MODULE DESCRIPTION FORM

نموذج وصف المادة الدراسية

Module Information معلومات المادة الدراسية		
Module Title	Physics of Diagnostic Radiology	**Module Delivery**
Module Type	Core	☐ Theory ☐ Lecture ☐ Lab ☐ Tutorial ☐ Practical ☐ Seminar
Module Code	MPH35123	
ECTS Credits	7	
SWL (hr/sem)	175	

Module Level	3	**Semester of Delivery**	2
Administering Department	MPH	**College**	AMS
Module Leader	Ahmed Musa Jafar	**e-mail**	ahmed.mo@uowa.edu.iq
Module Leader's Acad. Title	Assistant Professor	**Module Leader's Qualification**	Ph.D.
Module Tutor	Ahmed Musa Jafar	**e-mail**	ahmed.mo@uowa.edu.iq
Peer Reviewer Name	Prof. Dr. Hikmat Adnan Jawad	**e-mail**	hikmatadnan@gmail.com
Scientific Committee Approval Date	2026-2-1	**Version Number**	V1

Relation with other Modules العلاقة مع المواد الدراسية الأخرى			
Prerequisite module	None	**Semester**	None
Co-requisites module	None	**Semester**	None

Module Aims, Learning Outcomes and Indicative Contents أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية	
Module Objectives أهداف المادة الدراسية	**1.** Understand the fundamental principles of radiation physics and their application to diagnostic radiology. **2.** Explain the physical basis of image formation in various radiologic imaging modalities, including X-ray, CT, ultrasound, MRI, SPECT, and PET. **3.** Identify and describe how ionizing radiation interacts with matter and how these interactions influence image quality. **4.** Operate and evaluate radiation detectors and imaging equipment in both laboratory and clinical contexts. **5.** Assess image quality and apply optimisation techniques to enhance diagnostic performance and reduce unnecessary radiation exposure. **6.** Apply radiation protection principles and regulatory standards to ensure safety of patients, staff, and the public.
Module Learning Outcomes مخرجات التعلم للمادة الدراسية	**1.** Developing students' skills in logical thinking and analysis **2.** Enabling students to confront the fear of presenting in front of the public by presenting them with seminars related to the subject of physics of diagnostic radiology. **3. Radiation Physics and Radioactivity** • Describe atomic structure and nuclear decay mechanisms. • Calculate half-life, specific activity, and decay-related parameters. • Explain the behavior and biological relevance of different types of ionizing radiation. **4. X-ray Production and Interaction with Matter** • Describe the production of X-rays and the components of an X-ray tube. • Analyze how X-rays and gamma rays interact with tissues and materials. • Relate interaction types (photoelectric, Compton, pair production) to diagnostic imaging applications. **5. Radiation Detection and Dosimetry** • Operate radiation detectors including ionization chambers, GM counters, scintillation detectors, and semiconductor devices. • Measure and interpret radiation dose quantities relevant to diagnostic imaging. • Compare detector performance and sensitivity based on photon energy. **6. Image Receptors and Image Formation** • Differentiate between analogue and digital imaging systems. • Explain the functioning of photoluminescent screens, ADCs, and image pixelation. • Describe image capture processes and image quality factors such as contrast, unsharpness, and resolution. **7. Radiologic Image Quality and Optimisation** • Evaluate image quality using physical and physiological criteria. • Apply concepts such as SNR, CNR, MTF, DQE, and ROC in image assessment. • Optimize imaging parameters for improved diagnostic accuracy and reduced radiation dose. **8. Tomographic Imaging with X-rays (CT and Tomosynthesis)** • Explain data acquisition and reconstruction in CT and digital tomosynthesis. • Identify CT image artifacts and apply quality assurance protocols. • Analyze dose modulation strategies and their impact on patient safety and image quality. **9. Advanced and Special Radiographic Techniques** • Describe the physics and applications of mammography, subtraction imaging,

