Candidate Number ……………………………………………..

Ascham School

Trial Examination 2016

Physics

Time allowed: 3 hours (plus 5 minutes reading time)

Section 1

PART A 20 one mark multiple choice questions.

Write your answers in pencil on the Part A answer sheet. (20 marks)

Write your Candidate number on the Part A answer sheet.

PART B Short response questions.

Write your answers in the space provided. (65 marks)

Write your Candidate number on each section.

Using a black pen is highly recommended.

Section 2

Option: Medical physics (15 marks)

Write your answers to this section in space provided in this answer booklet

A Periodic Table, A Data sheet and a Formula sheet are provided.

There is a blank page at the back of this booklet that you may use for calculations or working out

Section 1

Total marks (85)

Part A

Total marks (20)

Attempt questions 1 to 20

Use the multiple choice answer sheet.

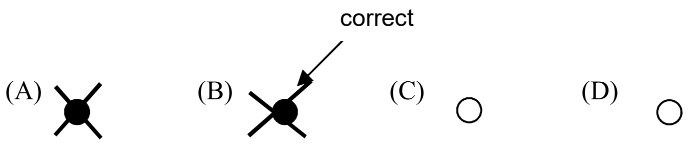
Select the alternative A, B, C or D that best answers the question. Fill in the response circle completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

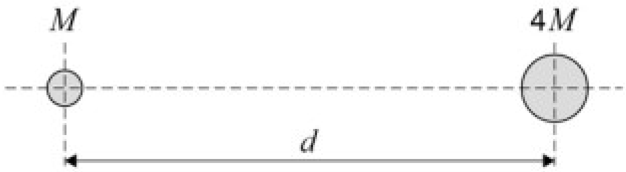
(A) ○ (B) ● (C) ○ (D) ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:



1 Two stars of mass M and 4M are at a distance ***d*** between their centres.



The resultant gravitational field strength is zero along the line between their centres at a distance y from the centre of the star of mass M.

What is the value of the ratio $\frac{y}{d}$?

(A) $\frac{3}{4}$

(B) $\frac{1}{3}$

(C) $\frac{2}{3}$

(D) $\frac{1}{2}$

2 Charged particles of mass m and charge q, travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B. Which expression gives the period of rotation of a particle in the beam?

(A) $\frac{\pi m}{qB}$

(B) $\frac{m}{qB}$

(C) $\frac{2\,\pi m}{qB}$

(D) $\frac{m}{2\,\pi qB}$

3 Light from source A is shone on to a metallic surface and electrons are emitted from the surface. When light from a source B is used no electrons are emitted from the metallic surface. Which property of the radiation from source B must be greater than that from source A?

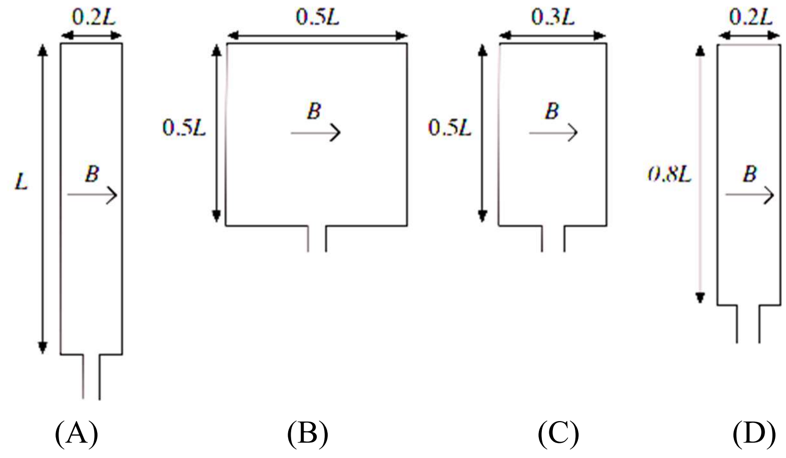
(A) Frequency

(B) Wavelength

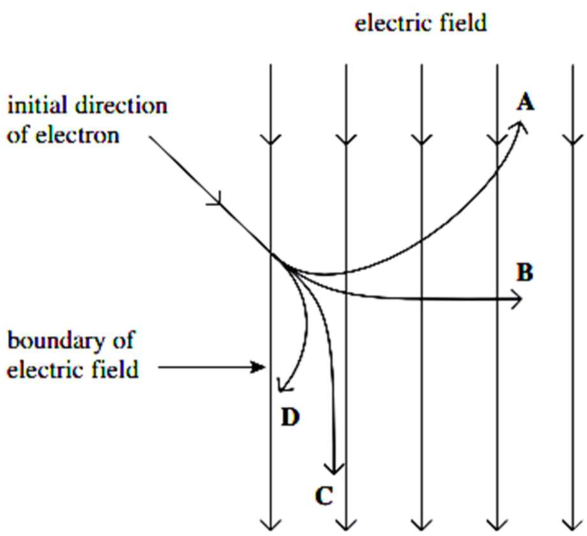
(C) Intensity

(D) Amplitude

4 Four rectangular single loops of wire A, B, C and D are each placed in a uniform magnetic field of the same flux density B. The direction of the magnetic field is parallel to the plane of the loops as shown. When a current of 1 A is passed through each of the loops, magnetic forces act on them. The lengths of the sides of the loops are as shown. Which loop experiences the largest torque?



5 Which path, A to D, shows how an electron moves in the uniform electric field represented in the diagram?



6 What observation in the 1800's caused scientists to hypothesise that cathode rays were waves?

(A) Cathode rays were not seen to be deflected by electric fields

(B) Cathode rays were not observed to be deflected by magnetic fields

(C) Cathode rays travelled in straight lines and were blocked by solid barriers

(D) The deflection of cathode rays was counteracted by opposing magnetic and electric fields.

