Assessment

Assessed with a 2 hour, 100 mark paper where all questions are answered.

Useful Data

Permittivity of free space, ε_0	8.85×10^{-12} C^2 N^{-1} m^{-2} (F m^{-1})
Elementary charge, *e*	1.60×10^{-19} C
Electron rest mass, m_e	9.11×10^{-31} kg
Proton rest mass, m_p	1.673×10^{-27} kg
Neutron rest mass, m_n	1.675×10^{-27} kg
Alpha particle rest mass, m_α	6.646×10^{-27} kg

Module 1: Electric and magnetic fields

You should be able to...	Unaware of this section	I am aware of this, but need to do more work	I understand this area well
5.1.1 Electric fields			
...state that electric fields are created by electric charges.			
...define electric field strength as force per unit positive charge.			
...describe how electric field lines represent an electric field.			
...select and use Coulomb's law in the form: $F = Qq / 4\pi\varepsilon_0 r^2$			
...select and apply: $E = Q / 4\pi\varepsilon_0 r^2$ for the electric field strength of a point charge.			
...select and use: $E = V / d$ for the magnitude of the uniform electric field strength between charged parallel plates.			
...explain the effect of a uniform electric field on the motion of charged particles.			

…describe the similarities and differences between the gravitational fields of point masses and electric fields of point charges.			
5.1.2 Magnetic fields			
…describe the magnetic field patterns of a long straight current-carrying conductor and a long solenoid.			
…state and use Fleming's left-hand rule to determine the force on current conductor placed at right angles to a magnetic field.			
…select and use the equations: $F = BIL$ and $F = BIL\sin\theta$			
…define magnetic flux density and the tesla.			
…select and use the equation: $F = BQv$ for the force on a charged particle travelling at right angles to a uniform magnetic field.			
…analyse the circular orbits of charged particles moving in a plane perpendicular to a uniform magnetic field by relating the magnetic force to the centripetal acceleration it causes.			
…analyse the motion of charged particles in both electric and magnetic fields.			
…explain the use of deflection of charged particles in the magnetic and electric fields of a mass spectrometer.			
5.1.3 Electromagnetism			
…define magnetic flux.			
…define the weber.			
…select and use the equation for magnetic flux: $\Phi = BA\cos\theta$			
…define magnetic flux linkage.			
…state and use Faraday's law of electromagnetic induction.			
…state and use Lenz's law.			
…select and use the equation: induced e.m.f. = –rate of change of magnetic flux linkage			
…describe the function of a simple ac generator.			
…describe the function of a simple transformer.			
…select and use the turns-ratio equation for a transformer.			
…describe the function of step-up and step-down transformers.			

Module 2: Capacitors and exponential decay

You should be able to...	Unaware of this section	I am aware of this, but need to do more work	I understand this area well
5.2.1 Capacitors			
...define *capacitance* and the *farad*.			
...select and use the equation $Q = VC$			
...state and use the equation for the total capacitance of two or more capacitors in series.			
...state and use the equation for the total capacitance of two or more capacitors in parallel.			
...solve circuit problems with capacitors involving series and parallel circuits.			
...explain that the area under a potential difference against charge graph is equal to energy stored by a capacitor.			
...select and use the equations: $W = \frac{1}{2} QV$ and $W = \frac{1}{2} C V^2$ for a charged capacitor.			
...sketch graphs that show the variation with time of potential difference, charge and current for a capacitor discharging through a resistor.			
...define the *time constant* of a circuit.			
...select and use *time constant* = *CR*.			
...analyse the discharge of capacitor using equations of the form: $x = x_0 e^{(-t/CR)}$			
...explain exponential decays as having a constant-ratio property.			
...describe the uses of capacitors for the storage of energy in applications such as flash photography, lasers used in nuclear fusion and as back-up power supplies for computers.			

Module 3: Nuclear physics

You should be able to...	Unaware of this section	I am aware of this, but need to do more work	I understand this area well
5.3.1 The nuclear atom			
...describe qualitatively the alpha-particle scattering experiment and the evidence this provides for the existence, charge and small size of the nucleus.			
...describe the basic atomic structure of the atom and the relative sizes of the atom and the nucleus.			
...select and use Coulomb's law to determine the force of repulsion, and Newton's law of gravitation to determine the force of attraction, between two protons at nuclear separations and hence the need for a short-range, attractive force between nucleons.			
...describe how the strong nuclear force between nucleons is attractive and very short-ranged.			
...estimate the density of nuclear matter.			
...define *proton* and *nucleon number.*			
...state and use the notation for the representation of nuclides.			
...define and use the term *isotopes.*			
...use nuclear decay equations to represent simple nuclear reactions.			
...state the quantities conserved in a nuclear decay.			
5.3.2 Fundamental particles			
...explain that since protons and neutrons contain charged constituents called quarks they are, therefore, not fundamental particles.			
...describe a simple quark model of hadrons in terms of up, down and strange quarks and their respective antiquarks, taking into account their charge, baryon number and strangeness.			
...describe how the quark model may be extended to include the properties of charm, topness and bottomness.			
...describe the properties of neutrons and protons in terms of a simple quark model.			
...describe how there is a weak interaction between quarks and that this is responsible for β decay.			
...state that there are two types of β decay.			
...describe the two types of β decay in terms of a simple quark model.			
...state that (electron) neutrinos and (electron) antineutrinos are produced during β^+ and β^- decays, respectively.			
...state that a β^- particle is an electron and a β^+ particle is a positron.			

