POST GRADUATE DEPARTMENT OF PHYSICS

UNIVERSITY OF KASHMIR, SRINAGAR

(Course Curriculum M.Sc Physics SEMESTER-III)

Academic years 2021, 2022 and 2023

Type of Course	**Course Code**	**Title of Course**	**No. of Credits**
Core (CR)			
CR	PHY18301CR	Nuclear Physics	04
CR	PHY18302CR	Condensed Matter Physics	04
CR	PHY18303CR	Atomic Molecular and Laser Physics	04
Discipline Centric Electives (DCE)			
DCE	PHY18304DCE	Astrophysics - I	02
DCE	PHY18305DCE	Atmospheric Physics - I	02
DCE	PHY18306DCE	Quantum Field Theory - I	02
DCE	PHY18307DCE	Physics of Nano-materials	02
DCE	PHY18308DCE	Superconductivity	02
Generic Electives (GE)			
GE	PHY18309GE	Microwave Devices and Circuits	02
GE	PHY18310GE	Advanced Lab. Methods	02
Open Electives (OE)			
OE	PHY18311OE	Lasers	02
OE	PHY18312OE	Radiation Physics	

Title:Nuclear Physics (Course Code:PHY18301CR)

Max.Marks:100 **Int. Assessment:** 20 **Ext. Examination:** 80 **Credits:** 04

Course Outcome: The course aims to provide a comprehensive understanding of nuclear physics, covering fundamental interactions, two-nucleon systems, bulk properties of nuclei, electromagnetic and weak interactions, and various models of nuclear structure. Students will gain theoretical knowledge and analytical skills to interpret and analyze different aspects of nuclear phenomena.

Learning Outcome: Upon completion of the course, the student should be able to:

- Understand fundamental interactions in nuclear physics.
- Explore the properties of the deuteron, including its magnetic moment and electric quadrupole moment.
- Investigate the Pion-Nucleon Interaction.
- Analyze the properties of the nucleon-nucleon force.
- Learn the Yukawa theory of nuclear forces.
- Explore nuclear size through Rutherford and Mott Scattering.
- Understand electron scattering form factor, charge radius, and charge density.
- Investigate nucleon elastic form factors.
- Study high-energy lepton scattering.
- Explore nuclear shape and electromagnetic moments.
- Understand the magnetic dipole moment of odd nuclei.
- Understand the photon-hadron interaction, including vector mesons.
- Investigate the continuous beta spectrum and survey weak processes.
- Explore weak interactions, beta decay, and nuclear beta decay.
- Understand the vibrational model of nuclear structure.
- Explore magic numbers and single-particle energy.
- Study spin-orbit interaction and many-body basic states.

- Analyze the Hartree-Fock single-particle Hamiltonian.
- Understand the single-particle shell model and its generalization.
- Explore nuclear deformation.
- Study rotational spectra of spinless nuclei.
- Understand the Fermi gas model.

Unit-I

Nuclear Forces and Two Nucleon Systems: Fundamental Interactions, The deuteron, Deuteron magnetic moment, Deuteron electric quadruple moment, Tensor forces and deuteron D-state, Symmetry and conservation laws, , Pion-Nucleon Interaction, Properties of b Nucleon-Nucleon Force, Yukawa theory of nuclear forces

Unit-II

Bulk Properties of Nuclei: Nuclear size, Rutherford and Mott Scattering, Electron scattering form factor, Charge radius and Charge density, Nucleon Elastic form factors, High energy lepton scattering, Nuclear shape and electromagnetic moments, Magnetic dipole moment of odd nuclei, Ground state spin and isospin, Nuclear binding energy, Semi-empirical mass formulae,

Unit-III

Electromagnetic and Weak Interactions: The Photon-Hadron Interaction:Vector Mesons, The Photo-Hadron Interaction: Real and Space-like Photons, Classical Electromagnetic Interaction, The Continuous Beta Spectrum, Survey of Weak Processes, Weak Interaction and Beta Decay, Nuclear Beta Decay

Unit-IV

Models of Nuclear Structure: Vibrational Model, Magic number and single-particle energy, Spin- Orbit interaction, Many body basic states, Hartree-Fock single-particle Hamiltonian, Single Particle Shell model, Generalization of Single-Particle Model, Nuclear deformation, Rotational spectra of spinless Nuclei, Fermi gas model.

