

Course Title	Course Code	Number of Study Hours			Year	Level	Prerequisites
		Theoretical	Laboratory	Credit			
Nuclear Physics 2	462PHYS	3	2	4	4 <sup>th</sup>	8 <sup>th</sup>	461PHYS

### (2) Brief Course Description

This is an advanced course offered to the 8<sup>th</sup> level undergraduate senior students at the Jazan University. Particle and radiation interactions with matter, particle detectors, particle accelerators, particles zoo and the standard model are the main chapters to be covered in this course. The learning outcome of this course is to let trainee understand the particles interaction (based on their identifications, e.g., electron, proton, alpha, photon etc.) with matter. These interactions measured by an electronic device named detector. Students learn the theoretical aspects on detector development and how it works. In order to produce the particles in the laboratory we need particle accelerators and students learn how to design these accelerators and their working mechanism. Students also learn the elementary particles based on their spin, charge, mass and lifetime. Finally they will learn the Standard Model briefly that describes the elementary particles and their interactions that shape our known universe. Students are also required to perform the practical classes (labs) concerning to the course contents.

### (2) Course Objectives

**This course is designed to provide students with:**

- The fundamental of particle and radiation interaction with matter, particle detection, acceleration, particle zoo and the standard model of elementary particles.
- Know how the particle detectors and accelerators are designed and familiar with the modern cutting edge technologies.
- Explain particle classifications and the corresponding theoretical model.
- Demonstrate concepts concerning the course by means of practical classes.
- Familiar with the advanced research in nuclear and particle physics fields.

### (3) Course Contents

#### Theoretical Part:

- **Energy Deposition in Media:** Charged particles interaction with matter, Bethe Bloch formula, Energy loss through bremsstrahlung, Photon interaction with matter, Photoelectric, Compton and pair production mechanism, Interaction of neutrons with matter, Interaction of hadrons with matter (briefly).
- **Particle Detection:** Ionization detectors, Ionization counters, proportional counters and Geiger Muller counters, Scintillation detectors, Time of Flight, Cherenkov detectors, Semiconductor detectors, Calorimeters, and Layer detectors (e.g. ATLAS, CMS at CERN).
- **Accelerators:** Electrostatic accelerators, Resonance accelerators, Synchronous accelerators, Phase stability, strong focusing and colliding beam, and Large Hadron Collider at CERN (basic information from web).
- **Properties and Interactions of Elementary Particles:** Four basic forces, Elementary particles (their history), Quantum number (Baryon, lepton, strangeness, isospin etc.), Gell-Mann\_Nisijima relation, Production and decay of resonances, Violation of quantum numbers, Weak interaction (Hadronic weak decays, semileptonic processes etc.), Electromagnetic interaction, Symmetries, Parity, Time Reversal, CPT theorem.
- **Formulation of the Standard Mode:** Quarks and leptons, Quark content of mesons, Quark content of baryons, Color quantum number, Quark model for mesons and baryons, Valance and sea quarks in hadrons, Chromodynamics and confinement.

#### Experimental Part:

- Plotting a GM Plateau
- Geiger Tube Efficiency
- Inverse Square Law
- Absorption of Gamma Rays
- Backscattering of Gamma Rays
- Determining the half-life of Ba-137
- Recording and calibrating a g spectrum
- Detection Efficiency of a NaI(Tl) Detector
- Calculation of  $\beta/\gamma$  ratio

**(4) Assessment Criteria**

- Periodic Exams: 15%
- Oral, Student Activity and Essay: 10%
- Laboratory Work: 25%
- Final Exam: 50%

**(5) Course Teaching Strategies**

- Lectures, Reports and Essay Assignments, Homeworks, and Web-based assignments.

**(6) Text Book**

- Introduction to nuclear and particle Physics; A. Das and T. Ferbel, World Scientific Publishing, 2005.

**(7) Reference Books**

- Radiation Detection and Measurement; G. Knoll, John Wiley & Sons, 2000.
- Nuclear Physics; Irving Kaplan, Addison-Wesley Publishing Company, Cambridge, Mass, 1962.