7 Students connected a transformer to the DC terminals of a power supply. It failed to work.

Which of the following best accounts for this?

(A) The transformer was connected into the circuit with reverse polarities.

(B) Alternating current is needed to oscillate electrons back and forth in opposite directions.

(C) The direct current was not large enough to produce electromagnetic induction.

(D) Electromagnetic induction only occurs in the presence of changing magnetic fields.

8 Which alternative in the table below, regarding the type of electrical discharge patterns produced in a gas discharge tube, is correct?

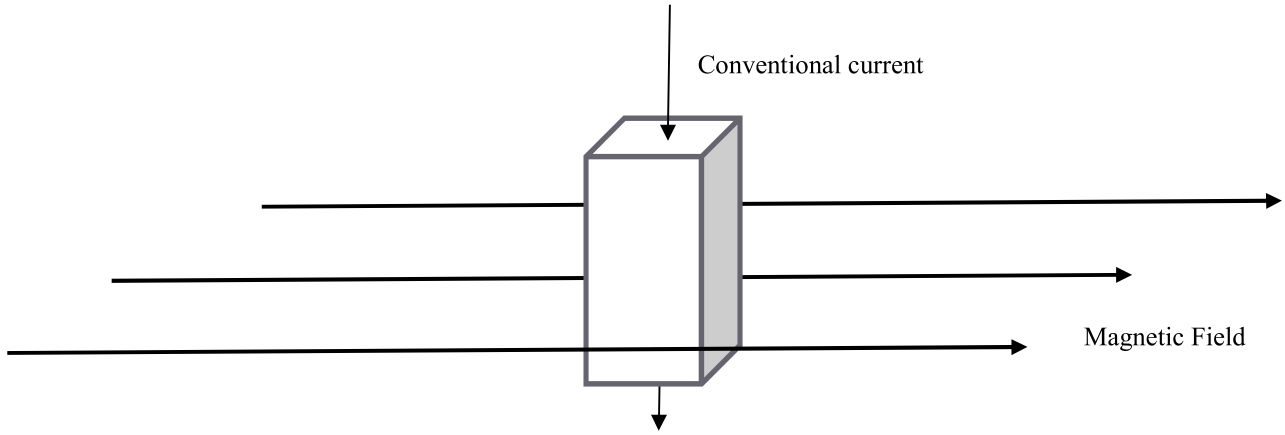
	Highest Pressure	**Low Pressure**	**Lowest Pressure**
(A)	Striations	Streamers	Green glow in glass
(B)	Striations	Green glow in glass	Streamers
(C)	Streamers	Striations	Green glow in glass
(D)	Green glow in glass	Streamers	Striations

9 A sample of pure Germanium is doped with Indium.

How does the electrical conductivity of the doped silicon change, and for what reason?

	Change in electrical conductivity	***Reason***
(A)	Increases	Increased number of free electrons
(B)	Decreases	Decreased number of free electrons
(C)	Decreases	Decreased number of holes
(D)	Increases	Increased number of holes

10 A current is passed through a semiconductor rod as shown. Half of the current is carried by holes. A magnetic field is then applied to the rod at 90^0 to its axis.



Which of the following correctly describes the movements of the holes and electrons in the rod when the magnetic field is applied?

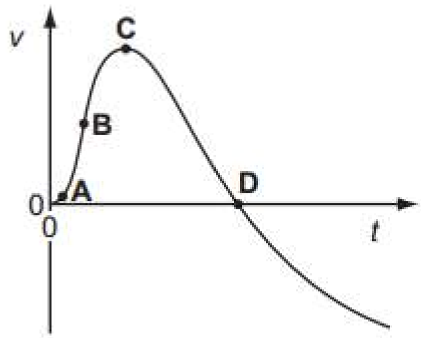
(A) They move to the same side of the rod

(B) They speed up

(C) They move to opposite sides of the rod

(D) They slow down

11 The graph below shows how the velocity of a toy rocket changes with time. At which point does the rocket have the greatest acceleration?



12 Two satellites, X and Y, orbit the Earth. The mass of X half that of Y. The orbital radius of X is twice that of Y.

What is the ratio of the orbital speed of satellite X to the orbital speed of Y?

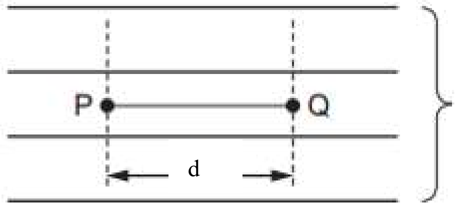
(A) $1 : \sqrt{2}$

(B) $\sqrt{2} : 1$

(C) 1 : 1

(D) 1 : 2

13 A mass m is situated in a uniform gravitational field.



When the mass moves through a small distance d, from P to Q, it loses an amount of gravitational potential energy E_P. Which choice below correctly specifies the magnitude and direction of the acceleration due to gravity in this field?

	Magnitude of acceleration	*Direction of acceleration*
(A)	$\frac{E_P}{md}$	→
(B)	$\frac{E_P}{md}$	←
(C)	$\frac{E_P}{d}$	→
(D)	$\frac{E_P}{d}$	←

14 Which list below includes the factors that affect the measured value of the acceleration due to gravity at a particular location?

