Course Specification

(Postgraduate Programs)

Course Title: Detector Instrumentation
Course Code: PHYS 633
Program: Master of Science in Physics
Department: Physics
College: College of Sciences
Institution: Majmaah University
Version: I
Last Revision Date: 30/12/2024

Table of Contents

A. General information about the course: 3

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods 4

C. Course Content 5

D. Students Assessment Activities 6

E. Learning Resources and Facilities 6

F. Assessment of Course Quality 8

G. Specification Approval 8

A. General information about the course:

1. Course Identification

1. Credit hours: (3)					
2. Course type					
A.	☐University	☐College	☒ Department	☐Track-1	☐Others
B.	☐ Required		☒ Elective		
3. Level/year at which this course is offered: (1st/ 2)					
4. Course general Description:					
Topics will include the performance and use of preamplifiers, spectroscopy systems, and multi-channel analyzers (MCAs). Digital methods for data acquisition, including digital pulse processing, pulse shape discrimination, and digital MCA systems. Instrumentation for scintillators and gas detectors. The module will also cover digital signal processing and the role of noise in affecting detector performance.					
5. Pre-requirements for this course (if any):					
Advanced Nuclear Physics, PHYS 621 Radiation Physics and Dosimetry, PHYS 622					
6. Co-requisites for this course (if any):					
N/A					
7. Course Main Objective(s):					
• This course is designed to understand detector instrumentation, its working, and design for radiation measurements. The course will cover basic mathematical and physics concepts necessary for understanding the basic principles of detector instrumentation. • This module explores the theory of operation and practical aspects of instrumentation for radiation detection, covering both traditional analog instrumentation techniques and the latest developments in digital pulse processing. Students will also critically evaluate the role of statistical processes in detector noise and electronic signal processing.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
Total		**45**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Describe instrumentation for radiation detectors and signal processing.	**K1**	• Lecturing through traditional methods and using a smart board • Group Discussion	•Mid Exams •Final Exam
1.2	Describe nuclear electronics, data collection, and its analysis.	**K3**	• Lecturing through traditional methods and using a smart board • Group Discussion	•Mid Exams •Final Exam
2.0	**Skills**			
2.1	Select and apply proper experimental techniques and instrumentation to measure radiation interactions and detector responses.	S1	• Lecturing • demonstrations • Hands-on experiments • Problem solving	•Mid Exams •Final exam
2.2	Design and optimize radiation detection systems, including shielding and signal processing chains, for specific applications in dosimetry.	S2	• Lecturing • Computational exercises • Software training • Problem solving	• Mid Exams • Final Exam • Design project • Home-Works
2.3	Perform numerical simulations and data analysis using computational tools to predict detector performance and radiation dose distributions.	S4	• Lecturing • Computational exercises • Software training • Problem solving	•Mid Exams •Final exam
3.0	**Values, autonomy, and responsibility**			

3.1	Work effectively both as individuals and in a group.	**V3**	• Discussion with students • Making students aware of time management in completing their assignments. • Encourage students to help each other. • Group presentation/ Group assignments	•Presentation •E-exam •H.W., Quizzes & Discussions
3.2	Present a short report in a written form and orally using appropriate scientific language.	**V3**	• Discussion with students • Making students aware of time management in completing their assignments. • Encourage students to help each other. • Group presentation/ Group assignments	•Presentation •E-exam •H.W., Quizzes & Discussions
3.3	Use information technology and modern computer tools to locate and retrieve scientific information relevant to radiation physics and dosimetry.	**V3**	• Discussion with students • Making students aware of time management in completing their assignments. • Encourage students to help each other. • Group presentation/ Group assignments	•Presentation •E-exam •H.W., Quizzes & Discussions