	interventional, pediatric, and dental radiology. • Evaluate how technical factors influence image quality and patient dose in specialized settings. **10. Imaging with Radioactive Materials (SPECT and PET)** • Describe gamma camera and PET system operation. • Interpret radionuclide imaging data including dynamic studies and functional imaging. • Apply quality control and safety procedures in nuclear medicine imaging. **11. Diagnostic Ultrasound** • Explain ultrasound wave propagation and image formation based on tissue properties. • Identify common artifacts and describe Doppler and harmonic imaging techniques. • Evaluate the clinical safety of diagnostic ultrasound. **12. Magnetic Resonance Imaging** • Describe the principles of nuclear magnetic resonance and spatial localization. • Interpret k-space image reconstruction and identify MRI artifacts. • Explain advanced MRI techniques including angiography and diffusion imaging. **13. Radiation Protection and Regulations** • Apply the principles of justification, optimization, and dose limitation. • Demonstrate the use of personal dosimetry tools and monitoring equipment. • Understand relevant national and international legislation in diagnostic radiology.
Indicative Contents المحتويات الإرشادية	<u>Theory Lectures</u> Learning concepts of each theoretical lecture or groups of lectures. [SSWL= 28] <u>Lab. Lectures</u> Learning concepts of each laboratory lecture or groups of lectures. [SSWL= 30] Total hrs = ∑SSWL + (Mid Exam hrs+ Final Exam hrs) Total hrs = 28 +30 + 1 +3 = 62

Learning and Teaching Strategies استراتيجيات التعلم والتعليم	
Strategies	**1.** Lecture **2.** Problem-based learning (PBL) **3.** Peer teaching and collaborative learning **4.** Reflective practice **5.** Workshops **6.** Laboratory sessions **7.** Student groups. **8.** Emphasis will be placed on linking physical principles to clinical imaging scenarios. **9.** Multimedia presentations (animations, videos, diagnostic images) will be used to illustrate complex concepts. **10.** Discussion. **11.** Giving students assignments to solve problems. **12.** Assigning students to prepare reports related to the course.

Student Workload (SWL) الحمل الدرا يس للطالب محسوب لـ ١٥ أسبوعا			
Structured SWL (h/sem) الحمل الدرا يس المنتظم للطالب خلال الفصل	76	**Structured SWL (h/w)** الحمل الدرا يس المنتظم للطالب أسبوعيا	5.07
Unstructured SWL (h/sem) الحمل الدرا يس غ ر المنتظم للطالب خلال الفصل	124	**Unstructured SWL (h/w)** الحمل الدرا يس غ ر المنتظم للطالب أسبوعيا	8.27
Total SWL (h/sem) الحمل الدرا يس الك يل للطالب خلال الفصل	**200**		

Module Evaluation تقييم المادة الدراسية																												
		Time Number	**Weight (Marks)**	**Week Due**															**Relevant Learning Outcome**									
				W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10
Formative	**Quizzes**	2	10%				x				x											x						
	Report	2	10%					x						x					x				x					
	Lab Report	1	5%									x														x		
	Project	1	5%												x								x			x		
	Online Assig.	-	-																									
	Onsite Assig.	1	10%										x								x			x				
	Seminar	-	-																									
Summative	**Mid. Exam**	1hr	10% (10)																									
	Final Exam	3hr	50% (50)	Week 16																								
Total assessment			100%																									

Delivery Plan (Weekly Syllabus) المنهاج الاسبو يع النظري	
	Material Covered
Week 1	**Fundamentals of Radiation Physics and Radioactivity:** 1. Structure of the Atom 2. Nuclear Stability and Instability 3. Radioactive Concentration and Specific Activity 4. Radioactive Decay Processes (β^- Decay, β^+ Decay and α Decay) 5. Exponential Decay and Half-life 6. Biological and Effective Half-Life 7. Quantum Properties of Radiation 8. Inverse Square Law 9. Interaction of alphas, betas or photons with matters

