



Ministry of  
Higher Education  
and Scientific Research



**Salahaddin University-Erbil**  
**College of Education**  
**Department of Physics**  
**(Course book) Master of Science**  
**Subject: Practical Gamma-ray**  
**Spectrometry**  
**Academic year: 2023-2024**

*Instructor Information:*

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**Lectures:**

Monday: 12:30 – 3:30 Pm in Hall 10

*General:*

Practical Gamma-ray Spectrometry is a course for a graduate (M.Sc.) in Nuclear Physics.

*Course Description:*

The main topics of this course are nuclear radioactivity, nuclear decay, nuclear radiation detections and gamma-ray spectrometry.

*Course Coordinator:*

The coordinator of this course is the nuclear radiation physics

*Course Objectives and expected outcomes:*

The objective of this course study nuclear radioactivity and nuclear radiation detection. It is not to be a complete survey of either field, but will instead cover selected topics and methods. The format will be lecture-based, with some homework and practice in reading, evaluating and writing scientific papers, and emphasis on the design of precision measurements and null tests.

The Syllabus of Nuclear radiation detection

**Chapter One: Radioactivity and Radioactivity decays**

1.1 Introduction (Radiation and Radioactive decay)

- 1.1.1 Radioactivity Decay Law
- 1.1.2 Production of a radio-isotope
- 1.1.3 Radioactivity Equilibrium
- 1.1.4 Radioactive decay Series

1.2 Alpha Decay

- 1.2.1 Energetics of Alpha Decay
- 1.2.2 Range of Alpha Particle
- 1.2.3 Interaction of Charged Particle with Matter

1.3 Beta Decay

- 1.3.1 Energetics of Beta - Decay
- 1.3.2 Electron Capture Decay

1.4 Gamma Decay

- 1.4.1 Energetic of Gamma Ray
- 1.4.2 Interaction of Gamma Rays with Matter.

## Chapter Two: Nuclear Radiation Detector

- 2.1 Gas-filled detectors
  - 1.2.1 Ionization chambers
  - 1.2.2 Proportional counters
  - 1.2.3 Geiger-Müller counters
- 2.2 Scintillation detectors NaI(Tl) crystals
- 2.3 Semiconductor detectors
  - 2.3.1 High-purity germanium (HPGe)
  - 2.3.2 Lithium-drifted silicon (Si(Li))
  - 2.3.3 Lithium-drifted germanium (Ge(Li))
  - 2.3.4 Radon detectors RAD7 radon detector

## Chapter Three: Electronic components for Gamma-Ray Spectrometry

- 3.1 Introduction
- 3.2 Pulse shapes in gamma spectrometry systems.
- 3.3 Detector power supply.
- 3.4 Preamplifiers.
- 3.5 Amplifiers and pulse processors.
- 3.6 Multichannel analyzers and their analogue-to-digital converters.
- 3.7 Detector Cool Down.

## Chapter Four: Counting Systems and Spectrum Analysis

- 4.1 Counting
- 4.2 Spectrum Analysis.
  - 4.2.1 Peak location (Energy Range).
  - 4.2.2 Peak Measurement
  - 4.2.3 Photo peaks.
  - 4.2.4 Compton edge peak.
  - 4.2.5 Annihilation peak.
  - 4.2.6 Sum peak
  - 4.2.7 Escape peak
  - 4.2.8 Backscatter peak
  - 4.2.9 Sum peak

- 4.2.10 X-ray peak
- 4.2.11 Quantitative Measurements

### **Chapter Five: Gamma-ray spectrometry Systems calibration**

- 5.1 Reference Data for Calibration
- 5.2 Sources for Calibration
- 5.3 Energy Calibration
- 5.4 Peak Width Calibration
- 5.5 Efficiency Calibration
  - 5.5.1 Counting Efficiency
  - 5.5.2 Absolute Efficiency
  - 5.5.3 Relative Efficiency
  - 5.5.4 Intrinsic Efficiency
  - 5.5.5 Efficiency of Marinelli Beakers
  - 5.5.6 Efficiency and Design of Well Detectors
  - 5.5.7 Detector Resolution and Sensitivity
- 5.6 Peak-to-Compton Ratio.

### **Chapter Six: Statistics of Counting (Measurement procedure)**

- 6.1 Introduction
- 6.2 The Poisson and gaussian distributions
- 6.3 Sampling statistics
- 6.4 Nuclide identification and quantitative analysis
- 6.5 Peak area measurement
- 6.6 Peaked-background correction
- 6.7 Minimum detectable activity (MDA)
- 6.8 Counting uncertainties

### **References:**

- ❖ Elements of Nuclear Physics Walter E. Meyerhof.
- ❖ Concepts of Modern Physics Arthur Beiser.
- ❖ Practical Gamma-ray Spectrometry G. Gilmore and John D. Hemingway
- ❖ Nuclear Radiation, Detectors and Experiments K. Mahesh and S. M. Mustafa