Text Books:

1. Introductory Nuclear Physics by Samuel S. M. Wong, Wiley-VCH

References:

1. Introductory Nuclear Physics, Kenth S. Krane, WIley, New York, 1987
2. Atomic and Nuclear Physics, S. N. Ghoshal
3. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley, 1982

Title: Condensed Matter Physics **(Course Code: PHY18302CR)**

Max.Marks:100 **Int. Assessment:** 20 **Ext. Examination:** 80 **Credits:** 04

Course Outcome: The course outcomes cover a broad spectrum of topics in solid-state physics, crystallography, quantum mechanics, and the behavior of materials in different dimensional systems, offering students a comprehensive understanding of the subject matter.

Learning Outcome:

- Understand crystal lattices planes, and directions within a crystal structure.
- Analyze crystallographic point groups, and their practical applications.
- Explain diffraction of waves by crystals, including scattered wave amplitude and Fourier Analysis of a crystal.
- Apply reciprocal lattice concepts to diffraction techniques, such as diffraction conditions in reciprocal space, Brillouin zones, crystal structure factor, and atomic scattering factor.
- Analyze electrons in a periodic lattice, emphasizing the origin of energy gaps.
- Apply Bloch theorem and understand Bloch modes and Schrödinger wave equation in reciprocal space.
- Comprehend the Tight Binding Approximation and its relevance.
- Analyze Fermi surfaces of solids and associated experimental methods.
- Explain experimental methods like De Hass-van Alfen effect, Cyclotron resonance.
- Understand the electronic structure of a two-dimensional electron gas and integral quantum Hall-effect.
- Analyze one-dimensional systems including DOS, 1D sub-bands, and Van-Hove singularities and their practical applications.
- Explain conductance quantization and the Landauer formalism.
- Understand resonant tunneling and the behavior of two potential barriers in series.
- Analyze Coulomb Blockade, and Single Electron devices.

Unit-I

Crystal lattice; crystal planes and directions. Crystal symmetry, crystallographic point groups and their applications. Space groups, Direct and reciprocal lattice. Diffraction of waves by Crystals, scattered wave amplitude, Fourier Analysis of a crystal. Reciprocal lattice and its applications to diffraction techniques, Diffraction conditions in reciprocal space, Brillouin zones, Crystal structure factor and atomic scattering factor.

Unit-II

Quantum mechanical free electron model, Density of state function, Electrons in a periodic lattice, origin of energy gaps. Bloch theorem, Bloch modes, Schrodinger wave equation in a reciprocal space; Tight binding approximation. Fermi surface of solids; experimental methods, De Hass-van Alfen effect, Cyclotron resonance, Electron motion in a uniform magnetic field, Landau Levels. Electronic structure of a two dimensional electron gas, Integral quantum Hall- effect.

Unit-III

Low dimensional electron systems: One dimensional systems; DOS, 1D sub-bands, Van-Hove singularities and their applications. Conductance quantization and the Landauer formalism. Resonant tunnelling, two potential barriers in series. Zero dimensional systems: quantized energy levels of semiconductor nano-crystals, DOS. Metallic dots, discrete charge states, Coulomb Blockade, Single Electron devices.

Unit-IV

Ferromagnetism: Weiss theory of ferromagnetism, Curie-Weiss law for susceptibility Heisenberg model and molecular field theory. Spin waves and Magnons, Bloch T3/2 law. Formation of Domains, Bloch-wall energy. Ferroelectricity: Classification of Ferroelectric Crystals, Landau theory of the ferroelectric phase transition. Soft mode theory. applications of ferroelectric materials.

Text Books:

1. Introduction to Solid State Physics, Charles Kittel, John Wiley and Sons
2. The physics of low dimensional semiconductors: An introduction by John H. Davis, Cambridge University Press.
3. Quantum mechanics for nanostructure by Cladimir Mitin, Dmitry Sementsov, Nizami Vagidov, Cambridge University Press.

References:

1. modern course in quantum theory of solids by Fuxuang Han, Wiley Scientific.
2. Solid state physics by Neil W. Ashcroft and N. David Mermin, Black Well Pub.

