



University of Al Ameer



Faculty of Health and Medical Technologies

Department of

All Department

Medical Physics

Course Description

Course Information

Course Information				
Course Title	Medical Physics	Course Delivery		
Course Code	MPH101	Method	H/Week	Frequency
Credits		Theory	2	1
Course Type	Core Course	Online Lecture	-	-
Course Level	First Year	Lab	2	1
Semester of Delivery	Second Semester	Tutorial	-	-
Administering Department		Practical	-	-
Instructor	Dr. Sara Ahmed	Seminar	-	-
Version Number		Faculty	Health and Medical Technologies	
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		Scientific Committee Approval Date	Version Number	

Brief Description

Medical Physics is an introductory course that applies the principles of physics to medicine and healthcare. The course introduces students to the physical concepts governing the structure and function of the human body and explains how these concepts are utilized in modern medical diagnosis, monitoring, and treatment.

Students study the physics of the skeletal and cardiovascular systems, bioelectric phenomena of the heart (ECG), medical acoustics and ultrasound, optical principles in medicine, X-ray production and medical imaging, together with the scientific foundations of measurement, modeling, and biomedical instrumentation. The course combines theoretical knowledge with clinical applications to prepare students for advanced studies in health and medical technologies.

Course Objective, Learning Outcomes and Indicative Contents

Course Objective	<p>Upon successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> 1. Establish a solid foundation in the fundamental principles of Medical Physics relevant to health sciences. 2. Integrate physical sciences with human anatomy, physiology, and clinical medicine to explain normal biological functions. 3. Interpret the physical mechanisms underlying diagnostic and therapeutic medical technologies. 4. Develop analytical and quantitative reasoning skills for solving healthcare-related physical problems. 5. Apply physical principles to the operation and safe use of biomedical equipment. 6. Evaluate the advantages, limitations, and clinical indications of major diagnostic modalities. 7. Promote radiation protection, patient safety, and quality assurance principles in medical practice. 8. Develop scientific inquiry, evidence-based thinking, and lifelong learning skills. 9. Demonstrate professional, ethical, and collaborative behaviors during laboratory and classroom activities. 10. Prepare students for advanced study in medical technology and clinical sciences. 11. Foster critical thinking and clinical decision-making through the application of Medical Physics concepts.
Course Learning Outcomes	<p>/*Important: Write at least 6 Learning Outcomes, better to be equal to the number of study weeks. MUST be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound)*/</p>

	<p>Knowledge</p> <ol style="list-style-type: none"> 1. Define the fundamental concepts, terminology, SI units, and measurement principles used in Medical Physics. 2. Explain the role of Medical Physics in diagnosis, patient monitoring, and therapeutic applications. 3. Describe the biomechanical functions and physical properties of the skeletal system. 4. Explain bone remodeling and the mechanical behavior of bone under physiological loading. <hr/> <p>Cognitive Skills</p> <ol style="list-style-type: none"> 5. Explain the electrical conduction system of the heart and the physiological basis of ECG generation. 6. Interpret normal ECG waveforms and calculate heart rate using standard ECG recording methods. 7. Analyze cardiovascular function using the principles of pressure, flow, resistance, work, and energy. 8. Apply the physical principles of sound propagation and ultrasound in medical diagnosis. 9. Differentiate between high- and low-frequency ultrasound according to image resolution and tissue penetration. 10. Explain the interaction of light with biological tissues, including reflection, refraction, absorption, and transmission. <p>Application & Clinical Reasoning</p> <ol style="list-style-type: none"> 11. Explain the production, interaction, and attenuation of X-rays in biological tissues. 12. Differentiate among major medical imaging modalities according to their physical principles, clinical indications, advantages, and limitations. 13. Perform fundamental laboratory measurements and operate basic biomedical instruments following standard laboratory procedures. 14. Interpret experimental observations and simple clinical data using scientific reasoning and evidence-based judgment. <p>Professional Skills</p> <ol style="list-style-type: none"> 15. Apply radiation protection, laboratory safety, and quality assurance principles during laboratory and clinical learning activities. 16. Demonstrate scientific communication, teamwork, ethical behavior, problem-solving, and evidence-based reasoning while completing laboratory and classroom activities.
<p>Indicative Contents</p>	<p><u>Theory Lectures</u></p> <p>Lecture One: Terminology, Modeling, and Measurement</p> <p>Reference: Cameron JR, Skofronick JG, Grant RM. <i>Physics of the Body</i>. 2nd ed. Medical Physics Publishing.</p> <p>Learning Concepts</p> <ul style="list-style-type: none"> • Introduction to Medical Physics and its applications in healthcare. • Physical quantities, SI units, dimensions, and unit conversions. • Scalars and vectors in biological and medical systems. • Measurement techniques, accuracy, precision, uncertainty, and sources of error. • Scientific notation and significant figures in biomedical measurements. • Mathematical modeling and problem-solving in Medical Physics. • Biomedical instrumentation and the importance of accurate measurements in clinical practice.

