphous semiconductors, Applications of electronic structure methods to materials design.	**12**
	Total	**42**

Reference Books:

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Introduction to Solid State Physics, C. Kittel*	Wiley India Edition, 2007
2.	*Solid State Physics, Neil W. Ashcroft and N. David Mermin*	Holt, Rinehart and Winston, 1976
3.	*Principles of the Theory of Solids, J. M. Ziman*	Cambridge University Press, 1972
4.	*Solid State Physics: An Introduction to Theory and Experiment. H. Ibach and H. Luth*	Springer Verlag; reprint edition, 1993
5.	*Quantum Theory of Solids, C. Kittel*	John Wiley & Sons Inc; New edition,1985
6.	*Condensed Matter Physics, M. P. Marder*	John Wiley & Sons, 2010
7.	*Many Particle Physics by G. D. Mahan*	Springer Science & Business Media, 2000
8.	*Advanced Solid-State Physics, Phillips*	Cambridge University Press, 2012
9.	*Lecture Notes on Electron Correlation and Magnetism, Patrik Fazekas*	World Scientific, 1999
10.	*Electronic Structure: Basic Theory and Practical Methods, Richard M Martin*	Cambridge University Press; 2008.

1. Subject code: **MSPH 213** Course titl**e: Advanced Numerical Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DSE
8. Pre-requisite: NIL
9. Objective: The aim of this course is to introduce students with the advanced numerical methods to solve the problems related to physics.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Classification of numerical problems, some important theorems: Superposition Principle, Uniqueness Theorem, Analytical Methods: Separation of Variables, Series Expansion Method	**8**
2.	Finite Difference Methods: Finite Difference Schemes for parabolic, hyperbolic and elliptic PDEs, Accuracy and Stability of finite difference solutions, Application to guided structures, Yee's Algorithm, Finite Differencing for nonrectangular systems, numerical integration, Finite difference time domain method, Split step Fourier method	**12**
3.	Variational Methods: Rayleigh Ritz Method, Weighted Residual Method, Collocation Method, Subdomain Method, Galerkin Method , Least Squares Method, Eigen Value problems	**10**
4.	Finite Element Method, Solution of Laplace's Equation, Poisson's and wave equation: Finite element discretization, element governing equations, assembling of all equations and solving resulting equations, automatic mesh generation, finite element methods for exterior problems Monte Carlo Methods, Generation of random numbers and variables, evaluation of error, numerical integration, Crude + 5Monte Carlo integration	**12**
	Total	**42**

Suggested Books:

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	Numerical Techniques in Electromagnetics by Matthew N.O. Sadiku	CRC Press (2011)
2.	Numerical Methods in Electromagnetism	Sheppard Salon and M. V. K. Chari
3.	Monte Carlo Methods for Electromagnetics	Matthew N.O. Sadiku
4.	Finite Difference Method	Allan Taflove