Title:Atomic Molecular and Laser Physics **(Course Code: PHY18303CR)**

Max.Marks:100 **Int. Assessment:** 50 **Ext. Examination:** 50 **Credits:** 04

Course Outcome: This course aims to provide students with a comprehensive understanding of atomic and molecular phenomena. Covering one-electron and two-electron atoms, participants will delve into the fine structure, energy shifts, and intricate interactions within these systems. Moving to many-electron atoms, the focus expands to central field approximation, spin- orbitals, and correlation effects. Molecular spectroscopy becomes a central theme, with students gaining expertise in analyzing molecular structures, rotations, vibrations, and Raman spectroscopy. Finally, the course delves into laser technology, imparting practical knowledge on absorption, emission, and population inversion principles, preparing students for applications in diverse scientific and technological domains.

Learning Outcome:

- Understand fine structure in hydrogenic atoms, including Lamb shift, hyperfine structure, and Zeeman effects.
- Solve Schrödinger equation for two-electron atoms and grasp the role of spin wave functions.
- Apply central field approximation and comprehend spin-orbitals and Slater determinants.
- Introduce Hartree-Fock method and analyze correlation effects in electronic structure.
- Apply Born-Oppenheimer separation to diatomic molecules and explore rotational and vibrational spectroscopy.
- Understand the quantum mechanical theory of Raman Effect.
- Grasp absorption, spontaneous and stimulated emission, Einstein coefficients, and transition probabilities.
- Analyze population inversion and its role in laser systems.
- Derive laser rate equations, explain line broadening mechanisms, and discuss optical resonators.
- Analyze operation and characteristics of He-Ne laser, CO2 laser, and properties of laser beams.

Unit-I

One-electron atoms: Fine structure of hydrogenic atoms. Energy shifts, The Lamb shift, Hyperfine structure, Zeeman effect, weak and strong fields-Paschen-Back effect, Stark effect (linear and quadratic). Two-electron atoms: The Schrodinger equation for two-electron atoms, Spin wave functions and the role of the Pauli exclusion principle, The independent particle model: The ground state of two- electron atoms.

Unit-II

Many-electron atoms: The central field approximation, Spin-orbitals and Slater determinants. The Thomas-Fermi model of the atom, The Thomas-Fermi Theory of multi-electron atoms, Introduction to Hartree-Fock method . Correlation effects, L-S coupling and j-j coupling: Possible terms of a multi-electron configuration in L-S coupling, Fine structure of terms in L-S coupling, Lande interval rule.

Unit-III

Molecular structure: The Born-Oppenheimer separation for diatomic molecules. The rotation and vibration of diatomic molecules, Rotational spectra of diatomic molecules: Vibrational and vibrational-rotational spectra of diatomic molecules, Raman Effect: quantum mechanical theory of Raman Effect, Rotational and Vibrational-Rotation Raman Spectroscopy.

Unit-IV

Absorption, spontaneous and stimulated emission. Einstein coefficients, Transition probability and lifetime of an atom in an excited state. Population inversion. Laser rate equations: The three level and four level systems. Line broadening mechanism. Shape and width of spectral lines. Optical resonators: Quality factor. Losses inside the cavity. Threshold conditions. Schawlow- Townes condition. Transverse and longitudinal mode selection. Laser Systems He-Ne laser. CO2 laser. Four level solid state . Properties of laser beam: directionality, monochromacity, intensity, coherence (temporal and Spatial).

Text Books:

1. Physics of atoms and molecules by B. H. Brandsen and C. J. Joachim, 2nd Ed.
2. Spectra of atoms and molecules by Peter F. Berth, Oxford University Press
3. Atoms and Molecules by Mitchel Weissbluth

References:

1. Fundamentals of molecular spectroscopy by C. B. Banwell
2. Introduction to molecular spectroscopy by G. M. Barrow

3. Modern spectroscopy, J. M. Holias

Title:Astrophysics - I **(Course Code: PHY18304DCE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 50 **Credits:** 02

Course Outcome: This course introduces stars their classification, properties and evolutions.

Learning Outcome:

- Students will be able to identify, classify and compare the stars on the Hertzsprung-Russell diagram.
- Students will be able to identify, classify and compare the objects in the Universe, including, nebulae, stars, stellar clusters, galaxies, clusters of galaxies, quasars.
- The students learn to solve problems to determine the surface temperature of a star in terms of the surface temperature of the sun if the luminosity of the star is determined.
- Students will be able to explain the evolution of stars as well as of the large scale structure of the Universe. Students will Comprehend the current state of hydrostatic equilibrium in which our sun exists.
- Students will Understand that the present age of stars, the present phase in the evolutionary life of the universe, and how it's coming to end, and its implications for the future history of life.

