PHY3230: NUCLEAR RADIATION AND MEASUREMENTS

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Nuclear Radiation and Measurements

Subject Code
PHY - Physics
Course Number
3230

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
AP3275/PHY3275 Radiation Protection and Dosimetry

Precursors
AP3210/PHY3210 Modern Physics for Nuclear Technology

Equivalent Courses
AP3206/PHY3206 Nuclear Radiation and Detection
AP3230 Nuclear Radiation and Measurements

Exclusive Courses
Nil

Part II Course Details

Abstract

This course aims to lay down the foundation knowledge on interaction of nuclear radiation with matter, and detection of nuclear radiation.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the nature of nuclear decay and nuclear radiations.		x		
2	Analyse the detection of nuclear radiation.			x	
3	Analyse the interactions of radiation with matter.			x	
4	Apply theories to solve problems in radiation detection.			x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Lecture and tutorials	1, 2, 3	1.6 hours/week
2	Lab Work	Laboratory sessions, report writing, lab test. The lab sessions will involve different data analysis techniques and experimental techniques, such as fitting radiation counts to statistical distributions, analysing radiation spectra in terms of different interactions of radiation and matter such as photoelectric effect, Compton scattering and pair production. Examples of experiments include studying the Poisson distribution of counts obtained by measuring a radioactive source with a Geiger counter, measuring environmental samples using a High Purity Germanium detector and using a NaI gamma detector.	1, 2, 3, 4	1.4 hours/week

3	Mini Project	A mini project, which is related to the lectures and lab work, and will apply theories learned in lectures and lab sessions to solve problems in real-life problems requiring knowledge in radiation detection. The mini-project may require students to read assigned journal papers, and produce a report to discuss the involvement of the nature of nuclear decay and nuclear radiations, detection of nuclear radiation, and/or interactions of radiation with matter. Experimental work may also be required in the mini-project, e.g., to repeat the experiments carried out in the journal paper, and/or to modify the experiments, and/or to extended the studies to the Hong Kong context.	4	1.4 hours/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3	10	
2	Mid-term Tests	1, 2, 3	10	
3	Lab Reports and Test	1, 2, 3, 4	20	
4	Mini Project	4	10	

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained

Assessment Rubrics (AR)

Assessment Task

1. Assignments

Criterion
The student can thoroughly identify the appropriate concepts required in given problems and apply them to formulate suitable solutions.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not reaching marginal level

Assessment Task
2. Mid-term Tests

Criterion
The student can thoroughly identify the appropriate concepts required in given problems and apply them to formulate suitable solutions.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not reaching marginal level

Assessment Task
3. Lab Reports and Test

Criterion
The student attends all lab sessions, submits all lab reports, and completes a lab test, and demonstrates excellent understanding of the laboratory skills and the involved scientific principles.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not reaching marginal level

Assessment Task
4. Mini project

Criterion
The student reads the assigned literature, and demonstrates excellent understanding of the laboratory skills and the involved scientific principles.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not reaching marginal level

Assessment Task
5. Examination

Criterion
The student can thoroughly identify the appropriate concepts required in given problems and apply them to formulate suitable solutions.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)

Not reaching marginal level

Part III Other Information

Keyword Syllabus

- Interactions of radiation with matter
  Energy loss mechanisms, attenuation, interaction cross section, linear and mass attenuation coefficients, half-value thickness, mean free path, flux and intensity.
- Radiation detection systems
  Types of detector, detector properties and functions; detection efficiency: geometrical attenuation, material attenuation, interaction efficiency, data recording efficiency; Energy resolution: full-width half-maximum, extrinsic and intrinsic resolution; Time resolution.
- Modes of Detector Operation:
  Pulse and current modes; Counting: counting statistics, Poisson distribution, Normal distribution, dead-time, paralyzable and non-paralyzable response; Spectroscopy: pulse-height spectra
- Gamma-ray spectroscopy
  full-energy peak/photopeak, Compton edge, Compton continuum, single and double escape peak; Effects of surrounding: characteristic X-ray peaks, backscattered peak, annihilation peak
- Detectors
  Gas filled detectors: ionization chamber, proportional counter, Geiger-Muller counter, I-V characteristics; Scintillation detectors: photomultiplier tube, NaI detector; semiconductor detectors: surface barrier detectors, Ge detector

Reading List

Compulsory Readings

	Title
1	K S Krane, “Introductory Nuclear Physics”, Wiley (latest ed.).

Additional Readings

	Title
1	Claus Grupen, Introduction to radiation protection [electronic resource] : practical knowledge for handling radioactive sources. Berlin ; London : Springer, 2010.
2	Marilyn E. Noz, Gerald Q. Maguire, Jr., Radiation protection in the health sciences. World Scientific, c2007.