UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

SEMESTER – I

MATHEMATICAL PHYSICS

PHY501

Unit I Complex Analysis: Analytic functions, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's Integral formula, Laurent series, Poles, Residue theorem, Evaluation of integrals.

Unit II Linear Differential Equations: Second order linear differential equations; Regular, regular singular and singular points; series expansion method.

Unit III Special Functions: Bessel, Legendre, Hermite and Laguerre differential equations with properties of their solutions.

Unit IV Integral transforms: Laplace transform, Fourier theorem, Fourier transforms.

Unit V Dirac delta function and Green's function: Green's function for Laplace operator, Solution of Poisson's equation, Inhomogeneous Wave equation and applications.

CLASSICAL MECHANICS

PHY502

Unit I Variational Principles and Langrange's Equations: Hamilton's principle, Calculus of variations, Langrange's equations, Conservation Theorems and symmetry properties.

Unit II Hamiltonian formalism: Legendre transformations and the Hamiltonian Equations of Motion, Cyclic coordinates.

Unit III Canonical Transformations: Canonical transformations, Poisson Bracket

Unit IV Hamilton – Jacoby Theory: Hamiltonian Jacoby equations; Hamiltonian Jacoby theory, geometrical optics and wave mechanics

Unit V Small oscillations and normal modes: Small oscillations about a stable equilibrium, Normal modes and their frequencies, Langrangian and Hamiltonian formalism of Classical Fields.

ELECTROMAGNETIC THEORY

PHY503

Unit I Guided electromagnetic waves: Transmission Lines and Wave Guides, Modes in a rectangular wave guide, Cavity resonators.

Unit II Tensor analysis: General coordinate transformation; contravariant, covariant and mixed tensors; metric tensor; raising and lowering of indices; contraction of indices.

Unit III Minkowsky space and Lorentz transformations: Geometry of space-time in Special Relativity; Minkowsky metric; Light cone and principle of causality; Invariance of Minkowsky metric under Lorentz transformations;Lorentz group; Proper, improper and orthochronous transformations; Pseudo-tensors.

Unit IV Covariant formulation of electromagnetism: Charge-current density four-vector; Scalar and Vector potentials; Gauge invariance; Electromagnetic potential four-vector; Electromagnetic field tensor; Lorentz transformation of electric and magnetic fields; Invariants of the electromagnetic field

Unit V Electromagnetic field of a charge moving with constant velocity, Covariant form of Lorentz force law; Dynamics of charged particles in static and uniform electric fields.

QUANTUM MECHANICS –I

PHY504

Unit I Dirac's Bra & Ket Notations, Hilbert Space, Vector Representations of States, Projection Operators, Observables as Operators, Orthonomality and Completeness of States, Relation between Ket and Wave-functions, Wave-functions in Coordinate and Momentum Representations

Unit II Matrix Theory of Harmonic Oscillator, Uncertainty Relations, Schrödinger, Heisenberg and Dirac Representations.

Unit III Orbital Angular Momentum, Angular Momentum Algebra, Spin, Addition of Angular Momenta

Unit IV Clebsch-Gordon Coefficients, Explicit Addition of Angular Momentum 1/2 with Angular Momenta 1/2 and 1, Spherical Harmonics in Central Field Problems, Spin-Orbit Coupling, Fine-Structure.

Unit V Non-Covariant Derivation of Lagrangian Equations for fields, Canonically Conjugate Momentum Density for Schrodinger Field, Quantum Conditions based on Commutation Relations and Second Quantization, Annihilation and Creation Operators, Second Quantization based on Anti-Commutation Relations, Simple Problems on Algebra of Annihilation and Creation Operators.

QUANTUM MECHANICS –II

PHY505

Unit I Time-Independent Perturbation Theory and Applications, Variational Method, WKB Method,

Unit II Time-Dependent Perturbation Theory, Constant and Harmonic Perturbation, Transition probabilities, Fermi's Golden Rule, Semi-Classical Theory of Radiation, Einstein A and B Coefficients, Selection Rules, Scattering,

Unit III Method of Partial Waves, Phase-Shifts, Born Approximation, Simple Applications.

Unit IV Klein Gordon Equation and Free Particle, Solution, Dirac Equation, Dirac Matrices, Covariance of Dirac Equation & Bilinear Covariants,

Unit V Solution for a Free Particle, Negative Energy states and Hole Theory, Spin, Position Operator.

STATISTICAL MECHANICS

PHY506

Unit I A review of Gibbs ensembles, Partition function for Perfect Gas and ensemble of Harmonic Oscillators, Partition Function for Gases containing Monoatomic, Diatomic and Polyatomic Molecules. Grand partition function,

Unit II Grand potential, FD and BE distribution in Grand Canonical ensemble Degenerate Bose Gas, Momentum Condensation, Liquid He II, Two fluid theory, Superfluidity.