(A) Air temperature and local geology

(B) Local geology and height relative to sea level

(C) Latitude and air temperature

(D) Air pressure, local geology and height relative to sea level

15 In a thought-experiment attributed to Einstein, Emily is in a train travelling at the speed of light. When Emily holds a mirror up to her face, one possibility is that she could not see her reflection. Einstein dismissed this because it

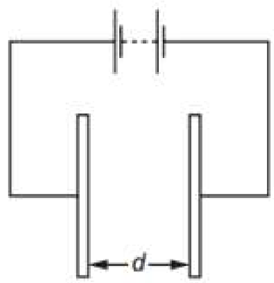
(A) implies that an occupant outside the train would measure the speed of light to be twice its normal value

(B) would provide support for the aether model of light-travel which states that light travels at c

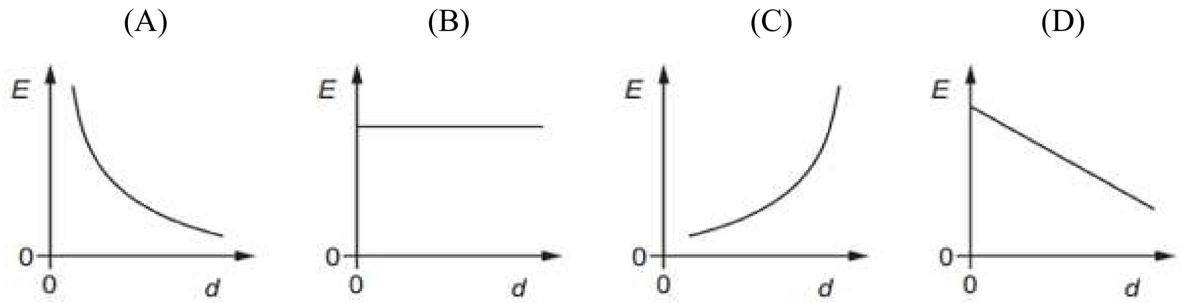
(C) defies everyday experience that reflections can always be seen in a mirror

(D) would mean that Emily could determine her velocity in an inertial frame of reference.

16 The diagram shows two metal plates connected to a constant high voltage.



Which graph shows the variation of the electric field strength, E, midway between the two plates as the distance between the two plates is increased?



17 It requires more torque to turn a generator when it is connected to an external circuit using electrical power than when the generator is not connected to an external circuit.

Why does it require more torque to turn the generator when it is supplying electrical power?

(A) The generator is more difficult to turn because a torque in the direction of rotation increases when it is connected to the external circuit.

(B) When it is connected to the external circuit, more current flows through the rotor coils and this produces a back EMF that makes the generator more difficult to turn.

(C) When it is connected to the external circuit, the generator starts producing voltage and this will make the generator more difficult to turn.

(D) When it is connected to the external circuit the current passing through the rotor coils produces an opposing torque that makes the generator more difficult to turn.

18 Which scientist is most associated with the distribution of electrical energy in an AC form?

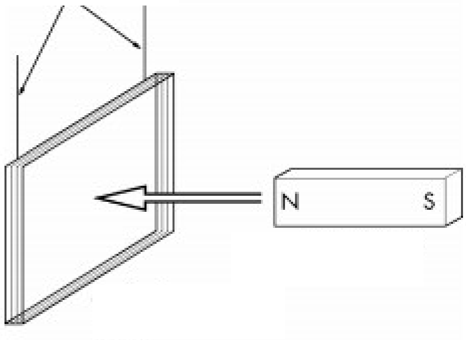
(A) Edison

(B) Planck

(C) Tesla

(D) Faraday

19 A permanent magnet is moved rapidly towards a coil of wire suspended from lightweight strings as shown below. The wires from each end of the suspended coil are connected together.



What direction of current will be induced in the coil, when viewed from the front, when the magnet is moved towards it?

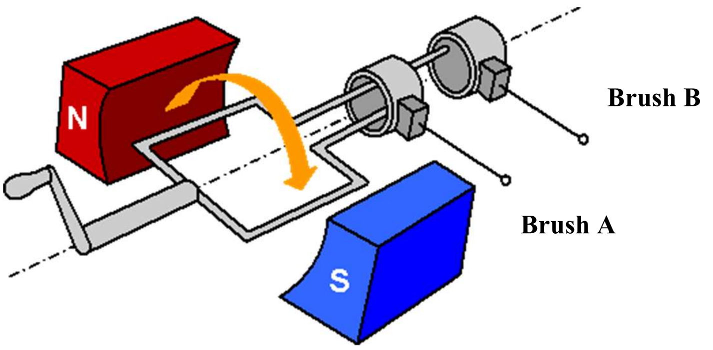
(A) An anticlockwise direction and the coil will be repelled by the approaching magnet.

(B) A clockwise direction and the coil will be attracted by the approaching magnet.

(C) A clockwise direction and the coil will be repelled by the approaching magnet.

(D) An anticlockwise direction and the coil will be attracted by the approaching magnet.

20 Below is a simple AC generator which is rotating in the direction indicated.



Choose the option which refers to the current in the rotor and the emf of the brushes in the external circuit, at the instant shown.