Lecture Two: Physics of the Skeletal System

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Overview of the skeletal system and its biological functions.
- Structure and composition of bone as a living tissue.
- Mechanical properties of bone (strength, elasticity, stiffness, and resilience).
- Stress, strain, Young's modulus, and bone biomechanics.
- Bone remodeling and factors affecting bone strength.
- Mechanical aspects of fractures and fracture healing.
- Clinical applications of biomechanics in orthopedics and rehabilitation.

Lecture Three: Electrocardiography (ECG)

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Electrical activity of the heart and the cardiac conduction system.
- Principles of electrocardiography (ECG).
- ECG electrodes and standard limb, augmented, and chest leads.
- Generation and interpretation of the P wave, QRS complex, and T wave.
- Heart rate determination using ECG recordings.
- Basic ECG measurements and waveform analysis.
- Clinical applications of ECG in the assessment of cardiac function.

Lecture Four: Physics of the Cardiovascular System

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Anatomy and physiological functions of the cardiovascular system.
- Structure and physical properties of blood and blood vessels.
- Hemodynamics: blood flow, pressure, resistance, and viscosity.
- Cardiac output and the determinants of blood circulation.
- Principles of blood pressure measurement and clinical interpretation.
- Fluid dynamics and their applications in the cardiovascular system.
- Clinical applications of cardiovascular physics in patient diagnosis and monitoring.

Lecture Five: Light and Optical Applications in Medicine

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Nature and physical properties of light.
- Electromagnetic spectrum and classification of optical radiation.
- Reflection, refraction, absorption, scattering, and transmission of light.
- Principles and medical applications of optical fibers and endoscopes.
- Ultraviolet (UV) radiation: properties, biological effects, and clinical applications.
- Infrared (IR) radiation: principles, thermal effects, and therapeutic applications.
- Fundamentals and medical applications of lasers in diagnosis and treatment.
- Safety considerations in the use of optical radiation in healthcare.

Lecture Six: X-ray and Medical Imaging

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Principles of X-ray production and characteristics of X-ray beams.
- Interaction of X-rays with biological tissues.
- X-ray attenuation and image contrast.
- Principles of radiographic image formation.
- Fundamentals of medical imaging systems.
- Image quality, image resolution, and common imaging artifacts.
- Radiation dose and radiation protection in diagnostic imaging.
- Clinical applications of X-ray imaging in medical diagnosis.

Lecture Seven: Sound and Ultrasound in Medicine

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Nature and physical properties of sound waves.
- Frequency, wavelength, amplitude, velocity, and intensity of sound.
- Propagation of sound through different biological tissues.
- Acoustic impedance, reflection, refraction, absorption, and attenuation of sound.
- Principles of ultrasound generation and transducer operation.
- Modes of ultrasound imaging and Doppler ultrasound.
- Clinical applications of diagnostic ultrasound in medicine.
- Advantages, limitations, and safety considerations of ultrasound imaging.

Lecture Eight: Heat and Cold in Medicine

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Principles of heat and temperature in biological systems.
- Mechanisms of heat transfer: conduction, convection, radiation, and evaporation.
- Human thermoregulation and maintenance of body temperature.
- Methods of body temperature measurement and clinical monitoring.
- Therapeutic applications of heat (**Thermotherapy**) in medicine.
- Therapeutic applications of cold (**Cryotherapy**) in medicine.
- Principles and clinical applications of **Cryosurgery**.
- Biological effects of heat and cold on tissues, with safety considerations in thermal therapies.

Lecture Nine: Pressure in Medicine

Reference: Cameron JR, Skofronick JG., Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Fundamentals of pressure and its units of measurement.
- Types of pressure in the human body (atmospheric, hydrostatic, blood, intracranial, intraocular, and respiratory pressures).
- Principles of fluid pressure and Pascal's law in biological systems.
- Measurement techniques and medical devices used for pressure assessment.
- Physiological significance of pressure regulation in the cardiovascular and respiratory systems.

