M.Sc. II Semester - III

3PHY-1 ELECTRODYNAMICS-II
(RADIATIONS AND PLASMA PHYSICS)

Unit-I : Wave Equation for Electric and Magnetic Fields in free space, Wave Equations for Vector and Scalar Potential, Retarded and Lienard-Wiechert Potentials, Electric and Magnetic fields due to a Uniformly moving charge and an Accelerating Charge. Total power radiated and Angular Distribution of Power Radiated by moving charge with linear and circular acceleration, Cerenkov radiation, Radiation Reaction Force.
Unit-II : Motion of charged Particles in Electromagnetic Field: Uniform E and B Fields, Nonuniform Fields, Diffusion Across Magnetic Fields, Time Varying E and B Fields, Adiabatic Invariants: First, Second and Third Adiabatic Invariants.
Unit-III : Definition of plasma, concept of temperature, Debye Shielding, Plasma Parameters, Applications of plasma Physics.Relation of Plasma Physics to ordinary electromagnetics, Classical treatment of Magnetic Materials and Dielectric. Dielectric constant of Plasma. Fluid equations of motion, Equation of continuity, equation of state, Fluid drifts parallel and perpendicular o magnetic field.
Unit-IV : Plasma Oscillations, Electron Plasma Wave, Ion waves, Plasma Approximation, Electrostatic electron oscillations perpendicular to B, Electrostatic Ion waves perpendicular to B, Electromagnetic wave without magnetic field, Electromagnetic waves perpendicular and parallel to static magnetic field B0.
Unit-V : Cutoffs and resonances, Whistler mode and Faraday rotation. Hydromagnetic Waves: Magnetosonic and Alfven Waves, CMA Diagram.Reflection of radio waves from ionosphere, effect of collision on reflection, Appleton- Hartee Formula and Propagation through Ionosphere and Magnetosphere.

References:

1. Introduction to Electrodynamics by David J. Griffiths, Publisher: PHI Learning (2009).
2. Electrodynamics: J. D. Jackson.
3. Elecrodynamics: Gupta Kumar Singh, Pragati Prakashan.
4. Electricity and magnetism: Mahajan and Rangawala Tata Mc Graw –Hill,New York.
5. Electrodynamics: Laud New Age Publication.
6. Introduction to Plasma Physics: Francis Chen, Plenum Press.
7. Fundamentals of Plasma Physics: BittenCourt, Pergamon Press.
8. Plasma Physics: Plasma State of Matter, S. N. Sen. Prgati Prakashan.

3PHY-2: STATISTICAL MECHANICS

Unit-I : Classical Statistics :- Specification of States, phase space, trajectory and density of states, Liouville's theorem, ensemble, micro canonical, Canonical and grand canonical ensembles, comparison of ensembles, Partition function and its correlation with thermodynamic quantities, Properties of partition function. Gibbs Paradox.
Unit-II : Quantum Statistics :- Basic Concepts regarding statistics of indistinguishable particles, Concepts about Fermi-Dirac and Bose-Einstein distribution. Ideal Bose-

Einstein gas, degeneracy, Bose-Einstein condensation. Thermal properties of B-E gas. Blackbody radiation and Planck's distribution law.

Unit-III : Ideal Fermi-Dirac Gas : Thermodynamic function of degenerate F-D gas, Free electron model and electron emission. Di-atomic molecule, specific heats of solids, Einstein & Debye theory,

Unit-IV : Phase Transitions : Landau's theory of phase transition, Fluctuation in Thermodynamic Quantities, Correlation of space - time dependent fluctuations, fluctuations and transport phenomena, Brownian motion and Random walk, The Fokker-Planck Equation and its solution.

Unit-V : Introduction to non-equilibrium processes**;** Diffusion equation. Super-fluidity, experimentally observed properties of super-fluid He II. Landau's theory.

