**Centre for High Energy Physics**
**Faculty of Science**
**University of the Punjab, Lahore**

# Course Outline

| Program | BSCP | Course Code | CPHY 451 | Credit Hours | 3 |
|---|---|---|---|---|---|
| **Course Title** | **Nuclear Physics** | | | | |

## Course Introduction

The course introduces Nuclear and Particle Physics at undergraduate level.

## Learning Outcomes

On the completion of the course, the students will:

1. Learn different nuclear models and explain the nuclear properties.
2. Theory of nuclear forces and its application to different nuclear processes.
3. Theories of radioactive decay.
4. Study of different mechanics of particles acceleration and detections.
5. Introduction of reactor physics.
6. Introduction of elementary particles and their interaction.

## Course Content

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| **Week 1** | Discovery of nucleus and its basic properties |
| | Differential and total cross sections |
| **Week 2** | Rutherford and Mott's formula |
| | Nuclear form factor |
| **Week 3** | Study of size of nucleus through electron experiments |
| | Study of size of nucleus through neutron scattering experiment and Optical Model |
| **Week 4** | The isotope shift method |
| | X-ray spectroscopy of muonic atoms |
| **Week 5** | The properties of stable nuclei |
| | Characteristics of experimental curve of binding energy per nucleon |
| **Week 6** | Liquid drop model |
| | Comparison of experimental and theoretical curves of binding energy per nucleons |
| **Week 7** | Decay modes of unstable nuclei |
| | Q value analysis of alpha and Energy level diagram |
| **Week 8** | Q value analysis of beta decay and Energy level diagrams |
| | Spontaneous fission. |
| **Week 9** | Total angular momentum of odd and even nuclei |
| | Magnetic moment, nuclear magneton |

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| **Week 10** | Schmidt model |
| | Parity of a nucleus |
| **Week 11** | Shell model: Nuclear magic numbers |
| | Spin- orbit coupling and energy level diagram of states of a nucleus |
| **Week 12** | Obtaining nuclear magic number from energy level diagram |
| | Gamow theory of alpha decay. |
| **Week 13** | Derivation of formula of decay constant of a alpha decay |
| | Nuclear Reactions and types |
| **Week 14** | Bohr's theory of compound nucleus and its limitations |
| | Breit-Wigner formula |
| **Week 15** | Interaction of nuclear radiation with matter |
| | Photographic emulsions; Gas-filled detectors; Scintillation counters and solid-state detectors |
| **Week 16** | Classification of elementary particles, Fundament interactions. |
| | The quark model |

**Textbooks and Reading Material**

1. Nuclear and Particle Physics (2nd edition), Burcham, E. E. and Jobes, M., Longman, *John Wiley & Sons* (1995).
2. Introduction to Nuclear and Particle Physics, Das, A. and Ferbel, T., *John Wiley and Sons* (1994).
3. Nuclear and Particle Physics, Williams, W.S.C., *Oxford University Press* (1995).
4. Elementary Particle Physics by D. Griffiths, *John Wiley and Sons* (1987).
5. Nuclear and Particle Physics Simulations, Michael J. Moloney& Roberta Bigelow, *John Wiley & Sons* (1996).

**Teaching Learning Strategies**

The instructor is required to make use of Mathematica/Maple/Python to teach the concepts through visualization/antimutation and symbolic/numerical calculations. The students are required to solve a large portion of related exercises/questions/problems of the main textbooks.

**Assignments: Types and Number with Calendar**

At least two assignments and two quizzes. A course project may also be assigned.

**Assessment**

| Sr. No. | Elements | Weightage | Details |
|---|---|---|---|
| 1. | Midterm Assessment | 35% | Written Assessment at the mid-point of the semester. |
| 2. | Formative Assessment | 25% | Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc. |

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| 3. | Final Assessment | 40% | Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc. |