1. Subject code: **MSPH 215** Course titl**e: Plasma Physics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DSE
8. Pre-requisite: Basic understanding of plasma physics, study waves in plasma via different models and various plasma applications
9. Objective: Acquiring basic knowledge concerning: 1) plasma production and discharges, single particle motion; 2) electrostatic waves in plasma; 3) electromagnetic waves in plasma; 4) kinetic and fluid theory; 5) plasma applications.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Introduction to plasmas, dc plasma discharge, rf plasma discharge, microwave plasma production, surface ionization (Q-Machine), laser produced plasma, plasma measurements (density and temperature), Langmuir probe. Beam-plasma system (Schematic, electron gun design and operation, plasma production). Motion of a charged particle in electric and magnetic fields, electric field drifts, external force drifts, Magnetic moment and Adiabatic invariance, motion of charged particle in the presence of static inhomogeneous magnetic field–curvature and gradient drifts.	**12**
2.	Electrostatic Waves in unmagnetized Plasma (Langmuir waves, Ion acoustic waves and Electromagnetic waves). Electrostatic Waves in Magnetized Plasma (upper hybrid wave, lower hybrid wave, ion-acoustic wave, ion-cyclotron wave), energy flow in an electrostatic wave.	**08**
3.	Electromagnetic Waves in Magnetized Plasma (whistler waves, Alfven waves), Raleigh- Taylor instabilities, Kelvin Helmholtz instabilities, Weibel instabilities, Two stream instability (linear), Magneto-hydrodynamic instabilities. Korteweg-de Vries (KDV) equation and Nonlinear Schrödinger equation. Electromagnetic wave propagation in a magnetized plasma and Conductivity of a magnetized plasma (D.C. and A.C. conductivity).	**10**
4.	Introduction to Kinetic theory, Vlasov plasma model, Fluid model from kinetic model, electron plasma waves and Landau damping, solution of Vlasov equation. **Plasma Nanotechnologies**: Nanoparticles and dusty plasmas, Carbon Nanotubes (CNTs), Graphene & g-CNT hybrids. FEL: FEL Physics (motion in a wiggler magnetic field), Gain estimate and efficiency in Compton and Raman regime. CFEL: Cerenkov free electron laser interaction, electron-beam excitation of a slow wave, laser driven fusion and laser driven electron acceleration, Tokamak Confinement, Introduction to ITR.	**12**
	Total	**42**

Suggested Books:

S. No.	Name of Books/ Authors	Year of publication/ reprint
1.	Introduction to Plasma Physics and Controlled Fusion, F.F. Chen, Springer (1983)	1983
2.	Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, McGraw-Hill LTD (1986)	1986
3.	Laser Driven Fusion, Brueckner and Jorna, Rev. Modern Physics, Vol. 46(2), P.325, 1974.	1974
4.	Interaction of Electromagnetic Waves with Electron Beams and Plasmas, C.S. Liu and V.K. Tripathi, World Scientific Singapore (1994)	1994
5.	A Review of free electron lasers, C.W. Roberson and P. Sprangle, Physics of plasmas, 1(1)**,** P. 3, Jan 1989.	1989
6.	Free Electron Lasers by T.C. Marshall, Macmillan Publishing Co., New York (1985)	1985

1. Subject code: **MSPH 217** Course title: **Characterization Techniques**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: ODD
7. Subject area: DSE
8. Pre-requisite: NIL
9. Objective: The aim of this course is to introduce students with the basic concepts and principles of optical and electron microscopy, X-ray diffraction, thermogravimetric analysis, surface probe techniques and various spectroscopic techniques need to characterize the materials from bulk to nano scale associated to scientific and engineering aspects.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Diffraction Methods:** Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction. **Surface Analysis:** Atomic force microscopy (AFM), Magnetic force microscopy (MFM) scanning tunneling microscopy (STM), X-ray photoelectron spectroscopy (XRS/ESCA), Deep Level Transient Spectroscopy (DLTS).	**15**
2.	**Optical microscope -** Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarized light, Hot stage, Interference techniques), Stereomicroscopy.	**9**
3.	**Electron Microscopy:** Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.	**9**
4.	**Spectroscopy:** Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform, infrared spectroscopy, Raman spectroscopy. **Thermal Analysis:** Thermo gravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Thermo mechanical analysis and dilatometry.	**9**
	Total	**42**

Suggested Books:

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*Elements of X-Ray Diffraction by* B.D. Cullity, and R.S. Stock.	Prentice-Hall, (2001)
2.	*Fundamentals of Light Microscopy and Electronic Imaging by* Murphy, Douglas B,	Wiley-Liss, Inc. USA, (2001)
3.	*Materials Characterization Techniques Sam Zhang by* Li, Lin, Ashok Kumar	CRC Press, (2008)
4.	*Characterization of Materials by* Wachtman, J.B., Kalman, Z.H.,	Butterworth Heinemann, (1993)
5.	*Thermal Analysis by Wendlandt, W.W.*	John Wiley & Sons, (1986)
6.	*Advanced Techniques for Materials Characterization, by* Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S.	Materials Science Foundations (monograph series), Volumes 49 – 51, (2009)
7	*Fundamentals of molecular spectroscopy by* C. N. Banwell,	Tata McGraw
8.	Electron Microscopy and Analysis by Googhew P.J. et al	Taylor & Francis, London (2001)

