BACHELOR WITH PHYSICS AS MAJOR

4th SEMESTER

PHY422J3: NUCLEAR PHYSICS **CREDITS: THEORY – 4, PRACTICAL - 2**

THEORY (4 CREDITS: 60 HOURS) **MAXIMUM MARKS: 100, MINIMUM MARKS: 36**

Learning outcomes:

Upon completing this course, students will have a strong foundation in nuclear physics, radiation physics, and the safe handling of radiation sources. They will be capable of analyzing and solving problems related to nuclear structure, decay processes, nuclear reactions, and radiation safety, and they will be prepared for further studies or careers in fields such as nuclear physics, radiology, and radiation therapy.

1. Students will understand and describe the fundamental properties of atomic nuclei.
2. Students will be able to explain the law of radioactive decay calculate half-lives.
3. Students will identify and differentiate various radioactive series, gaining insights into the decay processes involved.
4. Students will comprehend the concept of binding energy and its significance in understanding nuclear stability.
5. Students will analyze alpha decay,beta-decay and gamma decay.
6. Students will classify nuclear reactions, apply conservation laws, differentiate between compound and direct reactions.
7. Students will evaluate the Liquid Drop Model and the Shell Model to describe nuclear structure and properties.
8. Students will explore the principles of radiation detection and analyze the operation of detectors.
9. Students will distinguish between electromagnetic radiation, ionizing, and non-ionizing radiation.
10. Students will describe the interactions of X-rays and gamma rays with matter and understand the concepts of exposure, Roentgen and photon fluence.
11. Students will learn safety measures related to radiation, comprehend radiation protection laws and regulations, and demonstrate knowledge of safety protocols and practices in radiation-related environments.

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Unit-I (15 HOURS)

Structure of nuclei: Basic Properties of Nuclei: Mass, Radii, Charge, Angular Momentum, Spin, Magnetic Moment , Stability and Binding Energy. Radioactivity: Law of Radioactive Decay. Half-life, Theory of Successive Radioactive Transformations. Radioactive Series, Binding Energy, Mass Formula .

Unit-II (15 HOURS)

Alpha-decay : Range of α-particles, Geiger-Nuttal law and α-particle Spectra. Gamow Theory of Alpha Decay. β-decay: Energy Spectra and Neutrino Hypothesis. γ- Decay : Origin of γ-rays, Nuclear Isomerism and Internal Conversion. Nuclear Reactions :Types of Reactions and Conservation Laws. Concept of Compound andDirect Reaction. Compound Nucleus. Scattering

Cross-section. Reaction Rate. Q- value of Reaction. Fission and Fusion.

Unit-III (15 HOURS)

Nuclear Models : Liquid Drop Model. Mass formula. Shell Model. Meson Theory of Nuclear Forces and Discovery of Pion.

Accelerators: Van de Graaff Generator, Linear Accelerator, Cyclotron, Betatron,

Detectors of Nuclear Radiations: Interaction of Energetic particles with matter. Ionization chamber. GM Counter. Cloud Chambers. Wilson Cloud Chamber. Bubble Chamber. Scintillation Detectors. Semiconductor Detectors.

Unit-IV (15 HOURS)

Radiation Physics: 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.

PRACTICALS (2 CREDITS: 30 HOURS) **MAXIMUM MARKS: 50**

MINIMUM MARKS: 18

1. Determination of end-point energy of beta sources.
2. Characterization of GM-counter.
3. Gamma spectrum recording of gamma sources (137Cs) and determination of internal conversion coefficient of 137mBa
4. To study the Compton effect of gamma rays and determine the rest mass of electron.
5. To determine the efficiency of NaI (Tl) Scintillation detector.
6. To study the x-ray fluorescence and verify the Moseley's law.
7. To determine the window thickness of beta-counter using beta-sources (90Sr, 204Tl)
8. To study the energy loss of 241Am alpha-particles in air at different pressures.

Text Books:

1. Introduction to Nuclear Physics by S. N. Ghoshal
2. Introductory Nuclear Physics by David Halliday (John Willey)
3. Nuclear Physics by Irving Keplan (Narosa Publishing House)
4. Medical radiation Physics by W.R. Handee.
5. Radiation Physics for Medical Physicists by Podgorsak E.B.
6. Radiation Oncology Physics by Podgorsak E.B.

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Suggested readings

1. Experimental Nuclear Physics by Glenn F. Knoll
2. Experimental Techniques in Nuclear Physics by William R. Leo
3. Introduction to Experimental Nuclear Physics by R. M. Singhru
4. Introductory Nuclear Physics by Kenneth S. Krane
5. Introduction to Nuclear Physics by H. A. Enge (Addison-Wesley