Unit III Degenerate FD Gas, Conduction Electrons in a Metal, Fluctuations, One dimensional Random walk, Gaussian Distribution, Fluctuation in energy in canonical ensemble and concentration in Grand Canonical ensemble.

Unit IV Random processes, Markoff process, Langevin Equation, Correlation functions, Fluctuations Dissipation Theorem, Weiner-Khintchine theorem, Nyquist theorem,

Unit V Conditional probability, Fokker Plank Equation, Brownian motion.

SOLID STATE ELECTRONICS

PHY507

Unit I P-N Junction Diode: Rectifier with LC Filter, Electronic regulator. Bipolar Junction Transistors: h-parameters, inter conversion in different configurations, low frequency transistor amplifier, thermal stability and bias stabilization.

Unit II Field Effect Transistors: Small signal model and dynamic parameters, CS and CD amplifiers. Multistage Amplifiers: BJT at high frequencies, frequency response of gain and phase shift, frequency response of RC coupled amplifier.

Unit III Feedback Amplifiers and Oscillators: Different negative feedback amplifiers, stability and Nychist criteria , sinusoidal oscillators , phase shift and Wien's bridge oscillators, Crystal oscillator, astable multivibrator.

Unit IV Power and Radio Frequency Amplifier: Large signal amplifier and distortions, push-pull amplifier, single and double tuned amplifiers.

Unit V Modulation: Frequency and phase modulation, frequency modulation Demodulation: Frequency changing and tracking; AGC, AFC, FM detection, amplitude limiter, phase discriminator, ratio detector.

ATOMIC & MOLECULAR PHYSICS

PHY508

Unit I Quantum states of an electron in an atom, Spectrum of Hydrogen and Helium atom, fine structure Spectra of Alkali atoms; energy level diagrams, Sharp, Principal, Diffuse and fundamental series.

Unit II Width of spectral lines, X-ray spectroscopy, Spectroscopic terms; LS & JJ couplings, Hyperfine structure

Unit III Zeeman, Paschen Back & Stark effect, Electron spin resonance, Nuclear magnetic resonance, chemical shift

Unit IV Spectra of Diatomic Molecules Rotational Spectra (rigid rotator and non rigid rotator model) Vibrational Spectra (harmonic and enharmonic model) Molecular Symmetric Top, Vibrating rotator Isotopic shift

Unit V Raman Spectra (Quantum mechanical and classical approach) Electronic Spectra-vibrational structure of band system, fine structure of the band systems. Intensity distribution in band systems: Frank Condon principle

Semester I and II laboratory course code

General Lab	**PHY531**
Electronics Lab	**PHY532**

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

SEMESTER – III

Paper - I CONDENSED MATTER PHYSICS

PHY601

Unit I Electron band theory: one electron band theories. Plane wave like and localized wave functions. Nearly free electron approximation. Elementary discussion of orthogonalized Plane Wave (OPW) and Pseudo potential methods, Variation of Fermi energy in extrinsic semiconductors, de-Hass-van Alphen effect experiment to investigate Fermi surface.

Unit II Superconductivity: Meissner effect, isotope effect, type I and II superconductors. Cooper pairs. Elementary ideas of BCS theory, Approximate estimate of transition temperature, superconducting energy gap , Measurement of energy gap by infrared absorption and electron tunneling methods, Elementary ideas about Josephoson effect and high Tc superconductors.

Unit III Ionic lattice in presence of infrared field, dielectric constant, L.S.T. relation, LO and TO modes, Ordered phases of matter, translational and orientational order, Quasicrystals, conducting polymers.

Unit IV Lattice defects: Frenkel and Schottky defects, colour centres, number of defects (vacancies) in equilibrium, Dislocations, edge and screw Burgers vector.

Unit V Diamagnetism, Langevin diamagnetic equation, Quantum theory of paramagnetism rare earth ions and iron group ions. Ferromagnetism, Curie temperature, Heisenberg model, Temperature dependence of saturated magnetization.

Paper - II NUCLEAR PHYSICS

PHY602

Unit I Deuteron, n-n scattering, n-p scattering, p-p scattering, charge symmetry of nuclear forces.

