SYLLABUS
FOR M.Sc. (PHYSICS)
ELECTRONICS SPECIALIZATION
(REGULAR)

w.e.f.
ACADEMIC SESSION 2016-2017 AND ONWARD
(1)

M.Sc. PHYSICS (I Semester): MATHEMATICAL PHYSICS

Unit 1. Polynomials: Legendre, Hermite and Laguerre polynomials and their generating functions. Recurrence relations and special properties of $P_n(x)$ as solution of Legendre differential equation, Rodrigues formula, orthogonality of $P_n(x)$, associated Legendre polynomials (Introduction only).

Unit 2. Bessel function of first kind, generating function, recurrence relations, $J_n(x)$ as solution of Bessel differential equation, Expansion of $J_n(x)$ when $n$ is half and odd integer, Integral representation.

Unit 3. Complex Variable: Function of a complex variable, Cauchy Riemann conditions, Cauchy’s integral theorem (without proof), Cauchy’s integral formula, Cauchy’s Residue theorem, singular points and evaluation of definite integrals of the type

$$
\int_0^{2\pi} f(\sin\theta, \cos\theta) d\theta, \quad \int_{-\infty}^{\infty} f(x) \, dx, \quad \int_{-\infty}^{\infty} f(x) e^{iax} \, dx
$$

Unit 4. Integral Transforms: Laplace Transform, First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function, Solution of initial value problems by using LT,

Unit 5. Fourier Series and Fourier Transform: Fourier series, Half range expansion, Arbitrary period, Fourier integral and transforms, FT of delta and Gaussian function.

Text and References Books
Mathematical method for Physics by G. Arfken
Advanced Engineering Mathematics by E.Kreyszig
Special Functions by E.D Rainville
Special Functions by W.W Bell
Functions of complex variable by R.V.Churchill
Mathematical Method for Physicists and Engineers by K.F.Reily, M.P.Hobson and S.J.Bence
Mathematical Physics by H.K. Das
M.Sc. PHYSICS (I Semester): CLASSICAL MECHANICS

Unit 1. Preliminaries: Newtonian mechanics of a particle, Mechanics of a system of particles, Constraints; their classification, D'Alembert’s principle, Virtual work, generalized coordinates and derivation of Lagrange's equations, Velocity-Dependent potentials and the Dissipation function, Applications of Lagrangian formulation: Simple Pendulum with rigid support, Two connected masses with string passing over a pulley.


Unit 3. Two body central force problem: Reduction to the equivalent one-body problem, Motion in a central force field, The Virial theorem, The inverse square law of force, The motion in central force in the Kepler problem.

Unit 4. Hamiltonian equations of motion: Legendre transformations and Hamilton equations of motion, Cyclic coordinates and conservation theorems, Canonical transformation generating functions, Properties, Poisson bracket, Poisson theorem, Relation of Poisson brackets, Hamilton Jacobi method

Unit 5. Small oscillations: Concept of small oscillations, Expression of kinetic energy and potential energy for the problem of small oscillations, Frequencies of free vibration, and Normal coordinates.

Text and Reference Books
H. Goldstein: Classical Mechanics
N.C. Rana and P.S. Joag: Classical Mechanics
A. Sommerfiel: Mechanics
Perceival and D. Richards: Introduction to Dynamics
Unit 1. Wave Mechanics: Dual nature of matter and radiation, Schrodinger equation, Principle of superposition, Motion of wave packets, Uncertainty principle, Fundamental postulates of wave mechanics, Eigenvalues and eigenvectors, Probabilistic interpretation, normalization of bound and continuum state wave functions, Expectation values of dynamical variables, Coordinate and momentum representation, Hermitian operator, Commutator algebra and uncertainty relation, Three dimensional potential well and Hydrogen atom.

Unit 2. Representation and Transformations: State vectors, Hilbert Space, Dirac notations, Dynamical and linear operators in matrix form, Linear harmonic oscillator in matrix formulation, Space and time displacements, Rotation generators, Transformations of dynamical variables, Symmetry and conservation laws. Symmetric and anti symmetric wave-functions and Pauli exclusion principle.


Unit 4. Angular momentum: Commutation relations involving angular momentum operators, the eigenvalue spectrum, Matrix representation of $J$, Addition of angular momentum, Clebsch-Gordon coefficients, Spin angular momentum, Spin wave functions, Addition of spin and orbital angular momentum.