	Current direction in rotor	**Emf of external circuit**
(A)	From A to B	Brush A is at a positive potential
(B)	From B to A	Brush B is at a positive potential
(C)	From A to B	Brush B is at a positive potential
(D)	From B to A	Brush B is at a negative potential

Section I – continued

Part B Total marks (65)
Attempt Questions 21 – 33. Allow about 1 hour 50 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

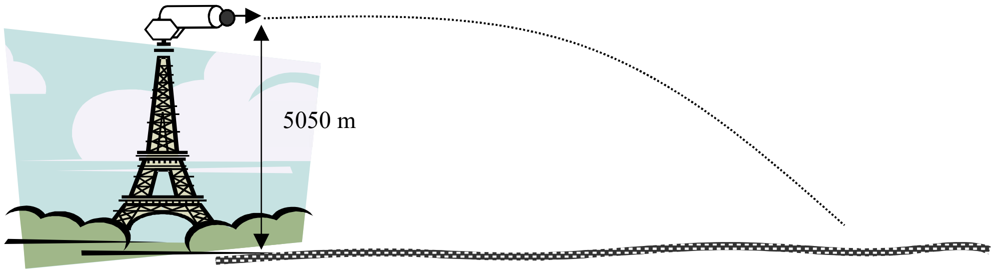
Question 21 (3 marks)

(a) On the diagram below, label the gravitational force on the Moon due to Earth and the gravitational force on Earth due to the Moon. **1**

(b) Sketch a diagram of the gravitational field between the Earth and the moon below. **2**

Question 22 (5 marks)

Jane builds a tall tower with a cannon on top. The cannon is able to launch a cannon ball horizontally at any speed.



(a) If the cannon ball is fired at a speed of 830 m s^{-1} at a height of 5050 m above the ground, calculate the range of the cannon ball, assuming the ground is horizontal. **2**

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(b) If the cannon ball is shot at the appropriate speed to achieve circular orbit, calculate the required period of orbit to achieve this motion. The following data must be used in your calculation:

The orbital radius of the ball is 6.385×10^6 m, the orbital radius of the Moon is 3.84×10^8 m and the orbital period of the Moon is 27.3 days. **2**

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(c) Identify the principal force acting on the cannon ball during its flight. **1**

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Question 23 (8 marks)

(a) One of the two postulates of Einstein's theory of special relativity is that the speed of light in free space is invariant. Explain what is meant by this postulate. **1**

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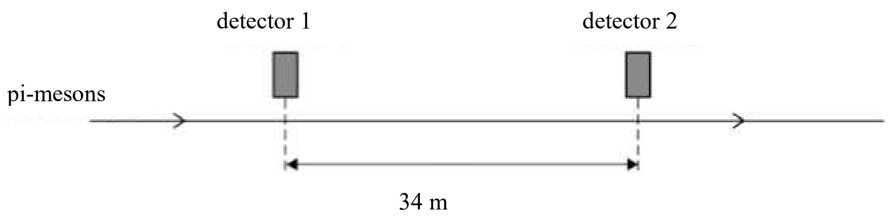
Experiments with a type of radioactive particle, the pi-meson, have been undertaken to verify Einstein's theory of relativity. Pi-mesons are unstable and decay with a half-life of 18 ns.

(b) Two detectors are measured to be 34 m apart by an observer in a stationary frame of reference. A beam of pi-mesons travel in a straight line at a speed of 0.95 c past the two detectors, as shown



(i) Calculate the time taken in the frame of reference of the observer, for a pi-meson to travel between the two detectors. State your answer in nanoseconds. **1**

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(ii) It is found in experiments that approximately 75% of the pi-mesons decay before reaching the second detector.

Assess how the stated result of this experiment provides evidence to support the theory of special relativity. In your answer compare the percentage expected by the laboratory observer with and without application of the theory of special relativity. **6**

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Question 24 (5 marks)

Jill connects a voltmeter across the ends of the coil of a DC electric drill, connected to a 12 volt battery. At t = 0, she starts to drill a hole in a brick wall and records the voltmeter reading.

Time (s)	Voltage (V)	Depth of hole (cm)
1	11.0	0.1
10	5.2	0.5
20	5.2	1.0
30	9.4	1.2
40	10.2	1.3
50	4.7	2.0
60	5.2	2.5

Account for the readings shown being less than 12V and varying as the hole is drilled **5**

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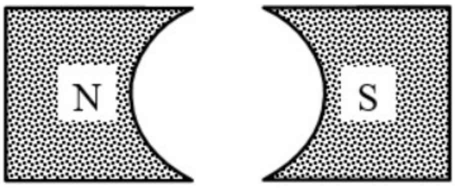
Question 25 (4 marks)

(a) On the diagram below sketch the radial magnetic field between the poles. **2**



(b) Explain why radial fields are useful in DC motors. **2**

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Question 26 (4 marks)

Name a device, other than an electric motor, that utilises the motor effect and with the aid of labelled diagrams, describe how the motor effect is used in the operation of the device. **4**

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Question 27 (4 marks)

Electromagnetic braking has several advantages over conventional braking. It is particularly useful in applications such as high speed trains.

Describe with the use of labelled diagrams, the role of Lenz's Law in the principle of electromagnetic braking, as used in trains. **4**

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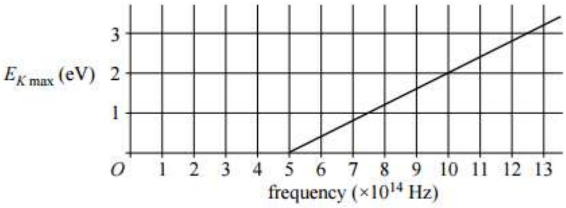
Question 28 (7 marks)

Students conduct three experiments to investigate the photoelectric effect. For experiment 1, light of various frequencies is shone on the surface of metal A. Below is shown the graph of maximum kinetic energy of the photoelectrons against frequency from experiment 1.