Unit II Shell Model, Extreme Single particle picture and angular momentum, magnetic moment, quadrupole moment of nuclei, Nuclear Isomerism, Collective model (qualitative discussion)

Unit III Compound Nucleus, Breit Wigner Formula, Direct Interaction, Heavy Ion Reactions, Relativistic Kinematics

Unit IV Fundamental types of Interactions, General Classifications of Elementary Particles, Isospin, Strangeness ,Conservation Laws , Symmetries (C, CP, CPT), SU(3) and quark model

Unit V Alpha, beta and gamma decay

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

Special Papers

CONDENSED MATTER PHYSICS

Paper – III CONDENSED MATTER PHYSICS

PHY651

Unit I Ewald's method, Lorentz field

Unit II Phonons in perfect-crystals: General theory of lattice dynamics of non-primitive lattice, normal coordinate description

Unit III Phonon concept, Ionic crystals

Unit IV Quantization of lattice vibrations, shell model.

Unit V Inelastic scattering of slow neutrons by crystals for study of phonons. Kramer-Kronig relation.

Paper – IV CONDENSED MATTER PHYSICS

PHY652

Unit I Dielectric constant of ionic crystals. Static polarizability, polarizability in variable field, placzek's approximation, first order Raman scattering, second-order Raman scattering,

Unit II Elementary ideas of the study of phonons by Raman scattering Plasmons, interaction of electromagnetic waves with phonons and polaritons.

Unit III Excitation in imperfect crystals: Definition of classical Green functions, application to one dimentional harmonic oscillator, principle of causality. Double-time quantum Green functions, correlation functions, spectral density.

Unit IV Static Green function (Fourier transform), application to lattice vibrations and electron energy states.

Unit V Point defect in one-dimensional lattice, localized, gap and resonance modes. Elementary ideas of extension to impurity electron energy states, gap states.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

ELECTRONICS

PAPER – III: ANALOG AND DIGITAL ELECTRONICS

PHY653

Unit I Wide band amplifier: Review of BJT at high frequencies. Hybrid pi-equivalent model, Junction capacitance, Base spreading resistance, Laplace Transform. RC Amplifier (CE BJT case only), transient response using Laplace Transforms. Effect of an emitter bypass capacitor on low frequency response. High and low frequency compensations.

Unit II Operational Amplifier: Ideal op-amp. Emitter coupled differential amplifier. CMRR, Effect of constant current source IC op-amp (emitter follower, level translation and out put device). Off – set error voltage and current and there balancing circuits. Temperature drifts, measurement of op-amp parameters.

Unit III Linear Analog System: Basic op-amp Applications: Inverter, Scale changer, phase shifter, adder, voltage to current converter, current to voltage converter, d.c. voltage follower, differential dc and bridge amplifier, a.c voltage follower, analog integration and differentiation, analog compensation, solution of simultaneous and differential equations upto second order, amplitude and time scaling. Active filter, Butterworth filter, active resonant band pass filter.

Unit IV Non-linear Analog System: Comparators, sample and hold circuits, AC/DC converters and detectors, log and antilog amplifiers, log multiplier, wave form generator, regenerative comparator.

Unit V Digital Electronics (TTL Based): Review upto combination logic, Flip Flop: DSR, JK, Master slave, Registers and counters: Shift Register, ripple counter, up down ashynchronous and synchronous counters, ring counter and sequence generators.

PAPER – IV: MICROWAVES

PHY654

Unit I Cylindrical W/G, two conductor system and TEM mode, discontinuity reflection coefficient and SWR, Scattering coefficients of multiple junction, directional coupler, hybrid T, cylindrical cavity resonator ; S.O. of a cavity resonator, wave meter, attenuator, slotted line, magnetic properties of Ferrites, Faraday rotation, Gyrator and Isolator, Microwave Integrated circuits.

Unit II Vacuum Tube Microwave Generators: Velocity modulation and density modulation, small signal theory of bunching, two cavity klystron amplifier and multiplier, two cavity klystron Oscillator, Reflex klystron: Theory of bunching, optimum power, effect of repeller voltage, electronic admittance, efficiency, electronic tuning.

Unit III Magnetron: Travelling wave magnetron, modes of oscillations, output power.

Unit IV Travelling wave tube: Description, dynamic of electron beam, coupling of beam and slow wave structure, waves in periodic structure, TWT amplifier and BWO, Generation of mm waves.

Unit V Microwave Measurements: Power, frequency, VSWR, Impedance, dielectric permittivity, Network Analyzer and scattering coefficients.

LASER AND SPECTROSCOPY

Paper – III: LASER SPECTROSCOPY

PHY655

Unit I Light Sources (Arc, Spark, Discharge, Beam Foil etc.), Synchrotron, Laser, Thermal and Direct Photo Detectors, Optical Multichannel Analyzer, Charged Coupled Devices (CCD), Integrated Charged Coupled Devices (ICCD).