Unit 5. Scattering Theory: Laboratory and centre-of-mass systems, scattering by potential field, scattering amplitude, differential and total cross sections, phase shift, Lippmann-Schwinger equation, First Born approximation.

Text and References Books
Modern Physics by S.P. Khare.
Quantum Mechanics by S. Gasiorowicz.
A text book of Quantum Mechanics by P.M. Mathews and K. Venkatesan
Introduction to Quantum Mechanics by E. Merzbacher
Quantum Mechanics by L.I. Schiff
Unit 1. Conduction Mechanism in Semiconductors: Classification of semiconductors - Elemental and compound semiconductors, Direct band and indirect band gap semiconductors, Charge carriers in extrinsic semiconductors, Carrier concentrations; The Fermi Level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, drift of carriers in electric and magnetic fields; conductivity and mobility, drift and resistance, effect of temperature and doping on mobility, The Hall effect, Diffusion of carriers in semiconductors; diffusion processes, diffusion and drift of carriers, diffusion and recombination, The continuity equation.

Unit 2. Semiconductor-diode characteristics: Qualitative theory of P-N junction, The Contact Potential, Space charge at a junction, Capacitance of p-n junctions, Forward and reverse bias junctions, Reverse bias breakdown, Zener diode, Tunnel diode.


Unit 4. Field Effect Transistors: 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, Depletion and enhancement type MOSFETs.


Text and Reference Books
Solid State Electronic Devices by B.G. Streetman
Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
Integrated Electronics by J. Millman and C.C. Halkias
Introduction to Semiconductor Devices by M. S. Tyagi
Electronic Devices and Circuits by Balbir Kumar and S.B. Jain
M.Sc. PHYSICS (II Semester): QUANTUM  MECHANICS- II


Unit 2. Induced and Spontaneous radiations: Einstein A and B coefficients, Induced and spontaneous emissions of radiations, their applications in the construction of gas and solid lasers.

Unit 3. Quantum Theory of Radiation: Classical radiation field, Fourier decomposition and radiation oscillators, Creation, annihilation and number operators, Photon states, Quantized radiation field, Basic matrix elements for emission and absorption, Spontaneous emission in the dipole approximation, Plank’s radiation law.

Unit 4. Relativistic Equations: Klein-Gordon equation and its plane wave solution, Probability density in KG theory, Difficulties in KG equation, Dirac equation for a free electron, Dirac matrices and spinors, Plane wave solutions, Charge and current densities, Existence of spin and magnetic moment from Dirac equation of electron in an electromagnetic field.

Unit 5. Dirac Equation: Dirac equation for central field with spin orbit interaction, Energy levels of Hydrogen atom from the solution of Dirac equation, Covariant form of Dirac equation.

Text and Reference Books
Quantum Mechanics by L.I. Schiff
Modern Quantum Mechanics by J.J. Sakurai
A Text Book of Quantum Mechanics by P.M. Mathews and K.Venkatesan
Quantum Mechanics by A. P. Messiah
M.Sc. PHYSICS (II Semester): STATISTICAL MECHANICS

Unit 1. Foundation of Statistical Mechanics & Ensembles: Phase space, concept of Ensemble, Ensemble average, Liouville’s theorem, equation of motion and Liouville’s theorem, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, partition functions.


Unit 4. Cluster expansion for a classical gas, virial equation of state, Ising model, mean-field theories of the Ising model in three, two and one dimensions, Exact solutions in one-dimension. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.

Unit 5. Fluctuations: Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, The Fokker-Plank equation.

Text and Reference Books
Statistical and Thermal Physics by F. Reif
Statistical Mechanics by K. Huang
Statistical Mechanics by R. K. Pathria
Statistical Mechanics by R. Kubo
Statistical Physics by Landau and Lifshitz
Statistical Mechanics and properties of matter, theory and application by E.S.R. Gopal
M.Sc.PHYSICS (II Semester): ATOMIC AND MOLECULAR PHYSICS

Atomic Physics:
Unit 1. Quantum Mechanical Treatment of one-electron Atom, Spin-Orbit interaction and fine structure of hydrogen atom, Spectra of alkali elements. Singlet and triplet States of Helium.


Molecular Physics:


Unit 5. Photoelectron Spectroscopy, Photoelectron Spectrometer, Nuclear Magnetic Resonace, Chemical Shift, NMR Spectrometer, Electron Spin Resonance (Introduction and their principles only), ESR Spectrometer.

