NUCLEAR PHYSICS (Theory)
[As per Choice based Credit System (CBCS) Scheme]
Semester-II (M.Sc. Physics)

Course Code	20PNP21	Maximum Marks (CIE)	50
Number of Lecture (H/W)	04	Maximum Marks (SEE)	50
Total Number of Lectures	48	Exam Hours	03
CREDITS – 04			

Objectives of the Subject:

- Introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.
- Provide students with opportunities to develop basic knowledge and understanding of: scientific phenomena, facts, laws, definitions, concepts, theories, scientific vocabulary, terminology, conventions of basic Nuclear Physics.
- Students understand basic properties of nuclei.
- Students understand various phenomenological models of nuclei.

Module-1 [10 hours]

Atoms & Nuclei: Introduction, Alpha particle scattering experiment, Rutherford's Nuclear Model of Atom, Nuclei: Introduction, Composition of Nucleus & Atomic mass, Isotopes, Isobars and Isotones, Mass-Energy and Nucleus Binding energy, Nuclear forces, Radioactivity, Nuclear Energy.

Module- 2 [10 hours]

Basic properties of Nuclei: Nuclear constitution, The notion of nuclear radius and its estimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei, The nomenclature of nuclei, and nucleon quantum numbers, Nuclear electric moments and shape of the nucleus. Nuclear Forces**:** General features of nuclear forces, Bound state of deuteron with square well potential, binding energy and size of deuteron, Yukawa's meson theory of nuclear forces.

Module- 3 [10 hours]

Nuclear Reactions: Reaction scheme, types of reaction and conservation laws, Reaction kinematics, threshold energy and Q-value of nuclear reaction, Energetics of exoergic and endoergic reactions, Reaction probability and cross section, Bohr's compound nucleus theory of nuclear reaction.

Module- 4 [10 hours]

Nuclear Decays: Alpha decay: Quantum mechanical barrier penetration, Gammow's theory of alpha decay and alpha half-life systematic, Beta decay: Continuous beta spectrum beta comparative half-life systematic, Gamma decay: Qualitative consideration of multipole character of gamma radiation, Interaction of gamma rays; photoelectric, Compton and pair production processes, Nuclear radiation detectors- G M counter and Scintillation detector.

Module- 5 [08 hours]

Elementary Particle Physics: Fundamental interactions in nature and their general features, Elementary particles and their classification; Conservation laws in elementary particle interactions, Quark model of elementary particles, Nuclear Energy: Fission process, fission chain reaction, four factor formula and controlled fission chain reactions.

Course Outcomes
20PNP21: NUCLEAR PHYSICS
After Successful completion of course students will

CO1: Gather advanced knowledge in Nuclear physics. The different nuclear interactions and the corresponding nuclear potentials and its dependence on the couplings are learned. The knowledge helps to choose for an Advance course in Nuclear and particle Physics.
CO2: Study about the Rutherford's Nuclear model of atom and nuclear forces.
CO3: Understand nuclear composition and elementary particles, charge symmetry and independence, spin dependence of nuclear force.
CO4: State law of radioactive decay and its application
CO5: Understand nuclear reaction and conservation laws
CO6: Discuss Bohr's compound nucleus theory of nuclear reaction
CO7: Demonstrate knowledge of fundamental aspects of the structure of the nucleus radioactive decay
CO8: Understand the nuclear radiation detector and scintillation detector.
CO9: Discuss nuclear and radiation physics connection with other physics disciplines-solid state, elementary particle physics.
CO10: Discuss about Nuclear energy, fusion process, fission chain reaction.

References

1. The Atomic Nucleus: R D Evans (TMH)
2. Nuclear and Particle Physics: W E Burcham and M Jobes (Addison Wesley, 1998)
3. Subatomic Physics-Nuclei and Particles: L Valentin
4. Nuclei and Particles: E Segre (Benjamin)
5. Nuclear Physics: D C Tayal (Himalaya)
6. Nuclear Physics: R C Sharma (Khanna)
7. Introduction to Nuclear Physics: S B Patel (Wiley eastern)
8. Introductory Nuclear Physics: Kenneth S Krane (Wiley)
9. Atomic and Nuclear Physics: S N Ghoshal (Chand)

SOLID STATE PHYSICS (Theory)
[As per Choice based Credit System (CBCS) Scheme]
Semester-II (M.Sc. Physics)

Course Code	**20PSS22**	**Maximum Marks (CIE)**	**50**
Number of Lecture (H/W)	**04**	**Maximum Marks (SEE)**	**50**
Total Number of Lectures	**48**	**Exam Hours**	**03**
CREDITS – 04			

Objectives of the Subject:

- Provide a valuable theoretical introduction and an overview of the fundamental applications of the physics of solid and includes theoretical description of crystal and electronic structure, lattice dynamics, and optical properties of different materials (metals, semiconductors, dielectrics, magnetic materials and superconductors).
- Introduce students to the large, broad field of Solid State Physics. Students will be exposed to the standard approximations, models & methods of Solid State Physics (Condensed Matter Physics) & to the common features in the physics of crystalline materials.
- Demonstrate its applicability in predicting elastic, electrical, magnetic, optical, and thermal properties from the first principles. Examples of solid state materials will include insulators, metals, semiconductors
- Students can learn the Structure, defects and energy band theory of different solids.

