Semester – III				
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**	**Teacher**
Core (CR)	PHY15301CR	Nuclear Physics	04	WBT/MFM
	PHY15302CR	Condensed Matter Physics	04	BAW
	PHY15303CR	Atomic and Molecular Physics	04	NAK
Discipline Centric Electives (DCE)	PHY15304DCE	Astrophysics – I	02	SMM
	PHY15305DCE	Atmospheric Physics	02	BA/AH
	PHY15306DCE	Quantum Field Theory – I	02	MQL
	PHY15307DCE	Superconductivity	02	MAM
Generic Electives (GE)	PHY15308GE	Microwave Devices and Circuits	02	GBV
	PHY15309GE	Advanced Lab Methods	02	SAS
Open Electives (OE)	PHY15310OE	Lasers	02	NAK
	PHY15311OE	Radiation Physics	02	NIB

Semester III

Nuclear Physics

Course No: **PHY15301CR**	Max. Marks: 100
Duration of Examination: 2:30 Hrs.	External Examination: 80
No. of credits: **04**	Internal Assessment: 20

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, , Meson theory of Nucleon-Nucleon Force, Nucleon-nucleon scattering phase shifts, Low energy scattering parameters, The nuclear Potential.

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, Density of excited states, Low lying excited states, current-current Interaction, Survey of weak processed, Infinite nuclear matter

UNIT – III

Electromagnetic and Weak Interactions: The Photon-Hadron Interaction:Vector Mesons, The Photo-Hadron Interaction: Real and Spacelike Photons, Classical Electromagnetic Interaction, The Continous Beta Spectrum, Survey of Weak Processes, Weak Interaction and Beta Decay, Nuclear Beta Decay, The Weak Current of Leptons, The weak current of Hadrons at High Energies.

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 Book:

1. Samuel S. M. Wong, Introductory Nuclear Physics, Pentice-Hall f India Pvt. Ltd., New Delhi (2002)

Reference Books:

1. D. Griffiths, Introduction to Elementary Particles, Harper and Row, New York, 1987
2. Nuclear and Particle Physics-An introduction by B.R. Martin (Wiley Publication)
3. Physics of Nuclei and Particles-Marmier and Sheldon (Vol-I & II) Academic Press New York and London.
4. A. Bohr and B. R. Mottelson, Nuclear Structure, Vol. 1 (1969) and Vol. 2, Benjamin, Reading, A, 1975
5. Kenneth S. Kiane, Introductory Nuclear Physics, Wiley, New York, 1988
6. Ghoshal, Atomic and Nuclear Physics Vol. 2
7. P. H. Perkins, Introduction to High energy Physics, Addison-Wesley, London, 1982
8. Shirokov Yudin, Nuclear Physics Vol. 1&2, Mir Publishers, Moscow, 1982
9. H. A. Enge, Introduction to Nuclear Physics, Addison-Wesley, 1975
10. G. E. Brown and A.D. Jackson, Nucleon-Nucleon Interaction, North – Holland, Amsterdam, 1976

Semester III

Condensed Matter Physics

Course No: **PHY15302CR**	Max. Marks: 100
Duration of Examination: 2:30 Hrs.	External Examination: 80
No. of credits: **04**	Internal Assessment: 20

UNIT – I

Electrons in a periodic lattice, origin of energy gaps. Bloch functions, Schrodinger wave equation in a reciprocal space; Bloch theorem. Tight binding approximation, pseudo-potential methods for energy band calculations.

Fermi surface of solids; experimental methods, De Hass-van Alfen effect, Cyclotron resonance, Electron motion in a magnetic field and Landau Levels.

UNIT – II

Low dimensional electron systems: Electronic structure of a two dimensional electron gas, density of states (DOS). Integral quantum Hall effect. One dimensional systems; DOS, 1D sub-bands, Van Hove singularities and their applications. Conductance quantization and the Landauer formula. Resonant tunneling, two potential barriers in series. Zero dimensional systems: quantized energy levels of semiconductor nanocrystals, DOS, Metallic dots, discrete charge states, Coulomb Blockade, Single Electron devices.