Text and Reference Books
Introduction to atomic spectra by H.E. White
Spectra of diatomic molecules by Herzberg
Atoms and molecules by M. Weissbluth
Quantum theory of Atomic Structure Vol I by Slater
Quantum theory of molecules and Solids by Slater
Fundamentals of molecular spectroscopy by C.B.Banwell
Introduction to molecular spectroscopy by G.M.Barrow
Molecular spectroscopy by Jeanne L.McHale
Molecular spectroscopy by J.M.Brown
Spectra of atoms and molecules by P.F. Bemath
Modern spectroscopy by J.M. Holias
M.Sc.PHYSICS (II Semester): ELECTRODYNAMICS & PLASMA PHYSICS

**Unit 1.** Electrostatics: Electrostatic fields in matter; Dielectrics, Polarization, Field inside a dielectric, Electric displacement, Linear dielectrics. Laplace’s and Poisson Equations, Methods of images, point charge near an infinite conducting plane, Point charge in the presence of grounded conducting sphere, Point charge in presence of charged insulated sphere.

**Unit 2.** Magneticstatics: Magnetic vector potential, Magnetostatic fields in Matter: Magnetization, field of a magnetized object, magnetic field inside matter, linear and non linear magnetic media.

**Unit 3.** Time-Varying Fields: Maxwell’s displacement current, Maxwell’s equations, Maxwell’s equations in terms of vector and scalar potentials, Poynting theorem, Lienard- Wiechert potentials due to a point charge, Fields of a point charge in motion, Power radiated by an accelerated charge, Larmor’s formula and its relativistic generalization.

**Unit 4.** Plane Electromagnetic Wave: Reflection, Refraction of electromagnetic waves at an interface between dielectrics, Fresnel’s relation polarization by reflection and total internal reflection, Plain electromagnetic waves in free space, dielectrics and conducting media.

**Unit 5.** Plasma: Definition of plasma ,Concept of temperature, Debye shielding, Criteria for plasma, Single-particle motions in E and B fields, Magnetic mirrors and plasma confinement, Plasma as fluid, the fluid equation of motion, Equation of continuity and equation of state, Waves in plasmas, Plasma oscillations, Plasma frequency $\omega_p$, Electron plasma waves, ion waves, Electron and ion oscillations perpendicular to $B$ and parallel to $B$, Cutoffs and resonances.

**Text and Reference Books:**

- Classical Electrodynamics by J.D. Jackson
- Introduction to Electromagnetics by David J. Griffiths
- Introduction to Plasma Physics and Controlled Fusion, Vol-1: Plasma Physics by Francis F. Chen
- Plasma Physics by S.N. Sen.)
Unit 1. Crystal Physics and Defects in Crystals:
Crystalline solids, unit cell and direct lattice, Bravais lattice in two dimensions (plane lattice) and three-dimensional (space lattice), Closed packed structures.

Unit 2. Interaction of X-rays with matter, Absorption of X-rays, X-ray diffraction, The Laue, powder and rotating crystal methods, The reciprocal lattice and its important properties and applications, Diffraction intensity, Atomic scattering factor, Geometrical structure factor.


Unit 4. Electronics Properties of Solids:


Text and References Books
Verma and Srivastava: Crystallography for Solid State Physics
Azaroff: Introduction to Solids
Omar: Elementary Solid State Physics
Aschroff & Mermin: Solid State Physics
Kittel: Solid State Physics
Chaikin and Lubensky: Principles of Condenced Matter Physics
M. Sc. PHYSICS (III Semester): SPECIAL PAPER- I: ELECTRONICS


Unit 2. Digital Logic Gates: Symbols and truth tables, Classes of digital integrated circuits (Diode logic, DTL, TTL, ECL, MOSFET, CMOS), Transistor- Transistor Logic (TTL), Single Input TTL Inverter (transfer characteristic), Multi- collector transistors, Propagation delays, Diode Logic, DTL NAND Gate (transfer characteristic, noise immunity, fan out), Emitter Coupled Logic (transfer characteristic of OR/NOR gate, practical implementation, MOSFET Logic- Review of MOSFET, MOSFET Inverter with active load, MOSFET NOR and NAND gates, Complementary MOS (CMOS)- CMOS inverter, CMOS NOR and NAND, Power dissipation in CMOS, Advantages/Disadvantages of CMOS.

Unit 3. Digital Electronics and Logic Gate: Binary, Octal, Hexadecimal number system, Base conversion system, Bipolar junction and Field Effect transistor as switches, Basic digital logic gates (OR, AND and NOT, NOR, NAND and Exclusive OR), XOR gate, Boolean laws and theorem, Sum of Product (SOP) and Product of Sum (POS) method, Karnaugh map, pair, quad and octave, POS simplification, min-term, max-term.