Unit-I

Spectral classification, Stellar distances, Absolute magnitude and sistance modulus, The H-R diagram of stars. Stellar interiors: Equation of conservation of mass, hydrostatic equilibrium, thermal equilibrium and energy transport. Equation of state, Stellar opacity, Stellar Energy Sources. Application of virial theorem to isothermal spheres, Polytropic model, Lane-emden's equation, Central temperature and pressure,

Unit-II

Evolution of stars, interstellar dust and gas, Jean's criteria for stability, formation of stars, Evolution of stars on the basis of HR-diagram, Binary stars, masses of binary stars, Fate of massive stars, Supernovae, White dwarfs, Chandrashekhar limit, neutron stars, Pulsars, black holes.

Text Books:

1. Stellar evolution by Chandrashekhar
2. Modern astrophysics by B. W. Caroroll and D. A. Ostlie, Addison-Wesley Pub.

References:

1. Astronomy by R. H. Baker
2. Exploration of universe by G. Abell

Title: Atmospheric Physics - I (Course Code: PHY18305DCE)

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome:

Learning Outcome: Upon completion of the course, the students should:

-

Unit-I

Origin, Composition and Mean Structure of the Atmosphere, Vertical profiles of pressure and density, Variable constituents, The vertical temperature structure, General Circulation of the Atmosphere, Energy Balance of the Earth, Global Patterns of Insolation , Heating Imbalances, Earth's Energy Budget, Surface Energy Budget Modeling Energy Balance, Global Heat Balance, Atmosphere's Energy Budget, Natural Greenhouse Effect, Effect on Surface Temperature

Unit-II

Gas law and its application to dry air, water vapour, and moist air, Virtual Temperature, Hydrostatic Equation ,Geopotential, Scale Height, hypsometric equation, Reduction of Pressure to Sea Level, specific heat, adiabatic and isothermal processes, concept of air parcel, dry adiabatic lapse rate, potential temperature, first law thermodynamic applied to atmosphere, Moisture Parameters, potential temperature, Clausius Clapeyron equation, latent Heats, Saturated Adiabatic and Pseudo adiabatic Processes, The Saturated Adiabatic Lapse Rate, Equivalent Potential Temperature and Wet-Bulb Potential Temperature, Stability and instability

Text Books:

1. McIlveen R., Fundamentals of Climate, Chapman Hall, 1992
2. J. R. Holton, An introduction to dynamic metreology, 3rd Ed.

References:

1. The Physics of atmospheres by J. T. Houghton, 1986
2. Theory of satellite orbit in the atmosphere by King Hele
3. Weather satellite by L. F. Hubert

4. Meteorological satellite by W. K. Hedger
5. A guide to earth satellite by D. Fishlock

Title: Quantum Field Theory- I **(Course Code: PHY18306DCE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome: This course aims to equip students with a profound understanding of relativistic wave equations,including the Klein-Gordon and Dirac equations, emphasizing their Lorentz invariance and non relativistic limits. Students will explore bilinear invariants, the Lagrangian formulation, and Noether's theorem, linking theoretical concepts to the principles of symmetry and conservation laws. Through canonical quantization, students will interpret particles in the realm of relativistic wave equations, addressing both real and complex Klein-Gordon fields and the Dirac field. Additionally, the course covers PCT symmetries, electromagnetic fields with radiation gauge quantization, and the application of S-matrix expansion, Wick's theorem, and Feynman diagrams in processes such as Yukawa interaction and QED phenomena. The consequences of gauge invariance, particularly in electron-electron and Compton scattering, are explored, along with an examination of symmetry breaking and the Higgs Mechanism in the context of quantum field theory and particle physics.

Learning Outcome: Upon completion of the course, the students should:

- Understand and apply the relativistic wave equations, including the Klein-Gordon equation and the Dirac equation, while exploring their connections to Lorentz invariance and the non-relativistic limit.
- Analyze bilinear invariants and comprehend their significance within the context of relativistic wave equations.
- Demonstrate knowledge of the Lagrangian formulation and Noether's theorem, linking theoretical concepts to the principles of symmetry and conservation laws.
- Apply canonical quantization techniques and interpret particles in the realm of relativistic wave equations, with a focus on the real and complex Klein-Gordon fields, as well as the Dirac field.
- Understand and apply PCT symmetries, exploring their role in particle physics and quantum field theory.
- Analyze the electromagnetic field, including radiation gauge quantization, and understand their implications in quantum field theory.
- Demonstrate proficiency in the S-matrix expansion, Wick's theorem, and Feynman diagrams, particularly in the context of Yukawa interaction and the decay of a scalar.