Unit II Fixed-frequency and Tunable lasers, YAG, Argon Ion, Excimer, Dye, Semiconductor Lasers

Unit III Laser Photoacoustic Spectroscopy, Laser Induced Fluorescence (LIF), Laser Optogalvanic Spectroscopy

Unit IV Laser Raman Spectroscopy (CARS, SRS, SERS), Time Resolved Spectroscopy

Unit V Fourier Transform Spectroscopy, Laser Isotope Separation, Medical Applications of Laser.

Paper – IV: ELECTRONIC SPECTRA OF DIATOMIC MOLECULE

PHY656

Unit I Review of electronic spectra of diatomic molecules, Deslander's table, Franck Condom Principle

Unit II Thermal Distribution of quantum state's, Intensity of molecular band in electronic spectra. Effect of nuclear spin on the intensities of fine structure of electronic bands.

Unit III Classification of Molecular States, Multiplet Structure, Coupling and Uncoupling phenomena, Selection Rules for Electronic Transitions,

Unit IV Building up Principles. Electronic Configuration in diatomic molecule, Molecular Orbital Theory.

Unit V Basic concept of continuous and diffused spectra, Determination of heats of dissociation.

NON-LINEAR OPTICS

PAPER – III: COHERENCE THEORY AND ELEMENTARY NONLINEAR OPTICS

PHY657

Unit I Representation of Polychromatic Field by Analytic Signal. Mutual and Self Coherence Functions. Degree of Coherence, Relationship of Spectral-Profile with Correlation Functions.

Unit II Van Cittert Zernicke Theorem, Degree of Coherence of Thermal Circular Thermal Source,

Unit III Free Electron in Plane Electromagnetic Wave, Drift Acceleration of Electron, Second Harmonic Generation in Scattering of Plane Electromagnetic Wave (elementary discussion)

Unit IV Nonlinear Polarization, Classical Model of an Anharmonic Oscillator, Susceptibilities and Miller's Rule. Elementary discussion of Self-Focussing and Self-Steepening.

Unit V Simple explanation of Kerr Effect, Elementary Discussion of Harmonic Generation in Dielectric and Phase Matching.

PAPER – IV: QUANTUM STATES OF RADIATION

PHY658

Unit I Coherent States of Radiation and their Properties, Coherent State as wave packet, Expansion of States and Operators in Terms of Coherent States.

Unit II Density Operator of Radiation, Sudarshan-Glauber Representation, Density Operators of Coherent and Chaotic Radiation, Coherence and Characteristics Functions.

Unit III Polarization and Stokes Parameters, Annihilation and Creation Operators for Modes with General Polarization, Unpolarized Light.

Unit IV Photoelectron Counting Distribution, Hanbury Brown and Twiss Experiment, Bunching and Antibunching, Example of pure Fock State for Antibunching of Photons,

Unit V Schwartz Inequalities and Quantum Behaviour of Optical Fields, Squeezed States of Radiation (Elementary Discussion)

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

X-RAY AND ION BEAM

Paper- III: X-RAY PHYSICS AND INSTRUMENTATION

PHY659

Unit I General X-Ray Physics: Energy spectrum, continuous and characteristic X-ray spectra. Kramers theory of production of X-rays by thin and thick targets. Dispersion theory and refraction of X-rays.

Unit II Theory and observation of photoelectric effect and secondary Spectra. Screening doublets and X-ray energy level diagrams. Forbidden lines.

Unit III Relative intensities of X-ray lines, Theory of fine structure of absorption edges and absorption discontinuity.

Unit IV X-Ray Generators: Types of X-ray tubes and auxiliary equipment. Sealed source, rotating anode, and synchrotron, Detection of X-Rays: Photographic and electronic detectors

Unit V X-Ray Spectroscopic Techniques: One crystal, bent crystal, double crystal spectrometer and ruled gratings in X-ray spectroscopy. Soft X-rays spectroscopy and valence band spectra, XPS, AES, EXAFS, XANES.

Paper- IV: BEAM PHYSICS AND INSTRUMENTATION

PHY660

Unit I General Concepts: Emittance and brightness, Effects of space charge in charged particle sources; Interaction of particles with matter, cross section, survival probability, free path length, energy loss of heavy particles

Unit II Beam Sources: Survey of beam sources and some applications: Ion extraction and focusing geometries, positive & negative ion sources, radio frequency sources, ECR-source, atomic/molecular beam sources

Unit III Overview of accelerator types, beam manipulating elements, beam acceptance, betatron motion, lattice functions, tune, phase stability, luminosity, beam cooling, representative examples of accelerators.