Module- 1 [10 Hours]

Crystal structure: Crystal systems, crystal classes, Bravais lattice, Unit cell: Wigner-Seitz cell, Notations of planes and directions, Co-ordination number, Atomic packing factor, Concept of reciprocal lattice, co-ordination number, Examples of simple crystal structures: NaC1, ZnS and diamond.

Module- 2 [10 hours]

Crystal binding: Types of binding – van der Waals-London interaction, repulsive interaction, Modelung constant, Born's theory for lattice energy in ionic crystals and comparison with experimental results, Lattice vibrations: Vibrations of monoatomic lattices, First Brillion zone, Quantization of lattice vibration-Concept of phonon, phonon momentum, Einstein theory of Specific heat.

Module- 3 [10 hours]

Energy bands in solids: Formation of energy bands, Free electron model: free electron in one and three dimensional potential wells, electrical conductivity, Fremi-Dirac distribution, Defects in solids: Point defects, Schottky deffects, Frenkel defects and their equilibrium concentrations, Line defects: Dislocations, multiplication of dislocations, Frank-Read mechanism, Plane defects: grain boundary.

Module- 4 [10 hours]

Semiconductors: Intrinsic and extrinsic semiconductors, concept of majority and minority carriers, Statistics of electrons and holes, Mechanism of Current conduction in Semiconductors, electrical conductivity, Hall effect, p-n junction, Applications of Semiconductor device.

Module- 5 [08 hours]

X-ray diffraction: Bragg reflection, Scattering of X rays, Atomic scattering factor, Bragg law, Geometric structure factor, Ewald's sphere - its construction, Laue, Rotating crystal and powder experimental methods, Indexing of XRD pattern with examples, Reciprocal lattice and its properties.

Course Outcomes
20PSS22: SOLID STATE PHYSICS.
After Successful completion of course students will
CO1: Have basic knowledge of crystal systems with examples.
CO2: Know about different types of bonding in materials.
CO3: Explore the relationships between chemical bonding and crystal structure with many phenomena.
CO4: Come to know about motion of electrons.
CO5: Understanding different types of defects, dislocations and grain boundaries in the materials.
CO6: Understand and explore how electrons and holes behave in pure and impure semiconductors.
CO7: Demonstrate wide range of applications in electronic devices.
CO8: Be able to account for how crystalline materials are studied using diffraction, including concepts like Ewald's sphere and experimental concepts like Laue, rotating crystal and powder x-ray diffraction method.
CO9: Understand the arrangement of atoms and properties.
CO10: Be able to index XRD patterns.

References
1. Elementary Solid State Physics: Principles and Applications, M. A. Omar, Addison.
2. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
3. Solid State Physics: A. J. Dekkar, Prentice Hall Inc.
4. Semiconductor Physics, P. S. Kireev, MIR Publishers.

ATOMIC AND MOLECULAR PHYSICS (Theory)
[As per Choice based Credit System (CBCS) Scheme]
Semester-II (M.Sc. Physics)

Course Code	**20PAM231**	**Maximum Marks (CIE)**	**50**
Number of Lecture (H/W)	**04**	**Maximum Marks (SEE)**	**50**
Total Number of Lectures	**48**	**Exam Hours**	**03**
CREDITS – 04			

Objectives of the Subject:

- Explain the Zeeman affect and spin orbit coupling.
- Be able to define the concepts of identical particles and quantum statistics, and understand the role played by quantum statistics in e.g. the structure of the periodic table.
- Explain physical properties of elementary particles, nucleons, atoms, molecules and solids (band structure) based on quantum mechanics.
- Explaining the fine structure of Hydrogen, L-S and J-J coupling in atoms and nuclei.
- Develop a knowledge and understanding of the role of angular momentum in atomic and nuclear physics;
- Develop a knowledge and understanding of the molecular spectroscopy.
- Be able to study basic concepts of Lasers.

Module 1 [10 hours]

One and Two-electron system: Einstein's A and B coefficients transition probabilities, Hydrogen atom: Electron spin inter action terms, vector model and lamb shift Electrostatic interaction and exchange degeneracy, ground state and excited states of helium, electron spin functions and Pauli exclusion principle, gross structure of the alkalis and other types of coupling.