Week 2	**Production of X-Rays:** 1. The X-ray Spectrum 2. Components of the X-ray Tube 3. Spatial Distribution of X-rays 4. Rating of an X-ray Tube Mobile X-ray Generators
Week 3	**Interaction of X-Rays and Gamma Rays with Matter:** 1. Introduction to the Interaction Processes 2. Bound and Free Electrons 3. Attenuation, Scatter and Absorption 4. The Interaction Processes (Elastic Scattering, Photoelectric Effect, The Compton Effect and Pair Production) 5. Consequences of Interaction Processes when Imaging Patients
Week 4	**Radiation Measurement:** 1. Ionisation in Air as the Primary Radiation Standard 2. The Ionisation Chamber and The Geiger–Müller Counter 3. Relationship between Exposure and Absorbed Dose 4. Practical Radiation Monitors (Secondary Ionisation Chambers, Dose Area Product Meters and Pocket Exposure Meters for Personnel Monitoring) 5. Semi-conductor Detectors (Band Structure of Solids, Mode of Operation and Uses of the Silicon Diode) 6. Scintillation Detectors and Photomultiplier Tubes 7. Variation of Detector Sensitivity with Photon Energy
Week 5	**The Image Receptor:** 1. Analogue and Digital Images 2. Fluorescence, Phosphorescence, Photostimulation and Thermoluminescence 3. Phosphors and Photoluminescent Screens 4. X-ray Film, Film Used with a Photoluminescent Screen 5. Reciprocity 6. Film-Screen Unsharpness 7. Introduction to Digital Receptors and Associated Hardware • Analogue to Digital Converters (ADCs) • Pixellating the Image
Week 6	**The Radiological Image:** 1. The Meaning of Image Quality, The Primary Image and Contrast 2. Effects of Overlying and Underlying Tissue 3. Reduction of Contrast by Scatter 4. Variation in Scatter with Photon Energy 5. Reduction of Scatter 6. Resolution and Unsharpness 7. Quantum Mottle 8. Image Processing 9. Geometric Relationship of Receptor, Patient and X-ray Source 10. Review of Factors Affecting the Radiological Image a) Choice of Tube Kilovoltage, Tube Current and Exposure Time b) Focal Spot Size, Quality of Anode Surface, Beam Size, Grids c) Image Receptor, Focus-Receptor and Object-Receptor Distance Contrast Enhancement, Film Processing and Post-processing)
Week 7	Mid. Exam
Week 8	**Assessment of Image Quality and Optimisation:** 1. Factors Affecting Image Quality (Image Parametersو Observation Parameters and Psychological Parameters) 2. Operation of the Visual System a) Response to Different Light Intensities b) Rod and Cone Vision c) Relationship of Object Size, Contrast and Perception 3. Objective Definition of Contrast a) Limitations of a Subjective Definition of Contrast b) Signal-to-Noise Ratio and Contrast-to-Noise Ratio 4. Quantum Noise 5. Detective Quantum Efficiency (DQE) 6. Assessment of Image Quality