- Explore and apply the rules of Feynman diagrams in quantum electrodynamics (QED) processes, such as electron-electron scattering, Compton scattering, and scattering by an external field.
- Understand the consequences of gauge invariance in QED processes and its implications for physical interpretations of scattering phenomena.
- Gain insights into symmetry breaking and the Higgs Mechanism, examining their roles in the framework of quantum field theory and their impact on particle physics.

Unit-I

Relativistic Wave Equations: Klein-Gordon equation. Dirac equation, SU(2) and the rotation group; SL(2,C), and the Lorentz group. Prediction of antiparticles. Non-relativistic limit and Electron magnetic, moment.Construction of Dirac spinors: algebra of γ- matrices. Lagrangian formulation and Noether's theorem.

Unit-II

Canonical quantisation and particle interpretation: The real Klein-Gordon field. The complex Klein-Gordon field. The Dirac field. The electromagnetic field. Radiation gauge quantisation. Lorentz gauge quantisation. PCT symmetries, Symmetry Breaking and Higgs Mechanism.

Text Books:

1. A first book of quantum field theory, Lahiri and Pal, Narosa Publishing House
2. Quantum field theory, Lewis H. Ryder, Cambridge University Press

References:

1. Bjorken and Drell, Relativist quantum fields
2. Itzyken and Zubair, QUantum Field Theory

Title: Physics of nanomaterials **(Course Code: PHY18307DCE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome: Students should be equipped with the knowledge and skills necessary to understand, prepare, and characterize nanomaterials. This includes the ability to employ various fabrication techniques and characterization tools essential for research and applications in the field of nanotechnology.

Learning Outcome: Upon completion of the course, the students should:

- understand how we can transform bulk material into the nanomaterials and improve upon the existing properties remarkably.
- understand the main two critical paramaters surface to voulme ratio and quantum confinement effects play the main role due to which nanomaterials show varying kind of properties than their counter part bulk materials.
- classification of low dimensional materials
- confinement regimes such as strong, intermediate and weak
- Kubo gap
- density of states
- quantum dots
- understand various methods for preparation and characterizations of nanomaterials.

Unit-I

Introductory aspects: Overview of nanomaterials, definition of nanomaterials based on Bohr radius, de-Broglie wavelength, Exciton radius, Surface to volume ratio, Estimation of number of atoms in nanostuctures, ExcitonS, Confinement Regimes , Metallic and Semi conducting nanomaterials, Fermi Energy, Fermi Velocity, Kubo Gap, Density of state for bulk materials, Density of states for Quantum well, Quantum wire and Quantum Dots, Examples of nanomaterials

Unit-II

Preparation of Nanomaterials and General Characterization Techniques. Bottom up: Thermal Evaporation techniques, Sputtering technique, Pulsed Laser Deposition Technique, ion beam deposition, Top down: Ball Milling Scanning Electron Microscope

(SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope(AFM),X-ray Diffraction Technique,,Spectroscopies (UV-Vis, IR, FTIR and Raman), Vibrating Sample Magnetometer (VSM)

Text Books:

1. Introductory nanoscience: physical and chemical concepts: Masaru Kuno, Garland Science.
2. Nanotechnology nolecularly designed materials: G. M. Chow and K. E. Gonsalves, American Chemical Society.
3. Nanotechnology: Molecular speculations on global abundance: B. C. Crandall (MIT Press)
4. Nanotechnology: Principled=s and practices, Sulubha K. Kulkarni (Capital publishing company)

References:

1. Qantum dot hetereostructure, D. Bimerg, M. Grundamann and N. N. Ledontsov, Wiley.
2. Nanoparticle and nanostructure film preparation, characterisation and application: J. H. Fredler (Wiley)

Title: Superconductivity **(Course Code: PHY18308DCE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome: The course is designed to introduce the student to the unusual properties of superconducting materials, the theories of superconductivity, challenges in High Temperature and room temperature superconductivity and the vast technological applications of superconductivity. It is aimed to help the student develop a taste for the subject and to motivate him/her to choose it as a career option

Learning Outcome: Upon completion of the course, the student should be able to:

