



Course Specification

(Postgraduate Programs)

Course Title: **Applications of Ionizing Radiation Physics**

Course Code: **PHYS 631**

Program: **Master of Science in Physics**

Department: **Physics**

College: **College of Sciences**

Institution: **Majmaah University**

Version: **I**

Last Revision Date: **30/12/2024**



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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:

The course will include lectures and demonstrations of clinical equipment applications, as well as the basic principles of ionizing radiation, X-ray production, radiation interactions, imaging equipment, and radiation therapy equipment. Provide a basic understanding of ionizing radiation. The course will also cover basic mathematical and physical concepts necessary to understand the topics discussed above. To understand medical X-ray and gamma-ray imaging technology in terms of equipment components and their performance, and to relate this to the needs of diagnostic medical imaging. To provide students with a comprehensive overview of the techniques used in both *in vivo* and *in vitro* nuclear medicine studies. To give an overview of the use of radiopharmaceuticals in nuclear medicine. An appreciation of quality management, its aims, and its application to imaging and radiotherapy.

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):

NA

7. Course Main Objective(s):

1. The course will cover basic mathematical and physics concepts necessary to understand the basic principles of ionizing radiation.
2. Application of ionizing radiation for diagnostic and therapeutic purposes.
3. An introduction is given to imaging systems: X-radiography, gamma cameras, X-ray computed tomography, single photon computed tomography (SPECT), and positron emission tomography (PET).
4. An overview of radiotherapy techniques and the biological processes concomitant with this modality, with the discussion of isodose curves and variation with incident radiation energy, will be given.



2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid <ul style="list-style-type: none"> • 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 the basic principles of ionizing radiation physics.	K2	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
1.2	Describe the application of ionizing radiation for diagnostic and therapeutic purposes.	K3	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
2.0	Skills			
2.1	Apply the gained mathematical and experimental knowledge to	S1	Lectures, Teamwork, Discussions,	Exams, Quizzes, Homework,





	any physical phenomena to understand their behavior.		Exercises, Quizzes, Problem-solving	Assignments
2.2	Solve the numerical problems with confidence.	S3	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
3.0	Values, autonomy, and responsibility			
3.1	Work effectively in both groups and as individuals.	V1	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
3.2	Present a short report in written form and orally using appropriate scientific language.	V1	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
3.3	Use information technology and modern computing tools to locate and retrieve scientific information relevant to radiation physics and dosimetry.	V1	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments

C. Course Content

No	List of Topics	Contact Hours
1.	Introduction to ionizing radiation and its classification, and sources; principles of applications: tracer concept, scattering and attenuation of radiation, radiation processing of materials	6
2.	Applications: 1. Healthcare: Diagnostic application: Radioimmunoassay (RIA) and Related techniques; Diagnostic nuclear medicine: Radiopharmaceuticals, Diagnostic techniques and their applications: Radiology: Single photon emission computed tomography (SPECT), Positron emission tomography (PET), X-rays, computed tomography (CT) Scan, therapeutic application: Radionuclide therapy, Radiotherapy. Risk/benefit analysis in mammography. Elements of the mammographic imaging system: dedicated X-ray sets, films, intensifying screens, and film processing systems. Introduction to digital imaging modalities and their	15



	applications in mammography; Isodose curves and variation with incident radiation energy.	
3.	Applications: 2. Agriculture and industry: application in food and agricultural products: Food preservation; industry: radiation processing, non-destructive testing, radiotracer techniques, Facilities and devices for the application of nuclear techniques.	9
4.	Applications: 3. Application in Biology: Radiotracer, labeling methods; Labeled applications: In situ hybridization (ISH), DNA finger printing, molecular diagnostics, drug discovery.	6
5.	Applications: 4. Environmental studies and Pollution control.	3
6.	X-rays, γ -rays, Modulation Transfer Function (MTF) and Receiver Operating Characteristic (ROC) Analysis: Mathematical formulation of the imaging system; linear operator, principle of superposition, impulse response function, stationarity, edge spread function, convolution integral, MTF. Usefulness of MTF, modulation transfer function (MTF), modulation input and output, performance measures, cascade MTFs. Visual acuity, resolution criteria. Existence of observer, decision criteria, confidence thresholds, conditional probabilities, and types of decision. Construction of the ROC curve and the principle of ROC analysis.	6
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.	Presentation	Once a semester	10
4.	Homework, Quizzes & Discussions	Weekly	10
5.	E-exam	Once a semester	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