	a) Modulation Transfer Function b) Physical/Physiological Assessment 7. Receiver Operator Characteristic (ROC) Curves 8. Optimisation of Imaging Systems and Image Interpretation 9. Design of Clinical Trials
Week 9	**Tomographic Imaging with X-Rays:** 1. Longitudinal Tomography (Digital Tomosynthesis) 2. Principles of X-ray Computed Tomography (Data Collection and Data Reconstruction) 3. Spiral CT 4. Multi-Slice CT (Data Collection and Data Reconstruction and Storage) 5. Image Quality 6. Dose Optimisation (Tube Current Modulation) 7. Artefacts a) Mechanical Misalignment and Patient Movement b) X-ray Output Variation and Detector Non-Uniformities c) Partial Volume Effects, Beam Hardening, Aliasing, Noise, Scatter and Cone-Beam Artefacts 10. Quality Assurance 11. Special Applications
Week 10	**Special Radiographic Techniques:** 1. Mammography—Low Voltage Radiography a) Molybdenum Anode Tubes, Rhodium and Tungsten Anode Tubes b) Scatter, Image Receptors and Quality Control and Patient Doses 2. High Voltage Radiography (Principles, The Image Receptor and Scattered Radiation) 3. Magnification Radiography 4. Subtraction Techniques (Digital Subtraction Angiography, Dual Energy Subtraction and Movement Artefact) 5. Interventional Radiology 6. Paediatric Radiology 7. Dental Radiology
Week 11	**Diagnostic Imaging with Radioactive Materials:** 1. Principles of Imaging a) The Gamma Camera and Additional Features on the Modern Gamma Camera 2. Factors Affecting the Quality of Radionuclide Images 3. Dynamic Investigations a) Data Analysis; Cine Mode, Time-Activity Curves, Deconvolution and Functional Imaging b) Camera Performance at High Count Rates 4. Single Photon Emission Computed Tomography (SPECT) 5. Quality Standards, Quality Assurance and Quality Control a) Radionuclide Calibrators and Accuracy of Injected Doses b) Gamma Camera and Computer
Week 12	**Positron Emission Tomographic Imaging (PET):** 1. PET Radionuclide Production and Properties 2. Principles of PET Imaging and Detector Technology a) Positron Decay b) Coincidence Detection 3. Detector Geometry, Detector Construction, Detector Resolution and Detection Events 4. Image Formation and Image Reconstruction 5. Multimodality Imaging 6. Quality Control 7. Clinical Implementation—Radiation Safety Considerations for PET Imaging
Week 13	**Diagnostic Ultrasound:** 1. The physics of ultrasound propagation in the body. 2. The properties of tissues which cause image formation with ultrasound. 3. The mechanisms of action of ultrasound probes. 4. Technical aspects of B-mode ultrasound and B-mode artefacts. 5. More advanced techniques—tissue harmonic imaging, compound imaging, 6. coded imaging.

	7. Ways in which information can be obtained from the Doppler effect. 8. The safety of ultrasound
Week 14	**Magnetic Resonance Imaging:** 1. Basic principles (magnetic moment of protons, precession, Larmor equation) 2. Excitation and relaxation (RF pulses, spin-lattice and spin-spin relaxation) 3. Spatial localisation using magnetic field gradients (frequency and phase 4. encoding, slice selection) 5. Image reconstruction using *k*-space 6. Artefacts (effects of movement, flow, metal, encoding artefacts) 7. Magnetic resonance (MR) angiography and diffusion-weighted imaging
Week 15	**Practical Radiation Protection and Legislation:** Role of Radiation Protection in Diagnostic Radiology • Principles of Protection (Justification, Optimisation, Application of Dose Limits) • Patient • Protection. • Staff Protection. European And UK Legislations X-ray Rooms Personal Dosimetry Thermoluminescent Dosimeters (TLDs) and Film Badges (Lab) Film Badge Dosimeters

Delivery Plan (Weekly Lab. Syllabus) المنهاج الاسبو يع للمخت.ت	
	Material Covered
Week 1	**Introduction to Radiation Physics and Safety** • Radiation units (Bq, Gy, Sv, etc.) • Safe lab practices with radiation equipment • Use of survey meters and shielding materials • Demonstration: Inverse square law and exposure control
Week 2	**Lab 2: Production of X-rays** • Demonstration of X-ray tube components • X-ray spectrum measurement using aluminum filters • Spatial distribution analysis with radiation field mapping • Operation of mobile vs. stationary X-ray units
Week 3	**Radiation Interaction with Matter** • Attenuation and half-value layer (HVL) measurements • Variation in attenuation with material type and thickness • Experiment: Scatter intensity vs. incident angle or field size
Week 4	**Radiation Detectors and Dose Measurement** • Ionization chamber operation and calibration • Using a Geiger-Müller (GM) counter for radiation detection • Measuring exposure and absorbed dose • Introduction to Dose Area Product (DAP) meters
Week 5	**Advanced Detectors** • Semiconductor detector: Silicon diode performance • Scintillation detector + photomultiplier tube demo • Detector response vs. photon energy (spectral analysis) • Comparison of detector types in clinical context