Unit IV Detection and Controls systems: Transition radiation, detector characteristics (sensitivity, response, efficiency, dead time), gas detectors, calorimeters, semiconductor detectors, Cerenkov counters, scintillating chambers,

Unit V Interface buses for control instrumentation, CAMAC, current trends in data acquisition, Interpolation, concept of error propagation, Gaussian quadrature, Monte-Carlo method, Signal to noise ratio, pulse shaping and amplification, pulse height and timing measurements

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

NUCLEAR AND PARTICLE PHYSICS

Paper – III: ADVANCED NUCLEAR AND PARTICLE PHYSICS – I

PHY661

Unit I Review of Theoretical Techniques I: Rotational invariance in 3-dimesions, eigen values and eigen functions of angular momentum operators, addition of angular momenta, C.G. coefficients

Unit II Review of Theoretical Techniques I: Spherical tensors, Wigner Eckart theorem and its applications. Occupation number representation, calculation of the matrix element of one-and-two body type symmetric operators.

Unit III Nuclear Shell Model: Common potential V(r) in spherical shell model, wave function, quantum numbers. Two-particle outside a closed core, residual interaction and configuration mixing, effective interaction and operators. Transformation to center-of-mass and relative coordinates, Moshinsky transformation brackets, Mean Field models: Nuclear mean field, Hartree-Fock theory, Hartree-fock Bogolieubov , Pairing plus quadrupole interactions

Unit IV Energy level calculations. Spectra of closed shell nuclei, lp-lh excitations, three or more particles outside a closed core, coefficient of fractional percentage. Shell model Monte Carlo methods

Unit V Collective models: Nuclear vibrations, isoscalar vibrations, sum rule in vibration model, Giant resonances. Collective model of Bohr and Mottelson, back bending, high spin states, superdeformed and hyperdeformed shapes. Particle states in nonspherical nuclei-Nilsson's model, coupling of particle states and collective motion in unified model

Paper IV: ADVANCED NUCLEAR AND PARTICLE PHYSICS – II

PHY662

Unit I Symmetries and conservation laws, Noether theorem, Parity, Charge Conjugation and Time Reversal, CPT theorem, G-Parity, SU (2) of isospin

Unit II SU (3) and the quark model, meson and baryon spectra

Unit III Elementary particles as fields, Recapitulation of the quantization of free, scalar and electromagnetic fields

Unit V Dirac equation, helicity and chirality, quantization of Dirac fields

Unit V Interaction Hamoltonian in normal form, chronological products, Wicks theorem, S-matix formulation, Feyman digrams, propagators, Feynman rules, Compton scattering, Particle accelerators, fixed targets and colliding beam experiments, basic ideas of particle detection, discovery of J/ψ.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

SEMESTER – IV

Paper – I: EXPERIMENTAL TECHNIQUES & CONTROL SYSTEMS

PHY603

Unit I Data Interpretation and Analysis: precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and non linear curve fitting, chi-square test.

Unit II Optoelectronic Devices and Detectors: Solar cells, Photo-detector, Transducers (Temperature , Pressure, Vacuum pumps and Gauges)

Unit III Measurement and Control systems: Signal conditioning and recovery impedance matching. Ideal operational amplifier, characteristics and applications; Inverting and non inverting amplifier, integrator, differentiator, adder and comparator.

Unit IV Analogue v/s digital data: Statement of sampling theorem, A/D converters (Flash converters, single slope, double slope and successive approximation converter), D/A converter(R-2R ladder type and weighted resistor type converter), Digit filter (tapped delay line filter)

Unit V Fourier Transforms and lock-in detector, Box car averaging. Microprocessor and microcontroller basics, Instruction set related MOV, MVI and I/O commands. Addressing I/O devices (Memory mapped & I/O mapped I/O)

ELECTIVE PAPER

Paper - II

Elective – I

PROGRAMMING FOR NUMERICAL METHODS PHY663

Unit I C++ keywords: various data types, implicit conversions, for loop, while and do-while loop, break and continue statements, switch statement, if else, conditional operator, functions with default arguments, function overloading.

Unit II ++ and – operators, Arrays, Structures, Pointers, Compound assignment.

Unit III Basic concept of OOP: definition of class and object, declaration of classes and objects, simple applications.

Unit IV Programming in C++ for the following: Newton Raphson method, Iterative method, Integration by Trapezoidal and Simpson 1/3 rule, Interpolation, Matrix manipulations.

Unit V Programming in C++ for Euler's method, Runge Kutta (second order and fourth order) method, phase space trajectory, equilibrium points, stability analysis.

Elective – II

ELECTROYNAMICS AND SECOND QUANTIZATION PHY664

Unit I Radiation from a Moving Charge: Solution of Inhomogeneous Wave equation, Greens Functions, Lienard Wiechert Potentials and Field from a moving charge, Larmor's formula and its Relativistic Generalization

Unit II Angular Distribution of Radiation from an Accelerated Charge, Electromagnetic Field and Radiation from an Oscillating Localized Source.