-
- understand the normal and superconducting states and what makes superconductivity a peculiar phenomenon
- understand the basic properties like zero resistance, perfect diamagnetism, penetration depth, coherence length, specific heat, isotope effect together with the critical parametres like critical temperature, critical current density, critical magnetic field
- understand the most important theories (phenomenological and microscopic) to explain the phenomenon of superconductivity
- understand the limitations of theories and the challenges posed by high temperature superconductivity
- explore the possibility of room temperature superconductivity at ambient pressure
- Comprehend and appreciate the vast applications of superconductivity together with the anticipated future advances in superconducting devices

Unit-I

The superconducting state, Basic properties of the superconducting state: Zero resistance, Critical temperature, The Meissner effect (Perfect diamagnetism), Flux quantization, Isotope effect, Critical magnetic fields, Type-I and Type-II superconductors, Critical Current, Penetration depth, Coherence length, Thermodynamics of transition, First and Second order transitions, Entropy, specific heat, Energy gap, The Josephson effects.

Unit-II

Models and theories: Two fluid model, London equations, Ginzburg-Landau theory, main results of Bardeen Cooper and Schrieffer (BCS) theory: Instability of the Fermi

Surface in the presence of attractive Interaction between electrons, Electron distribution in the ground state of a Superconductor, Critical temperature, Energy gap, Origin of the attractive interaction. Introduction to Hi TC superconductivity. Applications: SQUIDS, Magnetic Shielding, Power Transmission, Energy Storage devices, and Medical Applications.

Text Books:

1. A. C. Rose-Innes, Introduction to superconductivity (Pregamon Press)

References:

1. C. P. Poole, Handbook of superconductivity (Academic Press 2000)
2. Andre Mourchakine, Room temperature superconductivity (Cambridge 2004)
3. Jeffery W. Linn, High temperature superconductivity (Springer Verlag 1990)
4. T. V. Rama krishnan and C. N. Rao, Superconductivity today (Wiley1992)
5. M. Tinkham, Introduction to superconductivity (McGraw Hill, 2004)

Title: Microwave Devices and Circuits (Course Code: PHY18309GE

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome:

Learning Outcome: Upon completion of the course, the student should be able to:

-

Unit-I

Introduction to microwaves and applications, advantages of microwaves, EM spectrum domain, electric and magnetic fields static electric and magnetic fields, time varying electric and magnetic fields, Microwave Tubes: Limitation of conventional tubes, microwave tubes, velocity modulation, method of producing the velocity modulation, principle of operation of two cavity klystron, reflex klystron principle of operation, velocity modulation in reflex klystron

Unit-II

Microwave Semiconductor Devices: Microwave bipolar transistor, FET, Principle of Operation and application of tunnel diode, Principle of operation of gun diode, application of gun diode advantages of gun diode, principle of operation of PIN diode and applications, Tunnel diode, IMPATT, TRAPATT Diodes

Text Books:

1. Microwave devices and circuits by S. Y. Liao

References:

1. Microwave engineering by S. N. Raju, IK International Publishers 2007
2. Microwave engineering by P. A. Rizzi, PHI, 1999
3. Microwave engineering, Non-reciprocal active and passive circuits by Joseph Helszajin, McGraw Hill, 1992

Title: Advanced Lab. Methods **(Course Code: PHY18310GE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome:

Learning Outcome: Upon completing

-

Unit-I

Types of Radiation, Radiation Detector, General Detector Properties, Geiger Counters ,Scintillator Detectors , Solid State (Semiconductor) Detectors , Specific Models: Binomial Distribution, Poisson Distribution Gaussian (Normal) Distribution. Properties of the Binomial Distribution, Poisson Distribution and Gaussian (Normal) Distribution. Examples. Error Propagation Formula, Sums or Differences of Counts, Multiplication or Division of Counts, Limits of Detection.

Unit-II

Lab Procedures Existence of Radiation:Become familiar with different sources of radiation around us, and measure the level of radiation emitted from them. Gamma-Ray Spectroscopy using NAI(Tl):Basic techniques used for measuring gamma rays, based on the use of a sodium iodide (NaI) detector that is thallium-activated (Tl). Spectrum Analysis of 60CO and 137CS explain some of the features other than the photo peaks, that are usually present in a pulse-height spectrum. These are the Compton edge, backscatter peak, and x- rays. Mass Absorption Coefficient :To measure experimentally the mass absorption coefficient in lead and other materials like iron Aluminium with sources Na-22, Cs.