C. Course Content

No	List of Topics	Contact Hours
1.	INTERACTION OF RADIATION WITH MATTER: An introduction, IMPORTANT FEATURES OF RADIATION DETECTORS: Modes of detector operation, Counting curves and plateaus, Energy resolution, Calibration and Detection efficiency, Dead time, Quenching.	9
2.	DETECTORS FOR NUCLEAR PARTICLES: Gas-filled Detectors: Ionization chamber, Proportional counter, GM counter; Scintillation detectors; Semi-conductor detectors: HPGe detector: Design and operation.	6
3.	PARTICLE ACCELERATORS: Van de Graaff generator, Pelletron Accelerator; Linear Accelerators (LINAC), Cyclotron, Microtron, Betatron, Synchrotron: - Design and operation.	6
4.	LINEAR AND LOGIC PULSE FUNCTIONS: Linear and Logic Pulses, Instrument Standards, Application Specific Integrated Circuits (ASICs), Summary of Pulse-Processing Units, Components Common to Many	9

	Applications, Pulse Counting Systems, Pulse Height Analysis Systems, Digital Pulse Processing, Systems Involving Pulse Timing, Pulse Shape Discrimination.	
5.	MULTICHANNEL PULSE ANALYSIS: Single-Channel Methods, General Multichannel Characteristics, The Multichannel Analyzer, Spectrum Stabilization and Relocation, Spectrum Analysis.	6
6.	DATA ANALYSIS AND TECHNIQUES: Counting statistics and error predictions: Characterization of data, Statistical models and their applications, Chi-square test, Precision and accuracy, Error analysis, propagation of errors, Limits of detectability, plotting of graphs, least squares fitting, linear and nonlinear curve fitting, Poisson statistics, Fourier analysis.	9
Total		**45**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	First exam*	6	15
2.	Second exam*	11	15
3.	E-exam	Once a semester	10
4.	Presentation*	Once a semester	10
5.	Homework, quizzes, and discussion	during the term	10
6.	Final exam*	End of the semester	40%

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	• Radiation Detection and Measurement G.F. Knoll, 5th Edition, Wiley, New York, 2020. • Nuclear Physics: An Introduction, S.B. Patel, New Age International (P) Ltd. Publications, New Delhi, ISBN: 8122401252, 1996. • Introduction of Experimental Nuclear Physics, R.M. Singru, John Wiley and Sons, Inc., New York, 1975. • Introductory Nuclear Physics, K. S. Krane, 3rd Ed., John Wiley and Sons, Inc., New York; ISBN: 047180553X, 1987. • Techniques for Nuclear and Particle Physics Experiments W.R. Leo, Second Edition, Springer-Verlag, New York, 1994.

	• Nuclear Radiation Detectors S.S. Kapoor & V.S. Ramamurthy, New Age International (P) Ltd. Publishers, New Delhi, 2005.
Supportive References	• Semiconductor Radiation Detectors, Lutz, G., Springer, 1999. • Nuclear Physics: Principles and Applications, Lilley, J., Wiley; John Wiley & Sons Ltd, 2001. • Semiconductors for Room Temperature Nuclear Detector Applications, Vol. 43 of Semiconductors and Semimetals, Ed. Schlesinger, T.E. and James, R.B., Academic Press, 1995. • Physics of Semiconductor Devices, Sze, S.M. and Kwok, K.N., Wiley-Interscience, Edition 3, 2007. • Nuclear Instruments and Methods in Physics Research Section (NIM A & B)
Electronic Materials	• Saudi Digital Library (SDL) • https://www.wikipedia.org/ • Web of Knowledge • Physics Today (web version) • MIT Courseware • Class presentation • Blackboard • Equipment manuals/handout • Software manuals/ user guide
Other Learning Materials	• Equipment manuals/handout • Software manuals/ user guide

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	• Lecture room with at least 25 seats. • Auditorium of a capacity of not less than 100 seats for large lecture format classes. • Computer lab for e-Quiz.
Technology equipment (projector, smart board, software)	• A smart board to write on, and a computer. • MS software suite • Origin Graphic Software • Smartboard with maintains feedback • Whiteboard
Other equipment (depending on the nature of the specialty)	• Library, Seminar Room, and Wi-Fi internet connections.

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Internal Reviewer Committee	Direct
Effectiveness of Students' Assessment	Students	Indirect
Quality of learning resources	Peer Reviewer	Direct
The extent to which CLOs have been achieved	Qiyas Center, Stockholder, and Others	Direct

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16
DATE	30/12/2024