Topic 1

	Radiation in treatment and medicine	
1.1	Demonstrate an understanding of the methods that medical physicists can employ to help doctors solve medical problems, including: a CAT scans b ultrasounds c endoscopes d ionising and non-ionising radiation	
1.2	Use the word ‘radiation’ to describe any form of energy originating from a source, including both waves and particles	
1.3	Demonstrate an understanding that the intensity of radiation will decrease with distance from a source and according to the nature of the medium through which it is travelling	
1.4	**Use the equation:** **intensity** = **power of incident radiation / area** $\boldsymbol{I = P/A}$	
1.5	Describe the refraction of light by converging and diverging lenses	
1.6	Relate the power of a lens to its shape	
1.7	Use the equation: power of lens (dioptre, D) 5 1/focal length (metre, m)	
1.8	*Investigate variations of image characteristics with objects at different distances from a converging lens*	
1.9	**Use the lens equation:** $\boldsymbol{1/f = 1/u + 1/v}$ **(*f* = focal length (m), *u* = object distance (m), *v* = image distance (m))** **The use of the real is positive sign convention is preferred and will be used in the exam**	
1.10	Identify the following features in a diagram of the eye – cornea, iris, pupil, lens, retina, ciliary muscles	
1.11	Demonstrate an understanding that light is focused on the retina by the action of the lens and cornea	
1.12	Recall that the average adult human eye has a near point at about 25 cm and a far point at infinity	
1.13	Explain the symptoms and causes of short sight and long sight (students will not be expected to draw scaled ray diagrams, but may be expected to interpret them)	
1.14	Compare and contrast treatments for short sight and long sight, including the use of: a simple lenses b contact lenses c **laser correction** (combined lens equation is not required; students will not be expected to draw scaled ray diagrams, but may be expected to interpret them)	
1.15	Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle	
1.16	**Calculate critical angle using Snell’s Law**	
1.17	Explain refraction in terms of change of speed of radiation	
1.18	*Investigate the critical angle for perspex/air or glass/air or water/air boundaries*	
1.19	*Investigate TIR between different media*	
1.20	Explain how TIR is used in optical fibres	
1.21	Explain uses of optical fibres in endoscopes	
1.22	Explain uses of ultrasound in diagnosis and treatment	

Topic 2

	X-rays and ECGs	
2.1	Relate the ionisation by X-rays to their frequency and energy qualitatively ($E = hf$ is not required)	
2.2	Explain the key features of passing a current through an evacuated tube, including: a thermionic emission of electrons from a heated filament b potential difference between the cathode (filament) and the anode (metal target) c why the vacuum is necessary d possible production of X-rays by collision with a metal target	
2.3	Explain why a beam of charged particles is equivalent to an electric current	
2.4	**Use the equation:** **current (ampere, A) = number of particles per second (1/second, 1/s)** x **charge on each particle (coulomb, C)** $I = N \times q$	
2.5	**Use the equation:** **kinetic energy (joule, J)** 5 **electronic charge (coulomb, C)** x **accelerating potential difference (volt, V)** **KE** = $1/2\, mv^2 = e \times V$	
2.6	Demonstrate an understanding of the inverse square law for electromagnetic radiation	
2.7	Relate the absorption of X-rays to the thickness of the material through which they are travelling, quantitatively	
2.8	Describe how X-rays are used in CAT scans and fluoroscopes	
2.9	Demonstrate an understanding of the comparison of the risks and advantages of using X-rays for treatment and diagnosis	
2.10	Explain how action potentials can be measured with an electrocardiogram (ECG) to monitor heart action	
2.11	Relate the characteristic shape of a normal ECG to heart action	
2.12	Use the equation: frequency (hertz, Hz) = 1/time period (second, s) $f = 1/T$	
2.13	Describe the use of a pacemaker to regulate the heart action	
2.14	Describe the principles and use of pulse oximetry	