Module 2 [10 hours]

Angular problems in many electron atoms: LS coupling-approx., allowed terms, fine structure and relative intensities; J-J coupling approximation, Interaction with static external fields: Zeeman effect in L-S coupling, relative intensities in Zeeman effect, quadratic and linear Stark effect, Microwave, Infra-red and UV-Visible Spectra:

Module 3 [10 hours]

Types of molecules: linear, symmetric top, asymmetric top and spherical top molecules, Theory of rotational spectra for rigid and non-rigid rotator diatomic molecules, energy levels, intensity of rotational lines, Microwave spectrometer, Vibrational energy of diatomic molecule as simple harmonic and an harmonic oscillators, energy levels and vibrational spectra.

Module 4 [10 hours]

Diatomic molecule as a vibrating-rotator, vibration-rotation spectra, IR – spectrometer, Electronic spectra of diatomic molecules, Born-Oppenheimer approximation, vibrational coarse structure - band progressions and sequences, Frank-Condon principle-intensity of vibrational-electronic spectra, Classification of electronic states and multiplet structure, selection rules for electronic transitions and simple electronic transitions, UV-Visible Spectrometer.

Module 5 [08 hours]

Lasers: Principles of lasers, population inversion techniques, criteria for lasing and threshold condition, Laser beam characteristics - spatial and temporal coherence, Types of lasers: Neodymium laser, nitrogen laser, dye laser and semiconductor laser; applications of lasers: Principle of holography, recording and reconstruction of holograms and applications.

Course Outcomes
20PAM231: ATOMIC AND MOLECULAR PHYSICS
After Successful completion of course students will

CO1: Discuss the relativistic corrections for the energy levels of the hydrogen atom and their effect on optical spectra.
CO2: State and explain the key properties of vector atom model importance of the Pauli Exclusion Principle.
CO3: Justify the selection rules and gross structure of the alkalis
CO4: Explain the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.
CO5: Explaining the fine structure of Hydrogen, L-S and J-J coupling in atoms and nuclei.
CO6: Define the types molecules based on moment of inertia.
CO7: Develop a knowledge and understanding of the role of angular momentum in atomic and nuclear physics;
CO8: Explain physical properties of elementary particles, nucleons, atoms, molecules and solids (band structure) based on quantum mechanics.
CO9: Understand the concept of halogram and their applications.
CO10: Be able to study basic concepts and applications of lasers.

References

1. Elementary Atomic Structure : G K Woodgate (Oxford,)
2. Introduction to Atomic Spectra : H B White (McGraw Hill)
3. Fundamentals of Molecular Spectroscopy : C N Banwell (TMH)
4. Molecular Spectra and Molecular Structure Vol.1: Spectra of diatomic molecules: G. Herzberg (Von Nostrand)
5. Spectroscopy-1, 2 & 3: B P Straughan and walker (Chapman and Hall).

PRACTICAL PAPERS (Practical)
[As per Choice based Credit System (CBCS) Scheme]
Semester-II (M.Sc. Physics)

Sl. No.	NAME OF THE EXPERIMENT
Paper: 20POPL25:- Optics and Photonics Lab-II	
01	Determination and absorption co-efficient of solutions.
02	Numerical aperture of optical fiber
03	Wavelength of laser beam using single slit
04	Measurement of diameter of the wire by diffraction light
05	Wavelength of laser light by using scale
Paper: 20PEL26:- Electronics Lab-II	
01	Maxwell - Wein Bridge.
02	Cathode ray Oscilloscope
03	De - Sauty's Bridge
04	Measurement of frequency using Lissajous figure
05	Passive filter
Paper: 20PSNL27:- Solid State and Nuclear Physics Lab-II	
01	Linear and mass attenuation coefficient for gamma rays
02	Verification of inverse square law : Gamma source
03	Energy gap determination using semiconductor diode
04	Dead time of G. M. counter
05	Characteristics of thermistor
06	Energy band gap of silicon

* **Note:** Experiments shall be added as and when developed

PROJECT PAPER (Practical)
[As per Choice based Credit System (CBCS) Scheme]
Semester-II (M.Sc. Physics)

Course Code: 20PHYP28
(CREDITS – 02)

Compulsorily each student has to carry out a project work under the supervision of a staff member or faculty of any research centre. The topic for project work can be of theoretical or experimental or computational in nature. A group of students or individual student can work under supervisor on a single topic for project. However, each student has to submit his/her own independently written original project report and face examination independently.

Maximum of two credits are given for the project work. On completion of the project work and at the end of the Semester II, a project report (certified by both supervisor and Chairman/Head of the Department) based on the project work carried out must be submitted to the Department. Project work will be valued for maximum of 100 marks (CIE 50 marks and SEE 50 marks).