- Clinical applications of pressure monitoring in diagnosis and patient care.
- Pressure-related disorders and their impact on human health.

Lecture Ten: Physics of the Respiratory System

Reference: Cameron JR, Skofronick JG, Grant RM. *Physics of the Body*. 2nd ed. Medical Physics Publishing.

Learning Concepts

- Mechanics of breathing and lung ventilation.
- Lung volumes and respiratory capacities.
- Pressure changes during inspiration and expiration.
- Gas exchange and diffusion in the alveoli.
- Pulmonary function testing and spirometry.
- Clinical applications of respiratory physics in diagnosis and patient monitoring.

Lab. Lectures

Lab One: Introduction to Medical Physics Laboratory

- Laboratory safety rules and regulations.
- Personal protective equipment (PPE).
- Safe handling of laboratory instruments.
- Laboratory measurements, data recording, and report writing.

Lab Two: Graphing Techniques and Error Analysis

- Principles of graphical representation of experimental data.
- Construction and interpretation of scientific graphs.
- Determination of the slope and intercept from experimental graphs.
- Basic statistical calculations and data analysis.
- Measurement errors, uncertainty, accuracy, and precision.
- Calculation of percentage error and experimental error.
- Presentation and interpretation of laboratory results.

Lab Three: Hooke's Law

- Principles of elasticity and Hooke's law.
- Relationship between force, extension, and spring constant.
- Determination of the spring constant from experimental measurements.
- Graphical analysis of force–extension data.
- Elastic deformation and its limitations.
- Applications of elasticity in biological tissues and biomechanics.

Lab Four: Electrocardiography (ECG)

- Principles of electrocardiography (ECG).
- Identification and correct placement of ECG electrodes.
- Recording a standard 12-lead electrocardiogram.
- Identification of the P wave, QRS complex, and T wave.
- Measurement of heart rate and basic ECG intervals.
- Recognition of normal ECG patterns.
- Clinical applications of ECG in cardiovascular assessment.

Lab Five: Viscosity of a Liquid

- Principles of fluid viscosity.
- Determination of viscosity using **Stokes' law**.

- Measurement of terminal velocity in viscous fluids.
- Factors affecting fluid viscosity.
- Relationship between viscosity and blood flow.
- Clinical applications of viscosity in the cardiovascular system.

Lab Six: Convex Lens

- Principles of light refraction through a convex lens.
- Determination of the focal length of a convex lens.
- Formation and characteristics of real and virtual images.
- Measurement of object distance, image distance, and magnification.
- Verification of the lens equation using experimental measurements.
- Medical applications of convex lenses in optical instruments and endoscopy.

Lab Seven: Velocity of Sound

- Principles of sound wave propagation.
- Measurement of the velocity of sound using the resonance tube method.
- Relationship between frequency, wavelength, and velocity of sound.
- Factors affecting the velocity of sound in different media.
- Analysis and interpretation of experimental data.
- Medical applications of sound in diagnostic ultrasound.

Lab Eight: Boyle's Law

- Principles of Boyle's law and the relationship between pressure and volume.
- Experimental verification of Boyle's law.
- Measurement of gas pressure and volume using laboratory apparatus.
- Graphical analysis of the pressure–volume relationship.
- Factors affecting the behavior of gases under constant temperature.
- Medical applications of Boyle's law in respiratory physiology and clinical practice.

Lab Nine: Simple Pendulum

- Principles of simple harmonic motion.
- Determination of gravitational acceleration using a simple pendulum.
- Measurement of oscillation period and pendulum length.
- Graphical analysis and interpretation of experimental data.
- Factors affecting the period of oscillation.
- Accuracy, precision, and error analysis in experimental measurements.

Lab Ten: Radiation Shielding and the Inverse Square Law

- Principles of the inverse square law.
- Relationship between radiation intensity and distance.
- Radiation attenuation by different shielding materials.
- Measurement of radiation intensity.
- Principles of radiation protection in diagnostic imaging.
- Safe handling of ionizing radiation in healthcare settings.

Learning and Teaching Strategies

Strategies

The course employs student-centered and outcome-based teaching strategies to promote active learning, critical thinking, and clinical reasoning. The main teaching strategies include:

- Interactive lectures supported by multimedia presentations.
- Case-based learning (CBL) to relate physical principles to clinical practice.
- Problem-solving sessions using quantitative and analytical approaches.
- Laboratory demonstrations and hands-on practical activities.
- Small-group discussions and collaborative learning.
- Question-and-answer sessions to enhance student engagement.
- Formative assessments and timely feedback to monitor students' progress.
- Self-directed learning through assigned readings and independent study.
- Use of medical images, simulations, and audiovisual resources to reinforce learning.
- Integration of evidence-based practice and patient safety concepts throughout the course.