Topic 3

	Production, uses and risks of ionising radiation from radioactive sources	
3.1	Evaluate the social and ethical issues relating to the use of radioactive techniques in medical physics	
3.2	Describe the properties of alpha, beta, gamma, positron and neutron radiation	
3.3	Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons	
3.4	Recall that in an atom the number of protons equals the number of electrons	
3.5	Describe the process of -βdecay (a neutron becomes a proton plus an electron)	
3.6	**Describe the process of β+ decay (a proton becomes a neutron plus a positron)**	
3.7	Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, βand γ decay)	
3.8	**Use given data to balance nuclear equations**	
3.9	**Describe the features of the *N-Z* curve for stable isotopes**	
3.10	**Identify isotopes as radioactive from their position relative to the stability curve**	
3.11	**Recall that nuclei with high values of *Z* (above 82) usually undergo alpha decay**	
3.12	**Recall that an isotope above the curve has too many neutrons to be stable and will undergo β- decay**	
3.13	**Recall that an isotope below the curve has too many protons to be stable and will undergo β+ decay**	
3.14	**Recall that the proton and neutron each contain three particles called quarks**	
3.15	**Describe the arrangement of up and down quarks in protons and neutrons**	
3.16	**Use given data to explain the arrangement of up and down quarks in protons and neutrons in terms of charge and mass**	
3.17	**Explain β- decay as a process that involves a down quark changing into an up quark (a neutron becomes a proton and an electron)**	
3.18	**Explain β+ decay as a process that involves an up quark changing into a down quark (a proton becomes a neutron and a positron)**	
3.19	Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation	
3.20	Describe the dangers of ionising radiation in terms of tissue damage and possible mutations	
3.21	Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel	
3.22	Compare and contrast the treatment of tumours using radiation applied internally or externally	
3.23	Describe palliative care including the use of radiation in some instances	
3.24	Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers	
3.25	Explain why isotopes used in PET scanners have to be produced nearby	

Topic 4

	Motion of particles	
4.1	Discuss how instruments, including particle accelerators, can help scientists develop better explanations about the physical world	
4.2	Discuss reasons for collaborative, international research into big scientific questions, including particle physics	
4.3	Explain how for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle	
4.4	Explain how particle accelerators called cyclotrons cause charged particles to move in a circular or spiral path, due to a magnetic field	
4.5	Demonstrate an understanding that certain stable elements can be bombarded with proton radiation to change them into radioactive isotopes	
4.6	Describe the use of particle accelerators (cyclotrons) to produce radioactive isotopes for medical purposes	
4.7	Demonstrate an understanding that for inelastic collisions momentum is conserved but kinetic energy is not conserved	
4.8	Demonstrate an understanding that for elastic collisions both momentum and kinetic energy are conserved	
4.9	Analyse collisions in one dimension in terms of momentum and kinetic energy	
4.10	**Carry out calculations using momentum conservation for a two-body collision (in one dimension only)**	
4.11	**Carry out calculations using conservation of kinetic energy for a two-body elastic collision (in one dimension only)**	
4.12	*Investigate factors affecting the height of rebound of bouncing balls*	
4.13	Recall that gamma rays can be produced by the annihilation of an electron and a positron	
4.14	Apply conservation of momentum and charge to positron electron annihilation	
4.15	Apply the idea of conservation of mass energy for positron electron annihilation a in a qualitative way (calculations involving $E = mc^2$ will not be required) b **in a quantitive way using the equation $E = mc^2$**	
4.16	Explain the use of radio isotopes in PET scanners to produce gamma rays	

Topic 5

	Kinetic theory and gases	
5.1	Use a simple kinetic theory model to describe movement of particles in the three states of matter	
5.2	Explain the pressure of a gas in terms of the motion of its particles	
5.3	Describe the effect of changing the temperature of a gas on the speed of its particles	
5.4	Describe the term absolute zero, 2273°C, in terms of the lack of movement of particles	
5.5	Convert between the Kelvin and Celsius scales	
5.6	Recall that the average kinetic energy of the particles in a gas is directly proportional to the Kelvin temperature of the gas	
5.7	*Investigate the temperature and volume relationship for a gas*	
5.8	Use the relationship: $V1 = \frac{V2\,T1}{T2}$ to calculate volume for gases of fixed mass at constant pressure (rearranging not required)	
5.9	*Investigate the volume and pressure relationship for a gas*	
5.10	Use the relationship: $V1\,P1 = V2\,P2$ to calculate volume or pressure for gases of fixed mass at constant temperature	
5.11	**Use the equation:** **initial pressure (pascal, Pa)** x **initial volume (metre^3, m^3) / initial temperature (kelvin, K)** = **final pressure (pascal, Pa)** x **final volume (metre^3, m^3) / final temperature (kelvin, K)** $\frac{P1V1}{T1} = \frac{P2V2}{T2}$	
5.12	Apply an understanding of the equation in 5.11 to the use of bottled gases in medicine, including the need for a pressure above atmospheric and the calculation of the volume of gas released at atmospheric pressure	