Reference Books:

(1) Statistical Mechanics, K.Huang, Wiley Eastern Limited.
(2) Statistical Physics, Landau and Lifshitz
(3) Statistical mechanics, Donald Allan McQuarrie, University Science Books
(4) Introduction to modern statistical mechanics, David Chandler, Oxford University Press.
(5) Statistical Mechanics, B. K. Agarwal, New Age International.
(6) Statistical mechanics, James Woods Halley, Cambridge University Press.
(7) Statistical mechanics, Shang-keng Ma, World Scientific.

Text books

(1) Statistical Mechanics, B.K.Agrawal and M.Eisner, Wiley Eastern Limited.
(2) Introduction to Statistical Mechanics, B.B.Laud.
(3) Statistical Mechanics, Gupta, Kumar, Pragati Prakashan, Meerut.

3PHY-3: ATOMIC & MOLECULAR PHYSICS

Unit-I : Vector atom model; Space quantization and spin of electron,significance of Principle quantum number (n), Orbital quantum number (l), Magnetic Orbital quantum number (m1), Spin quantum number (s), Magnetic spin quantum number (ms), Total Angular Momentum quantum number (j), Magnetic Total number (mj). l-s coupling for single valence electron atom. Stern Gerlac Experiment. Pauli's exclusion principle. Spectra of alkali elements. Fine structure in alkali spectra.

Unit-II : Normal and Anomalous Zeeman effect. Experimental setup to study Zeeman effect. Debye's explanation of Normal Zeeman effect. Theory of Anomalous Zeeman effect. Expression of Lande's spectroscopic splitting factor (g) and effective magnetic moment for single valance electron atom. Origin of Sodium D1 & D2 lines. Anomalous Zeeman effect in Sodium D1 & D2 lines.

Unit-III : Paschen Back effect; Stark effect. LS & JJ coupling in two valence electron atoms. Interaction energy in LS & JJ coupling. Hyperfine structure (Qualitative), Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation.

Unit-IV : Types of Molecules : Diatomic linear symmetric top, asymmetric top and spherical top molecules. Molecular (band) spectra. Classification of molecular spectra

(purerotational spectra, Rotation-vibration spectra, Visible and UV spectra), Rotational spectra of diatomic molecules as a rigid rotator. Quantum mechanical theory of pure rotational spectra (rigid rotator). Energy levels and spectra of nonrigid rotator. Comparison between spectra of rigid and nonrigid rotators. Isotopic effect in pure rotational spectra.

Unit-V : Vibrational energy of Diatomic molecule. Diatomic molecule as a simple harmonic oscillator. Energy levels and spectrum. Morse potential energy curve. Molecules as a vibrating rotator. Vibration spectrum of diatomic molecule. PQR branches, Raman spectra of diatomic molecules; IR spectrometer (Qualitative).

Reference Books :

1 Physics of Atoms and Molecules: Bransden and Joachain.
2. Introduction to Atomic Spectra: HG Kuhn.
3. Spectroscopy Vol. -I,II & III - Walker & Straughen
4. Introduction to Molecular Spectroscopy - G.M.Barrow
5. Spectra of Diatomic Molecules - Herzberg8.Molecular Spectroscopy - Jeanne L McHale
6. Molecular Spectroscopy - J.M.Brown
7. Spectra of atoms and molecules - P.F.Bemath
8. Modern Spectroscopy - J.M.Holias
9. Elements of Spectroscopy - Gupta, Kumar, Sharma, Pragati Prakashan, Meerut.

Text Books :

(1) Introduction to Atomic Spectra- H.E.White
(2) Fundamentals of Molecular Spectroscopy - C.B.Banwell

3PHY-4(i) : DIGITAL TECHNIQUES

Unit-I : Fundamental Digital Devices: The transistor as a switch Basic logical operation like OR, AND and NOT , ExOR, NAND, NOR Electronic Circuit operations using Various Logic Families devices like TTL(Std, Schotky, LP, HP), C-MOS, Comparison on Fan in Fan out, Propagation delays, voltage levels, power consumption packing density etc. Merits and Demerits. NOR and NAND devices as basic building blocks, Classification of Logic Circuits

Unit-II : Combinational Logic Design : Boolean algebra – Simplification of logic circuits Boolean algebraic methods, rules, limitations Demorgan's theorems - Exclusive OR gate, Simplification of logic circuits using K'Map Method and complementary K'Map min terms/max terms. Half Adder, Full Adder, 7483 IC, Adder-2-Subtractor, Arithmetic circuits for Binary Multiplier, Binary Divider,

Unit-III : Devices and converters: Multiplexer : 2:1, 4:1, 8:1 and 16:1, De-multiplexer : 1:2:,1: 4, 1:8 and 1:16, Decoder IC 7445, 7447, 74138, Encoder hex key, ASCII key ,SSD display Devices, CK/CA SSD codes , Data selector etc. 2-Bit ALU,, 4-Bit ALU-74181.