Semester-IV

1. Subject code: **MSPH 202**	Course title: **Advanced Semiconductor Devices**
2. Contact Hours:	L: 3 T: 1 P: 0
3. Examination Duration (Hrs):	Theory: 3 Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits:	4
6. Semester:	EVEN
7. Subject area:	DCC
8. Pre-requisite:	NIL
9. Objective:	This core course is for M.Sc. (Physics) students to make them familiar with basic and advanced semiconductor devices and their practical application.
10. Detail of Course:	Basics of semiconductor devices such as Microwave Devices, Photonic Devices, Memory devices and their working. To understand the various steps involves in the fabrication of semiconductor devices.

S. No.	Contents	Contact Hours
1.	**Microwave Devices:** Klystrons amplifiers, velocity modulation, Basic principles of two cavity klystrons, Multicavity klystron amplifier and Reflex klystron oscillator, Magnetrons, principles of operation of magnetrons and Travelling wave tube (TWT). Transferred electron devices, Gun effect, Principles of operations, modes of operation, Read diode, IMPATT diode, and TRAPATT diode.	**13**
2.	**Photonic Devices:** Radiative transition and optical absorption, LED, Semiconductor lasers, heterostructures and quantum well devices, photodetector, Schottky barrier and p-I-n photodiode, avalanche photodiode, photomultiplier tubes, electro-optic and magneto-optic devices.	**12**
3.	**Memory Devices:** Volatile-static and D-RAM, CMOS and NMOS, non-volatile-NMOS, ferroelectric semiconductors, optical memories, magnetic memories, charge coupled devices (CCD). **Other Devices:** Piezoelectric, pyroelectric and magnetic devices. SAW and integrated devices.	**12**
4.	**Fabrication of Semiconductor Devices:** Vacuum techniques, thin film deposition techniques, diffusion of impurities, , Czochralski Process, MBE Technique, MOCVD	**05**
	Total	**42**

Suggested Books

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	Semiconductor Devices Physics & Technology by S.M. Sze	John Wiley, 1985
2.	Semiconductor Optoelectronic Devices by Pallab Bhattacharya	PHI-India, 1995
3.	Microwave Devices & Circuits by S. Y. Liao	3rd Ed., PHI-India, 2007
4.	*Microwaves by K.L. Gupta*	

1. Subject Code: **MSPH 204** Course Title: **Space and Atmospheric Science**
2. Contact Hours: L : 3 T : 1 P : 0
3. Examination Duration (Hrs.) : Theory : 3 Practical : 0
4. Relative Weight : CWS : 25 PRS : 0 MTE : 25 ETE : 50 PRE : 0
5. Credits: 4
6. Semester: EVEN
7. Subject Area: DSE
8. Pre-requisite: Basic knowledge of space and atmospheric science
9. Objective : To impart the fundamental knowledge pertaining to space and atmosphere. Measurement of meteorological parameters using various techniques. Global warming its consequences. Effect of trace gases, aerosols on climatic conditions will be discussed.
10. Details of Course :