(a) Use the graph to calculate the value of Planck's constant, in Js **2**

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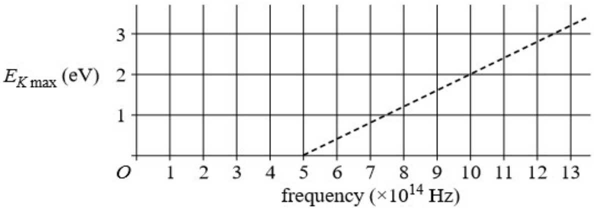
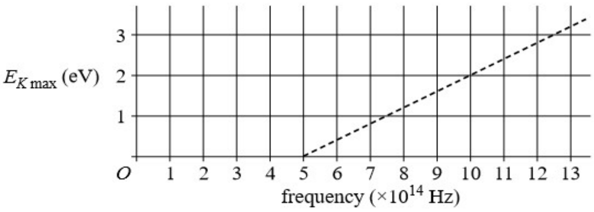
(b) In experiment 2, the intensity of the light is doubled and again shone on metal A. A dotted line shows the results of experiment 1. Below, draw a solid line to show how maximum kinetic energy varies with frequency. **1**



(c) In experiment 3, metal A is replaced with metal B that has a work function 50% larger than metal A. The original light intensity is used. A dotted line shows the results of experiment 1. Below, draw a solid line to show how maximum kinetic energy varies with frequency. **1**



(d) Sketch a diagram of the experimental set-up described in parts (a) to (c), clearly describing how the maximum kinetic energy of the electrons is determined. **3**

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Question 29 (4 marks)

Beginning in the late 19th century, observations and experiments on black body radiation and the photoelectric effect led physicists to revise their existing model of light.

Use the above as an example to explain how scientists test and validate models. **4**

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Question 30 (4 marks)

The energy bands of a solid are illustrated below.

By considering charge carriers and lattice vibrations, use band theory to explain the change of resistance of an intrinsic semiconductor with change of temperature from 0 K to room temperature. **4**

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Question 31 (5 marks)

Early investigations using cathode rays resulted in uncertainty as to their nature.

Explain how the behaviour of cathode rays indicates their properties. Include particular observations and why early observations made their nature uncertain. **5**

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Question 32 (2 marks)

The Bragg's used X-ray diffraction to investigate the crystal structure of a variety of materials.

Explain why the Bragg's chose to use X-rays rather than gamma rays or ultraviolet light. **2**

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Question 33 (10 marks)

(a) Calculate the current flowing in a motor having 210 turns of coil in the armature, which is a 3.0×3.0 cm square coil within a magnetic field of 0.023 T, when it is providing a maximum torque of 2.7×10^{-2} Nm. **1**

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Question 33…continued

(b) A satellite is in orbit around a planet. Each orbit takes 32 hours to complete and the radius of the orbit is 86, 000 km. Determine the mass of the planet. **2**

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(c) A source is used to produce X-rays for crystallography. The energy of one X-ray photon is measured to be 1.44×10^{-15} J. What is the wavelength of these X-rays? **1**

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(d) An electron moves in a magnetic field. If the radius of the circular path it follows is $10.0\ cm$, and the electron is moving at $2.0\times10^{7}\ ms^{-1}$, what is the strength of the magnetic field? **1**

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(e) A rocket of initial mass 2,000 tonnes produces a constant thrust of 8.0×10^{7} N, by expelling 8,000 kg of fuel per second. Determine the acceleration of an astronaut 30 s after lift-off. **2**

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(f) A stationary observer standing in a field perceives a rocket moving at 0.8 c to have a length of 30 m. What is the length of the rocket measured by the pilot? **1**

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(g) Two parallel conductors, each 1 m long and 1 m apart, carry equal currents. What is the magnitude of this current if there is an attractive force of 0.02 mN between the conductors? **1**

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(h) A mass ***m*** kg is moved from an orbit ***r*** above the centre of the Earth (mass ***M***), to an orbit **2r**. How much work is required? **1**

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Section 2

Question 34 – Medical Physics (15 marks)
QATS 13 C AND D

(a)	(i) Medical practitioners use the Doppler effect of ultrasound to detect the blood characteristics of the heart. Outline how the Doppler effect works and identify one cardiac problem that can be detected using this technique. **2**
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	(ii) The acoustic impedance of air is 400 kg m^{-2} s^{-1}. The speed of ultrasound in the chest muscle is 1600 m s^{-1} and the density of the chest muscle is 1050 kg m^{-3}. Determine the fraction of acoustic signal transmitted through a chest muscle–air interface. **2**
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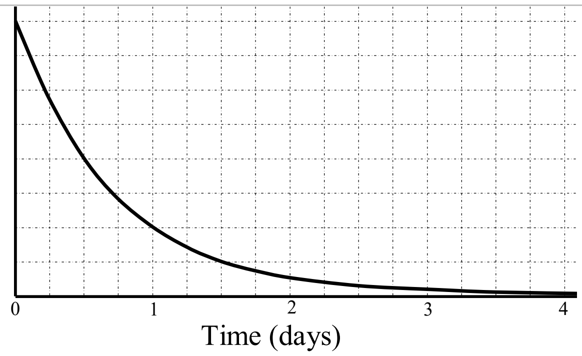
(b) Light travels in straight lines, yet, by using an endoscope, doctors are able to see inside a patient's body by means of flexible probes that bend through the passages of the body. Describe how light is transferred by optical fibres used in these endoscopes. **2**

(c)



This graph relates to a certain radioactive isotope that is to be used as a diagnostic tool for a patient with a suspected cracked elbow that an X-ray has been unable to reveal.

(i) If the initial dose given to the patient was 0.48 μg of the isotope, what mass would remain in her system after 72 hours? **2**

(ii) Describe how γ-radiation is produced and used in positron emission tomography (PET). **3**

(d) Well over a century since its discovery X-ray imaging continues to be a major technique for medical diagnosis. CAT scanning is a more recent enhancement of the X-ray principle, exploiting the development of solid state computing during the past 30 years.

