

## DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: ELEMENTS OF MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Elements of Modern Physics  PHYSICS DSC – 5	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	NIL

### LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

### LEARNING OUTCOMES

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

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

### SYLLABUS OF PHYSICS DSC – 5

#### THEORY COMPONENT

##### Unit - I

**(8 Hours)**

**Origin of Quantum Theory:** Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

## **Unit - II (7 Hours)**

**The Schrodinger Equation:** The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators

## **Unit – III (5 Hours)**

**Time Independent Schrodinger Equation:** Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

## **Unit – IV (5 Hours)**

**Atomic Physics:** Beyond the Bohr's Quantum model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra  
Correspondence principle  
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley Law.

## **Unit – V (5 Hours)**

**Basic Properties of Nuclei:** Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.  
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

### **References:**

#### **Essential Readings:**

- 1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
- 2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
- 3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
- 4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4<sup>th</sup> edition, 2013, Cengage Learning
- 5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- 6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
- 7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
- 8) Modern Physics, R. Murugesan, S Chand & Co. Ltd
- 9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
- 10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2<sup>nd</sup> edition, Tata McGraw-Hill Publishing Co. Ltd.
- 11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
- 12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
- 13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
- 14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
- 15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
- 16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

- 17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
- 18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

**Additional Readings:**

- 1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
- 2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

**PRACTICAL COMPONENT****(15 Weeks with 4 hours of laboratory session per week)****Mandatory activity:**

- 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
- Familiarization with Schuster's focusing; determination of angle of prism.

**At least six experiments to be performed from the following list**

- 1) Measurement of Planck's constant using black body radiation and photo-detector
- 2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
- 3) To determine the work function of material of filament of directly heated vacuum diode.
- 4) To determine the Planck's constant using LEDs of at least 4 different colours.
- 5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
- 6) To determine the ionization potential of mercury.
- 7) To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
- 8) To show the tunneling effect in tunnel diodes using I-V characteristics.
- 9) To determine the wavelength of a laser source using diffraction of a single slit.
- 10) 10. To determine the wavelength of a laser source using diffraction of double slits.
- 11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
- 12) One innovative experiment designed by the teacher relevant to the syllabus.

**References for laboratory work:**

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11<sup>th</sup> edition, 2011, Kitab Mahal.
- 3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> edition, reprinted, 1985, Heinemann Educational Publishers.
- 4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
- 5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
- 6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.