OCR Physics Specification A - H556

Module 6: Particles and Medical Physics

You should be able to demonstrate and show your understanding of:	Progress and understanding:			
	1	2	3	4
6.1 Capacitors				
Capacitance; the unit farad; $C = Q / V$				
Charging and discharging of a capacitor or capacitor plates with reference to the flow of electrons.				
Total capacitance of two or more capacitors in series; $1 / C = 1 / C_1 + 1 / C_2 + \ldots$				
Total capacitance of two or more capacitors in parallel; $C = C_1 + C_2 + \ldots$				
Analysis of circuits containing capacitors, including resistors.				
Techniques and procedures used to investigate capacitors in both series and parallel combinations using ammeters and voltmeters.				
p.d. – charge graph for a capacitor; energy stored is area under graph.				
Energy stored by capacitor; $W = ½ QV$ and $W = ½ Q^2 / C$ and $W = ½ V^2C$				
Uses of capacitors as storage of energy.				
Charging and discharging capacitor through a resistor.				
Techniques and procedures to investigate the charge and the discharge of a capacitor using both meters and data-loggers.				
Time constant of a capacitor–resistor circuit; $\tau = CR$				

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For capacitor–resistor circuits equations of the form; $x = x_0 e^{-t/CR}$ and $x = x_0 (1 - e^{-t/CR})$ You will be expected to know how ln*x*–*t* graphs can be used to determine *CR*.				
For a discharging capacitor graphical methods and spreadsheet modelling of the equation; $\Delta Q / \Delta t = -Q / CR$				
Exponential decay graph; constant-ratio property of such a graph.				
6.2 Electric Fields				
Electric fields are due to charges.				
Modelling a uniformly charged sphere as a point charge at its centre.				
Electric field lines to map electric fields.				
Electric field strength; $E = F / Q$				
Coulomb's law for the force between two point charges; $F = Qq / 4\pi\varepsilon_0 r^2$				
Electric field strength for a point charge; $E = Q / 4\pi\varepsilon_0 r^2$				
Similarities and differences between the gravitational field of a point mass and the electric field of a point charge.				
The concept of electric fields as being one of a number of forms of field giving rise to a force.				
Uniform electric field strength; $E = V / d$				
Parallel plate capacitor; permittivity; $C = \varepsilon_0 A / d$ $C = \varepsilon A / d$ $E = \varepsilon_r \varepsilon_0$				

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Motion of charged particles in a uniform electric field.				
Electric potential at a point as the work done in bringing unit charge from infinity to the point; electric potential is zero at infinity.				
Electric potential at a distance *r* from a point charge; changes in electric potential; $V = Q / 4\pi\varepsilon_0 r$				
Capacitance for an isolated sphere; $C = 4\pi\varepsilon_0 R$ Derivation expected from equation for electric potential and $Q = VC$.				
Force–distance graph for a point or spherical charge; work done is area under graph.				
Electric potential energy at a distance *r* from a point charge *Q;* $E = Vq = Qq / 4\pi\varepsilon_0 r$				
6.3 Electromagnetism				
Magnetic fields are due to moving charges or permanent magnets.				
Magnetic field lines to map magnetic fields.				
Magnetic field patterns for a long straight current-carrying conductor, a flat coil and a long solenoid.				
Fleming's left-hand rule.				
Force on a current-carrying conductor; $F = BIL \sin\theta$				
Techniques and procedures used to determine the uniform magnetic flux density between the poles of a magnet using a current-carrying wire and digital balance.				
Magnetic flux density; the unit tesla.				
Force on a charged particle travelling at right angles to a uniform magnetic field; $F = BQv$				
Charged particles moving in a uniform magnetic field; circular orbits of charged particles in a uniform magnetic field.				

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Charged particles moving in a region occupied by both electric and magnetic fields; velocity selector.				
Magnetic flux ϕ; the unit weber; $\phi = BA \cos\theta$				
Magnetic flux linkage.				
Faraday's law of electromagnetic induction and Lenz's law.				
e.m.f. = − rate of change of magnetic flux linkage; $\varepsilon = -\Delta(N\phi) / \Delta t$				
Techniques and procedures used to investigate magnetic flux using search coils.				
Simple a.c. generator.				
Simple laminated iron-cored transformer; for an ideal transformer; $n_s / n_p = V_s / V_p = I_p / I_s$				
Techniques and procedures used to investigate transformers.				
6.4 Nuclear and Particle Physics				
Alpha-particle scattering experiment; evidence of a small charged nucleus.				
Simple nuclear model of the atom; protons, neutrons and electrons.				
Relative sizes of atom and nucleus.				
Proton number; nucleon number; isotopes; notation ${}^{A}_{Z}X$ for the representation of nuclei.				
Strong nuclear force; short-range nature of the force; attractive to about 3 fm and repulsive below about 0.5 fm.				
Radius of nuclei where r_0 is a constant and A is the nucleon number; $R = r_0 A^{1/3}$				
Mean densities of atoms and nuclei.				
Particles and antiparticles; electron–positron, proton-antiproton, neutron-antineutron and neutrino-antineutrino.				
Particle and its corresponding antiparticle have same mass; electron and positron have opposite charge; proton and antiproton have opposite charge.				