Unit III Radiation Reaction and Self-Force: Radiation Reaction Force from Conservation of Energy, Line Width and Level Shift of an Oscillator.

Unit IV Covariant Lagrangian Formalism, Noether's Theorem, Energy-Momentum, Angular Momentum and Spin Tensors, Current Density Four Vector.

Unit V Second Quantization of Scalar field and of Electromagnetic Field in Radiation Gauge and of Dirac Field, Spin of Photons, Simple Problems on Algebra of Annihilation and Creation Operators.

Elective - III

GROUP THEORY PHY665

Unit I Group theory and its application: Abstract definitions: Group, Multiplication Table, Sub-groups, Isomorphism and homomorphism, complexes, Cosets and classes, Indirect-group, Direct product of groups.

Unit II Theory of Representation :Linear vector space, basis, matrix representation of operators, unitary space, Unitary matrices, representation of group, characters, reducible and irreducible representations, Invariant subspaces, Schur's Lemmas

Unit III Orthogonality theorem for irreducible representation and characters Regular representation, occurrence of, an irreducible representation in a reducible representation.

Unit IV Theorem for possible number of irreducible representations of a group. Direct product of representations. Relationship to Quantum mechanics: Symmetry transformations, degeneracy and invariant subspaces, projection operators, transformation of functions.

Unit V Applications to molecular and crystal symmetry, Fundamental point group operations and nomenclature, construction of thirty-two point groups and character tables for their irreducible representations.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

Special Papers

CONDENSED MATTER PHYSICS

Paper – III CONDENSED MATTER PHYSICS –I **PHY666**

Unit I Transport Theory : Phenomenological coefficient L_{ij} and their physical inter reaction. General Boltzmann equation and its linearization Entropy production. Relaxation time solution of Boltzmann equation.

Unit II Electronic contributions of thermal and electrical conductivities and to Peltier, Seeback coefficient for metals and electronis semiconductors. Relationship between electrical and ideas about lattice contribution to thermal conductivity.

Unit III Magnetism :Classical and Semi Classical Theories : Failure to explain large internal fields. Exchange interaction. Ising Model. Bragg William Approximation. Explanation of lerge external fields. Non-existence of ferromagnetism in two-dimensional Ising Model. Two sub-lattice Model and classical theories of antiferromagnetism and ferrimagnetism, Ferrites and garnets.

Unit IV Second Quantized Theory :Ferromagnetic Hiesenberg Hamiltonian, Holstein-Primakoff transformations and their application to Heisenberg Hamiltonian for small fractional spin reversal. Ferromagnetic magnons, Magnon heat capacity and saturation magnetization at small temperatures. Antiferromagnetic Hamiltonian and its reduction using Holstein Primakoff transformation, Antiferromagnetic magnons. Zero point sub-lattice magnetization.

Unit V The Magnetic Phase Transition :Order parameter, Landau's theory of second order phase Transitions. Fluctuations of the order parameter. Elementary qualitative ideas about critical exponents and scaling.

Paper – IV CONDENSED MATTER PHYSICS –II PHY667

Unit I Many Electron Systems :Second quantization for Fermions, field operators, electron density operator, Hamiltonian for two particle interactions in second quantized form : Coulmbian interaction and screened Coulombian interaction.

Unit II Linear Response Theory :Dielectric response analysis, dielectric constant for electron gas in self consistent approximation, Lindhard formula, dielectric constant. Dielectric screening of a point charge impurity.

Unit III Electron-Phonon Interaction :Long wavelength limit, deformation potential interaction, Born approximation, deformation potential perturbation Hamiltonian, Normal processes, polaron. Number of phonons accompanying electron.

Unit IV Electron-electron interaction via phonons, Attractive interaction, Cooper pairs, Reduced Hamitonian for superconducting state. Bogoliubo-Valatin tranformation, Diagonal and non-diagonal terms.

Unit V Superconducting ground state energy, nature of ground state, excited states, Temperature dependence of energy gap, Transition temperature, Simple treatment of Meissner effect and flux quantization.

ELECTRONICS

PAPER – III: MICROPROCESSOR PHY668

Unit I Microprocessor: Microprocessor 8085, Instruction set, Simple programs,

Unit II Memory organization and mapping, I/O devices Chip select and interfacing in I/O mapped and memory mapped I/O schemes.

Unit III Hardware description of 8085.

Unit IV PIA 8255 Handshaking via interrupt and polling, CMOS devices as RAM and ROM. Memory refresh.

Unit V A to D and D to A converter, IC ADC0809 and DAC08, Pin Out their interfacing with 8085.