Unit-IV : Sequential Logic Design: Bi-stable Multivibrator, Flip - Flops : the RS Flip-Flop, JK Flip - Flop - JK master slave Flip - Flops - T Flip - Flop – D flip - Flop - Shift

registers - SIPO, PISO, SISO, PIPO, Universal Shift operations using various ICs, Data latches, Controlled buffers, Unidirectional & Bidirectional controlled buffers. Counters Synchronous and Asynchronous and combination counters.
Unit-V : Memory Devices: Concept of a memory cell using DFF, Working of the memory cell for each type Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, nonvolatile- NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD). Read- only Memory (ROM) and applications. Random Access Memory (RAM) and applications. Memory Organization, Memory Map, Memory devices classification and features,Programmable, OTP Memory, EPROM, EEPROM, Memory map, Designing memory organization, Serial Expansion, Parallel Expansion using 6264, 2764, etc

References :
R. P. Jain & Anand, Pittman, Malvino & Leach, Tokheim, D. C. Green, Floyed

OR

3 PHY-4(ii) : CONDENSED MATTER PHYSICS-I

UNIT-I : Band Structure - Electron levels in periodic potential Kronig Penny Model), Bloch theorem - statement and proof. Crystal momentum, number of orbital's in a band, band index and the concept of effective mass. Motion of electrons in bands, Reduced, periodic and extended zone schemes, Construction of Fermi surface. Nearly free electron model: qualitative proof for origin of gap in periodic potential and perturbation theory. Tight binding model: assumptions and applications to SC, FCC and BCC structures.
UNIT-II : Magnetism: Atomic Magnetic Moment, Larmor Precession, Diamagnetism: Classical and Quantum Theory, Paramagnetism: Origin of permanent magnetic moment, Ideal Magnetic Gas, Classical and Quantum Mechanical Treatments of Paramagnetism, Paramagnetism in rare earth ions, Paramagnetic cooling.
UNIT-III : Ferromagnetism: Weiss Theory, Heisenberg Model of Molecular Field Theory, Spin Waves And Magnons, Curie- Weiss Law, Theory of Ferri and Antiferro Magnetism, Domains And Domain Walls.
UNIT-IV : Dielectrics: Concept of dielectrics, Macroscopic and Local electric fields, Claussius. Mosotti relation, Types of Polarization mechanisms, complex dielectric constant, relaxation time, Concept of Ferroelectricity, Theories of ferroelectricity, Antiferrolectricity, Piezo electricity.
UNIT-V : Superconductivity: Introduction, Meissner effect, D.C. resistivity, the heat capacity, flux quantization, Type I and II superconductors. Superconducting energy gap, coherence length, London penetration depth, BCS theory, Ginzsberg- Landau theory, DC and AC Josephson effects, SQUID, Introduction to high Tc superconductors.
References:
1. Solid State Physics, N W Ashcroft and N D Mermin (Cenage Learning India Pvt Ltd, 2009).
2. Introduction to Solid State Physics, C. Kittel (John-Wiley, 8th Ed. 2005).

3. Introduction to Solids, L V Azaroff (Tata-McGraw Hill, 1984).
4. Introduction to Modern Solid State Physics, Yuri M Galperin.
5. Solid State Physics, R. L.Sighal, Ram Nath Kedar Nath & Co., Publishers Meerut.