Unit 5. Microprocessor-Intel 8085 microprocessor architecture, interfacing devices, BUS timing, instruction set, simple illustrative program.

Text and Reference Books
Electronic Device and Circuit: R. Boylested and L. Nashdsky
Analysis and Design of Digital Integrated Circuit: Hodges, Jackson and Saleh
Digital Principles and Implementation: A.P. Malvino and D.P. Leach
Op-Amp and Linear Integrated Circuit: Ramakant A. Gayakwad
M. Sc. PHYSICS ( III Semester ): SPECIAL PAPER II: ELECTRONICS

Unit 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.


Unit 4. Transmission and Radiation of signals: Primary line constants, phase velocity and line wavelength, Characteristic impedance, Propagation Coefficient, Phase and group velocities, Standing waves, Lossless line at radio frequencies, Voltage standing wave ratio, Slotted line measurements at radio frequencies, Transmission lines as circuit elements, Smith chart, Single and double Stub matching, Time domain reflectometry, Telephone lines and cables, Radio frequency lines.

Unit 5. Fiber optic communications: Principles of light transmission in a fiber, Propagation within a fiber, Effect of index profile on propagation, Modes of propagation, Single mode propagation, Losses in fibres, Dispersion, Fiber optic communication systems.

Text and Reference Books

Electronic Devices and circuit Theory by R. Boylested and L. Nashdsky
Principles of Communication Systems by H. Taub and Donald L. Schilling
Optoelectronics: Theory and Practice, Edited by Alien Chappal
Microwaves by K.L. Gupta
Electronic communications by Dennis Roddy and John Coolen
Unit 1. Introductory Concept of Nuclei: Binding energy and Binding energy per nucleon, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Isobaric spin concept, Systematic of stable nuclei.


Unit 3. Inter Nucleon Forces: Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon- nucleon scattering at low energy, Charge- independence of nuclear forces, Many – nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.


Unit 5. Particle Physics: Properties and origin, Elementary particles, Properties, classification, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell- Mann- Okubu mass formula.

Text and Reference Books
Nuclear Physics by Roy & Nigam
Introduction to nuclear Physics by H. Enge
Theoretical Nuclear Physics by J.M. Blatt and V.F. Weisskopf
Theoretical nuclear and Subnuclear Physics by J.D. Walecka
Particle Physics An introduction by M.Leon
Group Theory in Subnuclear Physics by F.I. Stancu
Introduction to Particle Physics by R. Ones.
Fundamentals of Nuclear Physics by B.B. Srivastava
Nuclear Physics by D.C. Tayal
Introduction to Nanostructure Materials: Nanoscience & nanotechnology, Size dependence of properties, Moor’s law, Surface energy and Melting point depression of nanoparticles, Free electron theory (qualitative idea) and its features, Idea of band structure, insulators, semiconductors and conductors, Energy band gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, variation of density of states with energy and size of crystal.

Quantum Size Effect: Quantum confinement, Nanomaterials structures, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.

Characterization techniques of Nanomaterials: Determination of particle size, XRD (Scherrer’s formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, shift in photoluminescence peaks, Electron microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM) and Atomic Force Microscopy (AFM).

Synthesis of Nanomaterials: Key issues in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Cluster beam evaporation, Ball Milling, Chemical vapor deposition, capping agents, Carbon nanotubes (CNT)- Synthesis, Properties and Applications.

Text and References Books
Nanostructures & Nanomaterials, Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press.
Introduction to Nanotechnology, by Charles P. Poole, Jr. Frank J. Owens, John Wiley & Sons Inc. Publication.
Quantum Wells, Wires and Dots by Paul Harrison, John Wiley & Sons Ltd.
Quantum Dot Hetrostructures, by D. Bimberg, M. Grundman, N.N. Ledenstov.
Carbon Nanotechnology by Liming Dai
M. Sc. PHYSICS (IV Semester): SPECIAL PAPER III ELECTRONICS

Unit 1: Digital communication: Elements of a digital communication system, sampling theorem – Low Pass and Band Pass signals, Pulse Amplitude Modulation, Natural sampling. Flat – top sampling, Other forms of Pulse Modulation, Pulse Code Modulation, uniform and non-uniform Quantization of signals, Quantization error, Differential PCM, Delta Modulation, Adaptive Delta Modulation.