- The Physics of Radiology, 4th Edition, Harold Elford Johns, and John Robert Cunningham, ISBN-13: 978 0398046699, ISBN-10: 0398046697, 2020.
- Radiologic Science for Technologists, 10th Edition, Stewart Bushong, ISBN: 9780323292078, ISBN: 9780323081368, Mosby one Imprint of Elsevier, 2012.



Supportive References

- Workbook for Radiologic Science for Technologists, 10th Edition, Stewart Bushong, ISBN-13: 978-0323081375, ISBN-10: 0323081371, Mosby one Imprint of Elsevier, 2012.
- The Essential Physics of Medical Imaging, 3rd Edition, Jerrold T. Bushberg, ISBN-13: 978-0781780575, ISBN-10: 0781780578 Lippincott Williams & Wilkins, 2012.
- Nuclear Physics Principles & Applications, John Lilley, ISBN-13: 978-0471979364, ISBN-10: 0471979368 John Wiley & Sons, 2001.
- Fundamentals of Radiochemistry, DD Sood, AVR Reddy, N Ramamurthy, third edition, Perfect Prints, Thane, India, 2007.
- Radiation Oncology Physics. Ed. E.B. Podgorsak, IAEA, 2005.
- Linear Accelerators for Radiotherapy, Greene D, Adam Hilger (Medical Physics Handbook 17), 1986.
- Physics of Electron Beam Therapy, Klevenhagen SCB, Adam Hilger (Medical Physics Handbook 13), 1985.
- Medical Electron Accelerators, Karzmark CJ, Nunan CS & Tanabe E, McGraw-Hill (1993).
- Radiotherapy Physics (in practice), Williams JR & Thwaites DI. Oxford Medical Publications, 1993.
- The Physics of Radiation Therapy, Khan FM, Williams and Wilkins, 3rd Edition, 2003.
- Physical Aspects of Brachytherapy, Godden TJ, Adam Hilger 1988.
- The Essential Physics of Medical Imaging, Ed J T Bushberg, Williams & Wilkins, 1994.
- The Physics of Medical Imaging, Ed S Webb, IoPP, 2002.
- Medical Radiation Detectors, Editor N F Kember, IoPP, 1994.
- Physics for Radiologists. Dendy & Heaton, Taylor & Francis; 2nd Edition, 1999.
- Christensens Diagnostic Radiology, Lippincott Williams & Wilkins; 4th Edition, 1990.
- Basic Science of Nuclear Medicine, Parker, Smith & Taylor, Churchill/Livingstone, 1984.
- Practical Nuclear Medicine, Sharp, Gemmell & Smith. OUP 2nd Edition, 1998.
- Physics in Nuclear Medicine, Cherry, Sorenson, Phelps. Saunders, 3rd Edition, 2003.
- Radiotherapy Physics in Practice, Ed: Williams & Thwaites, Oxford Medical Pub 2nd Edition, 2000.
- Practical Radiotherapy Planning, Dobbs J, Barratt A and Ash D, Edward Arnold, 3rd Edition, 1999.
- Intensity Modulated Radiation Therapy, Webb, S, Institute of Physics Publishing Ltd., 2001.



	<ul style="list-style-type: none"> • A cost comparison of full-field digital mammography with film-screen mammography in breast cancer screening. NHS BSP Equipment Report 0403, 2004. • Computer-Aided Detection in Mammography. NHS BSP Pub 48, 2001. • IPEM Rep. 89. The Commissioning & Routine Testing of Mammographic X-ray Systems, 2005.
Electronic Materials	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Equipment manuals/handout • Software manuals/ user guide

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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	Internal Reviewer Committee	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