UNIT – III

Superconductivity: Critical temperature, heat capacity, energy gap, isotope effect, Meissner effect, Types of superconductors, London equations, BCS theory (Qualitative), Josephson effect.

Point defects and line defects; the role of dislocations in plastic deformation and in crystal growth.

UNIT – IV

Ferromagnetism: Weiss theory of ferromagnetism, Curie-Weiss law for susceptibility Heisenberg model and molecular field theory. Spin waves and Magnons, Bloch $T^{3/2}$ law. Formation of Domains, Bloch-wall energy

Ferroelectricity: Classification of Ferroelectric Crystals, applications. Landau theory of the ferroelectric phase transition.

Text Books:

1. Introduction to Solid State Physics by Charles Kittel, John Wiley & Sons.
2. The Physics of Low dimensional Semiconductors, An Introduction, by John H. Davies, Cambridge University Press.

Reference Book:

1. Solid State Physics by J. S. Blakemore, Cambridge University Press.
2. Solid State Physics by Neil W Ashcroft, N. David Mermin, BlackWell Pub.

Semester III

Atomic and Molecular Physics

Course No: **PHY15303CR**	Max. Marks: 100
Duration of Examination: 2:30 Hrs.	External Examination: 80
No. of credits: **04**	Internal Assessment: 20

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 multielectron 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

Interaction of atom with an electromagnetic field: Transition rates for absorption, stimulated emission and spontaneous emission, dipole approximation, The Einstein's coefficients, Selection rules of one electron atoms, Selection rules for many-electron atoms; electric dipole transitions. Line shapes and widths: Pressure Broadening and Doppler Broadening.

UNIT – IV

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.

Text Books:

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

Reference Books:

1. Fundamentals of molecular spectroscopy – C B Banwell (T)
2. Introduction to Molecular Spectroscopy – G M Barrow
3. Spectra of diatomic molecules – Herzberg
4. Modem Spectroscopy – J M Holias

Semester III

Astrophysics - I

Course No: **PHY15304DCE**	Max. Marks: 50
Duration of Examination: 1 Hr 15 Mins.	External Examination: 40
No. of credits: **02**	Internal Assessment: 10

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 equillibrium, thermal equillibrium 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, Chandershker limit, neutron stars, Pulsars, black holes.

Text books

1. Steller Structure by Chanderskher
2. Modern Astrophysics by B.W.Carroll and D.A.Ostlie Addison-Weslet Publishing

Reference Books:

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

Semester III

Atmospheric Physics

Course No: **PHY15305DCE**	Max. Marks: 50
Duration of Examination: 1 Hr 15 Mins.	External Examination: 40
No. of credits: **02**	Internal Assessment: 10

UNIT – I

Introduction to the atmosphere

Structure and composition of the atmosphere, Atmospheric parameters and their variations.

Atmospheric thermodynamics

Gas laws, Concept of Virtual Temperature, The Hydrostatic equation and hydrostatic equilibrium, Geopotential . First Laws of thermodynamics and specific heats , Dry and saturated adiabatic lapse rates , potential temperature, equivalent potential temperature.

UNIT – II

Radiative Transfer

Radiation spectrum, Blackbody radiation; Planck's law , Wien's displacement law and Stefan -Boltzmann law . Radiative transfer in Planetary atmosphere ; Beers law , Reflection and Absorption by Atmospheric layers , Absorption of IR radiation.

Atmospheric dynamics

Elementary ideas of atmospheric motion, equation of motion and concept of basics forces in atmosphere. Atmospheric stability .

Text Book:

1. Atmospheric Science : An introductory survey ; J Wallace and P Hobbs ; The Academic Press
2. The Physics of Atmospheres ; John Houghton ; Cambridge University Press.

3. An introduction to dynamic meteorology , J R Holton.

Semester III

Quantum Field Theory - I

Course No: **PHY15306DCE**	Max. Marks: 50
Duration of Examination: 1 Hr 15 Mins.	External Examination: 40
No. of credits: **02**	Internal Assessment: 10

UNIT – I

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

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. The massive vector field.

