Course Title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Modern Physics GE – 13	4	3	0	1	Class XII pass	NIL

LEARNING OBJECTIVES

The objective of this course is to teach the physics foundation necessary for learning various topics in modern physics which are crucial for understanding atoms, molecules, photons, nuclei and elementary particles. These concepts are also important to understand phenomena in Laser physics, condensed matter physics and astrophysics.

LEARNING OUTCOMES

After getting exposure to this course, the following topics would have learnt,

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics, laying the foundation of modern physics.
- Formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
- The spontaneous and stimulated emission of radiation, optical pumping and population inversion, Basic lasing action.
- The properties of nuclei like density, size, binding energy, nuclear force and structure of atomic nucleus, liquid drop model and mass formula.
- Radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
- Fission and fusion: Nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.

In the laboratory course, the students will get opportunity to measure Planck's constant, verify photoelectric effect, and determine e/m of electron and work function of a metal. They will also find wavelength of Laser sources by single and double slit experiment, wavelength and angular spread of He-Ne Laser using plane diffraction grating.

SYLLABUS OF GE – 13

THEORY COMPONENT

Unit 1: **(10 Hours)**
Origin of Modern Physics: Blackbody Radiation: Failure of explanation from classical theory; Planck's idea of a quantum; Quantum theory of Light: Photo-electric effect and Compton scattering, de Broglie wavelength and matter waves; Davisson-Germer experiment; Wave description of particles by wave packets, Group and Phase velocities and relation between them.

Unit 2: **(10 Hours)**
Problems with Rutherford model: Instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen-like atoms and their spectra.
Uncertainty principle: Gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Impossibility of an electron being in the nucleus, Energy-time uncertainty principle; origin of natural width of emission lines

Unit 3: **(10 Hours)**
Basics of quantum Mechanics: Two-slit interference experiment with photons and electrons; Concept of wave functions, linearity and superposition, Time independent Schrodinger wave equation for non-relativistic particles; Momentum and Energy operators; physical interpretation of a wave function, probabilities, normalization and probability current densities in one dimension. Problem: One dimensional infinitely rigid box. An application: Quantum dot.

Unit 4: **(05 Hours)**
X-rays: Ionizing Power, X-ray Diffraction, Bragg's Law. Critical Potentials, X-rays-Spectra: Continuous and Characteristic X-rays, Moseley's Law.
LASERs: Properties and applications of Lasers. Emission (spontaneous and stimulated emissions) and absorption processes, Metastable states, components of a laser and lasing action.

Unit 5: **(10 Hours)**
Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight; Nature of nuclear force, Stability of the nucleus; N-Z graph, Drip line nuclei, Binding Energy, Liquid Drop model: semi-empirical mass formula.
Radioactivity: Different equilibrium, Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation:
Fission and fusion: Mass deficit and generation of energy; Fission: nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions only).

References:

Essential Readings:

1) Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

2) Modern Physics by R. A. Serway, C. J. Moses and C. A. Moyer, 3rd edition, Thomson Brooks Cole, 2012.

3) Modern Physics for Scientists and Engineers by S. T. Thornton and A Rex, 4th edition, Cengage Learning, 2013.

4) Concepts of Nuclear Physics by B. L. Cohen, Tata McGraw Hill Publication, 1974.

5) Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Laxmi Publications, 2019

Additional Readings:

1) Six Ideas that Shaped Physics: Particle Behave like Waves, T.A. Moore, 2003, McGraw Hill.

2) Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY: Doubleday, 1966.

3) New Physics, ed. Paul Davies, Cambridge University Press (1989).

4) Quantum Theory, David Bohm, Dover Publications, 1979.

5) Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019

6) Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

7) Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.

PRACTICAL COMPONENT – 30 Hours

- Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the modern physics lab, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

Every student must perform at least 06 experiments from the following list of experiments.

1) Measurement of Planck's constant using black body radiation and photo-detector.

2) Photo-electric effect: estimate Planck's constant using graph of maximum energy of photo-electrons versus frequency of light.

3) To determine work function of material of filament of directly heated vacuum diode.

4) To determine the Planck's constant using LEDs, using at least 4 LEDs.

5) To determine the wavelength of H-alpha emission line of Hydrogen atom.

6) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

7) To setup the Millikan oil drop apparatus and determine the charge of an electron.

8) To show the tunneling effect in tunnel diode using I-V characteristics.

9) To determine the wavelength of laser source using diffraction of single slit.

10) To determine wavelength and angular spread of He-Ne laser using plane diffraction grating.

11) To determine the wavelength of laser source using diffraction of double slits.

References (for Laboratory Work):

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.

2) Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

3) A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

4) Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press.

5) B. Sc. Practical Physics, Geeta Sanon, R. Chand, 2016.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.