PHY-473 Nuclear Physics

Credit Hours: 3-0

Prerequisite: None

Course Objectives: It is an undergraduate course which aims to build the foundation of Nuclear Physics with little flavor of Particle Physics. This course introduces the concepts of Nuclear Physics for example nuclear properties, nuclear forces, different nuclear models, nuclear radiations, particle detectors, radioactive decays, nuclear reaction cross sections, along with brief introduction to elementary particles and forces in nature.

Core Contents: Nuclear Properties, Nuclear Forces, Nuclear Models, Introduction to Nuclear Radiation, Particle Detectors, Reaction Cross Sections, Properties and Interactions of Elementary Particles.

Detailed Course Contents: Nuclear Properties: The Nuclear Radius, Mass and Abundance of Nuclides, Nuclear Binding Energy, Nuclear Angular Momentum and Parity, Nuclear Electromagnetic Moments, Nuclear Excited States, Nuclear Forces, Nucleon-Nucleon Scattering, Proton-Proton and Neutron-Neutron Interactions, Properties of the Nuclear Force, The Exchange Force Model, Yukawa's theory of nuclear forces, Nuclear Models, Liquid drop Model, Fermi Gas Model, Shell Model, Collective Model, Introduction to Nuclear Radiation, Alpha decay, Barrier penetration, Beta decay, Gamma decay, Particle Detection, Ionization Detectors, Scintillation Detectors, Semiconductor Detectors, Calorimeters, Types of Reactions and Conservation Laws, Energetics of Nuclear Reactions, Reaction Cross Sections, Compound-Nucleus Reactions, Direct Reactions, Resonance Reactions, Transmutation by alpha-particles: alpha-proton reactions, The neutron: alpha-neutron reactions, Transmutation by protons, Transmutation by deuterons, Transmutation by neutrons, Transmutation by photons, Properties and Interactions of Elementary Particles, Forces, Elementary Particles, Quantum Numbers, Gell-Mann-Nishijima Relation.

Course Outcomes: At the end of the course, students will be able to

- understand the nuclear properties and the nature of nuclear forces.

- understand the nuclear structure using different nuclear models.
- understand the measurement techniques used in the different detectors.
- understand different types of nuclear reactions and their reaction cross sections.

Textbooks: A. Das and T. Ferbel, Introduction to Nuclear and Particle Physics, 2nd ed. World Scientific, 2003. (DF)

Reference books:

1. Kenneth S. Krane, Introductory Nuclear Physics, John Wiley & Sons, 1988. (KSK)
2. Irving Kaplan, Nuclear Physics, 2nd ed. Addison Wesley, 1980. (IK)
3. Emilio Segre, Nuclei and particles, 2nd ed. W.A. Benjamin, Inc. 1977.

Weekly Breakdown		
Week	Section	Topics
1	KSK 3.1-3.3	Nuclear Properties: The Nuclear Radius, Mass and Abundance of Nuclides, Nuclear Binding Energy
2	KSK 3.4-3.6	Nuclear Angular Momentum and Parity, Nuclear Electromagnetic Moments, Nuclear Excited States
3	KSK 4.2-4.3	Nuclear Forces: Nucleon-Nucleon Scattering, Proton-Proton and Neutron-Neutron Interactions
4	KSK 4.4-4.5	Properties of the Nuclear Force, The Exchange Force Model, Yukawa's theory of nuclear forces
5	DF 3.2-3.3	Nuclear Models: Liquid drop Model, Fermi Gas Model
6	DF 3.4-3.5	Shell Model, Collective Model
7	DF 4.1-4.3	Introduction to Nuclear Radiation, Alpha decay, Barrier penetration
8	DF 4.4-4.5	Beta decay, Gamma decay
		Midterm Exam
9	DF 7.1-7.3	Particle Detection, Ionization Detectors, Scintillation Detectors
10	DF 7.6-7.7	Semiconductor Detectors, Calorimeters
11	KSK 11.1-11.2	Types of Reactions and Conservation Laws, Energetics of Nuclear Reactions
12	KSK 11.4, 11.10-11.11	Reaction Cross Sections, Compound-Nucleus Reactions, Direct Reactions
13	KSK 11.12 IK 11.1, 11.3	Resonance Reactions, Transmutation by alpha-particles: alpha-proton reactions, The neutron: alpha-neutron reactions

14	IK 11.5-11.8	Transmutation by protons, Transmutation by deuterons, Transmutation by neutrons, Transmutation by photons
15	DF 9.1-9.3	Properties and Interactions of Elementary Particles, Forces, Elementary Particles
16	DF 9.4-9.5	Quantum Numbers, Gell-Mann-Nishijima Relation