Text Book:

1. Quantum Field Theory by Lewis H. Ryder, Cambridge University Press

Reference Books:

1. Bjorken & Drell, Relativistic Quantum Mechanics.
2. Bjorken & Drell, Relativistic Quantum Fields.
3. Itzkyson & Zuber: Quantum Field Theory.
4. Bogoliubov & Shirkov: Introduction to the theory of Quantized Fields.
5. Weinberg S: The Quantum Theory of Fields, Vol I.

Semester III

Superconductivity

Course No: **PHY1507DCE**	Max. Marks: 50
Duration of Examination: 1 Hr 15 Mins.	External Examination: 40
No. of credits: **02**	Internal Assessment: 10

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 T_C superconductivity.

Applications: SQUIDS, Magnetic Shielding, Power Transmission, Energy Storage devices, and Medical Applications.

Text Book:

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

References Books:

1. C. P. Poole, Handbook of superconductivity (Academic Press 2000)
2. Andrei Mourachkine, Room Temperature Superconductivity (Cambridge 2004)
3. Jeffrey W. Lynn (Ed.), High Temperature Superconductivity (Springer-Verlag 1990)
4. T. V. Ramakrishnan and C. N. R. Rao, Superconductivity Today (Wiley 1992)
5. M. Tinkham Introduction to Superconductivity (Mc Graw Hill, 2004)

Semester III

Microwave Devices and Circuits

Course No: **PHY15308GE**		Max. Marks:	50
Duration of Examination: 1 Hr 15 Mins.		External Examination:	40
No. of credits: **02**		Internal Assessment:	10

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 gunn diode, application of gunn diode advantages of gunn diode, principle of operation of PIN diode and applications, Tunnel diode, IMPATT, TRAPATT Diodes

Text Books:

1. Microwave Devices and Circuits, S.Y. Liao

Reference Books:

1. Microwave Engineering by Prof. G. 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.

Semester III

Advanced Lab. Methods

Course No: **PHY15309GE**	Max. Marks: 50
Duration of Examination: 1 Hr	External Examination: 25
No. of credits: **02**	Internal Assessment: 25

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 ^{60}CO and ^{137}CS explain some of the features other than the photopeaks, 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 Aluminum with sources Na-22, Cs.

References Books:

1. Radiation Detection and Measurement by Glenn F. Knoll
2. Radiation detection - W. H. Tait

Text Books:

1. Physics and Engineering of Radiation Detection by Syed Naeem Ahmed
2. Practical Gamma-ray Spectroscopy By Gordon Gilmore
3. The Design and Construction of a NaI(T1) Scintillation Detector by Samuel Strit

Forms of examination

The student's knowledge will be tested by a written and/or oral exam in combination with written and/or oral presentations of the laboratory exercises.

Aims and Objectives:

The theory part treats statistical methods for data analysis and introduces students to .Radiation ,detection of Radiation and radiation detection systems.

In the experimental part the student gets training in planning and performing experiments, in analyzing experimental data with statistical, computer based methods estimating statistical and systematic uncertainties.

Semester III

<u>Lasers</u>

Course No: **PHY15310OE**	Max. Marks: 50
Duration of Examination: 1 Hr 15 Mins.	External Examination: 40
No. of credits: **02**	Internal Assessment: 10

UNIT – I

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

UNIT – II

Laser Systems He-Ne laser. CO_2 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.

Textbooks:

1) Thyagarayan, K. and Ghatak, A.K. : LASERS: Theory & Application
2) Laud, B.B. : Laser and Non-linear Optics (Wetey-Eastern)

Semester III

Radiation Physics

Course No: **PHY15311OE**		Max. Marks:	50
Duration of Examination: 1 Hr 15 Mins.		External Examination:	40
No. of credits: **02**		Internal Assessment:	10

UNIT – I

Awaited

UNIT – II

Awaited

Text books:

1) Awaited