3PHY-4 (iii) : ANALOGUE COMMUNICATION

UNIT-I : Amplitude Modulation- Generation of AM waves - Demodulation of AM Waves - DSBSC modulation. Generation of DSBSC waves, coherent detection of DSBSC waves SSB modulation, Generation and detection of SSB waves. Vestigial sideband modulation. Frequency Division multiplexing (FDM).

Unit-II : Radar block diagram, an operator radar frequency, pulse considerations. Radar range equation, derivation of radar range equation, minimum detectable signal, receiver noise, signal to noise ratio, integration of rader pulses. Radar cross section. Pulse repetition frequency. Antenna parameters. System Losses and Propagation losses. Radar transmitters, receivers. Antennas, Displays.

UNIT-III : Klystrons, Magnetrons and traveling Wave Tubes, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons.Helix Travelling Wave Tubes, Wave Modes. Transferred electron devices, Gunn Effect, Principles of operation. Modes of operation , Read diode, IMPATT diode, TRAPATT Diode.

Unit-IV : Advantages and disadvantages of microwave transmission, loss in free space, propagation of microwaves atmospheric effects on propagation, Fresnel Zone problem, ground reflection, fading sources, detectors components, antennas used in MW communication systems.

Unit-V : Satellite communications : Orbital satellites, geostationary satellites , orbital patterns, look angles, orbital spacing, satellite systems. Link modules.

Text and Reference Books :

1. “Microelectronics “ by Jacob Millman, Megraw-hill, International Book Co., New Delhi, 1990.
2. “Optoelectronics : Theory and Practice” Edited by Alien chappal MeGrawHill Book Co., New York.
3. “Microwaves “ by K.L. Gupta , Wiley Eastern Ltd., New Delhi, 1983.
4. “Advanced Electronics Communications systems “ by Wayne Tomasi, Phi.Edn.
5. “Electronic Devices and circuit theory” by Robert Boylested and Louis Nashdsky PHI., New Delhi-110001, 1991.

TUTORIAL : ELECTRONICS :

1. Radiowave propagation in free space.
2. Tropospheric & ionospheric propagation.
3. Applications of counters & shift registers.
4. Dedicated systems using microprocessor.
5. Sampling Theorem - smaple and hold circuits,
6. Second and higher order filter design concepts.
7. A/D & D/A interfacing.
8. Photo electric effect.

9. Photo emissive cells.
10. Microwave amplification.
11. Klystron and Gunn Oscillator characteristics.
12. Concepts of wave guides.

13. Microwave propagation.

14. Design considerations of microwave links.

Different types of Radar systems.
i) Weather Radars
(ii) Cyclone detection radars
(iii) Moving target indicators. Frequency considerations in satellite communications.
In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

OR

3PHY-4 (iv) Photonics-1: Fundamentals of Photonics

Unit-I : Maxwell's equations, Maxwell's wave equations for a vacuum, solution of the general wave equation, Group and Phase velocity, generalized solution of the wave equation,, transverse electromagnetic wave, flow of electromagnetic energy, electric dipole radiation, Fundamentals of geometrical optics, Ray tracing, paraxial approximation, Aberrations, Designing Optical set-ups, Thin lens theory
Unit-II : Fundamentals of Modern Optics: Wave propagation, wave particle duality, Kramers - Kronig relations, Electromagnetic fields in homo and inhomogeneous dispersive media, diffraction theory, Polarization of light.
Unit-III : Fourier Optics: Plane waves, spatial frequency, Optical Fourier Transform, Diffraction of light, special function in Photonics and their Fourier transform, convex lens and its function, Image formation, spatial filters, Holography, Applications of Holography.
Unit-IV : Near Field optics: The evanescent waves, Goos-Hänchen Shift, generation of evanescent waves, Photon tunneling microscope, scanning near field optical microscope, probes to detect the evanescent field.
Unit-V : Radiation pressure of laser light, Optical Tweezers and its applications, Raman-optical tweezers, Laser cooling of atoms, Bose Einstein Condensate, Atom laser.
References
1) Keigo Iizuka, "Elements of PHOTONICS Vol. 1 (In free space and special media) and 2 (for fiber and integrated optics)," Wiley Series in Pure and Applied Optics.
2) Eugene Hecht, "Optics (International Edition)," Addison Wesley,(2003).
3) F G Smith, T A King and D Wilkins, "Optics and Photonics: An Introduction," John Wiley & Sons, Ltd, San Francisco, USA, (2007).
4) David J. Griffiths, "Introduction to Electrodynamics (3rd edition)," Pearson Publishers.