Text Books:

1. Radiation detection and measurement by Glenn F. Knolly

References:

1. Physics of radiation detection and measurement by Syed Nayeem Ahmad
2. Practical gamma ray spectroscopy by Gordon Gilmore
3. The design and construction of NaI(Tl) scintillation detector by Samuel Trit.

Title: Lasers **(Course Code: PHY18311OE)**

Max.Marks:100 **Int. Assessment:** 20 **Ext. Examination:** 80 **Credits:** 04

Course Outcome: The course aims to provide a comprehensive understanding of laser physics and technology, covering fundamental concepts such as absorption, emission processes, and laser rate equations. Students will explore various types of lasers, their properties, and applications, gaining knowledge and skills relevant to laser technology and its diverse applications, from medical to industrial and scientific fields.

Learning Outcome: Upon successful completion students will have the knowledge and skills to

- Understand absorption, spontaneous, and stimulated emission in the context of laser operation.
- Explore Einstein coefficients and their significance in laser physics.
- Analyze transition probability and the lifetime of atoms in excited states.
- Study population inversion as a key condition for laser action.
- Understand the laser rate equations for both three-level and four-level laser systems.
- Investigate line broadening mechanisms influencing the shape and width of spectral lines.
- Explore optical resonators, including the quality factor, losses inside the cavity, and threshold conditions.
- Understand Schawlow-Townes condition for laser operation.
- Analyze the concepts of transverse and longitudinal mode selection.
- Study various laser systems, including He-Ne laser, CO2 laser, four-level solid-state lasers, dye lasers, Ar+ lasers, and excimer lasers.
- Investigate the applications of lasers in different fields.

Unit-I

Absorption, spontaneous and stimulated emission. Einstein coefficients, Transition probability and lifetime of an atom in an excited state. Population inversion. Laser rate equations: The three level and four level systems. Line broadening mechanism. Shape and width of spectral lines. Optical resonators: Quality factor. Losses inside the cavity. Threshold conditions. Schawlow- Townes condition. Transverse and longitudinal mode selection.

Unit-II

Laser Systems He-Ne laser. CO2 laser. Four level solid state lasers. Dye lasers. Ar+ laser. Excimer lasers. Properties of laser beam: directionality, mono chromacity, intensity, coherence (temporal and Spatial). Applications oflasers: Laser induced fusion. Isotope separation.

Text Books:

1. Lasers: theory and applications by K. K. Thyagarajan and A. K. Ghatak
2. Laser and non-linear optics, B. B. Laud

Title:Radiation Physics **(Course Code: PHY18312OE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome: Explain what radon is, and Describe the main source of human exposure to alpha radiation.Identify the main source of indoor radon, and Identify the most important route of exposure to radon. Identify the population with the highest risk of exposure to increased levels of radon gas, Describe those at risk from exposure to radon as an environmental cause of lung cancer deaths, and Describe the estimated risk of lung cancer from radon exposure for persons who smoke cigarettes as compared with those who have never smoked.

Learning Outcome:

- Describe the physics of radon;describe the health effects of breathing radon;
- list the ways radon enters a home;describe the testing procedures for radon;
- test for radon in water and how to remove radon from water;
- list different ways to approach radon mitigation in homes; Various Potential Health Effects from Exposure to Increased Levels of Radon?
- Clinically Assess a Patient Potentially Exposed to Increased Levels of Radon?
- Treatment of Patients Potentially Exposed to Increased Radon
- What Instructions Should Be Given to Patients to Reduce Potential Health Risks from Exposure to Radon?

Unit-I

Dosimetric concepts and quantities: Electromagnetic Radiation, Ionizing and Non Ionizing Radiation, Radiation Units, Exposure and Dose, Dose equivalent Unit, Particle flux, X Rays and Gamma Rays, their interaction with matter, Photoelectric and Compton effect, Exposure-Roentgen - photon fluence and energy fluence, Kerma and absorbed dose, stopping power - relationship between the dosimetric quantities, Safety measures, Radiation Protection laws.

Unit-II

Principles of radiation detection: Radiation monitoring – Area survey meters – Ionization chambers – proportional counters – neutron area survey meters – GM survey meters – scintillation detectors – Personal monitoring – film badge – TLD . Properties of personal monitors - Radiophtoluminesce glass dosimetry system - OSLD. Principles of Radiation detection – properties of dosimeters - Theory of gas filled Detectors.