Week 6	**Analogue and Digital Image Receptors** • X-ray film and screen imaging • Demonstration of phosphor response: fluorescence vs. phosphorescence • Digital receptor simulation: ADCs and image pixelation • Evaluate film-screen vs. digital image quality
Week 7	Mid-term exam
Week 8	**Image Quality Parameters** • Contrast, resolution, and noise analysis using phantoms • Quantum mottle visualization under low-dose conditions • Demonstrate geometric unsharpness (source-object-receptor geometry) • Use of grids and their effect on scatter
Week 9	**CT Imaging Principles** • Simulate data acquisition and reconstruction (filtered back projection or iterative) • CT image formation demo using virtual or physical phantom • Explore effects of pitch, slice thickness, and rotation time • Identify common CT artefacts (beam hardening, motion, etc.)
Week 10	**Special Radiographic Techniques** • Demonstration: Mammography unit components and low-kV operation • Image acquisition using magnification radiography • Subtraction techniques demo (digital subtraction angiography) • Dental or pediatric exposure techniques (dose management)
Week 11	**SPECT Imaging** • Gamma camera demonstration and image acquisition • Collimator selection and field uniformity test • Acquisition of static and dynamic images • Quality assurance on SPECT systems
Week 12	**PET Imaging** • Simulate positron decay and annihilation event detection • Coincidence detection and PET ring geometry demo • Resolution measurement and time-of-flight (TOF) simulation • Quality control steps in PET/CT scanners
Week 13	**Diagnostic Ultrasound** • B-mode probe handling and image acquisition • Phantom imaging: resolution, contrast, and depth analysis • Doppler effect demonstration and spectral waveform recording • Identify artefacts: acoustic shadow, enhancement, reverberation
Week 14	**MRI Physics** • Demonstration: Precession, Larmor frequency, and resonance • Simulate spatial encoding (slice selection, phase/frequency encoding) • K-space visualisation tool and 2D image reconstruction • Artefact demonstration: motion, aliasing, metal implants
Week 15	**Radiation Protection and Legislation** • Demonstrate patient and staff shielding techniques • Dosimeter usage: TLDs, film badges, and electronic dosimeters • Simulate personal dose monitoring workflow • Review key aspects of local/national radiation safety legislation

Learning and Teaching Resources مصادر التعلم والتدريس		
	Text	**Available in the Library?**
Required Texts	P Dendy, B Heaton, "Physics for Diagnostic Radiology", 3rd Edition, Taylor and Francis (2012).	No
Recommended Texts	1. Curry, T. S., Dowdey, J. E., & Murry, R. C. (1990). Christensen's physics of diagnostic radiology. Lippincott Williams & Wilkins. 4th edition.	No
Websites	https://www.britannica.com/Science-Tech https://www.sciencedirect.com/	

Grading Scheme مخطط الدرجات				
Group	**Grade**	التقدير	**Marks %**	**Definition**
Success Group (50 - 100)	**A -** Excellent	امتياز	90 - 100	Outstanding Performance
	B - Very Good	جيد جدا	80 - 89	Above average with some errors
	C - Good	جيد	70 - 79	Sound work with notable errors
	D - Satisfactory	متوسط	60 - 69	Fair but with major shortcomings
	E - Sufficient	مقبول	50 - 59	Work meets minimum criteria
Fail Group (0 – 49)	**FX –** Fail	راسب (قيد المعالجة)	(45-49)	More work required but credit awarded
	F – Fail	راسب	(0-44)	Considerable amount of work required

Note: Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.