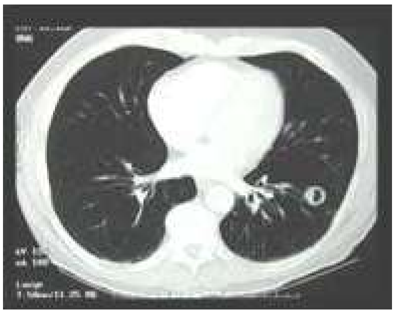


Image 1

Image 2

(i) Identify a key reason why CAT scanning has not completely replaced conventional x-ray imaging. **1**

(ii) The images above show the lungs. Image 1 is a CAT scan showing a horizontal slice across the chest. Image 2 is a conventional X-ray image of the lungs

Account for the different appearance of the CAT image in terms of the way in which data from X-ray scanning is processed in this imaging technique. **3**

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}

FORMULAE SHEET

$v = f\lambda$

$I \propto \frac{1}{d^2}$

$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$

$E = \frac{F}{q}$

$R = \frac{V}{I}$

$P = VI$

Energy $= VIt$

$v_{av} = \frac{\Delta r}{\Delta t}$

$a_{av} = \frac{\Delta v}{\Delta t}$ therefore $a_{av} = \frac{v-u}{t}$

$\Sigma F = ma$

$F = \frac{mv^2}{r}$

$E_k = \frac{1}{2}mv^2$

$W = Fs$

$p = mv$

Impulse $= Ft$

$E_p = -G\frac{m_1 m_2}{r}$

$F = mg$

$v_x{}^2 = u_x{}^2$

$v = u + at$

$v_y{}^2 = u_y{}^2 + 2a_y \Delta y$

$\Delta x = u_x t$

$\Delta y = u_y t + \frac{1}{2}a_y t^2$

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$F = \frac{Gm_1 m_2}{d^2}$

$E = mc^2$

$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$

$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number / Symbol of element / Atomic Weight / Name of element
79 Au 197.0 Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Use this space for working out, calculations etc. This page will NOT be marked.

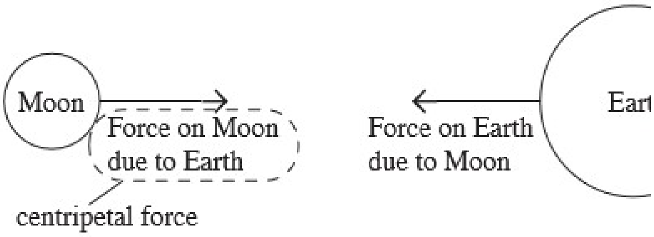
Ascham School

Trial Examination 2016

Criteria

Question 21 (4 marks)

(a)



Marking Criteria	Marks
Both arrows correctly identified and force on moon identified	**1 mark**

(b)

Marking Criteria	Marks
Correctly shows field skewed closer to Moon and direction of field correct at all points	**2 mark**
Correctly shows field skewed closer to Moon OR direction of field correct at all points OR shows symmetric field	**1 mark**

Question 22 (3 marks)

(a)

Criteria	Marks
• Correctly analysing the vertical motion to find a value for t, ***and*** • Substituting into the appropriate formula to find the range Δx.	2
• Doing only one of these.	1

Sample answer

$\Delta y = -5050$ m; $u_y = 0$ m s^{-1}; $a_y = -9.8$ m s^{-2}; $t = ?$

$\Delta y = u_y t + \frac{1}{2} a t^2 \quad \therefore \; -5050 = 0 - \frac{1}{2} \times 9.8 \times t^2 \quad \therefore \; t = 32.1$ s

$\Delta x = ?$; $u_x = 830$ m s^{-1}; $a_x = 0$; $t = 32.1$ s

$\Delta x = u_x t = 830 \times 32.1 = 26\,600$ m.

(b)

Criteria	Marks
• Correctly substituting for R_1 and R_2 into an appropriate formula that allows T_1 to be found, ***and*** • Including the appropriate cubes and squares in the substitution.	2
• Incorrectly substituting into a correct formula, ***or*** • Converting 27.3 days into seconds or hours.	1

Kepler's law: $\dfrac{R_1^3}{T_1^2} = \dfrac{R_2^3}{T_2^2} \quad \therefore \; \dfrac{(6.385 \times 10^6)^3}{T_1^2} = \dfrac{(3.84 \times 10^8)^3}{(27.3)^2}$

$\therefore \; T_1 = 0.0585$ days (= 1.4 hours)

Question 23 (3 marks)

(a)

Marking Criteria	Marks
Correctly identifies postulate	**1 mark**

Sample response

The speed of light, as measured by all observers, is the same

(b) (i)

Marking Criteria	Marks
Correctly calculates time	**1 mark**

Sample response

T = d/v = 34 / 0.95 x 3 x 10^8 = 119 ns

(b) (ii)

Marking Criteria	Marks
Calculates time to decay in observer's f.o.r (or distance travelled) t (58 ns) Uses this time to calculate number of half-lives lived by mesons (approx. 2) Uses this data to calculate expected number of mesons to survive in f.o.r of observer (¼) . Determines that 6 half-lives have passed in moving between detectors if relativity not taken into account. States that results of experiment show that data could only be correct if special relativity is used, otherwise data makes no sense. So expt is linked with theory (final point essential for full marks)	**5-6**
Most of above calculations done but with errors or with incorrect substtution (final point essential for full 4 marks)	**4**
Some attempt to calculate using theory of relativity using correct expressions and statement made linking data from experiment and theory	**2-3**
Attempt made to explain data in terms of theory but with no calculations to justify claim OR Some attempt made using any relevant expression but with errors made.	**1-2**

Sample answer

t = 18 ns (1 - 0.952 c2 / c2) $^{-1/2}$ = 58 ns (using relativity to determine life-time of meson in observer's f.o.r.
time taken for π meson to pass from one detector to the other = 120 ns = 2 half-lives (approx) in observer's f.o.r.
two half-lives corresponds to a reduction to 25 % so 75% of the π mesons passing the first detector do not reach the second detector - agrees with theory
OR Appreciation that in the lab frame of reference the time is about 6 half-lives had passed
In 6 half-lives 1/64 left so about 90% should have decayed
Clear conclusion made Either Using special relativity gives agreement with experiment or Failure to use relativity gives too many decaying.