…state that electrons and neutrinos are members of a group of particles known as leptons.			
5.3.3 Radioactivity			
…describe the spontaneous and random nature of radioactive decay of unstable nuclei.			
…describe the nature, penetration and range of α-particles, β-particles and γ-rays			
…define and use the quantities *activity* and *decay constant.*			
…select and apply the equation for activity $A = \lambda N$			
…select and apply the equations: $A = A_0e^{-\lambda t}$ and $N = N_0e^{-\lambda t}$ where A is the activity and N is the number of undecayed nuclei.			
…define and apply the term *half-life.*			
…select and use the equation $\lambda t_{1/2} = 0.693$			
…compare and contrast decay of radioactive nuclei and decay of charge on a capacitor in a C–R circuit.			
…describe the use of radioactive isotopes in smoke alarms.			
…describe the technique of radioactive dating (ie carbon-dating).			
5.3.4 Nuclear fission and fusion			
…select and use Einstein's mass–energy equation: $\Delta E = \Delta mc^2$			
…define *binding energy* and *binding energy per nucleon*.			
…use and interpret the binding energy per nucleon against nucleon number graph.			
…determine the binding energy of nuclei using $\Delta E = \Delta mc^2$ and masses of nuclei.			
…describe the process of induced nuclear fission.			
…describe and explain the process of nuclear chain reaction.			
…describe the basic construction of a fission reactor and explain the role of the fuel rods, control rods and the moderator.			
…describe the use of nuclear fission as an energy source.			
…describe the peaceful and destructive uses of nuclear fission.			
…describe the environmental effects of nuclear waste.			
…describe the process of nuclear fusion.			
…describe the conditions in the core of stars that make fusion possible.			
…calculate the energy released in simple nuclear reactions.			

Module 4: Medical imaging

You should be able to…	Unaware of this section	I am aware of this, but need to do more work	I understand this area well
5.4.1 X-Rays			
…describe the nature of X-rays.			
…describe in simple terms how X-rays are produced.			
…describe how X-rays interact with matter (limited to photoelectric effect, Compton Effect and pair production).			
…define *intensity* as the power per unit cross-sectional area.			
…select and use the equation $I = I_0 e^{-\mu x}$ to show how the intensity I of a collimated X-ray beam varies with thickness x of medium.			
…describe the use of X-rays in imaging internal body structures including the use of image intensifiers and of contrast media.			
…explain how soft tissues like the intestines can be imaged using barium meal.			
…describe the operation of a computerised axial tomography (CAT) scanner.			
…describe the advantages of a CAT scan compared with an X-ray image.			
5.4.2 Diagnosis methods in medicine			
…describe the use of medical tracers like technetium-99m to diagnose the function of organs.			
…describe the main components of a gamma camera.			
…describe the principles of positron emission tomography (PET).			
…outline the principles of magnetic resonance, with reference to precession of nuclei, Larmor frequency, resonance and relaxation times.			
…describe the main components of an MRI scanner.			
…outline the use of MRI (magnetic resonance imaging) to obtain diagnostic information about internal organs.			
…describe the advantages and disadvantages of MRI.			
…describe the need for non-invasive techniques in diagnosis.			
…explain what is meant by the Doppler effect.			
…explain qualitatively how the Doppler effect can be used to determine the speed of blood.			
5.4.3 Ultrasound			
…describe the properties of ultrasound.			
…describe the piezoelectric effect.			
…explain how ultrasound transducers emit and receive high-frequency sound.			
…describe the principles of ultrasound scanning.			
…describe the difference between A-scan and B-scan.			

…calculate the acoustic impedance using the equation: $Z = \rho c$			
…calculate the fraction of reflected intensity using the equation: $I_r / I_0 = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$			
…describe the importance of impedance matching.			
…explain why a gel is required for effective ultrasound imaging techniques.			

Module 5: Modelling the universe

You should be able to...	Unaware of this section	I am aware of this, but need to do more work	I understand this area well
5.5.1 Structure of the universe			
...describe the principal contents of the universe, including stars, galaxies and radiation.			
...describe the solar system in terms of the Sun, planets, planetary satellites and comets.			
...describe the formation of a star, such as our Sun, from interstellar dust and gas.			
...describe the Sun's probable evolution into a red giant and white dwarf.			
...describe how a star much more massive than our Sun will evolve into a super red giant and then either a neutron star or black hole.			
...define distances measured in astronomical units (AU), parsecs (pc) and light-years (ly).			
...state the approximate magnitudes in metres, of the parsec and light-year.			
...state Olbers' paradox.			
...interpret Olbers' paradox to explain why it suggests that the model of an infinite, static universe is incorrect.			
...select and use the equation $\Delta\lambda/\lambda = v/c$			
...describe and interpret Hubble's redshift observations.			
...state and interpret Hubble's law.			
...convert the Hubble constant H_0 from its conventional units (km s^{-1} Mpc^{-1}) to SI (s^{-1}).			
...state the cosmological principle.			
...describe and explain the significance of the 3K microwave background radiation.			
5.5.2 The evolution of the universe			
...explain that the standard (hot big bang) model of the universe implies a finite age for the universe.			
...select and use the expression: age of universe = $1/H0$			
...describe qualitatively the evolution of universe 10^{-43} s after the big bang to the present.			
...explain that the universe may be 'open', 'flat' or 'closed', depending on its density.			
...explain that the ultimate fate of the universe depends on its density.			
...define the term *critical density*.			
...select and use the expression for critical density of the universe: $\rho_o = 3H_o^2/ 8\pi G$			
...explain that it is currently believed that the density of the universe is close to, and possibly exactly equal to, the critical density needed for a 'flat' cosmology.			