Text Books:

1. The physics of radiation therapy by F. M. Khan, 3rd Ed. Lippincott Williams and Wilkins, USA, 20003

References:

1. The Physics of radiology by H. E. Jones and J. R. Cunnigham, Charles C. Thomas, New York 2002
2. Fundamental physics of radiology by W. J. Meredith and J. B. Massey, John Wright and Sons UK, 2002
3. Medical radiation physics by W. R. Handee, Yearbook medical publishers Inc. London, 2003

Title: Crystallography **(Course Code: PHY18208GE)**

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome:The course outcome aim to provide students with a strong foundation in crystallography, including understanding crystal structures, symmetry, diffraction principles, and techniques used in structure determination using X-ray diffraction methods.

Learning Outcome: Upon completing the course students should be able to:

- Define crystal lattice in two and three dimensions, including crystal planes and directions within a lattice.
- Explain crystal symmetry, crystallographic point groups, and their applications in crystallography.
- Understand space groups, graphical representations of space , and building crystal structures based on them.
- Demonstrate understanding of direct and reciprocal lattices, specifically for simple, body-centered, and face-centered cubic lattices.
- Explain the phenomenon of diffraction of waves by crystals and understand the concept of scattered wave amplitude.
- Utilize reciprocal lattice concepts for diffraction techniques, including understanding diffraction conditions and Brillouin Zones.
- Calculate crystal structure factors and comprehend the intensity of diffraction maxima.
- Explain atomic scattering factors and their significance in diffraction.
- Differentiate between powder X-ray diffraction and single-crystal X-ray diffraction techniques.

Unit-I

Crystalline solids and their growth methods. Crystal lattice; two and three dimensional lattices, crystal planes and directions. Crystal symmetry, crystallographic point groups and their applications. Space groups, graphical representation of space groups, building crystal structure from space groups, crystal structure of some simple compounds. Direct and reciprocal lattice. Reciprocal lattice of simple, body centered and face centered cubic lattices.

Unit-II

Diffraction of Waves by Crystals, Scattered Wave Amplitude, Fourier Analysis of a crystal structure. Reciprocal Lattice and its applications to diffraction techniques, Diffraction Conditions, Brillouin Zones, Crystal structure factor and intensity of diffraction maxima, atomic scattering factor. Extinctions due to lattice centering. Powder X-ray diffraction, Single crystal X-ray diffraction. Structure determination using X-ray diffraction.

Text Books:

1. Crystal and Crystal Structure by Richard Tilly, Wiley Pub.
2. Introduction to Solid State Physics by Charles Kittel, Wiley Pubb.

References:

1. An Introduction to Crystallography by M. M. Woolfson, Cambridge University Press
2. Structure and Boding in Crystalline Materials by G. S. Rohrr, Cambridge University Press

Title: Philosophical Foundations of Physics (Course Code: PHY18209OE)

Max.Marks:50 **Int. Assessment:** 10 **Ext. Examination:** 40 **Credits:** 02

Course Outcome:Students will be able to Enables a student to ask questions and to gather some background information after the question is developed. Next a student learns to develop hypothesis . Develops a testable hypothesis, Designs an experiment and carries out. define the accepted value of a measurement, define absolute measurement error, define relative measurement error, calculate relative measurement error values.

Learning Outcome: Upon completing the course, students should be able to:

- The main objective of this course is to introduce the importance of experiments in research.
- Ability to conduct experiments, analyze and interpret data.
- For this course, the students will have to follow instructions, set-up experiments, collect data and interpret data, and discover any sources of error.

Unit-I

Laws, Explanation and Probability:

The value of laws: Explanation and prediction, Induction and statistical probability, Induction and logical probability, The experimental method. **Measurement and quantitative language:**

Three types of concepts in science, The measurement of quantitative concepts, Extensive magnitudes, Time, Length, Derived magnitudes and quantitative language, Merits of quantitative method, The magic view of language.

Unit-II

The structure of space:

The structure of space: Euclid's parallel postulate, Non-euclidean geometries, space in relativity theory, Poincare versus Einstein, advantages of non-Euclidean physical geometry. **Casualty and determinism:** Casualty, Does casualty imply necessity?, The logic of casual modalities, Determinism and free will.

Text Books:

1. Philosophical Foundations of Physics by Rudolph Carnap, Basic Books Foundation, New York

References:

1. Galileo and Einstein by Michael Fowler, UVa Physics