Programme: B.Sc. Honours in Physics (Major)

w.e.f. AY 2023-24

COURSE STRUCTURE

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
IV		9	Electricity and Magnetism	3	3
			Electricity and Magnetism Practical Course	2	1
		10	Modern Physics	3	3
			Modern Physics Practical Course	2	1
		11	Introduction to Nuclear and Particle Physics	3	3
			Introduction to Nuclear and Particle Physics Practical Course	2	1

SEMESTER-IV

COURSE 11: INTRODUCTION TO NUCLEAR AND PARTICLE PHYSICS

Theory Credits: 3 3 hrs/week

COURSE OBJECTIVE:

The course aims to provide students with an understanding of the principles of Nuclear and Particle physics and their applications in various fields.

LEARNING OUTCOMES

By successful completion of the course, students will be able to

1. know about high energy particles and their applications which prepares them for further study and research in elcitrapphysics

2. Students can explain important concepts on nucleon-nucleon interaction, such as its short-range, spin dependence, isospin, and tensors.

3. Students can show the potential shapes from nucleon nucleon interactions.

4. Students can explain the single particle model, its strengths, and weaknesses

5. Students can explain magic numbers based on this model

UNIT-I: Introduction to Nuclear Physics

Nuclear Structure: General Properties of Nuclei, Mass defect, Binding energy; Nuclear forces:Characteristics of nuclear forces- Yukawa's meson theory; Nuclear Models- Liquid drop model- Semi empirical mass formula, nuclear shell model.

UNIT-II: Elementary Particles and Interactions

Discovery and classification of elementary particles, properties of leptons, mesons and baryons; Types of interactions-strong, electromagnetic and weak interactions; Conservation laws– Isospin, parity, charge conjugation

UNIT-III: Nuclear Reactions and Nuclear Detectors

Nuclear Reactions: Types of reactions, Conservation Laws in nuclear reactions, Reaction energetic, Threshold energy, nuclear cross-section; Nuclear detectors: Geiger- Muller counter, Scintillation counter, Cloud chamber

UNIT-IV: Nuclear Decays and Nuclear Accelerators

Nuclear Decays: Gamow's theory of alpha decay, Fermi's theory of Beta- decay, Energy release in Betadecay, selection rules. Nuclear Accelerators: Types- Electrostatic and electrodynamics accelerators; Cyclotron-construction, working and applications; Synchrocyclotron-construction, working and applications.

UNIT-V: Applications of Nuclear and Particle Physics

Medical Applications: Radiation therapy and imaging techniques, nuclear energy: nuclear reactors and power generation, Particle physics in high-energy Astro Physics

Reference Books:

1. Nuclear Physics, Irving Kaplan, Narosa Pub. (1998).

2. Nuclear Physics, Theory and experiment – P.R. Roy and B.P. Nigam, New Age Int.1997.

3. Atomic and Nuclear Physics (Vol.2), S.N. Ghoshal, S. Chand & Co. (1994).

4. Nuclear Physics, D.C. Tayal, Himalaya Pub. (1997).

5. Atomic and Nuclear Physics, R.C. Sharma, K. Nath& Co., Meerut.

6. Nuclei and Particles, E. Segre.

7. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley (1975).

SEMESTER-IV

COURSE 11: INTRODUCTION TO NUCLEAR AND PARTICLE PHYSICS

Practical Credits: 1 2 hrs/week

COURSE OBJECTIVE:

To familiarize students with experimental techniques and methodologies used in nuclear and particle physics.

To provide hands-on experience in conducting experiments related to nuclear and particle physics.

LEARNING OUTCOMES:

1. Gain a solid understanding of fundamental concepts in nuclear and particle physics.

2. Acquire knowledge of experimental techniques and methodologies used in the field.

3. Understand the principles and operation of laboratory equipment and instruments specific to nuclear and particle physics experiments.

4. Develop proficiency in conducting experiments related to nuclear and particle physics.

5. Acquire skills in data acquisition, analysis, and interpretation using appropriate software and techniques.

6. Learn to design and perform experiments, including calibration, measurement, and control of variables.

Experiments List

1. GM counter – Determination of dead time

2. Study of Characteristic curve of GM counter and estimation of its operating voltage

3. Estimation of efficiency for a gamma source of the GM counter

4. To verify inverse square law using GM counter

5. Production and attenuation of berms strahlung

6. Estimation of efficiency for a beta source of the GM counter

7. Study of back scattering of beta particles

STUDENT ACTIVITIES

UNIT-I: INTRODUCTION TO NUCLEAR PHYSICS

Provide students with a computer simulation or interactive app that allows them to explore radioactive decay processes.

Ask students to observe and analyze the decay patterns of different isotopes, including the concept of halflife.Guide students to make connections between the simulation results and the fundamental principles of nuclear physics

UNIT-II: ELEMENTARY PARTICLES AND INTERACTIONS

Divide students into small groups and assign each group a specific elementary particle (e.g., proton, electron, neutrino, quark).Instruct students to create a poster showcasing their assigned particle, including its properties, classification, and interactions. Encourage creativity in the presentation of information, such as diagrams, illustrations, and concise explanations. Have each group present their posters to the class, promoting discussion and comparisons between different particles.

UNIT-III: NUCLEAR REACTIONS AND NUCLEAR DETECTORS

Divide students into small groups and assign each group a specific scenario that requires radiation shielding, such as a nuclear power plant, a medical facility, or a space mission.Instruct students to research and design an effective radiation shielding system for their assigned scenario, considering factors such as the type of radiation, the intensity of radiation, and the materials available for shielding.Encourage students to calculate and compare the attenuation properties of different materials and discuss the trade-offs between effectiveness, cost, and practicality in their designs.Have each group present their shielding design to the class, explaining their rationale and addressing potential challenges or limitations

UNIT-IV: NUCLEAR DECAYS AND NUCLEAR ACCELERATORS

Provide students with a radioactive decay chain involving multiple decays, such as alpha decay, beta decay, and gamma decay.Instruct students to analyze the decay chain and determine the sequence of decays, including the types of particles emitted and the resulting daughter nuclei.Ask students to calculate the half-lives of the parent and daughter nuclei based on the decay data and explore the concept of radioactive equilibrium.Encourage students to discuss the practical applications and significance of decay chains in fields such as radiometric dating or medical imaging

UNIT-V: APPLICATIONS OF NUCLEAR AND PARTICLE PHYSICS

Assign students specific medical imaging techniques based on nuclear and particle physics, such as positron emission tomography (PET), single-photon emission computed tomography (SPECT), or computed tomography (CT).Instruct students to research and present on the principles behind their assigned imaging technique, including the interaction of particles or radiation with matter, detector technology, and image reconstruction methods.Ask students to discuss the advantages, limitations, and specific medical applications of their assigned imaging technique.Encourage students to critically analyze the role of nuclear and particle physics in advancing medicaldiagnostics and treatment planning