S. No.	Contents	Contact Hours
1.	**Earth's Atmosphere:** Layers of atmosphere, variation of temperature with height in the atmosphere: Atmospheric pressure; composition of atmosphere; Energy balance of earth and atmosphere; Green House effect; Solar and terrestrial radiation; Black body radiation, laws of black body radiation-Plank's law, Stefan-Boltzmann law and Wien's displacement law.	**10**
2.	**Meteorological Instrumentation:** Ground based climatic station and automatic weather station for the measurement of air temperature, humidity, atmospheric pressure; wind speed, velocity and rain fall. Air borne systems for upper air observations-Rawinsonde, Radiosonde, GPS sonde-estimation of convective boundary layer height, thermos dynamical parameters and construction of T-phigram; Introduction to Space borne systems for the measurement of meteorological parameters.	**12**
3.	**Air pollution and its measurement techniques:** Primary gaseous pollutants (CO_2, CH4, CO and Nox)-sources and their effects on climate/human health. Secondary gaseous pollutants (Ozone and PAN)-Formation and their effect on human health. Gaseous pollutants measurement techniques-principles block diagrams and working. Description of aerosols, sources of aerosols, aerosol production mechanisms, effects of aerosols on climate and human health. Measurement techniques-Direct measurements by sampling and remote sensing measurements by Multi wavelength solar radiometer and Lidar.	**10**
4.	**Radar Principles and Meteorology:** Introduction to RADAR, types of Radars- Mono-static, pulsed radar, FM-CW radar; Basic principles of pulsed (Wind Profiler) radar- Antenna Basics-radar signal processing; Types of Radar Scattering theory-Wind vector calculations; Wind Profiler Applications-Aviation, Tropical Cyclone, Thunderstorm, Meteorological (Synoptic and Mesoscale) and Environmental.	**10**
	Total	**42**

Suggested Books

S. No.	Name of Books/Authors	Year of Publication/ Reprint
1	Hand book of the Atmospheric Science-Principles and Applications by C.N.Hewitt and Andrea V.Jackson Black	Wiley (1970)
2	Atmospheric Chemistry and Physics by John H.Seinfield and Spyros N. Pandias	Prentice Hall (1990)
3	An Introduction to dynamics Meteorology by James R. Hotton,	Wiley (1986)
4	A first course in Atmospheric Thermodynamics by Petty G.W,	Cambridge University press (1998)

1. Subject code: **MSPH 206** Course title: **Lasers and Spectroscopy**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: EVEN
7. Subject area: DSE
8. Pre-requisite: Knowledge of atomic and molecular physics.
9. Objective: The aim of this course is to introduce students with the advance concepts of Lasers and spectroscopy along with their applications

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Einstein's coefficients, Stimulated Absorption, Stimulated Emission and Spontaneous Emission, Gain Coefficient. Radiative Lifetime, Nonradiative Transitions and Spontaneous Transition probabilities. Saturation of Absorption. Gain Saturation. Widths and Profiles of Spectral Lines, Homogeneous and Inhomogeneous Broadening. Natural Linewidth, Doppler Width. Collisional Broadening of Spectral Lines.	**10**
2.	Basic Principles of LASERS: Laser Amplification, Laser Oscillation, Optical and Electrical Pumping, Optical Resonators, Optimization of Favorable Losses in Resonators, Resonance Frequencies of Optical Resonators, Laser Modes, Rate Equations for Two-Level, Three-Level and Four-Level Lasers, Steady-State Output. CW and Transient Laser behavior, Single-Mode Operation, Mode Locking and Q-Switching.	**12**
3.	LASER Systems and their Applications: Types of Lasers, Solis State lasers, Gas Lasers, Dye Lasers, Semiconductor Lasers, Excimer Lasers and Applications of Lasers. Non-Linear Spectroscopy: Harmonic generation, Phase matching, Second harmonic generation, Third harmonic generation, Optical mixing, Parametric generation of light, Self-focusing of light.	**10**
4.	Steady-state and Time-resolved Spectroscopy, Photoexcitation dynamics, Transient Absorption, Two Photon Processes, Frequency up-conversion, Raman Spectroscopy.	**10**
	Total	42

<u>Suggested Books:</u>

S. No.	**Name of Books/ Authors**	**Year of publication/ Reprint**
1.	K.Shimoda : Introduction to Laser Physics;	(Springer-Verlag)
2.	O. Svelto: Principles of Lasers	(Plenum Press)
3.	Laud B.B: Laser and Nonlinear optics,	Wiley eastern.
4.	W Demtroder. Laser Spectroscopy A Basic Concepts and Instrumentation	(Springer Ver-lag).
5.	Thyagarajan and Ghatak: Lasers- Theory and Applications	
6.	Hollas J. M.: Laser and non-linear optics.	