Question 24 (5 marks)

Criteria	Marks
• Identifies back emf as reducing voltage, correctly relates size of back emf to speed of rotation and reason for speed variation	3
• Identifies TWO of the following points: back emf as reducing voltage, correctly relates size of back emf to speed of rotation, reason for speed variation	2
• Identifies ONE of the following points: back emf as reducing voltage, correctly relates size of back emf to speed of rotation, reason for speed variation	1

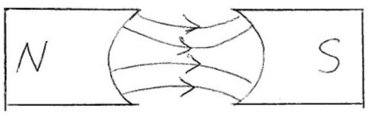
***Sample answer*:** As the motor coil in the drill rotates, it cuts magnetic field and an induced emf is produced in the coil. The direction of this emf (Lenz's Law) opposes the supply emf (it is a back emf) so the net voltage across the coil reduces.

The size of the emf and voltage drop increases with speed of rotation. Therefore if the drill speed is slowed by harder material in the wall, the voltage reading will be higher.

Question 25 (3 marks)

On the diagram below sketch the radial magnetic field between the poles. **2**

Marking Criteria	Marks
• Correct answer with shape of magnets clear	2
• Correct shape of magnetic field OR • Force lines between linear magnets shown	1



Explain why radial fields are useful in DC motors. **2**

Marking Criteria	Marks
• Explanation refers to the interaction of the field and current AND • Reference to maximum torque being extended	2
• One of the above	1

With a radial magnetic field, the field lines are perpendicular to the current in the coil for a greater part of one whole revolution of the coil rather than at only one instance every half turn. This allows for the maximum torque to be produced for a greater percentage of the time the motor is operating.

Question 26 (4 marks)

Marking Criteria	Marks
• An appropriate device is identified AND • Motor effect is explained AND • reference is made to the application of the motor effect AND • diagram is provided that CLEARLY assists in explanation	**4**
• An appropriate device is identified AND • Motor effect is explained AND • reference is made to the application of the motor effect OR • diagram is provided that partly assists in explanation	**3**
• An appropriate device is identified AND • Motor effect is explained OR • reference is made to the application of the motor effect OR • diagram is provided that partly assists in explanation	**2**
• Any relevant point related to a device using motor effect	**1**

Question 27 (5 marks)

Marking Criteria	Marks
Complete description of Lenz's Law in the role of EM braking Description of opposing force \ field\current Diagram showing induced current OR forces opposing motion	**4**
Lenz's Law described but not fully linked to role in EM braking Description of opposing field\ \current but not related to force Diagram which assists explanation	**3**
Reference to Lenz's Law OR diagram showing forces opposed to motion	**2**
A reference to Lenz's Law, not in context	**1**

As a metal disc rotates within a region of a magnetic field, eddy currents are induced in the disc as that part of the disc nears the magnetic field (i.e. flux through disc is increasing). Eddy current direction is such that magnetic field produced opposes the external field (Lenz's Law). The forces resulting from the interaction of the external and induced magnetic fields oppose the motion of the disc. In region of disc leaving magnetic field, similar (but opposite direction) eddy currents again produce magnetic fields that still oppose motion of disc: → EM braking.

Question 28 (4 marks)

Criteria

(a) **Sample answer**: calculate h from slope eg 2 eV/5 x 10^{14}
AND
Converts answer using 1 eV = 1.602 x 10^{-19} J

(b) **Sample answer**: draws line on parallel to existing line

(c) **Sample answer**: draws line on top of existing line with x-intercept approx. at 7.5

(d) Draws correct circuit with photo emissive surface clearly shown AND photoelectrons moving towards region of negative potential. **2 marks**
Identifies that KEis measured using stopping voltage (or when photocurrent = 0 A) **1 mark**

Question 29 (4 marks)

MARKING GUIDELINES

Criteria	Marks
• Explains the components of scientists' methods in relation to testing and validating a model and uses specific information relating to investigations into black body radiation and photoelectric effect	4
• Explains the components of scientists' methods in relation to testing and/or validating a model refers briefly to information relating to black body radiation or photoelectric effect	3
• Describes scientists' methods with no reference to black body radiation or photoelectric effect OR • Describes black body radiation and photoelectric effect	2
• Outlines methods used by scientists OR • Describes either black body radiation or photoelectric effect	1

Question 30 (4 marks)

Criteria and sample answer

Describes location of charge carriers in correct energy bands at 0 K… **at 0 K, VB is filled, CB is empty** ……AND
Describes thermal energy input as causing movement of charge carriers into correct energy band…..**as temp rises, electrons gain energy to enter CB and positive holes are formed in VB**…….AND………
Describes thermal energy input as causing increased motion of lattice ….. **lattice vibrations increase as temp rises** …….AND………
Compares two contrasting effects on overall effect on electrical resistance………. **effect due to increase in charge carriers outweighs effect due to increase in lattice vibrations so current larger and resistance smaller**

Question 31 (4 marks)

Marking Criteria	Marks
• Observations linked and related to explain the properties of cathode rays thoroughly • Reasons for early uncertainty of nature outlined clearly • Response is in a logical and sequential manner	**4**
• Observations related to properties of cathode rays • Reasons for early uncertainty of nature identified	**3**
• An observation linked to a property of cathode rays	**2**
• A characteristic or property of cathode rays identified	**1**

