AQA Physics - 7407/7408

Module 10: Medical physics

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
10.1 Physics of the eye				
10.1.1 Physics of vision				
The eye as an optical refracting system, including ray diagrams of image formation.				
Sensitivity of the eye; spectral response as a photodetector.				
Spatial resolution of the eye; explanation in terms of the behaviour of rods and cones.				
10.1.2 Defects of vision and their correction using lenses				
Properties of converging and diverging lenses; principal focus, focal length and power *power = 1 / f; (1 / u) + (1 / v) = 1 / f; m = v / u*				
Myopia, hypermetropia, astigmatism.				
Ray diagrams and calculations of powers (in dioptres) of correcting lenses for myopia and hypermetropia.				
The format of prescriptions for astigmatism.				
10.2 Physics of the ear				
10.2.1 Ear as a sound detection system				
Simple structure of the ear, transmission processes.				
10.2.2 Sensitivity and frequency response				
Production and interpretation of equal loudness curves.				
Human perception of relative intensity levels and the need for a logarithmic scale to reflect this.				
Definition of intensity.				

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
Intensity level = 10 log (I / I_0) Where the threshold of hearing I_0 = 1.0 x 10^{-12} W m^{-2}				
Measurement of sound intensity levels and the use of dB and dBA scales; relative intensity levels of sounds.				
10.2.3 Defects of hearing				
The effect on equal loudness curves and the changes experienced in terms of hearing loss due to injury resulting from exposure to excessive noise or deterioration with age (excluding physiological changes).				
10.3 Biological measurement				
10.3.1 Simple ECG machines and the normal ECG waveform				
Principles of operation for obtaining the ECG waveform; explanation of the characteristic shape of a normal ECG waveform.				
10.4 Non-ionising imaging				
10.4.1 Ultrasound imaging				
Reflection and transmission characteristics of sound waves at tissue boundaries, acoustic impedance, Z, and attenuation.				
Advantages and disadvantages of ultrasound imaging in comparison with alternatives including safety issues and resolution.				
Piezoelectric devices				
Principles of generation and detection of ultrasound pulses.				
A-scans and B-scans.				
Examples of applications.				
Use of the equations: $Z = \rho c$ and $I_r / I_i = ((Z_2 - Z_1) / (Z_2 + Z_1))^2$				
10.4.2 Fibre optics and endoscopy				
Properties of fibre optics and applications in medical physics; including total internal reflection at the core–cladding interface.				
Physical principles of the optical system of a flexible endoscope; the use of coherent and non-coherent fibre bundles; examples of use for internal imaging and related advantages.				

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
10.4.3 Magnetic resonance (MR) scanner				
Basic principles of MR scanner: • cross-section of patient scanned using magnetic fields • protons initially aligned with spins parallel • spinning hydrogen nuclei (protons) precess about the magnetic field lines of a superconducting magnet • 'gradient' field coils used to scan cross-section • short radio frequency (RF) pulses cause excitation and change of spin state in successive small regions • protons excited during the scan emit RF signals as they de-excite • RF signals detected and the resulting signals are processed by a computer to produce a visual image.				
Students will not be asked about the production of magnetic fields used in an MR scanner, or about de-excitation relaxation times.				
10.5 X-ray imaging				
10.5.1 The physics of diagnostic X-rays				
Physical principles of the production of X-rays; maximum photon energy, energy spectrum; continuous spectrum and characteristic spectrum.				
Rotating-anode X-ray tube; methods of controlling the beam intensity, the photon energy, the image sharpness and contrast, and the patient dose.				
10.5.2 Image detection and enhancement				
Flat panel (FTP) detector including X-ray scintillator, photodiode pixels, electronic scanning.				
Advantages of FTP detector compared with photographic detection.				
Contrast enhancement; use of X-ray opaque material as illustrated by the barium meal technique.				
Photographic detection with intensifying screen and fluoroscopic image intensification; reasons for using these.				
10.5.3 Absorption of X-rays				
Exponential attenuation.				

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
Linear coefficient μ, mass attenuation coefficient μ_m, half-value thickness $I = I_0 e^{-\mu x}$ $\mu_m = (\mu / \rho)$				
Differential tissue absorption of X-rays excluding details of the absorption processes.				
10.5.3 Absorption of X-rays				
Basic principles of CT scanner: • movement of X-ray tube • narrow, monochromatic X-ray beam • array of detectors • computer used to process the signals and produce a visual image.				
Comparisons will be limited to advantages and disadvantages of image resolution, cost and safety issues. Students will not be asked about the construction or operation of the detectors.				
10.6 Radionuclide imaging and therapy				
10.6.1 Imaging techniques				
Use of a gamma-emitting radioisotope as a tracer; technetium-99m, iodine-131 and indium-111 and their relevant properties.				
The properties should include the radiation emitted, the half-life, the energy of the gamma radiation, the ability for it to be labelled with a compound with an affinity for a particular organ.				
The Molybdenum-Technetium generator, its basic use and importance.				
PET scans.				
10.6.2 Half-life				
Physical, biological and effective half-lives; $(1/T_E) = (1/T_B) + (1/T_P)$ definitions of each term.				
10.6.3 Gamma camera				
Basic structure and workings of a photomultiplier tube and gamma camera.				

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
10.6.4 Use of high-energy X-rays				
External treatment using high-energy X-rays. Methods used to limit exposure to healthy cells.				
10.6.5 Use of radioactive implants				
Internal treatment using beta emitting implants.				
10.6.6 Use of radioactive implants				
Students will be required to make comparisons between imaging techniques. Questions will be limited to consideration of image resolution, convenience and safety issues.				