PAPER – IV: ELECTRONICS: SEMICONDUCTOR DEVICES PHY669

Unit I Semiconductor Physics: Carrier concentration in intrinsic and extrinsic semiconductors, recombination process, current density and continuity equations, decay of photo excited carrirs, steady state injunction, transient and steady state diffusion.

Unit II P-n junction diode : Junction and diffusion capacitance, diode equation, break downs, temperature dependence of voltage and current. Varactor diode and parametric conversion and amplification,

Unit III Tunnel diode, V-I characteristics, tunnel diode as an amplifier and as an oscillator.

Unit IV Gunn diode, modes of operation, power and frequency performance. Impact: Static and dynamic characteristic, small signal analysis and negative conductance, power and frequency performance, device design and performance. Schottky effect and Schottky diode.

Unit V BJT :Current voltage relations in active, cut off and saturation regions, microwave transistor, cut off frequency, device geometry and performance.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

LASER AND SPECTROSCOPY

Paper – III: ADVANCED ATOMIC SPECTROSCOPY PHY670

Unit I Lamb – shift in hydrogen spectrum,

Unit II Complex Spectra and their interpretation, nitrogen, oxygen and manganese as examples, Alternation of multiplicities, Inversion of states

Unit III Breit's Scheme for spectral term derivation, Rydberg atoms and Rydberg states

Unit IV Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy (ECP-MS) Photo electron spectroscopy (PES), Auger Electron Spectroscopy (AES), X-Ray Fluorescence Spectroscopy (XRF).

Unit V Limitations of Optical Microscope and Electron Microscope, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Electron Microscopy (STEM), Fluorescence Microscopy.

Paper – IV: IR & RAMAN SPECTRA OF POLYATOMIC MOLECULES PHY671

Unit I Symmetry Elements and Symmetry Operations, Point Groups, Classification of Molecules into Point Groups.

Unit II Rotation and Rotational Spectra of Linear Polyatomic Molecules and Symmetric Top Polyatomic Molecules, Energy Levels and Symmetry Properties, Influence of Nuclear Spin and Statistics, Rotational Structure in the Far Infrared, Rotational Structure in the Raman Spectra & Alteration of Intensity.

Unit III Vibrational Motion, Motion in Cartesian Coordinates, Mass Weighted Cartesian Coordinates, Normal Coordinates and Normal Modes of Motion; Vibrational Energy, Infra-red and Raman Vibrational Spectra

Unit IV Fermi Resonance, Several Potential Minima and Inversion in Ammonia Molecule, Torsional oscillations, Active and Inactive IR and Raman Fundamentals, Functional Group Analysis.

Unit V Interaction of Rotation and Vibration, Rotation Vibration Spectra of Linear Polyatomic Molecule, Energy levels and Symmetry Properties, Coriolis Interaction, IR and Raman Spectra of Linear Polyatomic Molecule.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

X-RAYS AND ION BEAM

Paper - III GEOMETRICAL X-RAY DIFFRACTION PHY672

Unit I Symmetries and classification of crystals. Point groups and space groups. Bragg's Law, Reciprocal lattice, Ewald Construction, Laue equations, Temperature effects.

Unit II Scattering of X-Rays by electron, Lorentz polarization factor, Atomic scattering factor, Diffraction by a composite lattice, integrated reflection from mosaic and perfect crystal.

Unit III Powder diffraction, Laue, Rotation, Oscillation and Weissenberg methods. Crystal structure analysis, Fourier method, phase problem, Patterson function.

Unit IV Diffuse scattering of X-rays by gases, liquids, polymers and Amorphous materials

Unit V Low angle scattering, Electron and neutron diffraction, X-ray study of order-disorder phenomena.

Paper – IV ION BEAMS INDUCED MODIFICATION AND CHARACTERIZATION TECHNIQUES PHY673

Unit I GENERAL CONCEPTS AND THEORETICAL BACKGROUND**:** Energy loss of Mev Ions in Solids: Interaction of a particle with a free electron gas, local density approximation in stopping power theory, electronic stopping cross section. Nuclear and Electronic energy loss. Theories of Energy transfer from Ion to matter: Thermal Spike, Coulomb Explosion, Lateral Mass Transport.

Unit II Simulation of range distribution by Monte-Carlo methods (SRIM/TRIM), Ion implantation, radiation damage and structure change, ion beam mixing, radiation enhanced diffusion, diffusion by vacancies, self-diffusion and impurity diffusion, impurity incorporation, silicide formation,

Unit III RBS and Channeling, ERDA, NRA, PIXE etc.

