PHY1015 Introductory Physics for Medical Sciences

Rationale

This course is tailored for entry level students pursuing life sciences and/or medical sciences. The human body functions on physics and physical concepts. This course will be a great tool to aim in the understanding of human physiology, radiological and imaging investigations, and many aspects of diagnostics and patient management.

Aim: To familiarize medical students with physics and its applications to medical sciences.

Objectives

Upon completion of the course, students should be able to relate:

i. mechanics and its applications to medical sciences;
ii. fluid mechanics and its application to medical sciences;
iii. electricity and electric charges to create a firm foundation for understanding cellular electro-physiology;
iv. electricity, magnetism and nuclear physics to various diagnostic and patient management instruments;
v. optics with optical applications such as visual defects and correction of visual defects, laser surgery and endoscopy.

Learning Outcome

Upon completion of the course, students should be able to:

i. relate knowledge of physics to the study of human body functioning;
ii. demonstrate an understanding of the basic physical concepts that underpin technology used for medical diagnostic and patient management;
iii. demonstrate an understanding of the use of some day-to-day medical instruments;
iv. list the medical instruments used for various conditions.

Course Contents

Mechanics [4 Weeks**]**

Linear Motion - Dimensional analysis, orders of magnitudes, vector algebra, equations of linear motion, momentum, Newton's laws of motion, projection motion, work, energy and power, conservation of energy, friction. *Medical applications* – standing on an incline, friction at the hip joint, vertical jump, effects of gravity on the vertical jump, running high jump, standing broad jump, long jump, motion through air.

Linear momentum – Conservation of linear momentum, elastic and inelastic collisions, impulse. *Medical applications* – fracture due to a fall, airbags and inflation collision protection devices, whiplash injury, falling from great height, osteoarthritis and exercise.

Rotational Motion – equations of angular motion, centripetal acceleration and force, forces on a curved path, angular momentum, moment of inertia. *Medical applications* - running on a curved track, simple pendulum, walking, physical pendulum, carrying loads, speed of walking and running, energy expended in running, operating principles of a centrifuge.

Equilibrium and Stability – Centre of gravity, translational equilibrium, levers, rotational equilibrium. *Medical applications* – Equilibrium considerations for the human body, stability of the human body under the action of an external force, skeletal muscles, the elbow, the hip, limping, the back, standing tip-toe on one foot, dynamic aspect of posture.

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Properties of Materials [2 weeks]
Mechanical Properties of Solids – Elasticity of length, shape and volume, moduli of elasticity, stress-strain curves, Hooke's law, strain energy. *Medical applications* – mechanical strength of bones, materials used in prosthetics, fracture and energy stored in a compressed bone.

Mechanical Properties of Fluids - Density, pressure and depth, Pascal's principle, Archimedes' principle, buoyancy, atmospheric pressure, barometers. Fluid flow; Bernoulli's equation, continuity equation, viscosity and Poiseuille's law, laminar and turbulent flow, Reynolds number. Surface tension, adhesive and cohesive forces, capillarity action, surfactants. *Medical applications* – energy required to remain afloat, U-tube manometer, flow rates of intravenous (IV) administration, spirometry, circulation of blood, blood pressure, blood flow control, energetics of blood flow, turbulence in blood, arteriosclerosis, power produced by the heart, measurement of blood pressure.

Heat and Thermodynamics [2 weeks]
Temperature, temperature measurement devices, heat, diffusion, transport of molecules by diffusion, diffusion through membranes, thermal expansion and heat transfer, zeroeth, first and second laws of thermodynamics. *Medical applications* – Clinical thermometer, infrared thermometer, thermodynamics of living systems, energy requirements of people, energy from food, regulation of body temperature.

Waves and Sound [2 weeks**]**
Description of waves, types of waves, properties of waves. Sound waves – speed, intensity, intensity level, echo, ultrasound, the Doppler Effect. *Medical applications* – The stethoscope, ultrasonic waves, Doppler ultrasound, ultrasonic imaging, ultrasonic flow meter, echocardiography, therapeutic use of ultrasound (i.e., diathermy).

Optics [2 weeks**]**
Nature of light, electromagnetic spectrum, properties of light, Snell's law, lenses (converging, diverging, planar convex, planer concave), thin lens equation, lenses immersed in material, power of the lens, telescope, microscope, fiber optics, lasers. *Medical Applications* – The camera and eye, aperture and depth of field, lens of the eye, reduced eye, resolving power of the eye, threshold of vision, lens for myopia, visual defects, vision correction, endoscopy, laser surgery (e.g., laparoscopy).

Electricity and Magnetism [2 weeks**]**
Electricity: Electric charge, electric field, electric potential, potential difference, electric current, resistor, capacitor, inductor. Magnetism: magnetic field, magnetic field of an electric current, motor effect, electromagnetic induction, Lenz's law. *Medical applications* - Magnetic Resonance Imaging (MRI), Electrocardiography (ECG), Electroencephalography (EEG), Defibrillators, Heart pacemakers and Implantable Cardioverter Defibrillators (ICD), electrical muscle stimulation, electroconvulsive therapy, nerve stimulation.

Nuclear Physics [1 week**]**
Radioactivity, sources of radiation, types of radiation, ionizing radiation, radio isotopes, radiation dosimetry, radiation safety. *Medical Applications* - Nuclear Magnetic Resonance (NMR), isotopic tracers, radiation therapies, mammography, Computed Tomography (CT) scan, radionuclide scan, positron emission tomography (PET) scan, Single-Proton Emission Computed Tomography (SPECT) scan.

Method of Teaching: Lectures: 4 hours per week, Tutorials: 1 hour per week, 3 Field Trips, Laboratory: 3 hour session per week.

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Assessment:	Laboratory Reports:	20%,
	3 Field Trip Reports:	15%,
	Assignments:	5%,
	Two Theory Tests:	15%,
	Final Exam:	50%,
	Total:	**100%**.

Prescribed Text

1. Paul Davidovits (2019), *Physics in Biology and Medicine, 5th Edition*, Academic Press, London, UK. ISBN: 978-0-12-813716-1.

Recommended Text

2. Susanne Amador Kane (2009), *Introduction to Physics in Modern Medicine, 2nd Edition*, CRC Press, Florida, USA. ISBN: 13-978-1-58488-943-4 .
3. Martin Young (2010), *Essential Physics for Medicine*, Chuchill Livingstone Elsevier, Dorset, UK. ISBN: 978-0-443-10342-1.
4. Fredrick J. Bueche and David A. Jerde (1995), Principles of Physics, 5th Edition, McGraw-Hill, New York, USA. ISBN: 978-0-0070088177.