5) Born and Wolf, "Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light," Cambridge University Press.
6) Joseph W Goodman, "Introduction to Fourier Optics," McGraw- Hill.
7) Hand Book/Optics, Vol. 1-IV, Optical Society of India, McGraw Hill

3PHY-5(i) : LAB COURSE ON DIGITAL TECHNIQUES

It is necessary to perform atleast seven experiments from the list given below. The experiments based on theory course are desirable.

1. Digital I: Basic Logic Gates, TTL, NAND, and NOR.
2. Digital II: Combinational Logic.7483, BCD Adder, A-2-S
3. Designing various binary counters using JKMSFF.
4. Designing various Shift resisters using JKMSFF
5. Study of Multiplexer : 2:1, 4:1, 8:1 and 16:1, De-multiplexer : 1:2:,1: 4, 1:8 and 1:16, Multiplexers and De-multiplexers.
6. Designing Memory using ICs of required organization Solving problems using K'Map
7. Design consideration of Combinational logic design circuits for HA/ FA/ Subtractor,
8. Design consideration of Multiplier, Divider etc using ICs.
9. Design consideration of Synchronous/asynchronous Modulo N Counters and Decade Counter,
10. Design consideration of SIPO, PISO, SISO, PIPO, Universal Shift operations,
11. Design consideration of, Memory expansion problems

3PHY-5(ii): LAB COURSE ON CONDENSED MATTER PHYSICS

It is necessary to perform atleast seven experiments from the list given below.

1.Determination of Magnetic Susceptibility of Material by Quincke's Method.
2. Study of Magnetic Properties (Coercivity, retentivity, saturation magnetization and hysteresis loops) of ferromagnetic samples (soft iron, hard steel & nickel).
3. To study variation of Dielectric constant of a given solid / liquid with temperature.
4. Determinations of specific heat of graphite sample.
5. Determination of magnetic susceptibility of a solid by Guoy balance method.
6. Determination of Curie temperature of a given sample.
7. Determination of Lande's g-factor of DPPH using Electron Spin Resonance Spectrometer.
8. Determination of band gap of semiconductor by variation of conductivity with temperature.
9. Determination of band gap by absorption coefficient measurement.
10. Demonstration of Meissner effect.
11. Determination of adiabatic compressibility of a given liquid.
12. Determination of Thermoelectric Power of a substance.

3PHY-5(iii) : LAB COURSE ON ANALOGUE TECHNIQUES

The experiments from serial no. 1 to 5 are compulsory & perform any two experiments from others. It is expected that the teacher may perform open ended experiments.

1. Pulse amplitude modulation and demodulation.
2. Pulse position modulation and demodulation.
3. Pulse width modulation and demodulation.
4. Study of delta modulation and demodulation.
5. Characteristics of antenna.
6. Study of amplitude modulator.
7. Study of frequency modulator.
8. Study of FSK modulator and demodulator
9. Study of super-heterodyne receiver.
10. Study of fibre optics voice transmission and reception.

3PHY-5 (iv) Lab on Photonics-1

A student should perform at least seven experiments from the following list. In the examination he will be asked to perform one experiment only

1) Handling, cleaning, maintenance of optical components and laser systems. Laser safety demonstration.
2) Characterization of laser beam.
3) Setting up of two and multi-beam Interferometer.
4) Measurement of UV-Visible Absorption spectra of standard samples.
5) Measurement of refractive index of the transparent material using Mach-Zahnder Interferometer.
6) Conversion of continuous wave laser into pulsed laser.
7) To study relaxation oscillation of diode laser.
8) Temporal pulse shaping of laser beam.
9) To study various polarized states of light.
10) To record and study Laser Induced Breakdown spectroscopy signal of known and unknown samples.**(Demo)** Setting up of high power interferometer demonstrative experiment.