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Classification of hadrons; proton and neutron as examples of hadrons; all hadrons are subject to the strong nuclear force.				
Classification of leptons; electron and neutrino as examples of leptons; all leptons are subject to the weak nuclear force.				
Simple quark model of hadrons in terms of up (u), down (d) and strange (s) quarks and their respective anti-quarks.				
Quark model of the proton (uud) and the neutron (udd).				
Charges of the up (u), down (d), strange (s), anti-up ($\bar{u}$), anti-down ($\bar{d}$) and the anti-strange ($\bar{s}$) quarks as fractions of the elementary charge *e*.				
Beta-minus (β^-) decay; beta-plus (β^+) decay.				
β^- decay in terms of a quark model; $d \rightarrow u + {}^{0}_{-1}e + \bar{\nu}$				
β^+ decay in terms of a quark model; $u \rightarrow d + {}^{0}_{-1}e + \nu$				
Balancing of quark transformation equations in terms of charge.				
Decay of particles in terms of the quark model.				
Radioactive decay; spontaneous and random nature of decay.				
α-particles, β-particles and γ-rays; nature, penetration and range of these radiations.				
Techniques and procedures used to investigate the absorption of α-particles, β-particles and γ-rays by appropriate materials.				
Nuclear decay equations for alpha, beta-minus and beta-plus decays; balancing nuclear transformation equations.				
Activity of a source; decay constant λ of an isotope; $A = \lambda N$				
Half-life of an isotope; $\lambda t_{1/2} = ln(2)$				
Techniques and procedures used to determine the half-life of an isotope such as protactinium.				

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The equations; $A = A_0e^{-\lambda t}$ $N = N_0e^{-\lambda t}$ Where A is the activity and N is the number of undecayed nuclei.				
Simulation of radioactive decay using dice.				
Graphical methods and spreadsheet modelling of the equation for radioactive decay; $\Delta N / \Delta t = -\lambda N$				
Radioactive dating, e.g. carbon-dating.				
Einstein's mass–energy equation; $\Delta E = \Delta mc^2$				
Energy released (or absorbed) in simple nuclear reactions.				
Creation and annihilation of particle–antiparticle pairs.				
Mass defect; binding energy; binding energy per nucleon.				
Binding energy per nucleon against nucleon number curve; energy changes in reactions.				
Binding energy of nuclei using $\Delta E = \Delta mc^2$ and masses of nuclei.				
Induced nuclear fission; chain reaction.				
Basic structure of a fission reactor; components – fuel rods, control rods and moderator.				
Environmental impact of nuclear waste.				
Nuclear fusion; fusion reactions and temperature.				
Balancing nuclear transformation equations.				
6.5 Medical Imaging				
Basic structure of an X-ray tube; components – heater (cathode), anode, target metal and high voltage supply.				
Production of X-ray photons from an X-ray tube.				
X-ray attenuation mechanisms; simple scatter, photoelectric effect,				

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Compton effect and pair production.				
Attenuation of X-rays where μ is the attenuation (absorption) coefficient; $I = I_0 e^{-\mu x}$				
X-ray imaging with contrast media; barium and iodine.				
Computerised axial tomography (CAT) scanning; components – rotating X-tube producing a thin fan-shaped X-ray beam, ring of detectors, computer software and display.				
Advantages of a CAT scan over an X-ray image.				
Medical tracers; technetium–99m and fluorine–18.				
Gamma camera; components – collimator, scintillator, photomultiplier tubes, computer and display; formation of image.				
Diagnosis using gamma camera.				
Positron emission tomography (PET) scanner; annihilation of positron–electron pairs; formation of image.				
Diagnosis using PET scanning.				
Ultrasound; longitudinal wave with frequency greater than 20 kHz.				
Piezoelectric effect; ultrasound transducer as a device that emits and receives ultrasound.				
Ultrasound A-scan and B-scan.				
Acoustic impedance of a medium; $Z = \rho c$				
Reflection of ultrasound at a boundary; $I_r / I_0 = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$				
Impedance (acoustic) matching; special gel used in ultrasound scanning.				
Doppler effect in ultrasound; for determining the speed v of blood in the patient; $\Delta f / f = 2v \cos\theta / c$				

The material in this checklist is based on the OCR Physics A Specification published at ocr.org.uk/**alevelphysicsa** by Oxford, Cambridge and RSA Examinations.