1. Subject code: **MSPH 212** Course title: **Spintronics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3+1 (T) Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: EVEN
7. Subject area: DSE
8. Pre-requisite: Knowledge of basic solid-state physics
9. Objective: The course on spintronics introduces the fundamental concepts on spin electronics. This course covers a deeper insight in theories and practical knowledge of Spin dependent transport. This course is designed to provide an understanding of fundamentals of spin electronics, spin relaxation, spin transport in metal and semiconductors, and advances in spin electronic technology and futuristic materials with high spin polarization.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Magnetism in metals: Pauli paramagnetism, Spontaneously spin-split bands, Landau levels, Landau diamagnetism, Magnetism of the electron gas, Excitations in the electron gas, Spin density waves, Kondo effect, The Hubbard model, History and overview of spin electronics, Classes of magnetic materials, The early history of spin, Quantum Mechanics of spin, The Bloch sphere, Spin-orbit interaction: Rashba interaction & Dresselhaus interaction, exchange interaction.	**12**
2.	**Spin relaxation & Spin dependent transport:** Spin relaxation mechanisms, Spin relaxation in a quantum dots, the spin Galvanic effect, Basic electron transport, Spin-dependent transport, spin dependent tunneling: Tunnel Magnetoresistance (TMR), Magnetic tunnel Junctions (MTJ), Tunnel Junctions with Half Metals.	**10**
3.	**Spin Polarization & Spin injection:** Spin polarization, Spin torque effects in magnetic systems, magnetization switching, Spin injection, spin accumulation, and spin current, Spin Hall effect and Inverse Spin Hall effect, Silicon based spin electronic devices: Toward a spin field effect transistor, transistor, Spin LEDs: Fundamental and applications, Spintronic devices based on Heusler alloy, Electron spin filtering, Monolithic and Hybrid Spintronics.	**10**
4.	**Quantum Computing with Spin:** The quantum inverter, Dissipation less NAND gate, Universal reversible gate, Quantum gates, Qubits, Superposition states, Universal quantum gates, 2-qubit spintronic universal quantum gates.	**10**
	Total	**42**

Reference Books:

S. No.	Name of Books/ Authors	Year of publication/ Reprint
1.	*S. Blundell, Magnetism in Condensed Matter, 1st edition*	Oxford University Press, 2001.
2.	*R. C. O'Handley, Modern Magnetic Materials*	John Wiley & Sons, Inc., 2000.
3.	*T. Shinjo (Ed.) Nanomagnetism and Spintronics*	1st edition, Elsevier, 2009.
4.	*E. Y. Tsymbal and I Zutic, Handbook of Spin Transport and Magnetism*	CRC Press, 2012.
5.	*Introduction to Spintronics, S. Bandhopadhyay, M. Cahay*	CRC Press, 2008.
6.	*Spintronics: From Materials to Devices, Editors: G. H Fecher, C. Felser*	Springer, 2013

1. Subject code: **MSPH 214** Course title: **Advanced Electronics**
2. Contact Hours: L: 3 T: 1 P: 0
3. Examination Duration (Hrs): Theory: 3 Practical: 0
4. Relative Weight: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits: 4
6. Semester: EVEN
7. Subject area: DSE
8. Pre-requisite: NIL
9. Objective: The aim of this course is to introduce students with the Advance concept of Electronics and their applications relevant to scientific and engineering aspects.