Unit IV ION BEAMS IN DEVICE MAKING: Amorphous superstructure and hetero-junctions, band discontinuities and local structure, ion induced amorphous to single crystal transition in silicon. Artificially structured materials, buried layers and band structural engineering for new functional devices,

Unit V Polymer. Special features of the super conducting state - magnetization M(H), specific heat, the energy gap. HTSC columnar defects and modification of super conducting properties; Conditions leading to

formation of defects using ions and tuning the Band Gaps, Photo-luminescence and Iono-luminescence properties

NON-LINEAR OPTICS

Paper – III: RESONANT INTERACTION OF ATOMS WITH RADIATION – I

PHY674

Unit I Homogeneous and Inhomogeneous Broadenings, Semi-classical Theory of Interactions of Two-Level Atoms with Radiation, Rotating Wave Approximation and Description by a Pseudo-spin Vector.

Unit II Optical Bloch Equations, Comparison of Classical and Semi-classical Descriptions, Elementary Ideas about Area of Pulses and Rabi solution of Optical Bloch Equations. Phenomenological Introduction of Decay Constants.

Unit III Solution of Optical Bloch Equations and Elementary Applications, Elementary Ideas about Optical Nutation and Adiabatic Following.

Unit IV Coupled Maxwell and Optical Bloch Equations, The Factorization Assumption, Elementary ideas about Self-Induced Transparency

Unit V Elementary ideas about Mc Call Hahn Area Theorem and, Photon Echo and its Direction

Paper – IV: RESONANT INTERACTION OF ATOMS WITH RADIATION– II

PHYS675

Unit I Two-Level Model of Atoms, Atomic Spin Operators and States and their properties, Rotations in Atomic Spin Space and Elementary Ideas about Berry's Phase.

Unit II Dicke's Collective Atom Operators and States, Degeneracy of Dicke States of an Assembly of Atoms, Holstein-Primakoff and Two-Boson Modes Representations of Dicke Operators and States.

Unit III Elementary Ideas about Entanglement of Two Two-Level Systems and their Use in Quantum Teleportation.

Unit IV Schrodinger, Heisenberg and Interaction Pictures. Hamiltonian for Interaction of an Atom with Radiation. Relative Contributions of **p.A** and $\mathbf{A}^2$ terms, Dipole Approximatiion, Rotating Wave Approximation.

Unit V Weisskopf-Wigner Approximation, Welton's Treatment of Lamb Shift, Superradiance.

UNIVERSITY OF ALLAHABAD
M.Sc. PHYSICS SYLLABUS

NUCLEAR AND PARTICLE PHYSICS

Paper – III : ADVANCED NUCLEAR AND PARTICLE PHYSICS

PHY676

Unit I Measurements Techniques and Data Processing: Interaction of charged particles and radiation with matter, experimental techniques in particle and gamma ray spectroscopy, gamma detector arrays, coincidence method, decay schemes, counters, statistics of counting, Poisson and Gaussian distribution, statistical quality of data, chi-square test

Unit II Nuclear Reaction: Compound nucleus model, Resonance, level density; decay, cross-section, entrance channel effect, Statistical theory, Pre equilibrium model

Unit III Direct reaction, Plane wave theory (Born approximation), general theory, examples of direct reactions, nuclear spectroscopy from direct reactions, Theory of average cross-section, optical model

Unit IV Heavy ion induced nuclear reactions, Features of medium and low energy heavy ion elastic scattering, diffraction model, Coulomb excitation.

Unit V Exotic Nuclei: Nuclear structure at the extremes of stability, proton and neutron drip lines, nuclear halos, neutron skins, proton rich nuclei and beyond, decay modes of exotic nuclei, RI B as a new experimental technique.

Paper – IV: ADVANCED NUCLEAR AND PARTICLE PHYSICS

PHY677

Unit I Basic relativistic kinematics, Mandelstam variables, Lorentz invariant phase space, cross section for $2\rightarrow2$ processes, decay width for $1\rightarrow2$ and for $1\rightarrow3$ processes

Unit II Lagrangian for electron-photon interaction, gauge invariance, $e^+e^- \rightarrow \mu^+\mu^-$

Unit III Weak interaction, parity violation and (V-A) theory, amplitude and calculation of decay width for pion and muon decays, Cabibbo angle,

Unit IV Brief overview of recent developments, qualitative introduction to deep inelastic scattering, parton model and quantum chromodynamics,

Unit V Unification of weak and electromagnetic interaction, Salam-Weinberg theory, spontaneous symmetry breaking and Higgs mechanism, neutral currents.

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M.Sc. PHYSICS SYLLABUS

Semester III and IV laboratory course code

Condensed Matter Lab	**PHY631**
Electronics Lab	**PHY632**
Laser & Spectroscopy Lab	**PHY633**
Non-Linear Lab	**PHY634**
X-rays & Ion Beam Lab	**PHY635**
Nuclear & Particle Physics Lab	**PHY636**