Course Evaluation

		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	4	5%			✓		✓		✓		✓						✓	✓	✓										
	Report	1	5%											✓							✓			✓	✓	✓				
	Lab Report	5	5%																											
	Project	-	-																											
	Online Assig.	-	-																											
	Onsite Assig.	-	-																											
	Seminar	-	-																											
Summative	Mid. Exam T	2	15%										✓			✓		✓	✓	✓	✓	✓	✓							
	Mid. Exam L	2	10%										✓			✓								✓	✓	✓	✓			
	Mid. Exam P																													
	Final Exam T			Week 16																										

	Final Exam L		35%															
	Final Exam P		25%															
Total assessment			100%															

Delivery Plan (Weekly Syllabus)

	Material Covered
Week 1	Terminology, Modeling, and Measurement
Week 2	Physics of the Skeletal System
Week 3	Electrocardiography (ECG)
Week 4	Physics of the Cardiovascular System
Week 5	Light and Optical Applications in Medicine
Week 6	Light and Optical Applications in Medicine
Week 7	X-ray and Medical Imaging
Week 8	X-ray and Medical Imaging
Week 9	Review and exam
Week 10	Sound and Ultrasound in Medicine
Week 11	Heat and Cold in Medicine
Week 12	Pressure in Medicine
Week 13	Physics of the Respiratory System
Week 14	Integrated Clinical Applications of Medical Physics (<i>Case-based discussions integrating imaging, ECG, ultrasound, and physiological measurements</i>)
Week 15	Midterm Theory Examination

Delivery Plan (Weekly Lab. Syllabus)

	Material Covered
Week 1	Introduction to Medical Physics Laboratory and Safety Rules
Week 2	Graphing Techniques and Error Analysis
Week 3	Simple Pendulum
Week 4	Hooke's Law
Week 5	Electrocardiography (ECG)
Week 6	Electrocardiography (ECG)
Week 7	Viscosity of a Liquid
Week 8	Midterm Laboratory Examination
Week 9	

	Velocity of Sound
Week 10	Velocity of Sound
Week 11	Boyle's Law
Week 12	Convex Lens
Week 13	Radiation Shielding and the Inverse Square Law
Week 14	Comprehensive Laboratory Review
Week 15	Practical Skills Assessment

Learning and Teaching Resources

	Title or Address	Available in the Library?
Required Texts	Cameron JR, Skofronick JG, Grant RM. <i>Physics of the Body</i> . 2nd ed. Madison, WI: Medical Physics Publishing; 1999.	Yes
	Bushberg JT, Seibert JA, Leidholdt EM Jr, Boone JM. <i>The Essential Physics of Medical Imaging</i> . 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2012.	Yes
	Hall JE. <i>Guyton and Hall Textbook of Medical Physiology</i> . 14th ed. Philadelphia: Elsevier; 2021.	Yes
Recommended Texts	Keevil SF, editor. <i>Introduction to Medical Physics</i> . Boca Raton, FL: CRC Press; 2017.	Yes
	Martin A, Harbison S, Beach K, Cole P. <i>An Introduction to Radiation Protection</i> . 6th ed. Boca Raton, FL: CRC Press; 2018.	No
	Hobbie RK, Roth BJ. <i>Intermediate Physics for Medicine and Biology</i> . 5th ed. Cham: Springer; 2015.!	No
Websites	https://www.iaea.org/	
	https://www.rsna.org/	
	https://www.who.int/	

Grade Policy

Class Participation	
Quizzes	
Report	
Lab Report	
Project	
Online Assig.	

Onsite Assig.	
Seminar	
Mid. Exam Theory	
Mid. Exam Lab.	
Mid. Exam Practical	
Final Exam Theory	
Final Exam Lab.	
Final Exam Practical	

Grading Scheme

Group	Grade	التقدير	Marks %
Success Group (50 - 100)	A – Excellent	امتياز	90 - 100
	B - Very Good	جيد جدا	80 - 89
	C - Good	جيد	70 - 79
	D - Satisfactory	متوسط	60 - 69
	P - Pass	مقبول	50 - 59
Fail Group (0 – 49)	Conditional Pass	راسب (قيد القرار)	(45-49)
	F – Fail	راسب	(0-44)

University Policy