Unit 2: Digital Modulation techniques: Principle of Binary Phase Shift Keying (BPSK), Generation and Reception of BPSK, Bandwidth of BPSK Signal, Differential Phase Shift Keying (DPSK); DPSK Transmitter and Receiver, Bandwidth of DPSK Signal, Quadrature Phase Shift Keying (QPSK); QPSK transmitter and Receiver, Bandwidth of QPSK Signal, Binary Frequency Shift Keying (BFSK), BFSK Transmitter and receiver, Amplitude Shift Keying (ASK).


Text and Reference Books;
(1) Principles of Communication Systems, second Edition by Taub and Schilling
(2) Communication Systems, third edition, by Simon Haykin
(3) Digital Communications, second edition by J.S. Chitode
M.Sc. Physics (IV- Semester ): SPECIAL PAPER – IV- ELECTRONICS

Unit 1. Materials for Integrated Circuits
Classification of IC, CMOS Process Overview, Electronic grade silicon, Crystal growth, Czochralski and float zone crystal growing methods, Silicon shaping lapping, Polishing and wafer preparation,

Unit 2. Hot Processes-I: Oxidation and Diffusion

Unit 3. Thin Films: Metals and Nonmetals
Vacuum Science and Technology, Evaporation theory and electron beam evaporation, evaporation system, idea of DC and R.F. sputtering system, Physical vapor deposition methods, Design construction of vacuum coating units, Chemicals Vapor Deposition, Reactors for Chemical Vapor Deposition, CVD Applications, Epitaxy methods for thin film deposition, Vapor-Phase Epitaxy,

Unit 4. Photolithography, Photoresist Processing and Etching
Wafer Cleaning methods, Wafer Preparation method: Vapor HMDS Treatment for adhesion improvement of photoresist, photoresist coating methods, soft backing of photo resist, post exposure backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi level photoresist exposure) and Resist Development, Hard Baking and Resist curing, Photolithographic Process Control.
Photolithography: An Overview, lithography, Raleigh criterion for resolution, Photolithography source, Resolution and numerical aperture, Photolithographic methods: Contact, proximity and projection and their resolution limit, Photo mask and mask Alignment, Limitations of optical lithography, Concept of phase-shift mask, Idea of electron beam lithography, Electron optics, Idea of an X-ray lithography and x-ray mask, Wet chemical dry etching for material removal, Reactive plasma etching, Ion milling,

Unit 5. Interconnections and Contacts and Packaging and Yield
Ohmic Contact Formation, Contact Resistance, Electromigration, Diffused Interconnections, Polysilicon Interconnections, Buried Contacts, Butted Contacts, Silicides, Multilayer Contacts, Liftoff Process, Multilevel Metallization.

Text and Reference Books:
Integrated Electronics- Milliman and Taub
Microelectronics –Milliman and Gros
Thin Film Phenomena- K.L. Chopra
Hand Book of Thin Film- Marshel and Glang
VLSI Technology- S.M. Sze.
Unit 1. **Computational methods:** Methods for determination of zeros of linear and nonlinear algebraic equations and transcendental equations, Bisection method, Muller’s method, Quotient-difference method, Newton-Raphson method
Solution of simultaneous linear equations, consistency of a system of linear equation, Gaussian elimination, LU decomposition method, matrix inversion, Jacobi iterative method, Gauss-Seidel method, convergence of Gauss-Seidel method

Unit 2. Diagonalization of matrices, Eigen values and eigenvectors of matrices, Power and Jacobi method.
Finite differences, Newton’s formula for interpolation, Gauss, Stirling, Bessel’s, Everett’s formulae, Divided differences, Newton’s general interpolation formula, Lagrange’s interpolation formula.

Method of Least square curve fitting, straight line and quadratic equation fitting, curve fitting of curves \( y = ax^b, \ y = ae^{bx}, \ xy = b \) and \( y = ab^x \), curve fitting by sum of exponentials, data fitting with cubic splines.


Unit 5. **Programming:** elementary information about digital computer principles, compilers, interpreters and operating systems, Fortran programming, flow charts, integer and floating point, arithmetic expressions, built in functions, executable and non executable statements, IF statements, GO TO statements, DO loop and implied DO loop, simple computer programmes.

**Text and References Books**
Introductory Methods of Numerical analysis by S.S. Shastri
Numerical Analysis by Rajaraman

Numerical Methods by E. Balagurusamy
Fortran Programming by Rajaraman
Numerical methods for scientific & Eng. Computations by Jain, Iyengar