10. Detail of Course:

S. No.	**Contents**	**Contact Hours**
1.	Enhancement mode & Depletion mode MOSFETs, Drain current and Transfer Characteristics Analysis-Linear Regime, and Saturation Regime, Parameter Evaluation: Transconductance, Drain Conductance, Cut-off Frequency	**9**
2.	Op-Amp Circuits: Characteristics of ideal and practical op-amp; Nonlinear amplifiers using op-amps- log amplifier, anti-log amplifier, comparators; Active filters; precision rectifiers; Op-amp based self oscillator circuits- RC phase shift, Wien bridge, non-sinusoidal oscillators.	**9**
3.	Elements of Communication Electronics: Principles of analog modulation- linear and exponential types; comparison among different techniques; power, bandwidth and noise immunity consideration; Generation of transmitted carrier and suppressed carrier type AM signals; principles of FM and PM signal generation. Principles of detection of different types of modulated signals (TC and SC types). Modulation techniques in some practical communication systems: AM and FM radio, VSB AM and QAM technique in TV broadcasting	**9**
4.	Shift register counters – Ring counter, Johnson counter, Asynchronous Ripple or serial counter Asynchronous Up/Down counter - Synchronous counters – Synchronous Up/Down counters – Programmable counters-Design of Synchronous counters: state diagram- State table –State minimization –State assignment - Excitation table and Circuit implementation; Modulo–n counter,– Non-Sequential Counter Design using JK, D and T-design. Introduction to Microprocessors: 8086, Instruction Set, Addressing Modes	**6**
5.	Digital to analog converter: Binary Weighted Resistors, Analog to digital converter-Successive Approximation Method; Classification of memories – ROM - ROM organization - PROM – EPROM – EEPROM – EAPROM RAM – RAM organization – Write operation – Read operation, memory expansion. Static RAM Cell-Bipolar RAM cell – MOSFET RAM cell – Dynamic RAM cell	**9**
	Total	**42**

Suggested Books:

S. No.	**Name of Books/ Authors**	**Year of publication/ Reprint**
1.	*Weste, "Principles of CMOS VLSI Design (2nd edition)"*	
2.	*Dougles A. Pucknell and kamran Eshraghian, "Basic VLSI Systems and Circuits, Prentice Hall of India Pvt. Ltd.*	
3.	*Kennedy, "Communication Systems". Prentice Hall of India.*	
4.	*Malvino and Leach, "Digital Principles and Application"*	
5.	*S.M.Sze, "Physics of Semiconductor Devices" (2 nd edition)*	
6.	*Morris Mano, "Digital Electronics And Logic Design"*	
7	*Gayakwad, "Operational Amplifiers"*	

1. Subject code: **MSPH 216**	Course title: **Advanced Functional Materials**
2. Contact Hours:	L: 3 T: 1 P: 0
3. Examination Duration (Hrs):	Theory: 3 Practical: 0
4. Relative Weight:	CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0
5. Credits:	4
6. Semester:	EVEN
7. Subject area:	DSE
8. Pre-requisite:	NIL
9. Objective:	The aim of this course is to introduce students with the basic concepts and principles of advance functional material preparation with different technique and the thereby change in properties of material related to scientific and engineering aspects.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Introduction, review of crystal structures, Concept of functional materials, Challenges in the science and technology of advanced materials, Classification of materials, bonding in materials	**10**
2.	Overview of the synthesis of functional materials (inorganic materials by procedures like solid state synthesis, sol-gel process, hydrothermal synthesis, etc.,)	**10**
3.	Characterization of materials, structural, morphological, optical, electrical, magnetic, dielectric, physical and thermal properties of materials, and other various properties of materials.	**10**
4.	Potential applications of selected functional materials from various areas of inorganic, organic and hybrid materials, Process and materials optimization, Optoelectronic materials and devices, Enhancement of device performance, Recent trends in Functional materials and devices and Future perspectives of advanced functional materials	**12**
	Total	**42**

Suggested Books:

S. No.	**Name of Books/ Authors**	**Year of publication/ Reprint**
1.	*Elements of X-Ray Diffraction by* B.D. Cullity, and R.S. Stock.	Prentice-Hall, (2001)
2.	*W. D. Callister, Fundamentals of Materials Science and Engineering,*	Wiley
3.	*Advanced functional materials: a perspective from theory and experiment, Edited by Biplab Sanyal,*	Eriksson
4.	*Materials Science and Engineering, by Raghavan, V.*	*Prentice Hall*
5.	*Smart Structures and Material by Brain Culshaw,*	-
6.	*Functional materials: preparation, processing and applications by A.K. Tyagi, and S. Banerjee*	Materials Science Foundations (monograph series), Volumes 49 – 51, (2009)