Observation of behaviour of cathode rays	Property responsible for behaviour and conclusion drawn
Travelled in straight lines/cast a shadow	Particle nature and also wave nature – so no conclusion drawn
Were deflected by a magnetic field	Possessed a charge (and therefore must be particles)
Were not deflected by an electric field in early investigations	Must be a wave without a charge
Were deflected by an electric field in later studies with better vacuums in the CRT	Possessed a charge and must be particles
Were able to rotate a paddle wheel	Possessed momentum – must have mass and therefore be particles

Question 32 (2 marks)

Marking Criteria	Marks
• Correctly identifies that diffraction of x-rays is being utilised OR • Atomic spacing is approx. same size as wavelength of x-rays AND • Diffraction occurs strongly when wavelength used is same size as "gap"	**2**
• Identifies any relevant feature of method used by Braggs	**1**

Question 33 (10 marks)

(a) I = 6.2 A

Marking Criteria	**Marks**
Correctly calculates current	**1 mark**

(b) mass = 2.84 x 10^{25} kg

Marking Criteria	**Marks**
Correctly uses full form of Kepler's 3rd law	**1 mark**
Correctly calculates mass	**1 mark**

(c) wavelength = 1.4 x 10^{-10}

Marking Criteria	**Marks**
Correctly calculates wavelength	**1 mark**

(d) B = 1.13 x 10^{-3} T

Marking Criteria	**Marks**
Correctly calculates strength of magnetic field	**1 mark**

(e) acceleration = 35.6 m/s/s

Marking Criteria	**Marks**
Correctly determines mass after 30 s	**1 mark**
Correctly calculates acceleration	**1 mark**

(f) length = 50 m

Marking Criteria	**Marks**
Correctly calculates length of rocket	**1 mark**

(g) I = 100 A

Marking Criteria	**Marks**
Correctly calculates current	**1 mark**

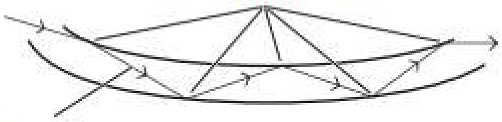
(h) Work done = GMm /2r

Marking Criteria	**Marks**
Correctly calculates work	**1 mark**

Section 2

Question 33 – Medical Physics (25 marks)

	Sample answer	Syllabus content, course outcomes and marking guide
(a) (i)	The Doppler effect is the apparent change in frequency when there is relative motion between the source of the reflected wave (i.e. the individual red blood cells which are moving towards and away from the receiver) and the observer (i.e. the transducer). Applications: To locate blockages which cause blood flow to slow down in arteries. To monitor the hearts of foetuses. To diagnose ruptures and/or lesions in vascular tissue. To locate leakages in heart valves.	9.6.1 H8, H13 • Correct description of the Doppler effect AND • Correct identification of one cardiac problem that can be detected with Doppler ultrasound. 2
		• Correct description of the Doppler effect OR • Correct identification of one cardiac problem that can be detected with Doppler ultrasound. 1
(ii)	$Z = \rho v$ $= 1076 \times 1580$ $= 1700000 \text{ kg m}^{-2} \text{ s}^{-1}$ OR 1.7 rayl $\frac{I_r}{I_o} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$ $= \frac{(400 - 1700000)^2}{(400 + 1700000)^2}$ $= 0.999$ $= 99.9\%$ Ultrasound would not be recommended for use on the lungs because only 0.1% of the incident signal is available to probe the lungs.	9.6.1 H8, H13, H14 • Correctly determines value of Z AND • Correctly determines value of I_r to I_i ratio **2**
		• Correct value of Z **1**

	Sample answer	Syllabus content, course outcomes and marking guide
(b)	 The outside of the optic fibre have a higher refractive index than the interior, which causes light impinging on the walls to undergo total internal reflection. The fibres are very long and thin, so that light entering will always meet the side of the fibre with an angle greater than the critical angle. This means that the light is reflected inside the fibre repeatedly until it emerges at the other end.	9.6.2 H13 • Provides detailed explanation of how total internal reflection applies to the apparatus 2
		• Identifies that total internal reflection is involved 1

(c) (i)

Criteria	Mark
• Correctly determines half-life	1

AND

Criteria	Mark
• Correctly determines mass remaining	1

Sample answer

The half-life of the isotope is ½ day, i.e. 12 hours. So after 72 hours = 6 half lives

0.0075 μg, i.e. 7.5×10^{-9} g remains

(ii) **Sample answer and criteria**

Describes gamma ray production by annihilation of positron and electron to produce 2 gamma rays (1 or 2)

Identifies that gamma rays are used to determine functional information (2 or 1)

Emphasis of response can be either on extension of production (eg a named positron emitter, insertion into body etc etc) OR on extension of use (eg activity of ccells/ tissues/ assessment of organ functioning etc etc)

(d) (i)

Criteria	Mark
• Correct reason stated	1

Sample answer

Normal X-ray scans have not been totally replaced because the equipment used for CAT scans, and the process itself, are far more expensive.

(ii)

Criteria	Marks
• Recognises multiple images captured by CAT, single image by X-ray • States that the CAT images are computer-processed to form 2-D and 3-D • States that a single image cannot be further processed	3
• Two of the above outcomes	2
• Correctly states one fact about either normal X-rays or CAT scans	1

Sample answer

A CAT scan (Image 1) consists of multi-images captured by a rotating gantry camera, whilst the normal X-ray shown in Image 2 has been captured by a single exposure. The many images are then computer-processed using images from different angles, allowing for a 2-dimensional and even 3-dimensional view of body sections, whereas the normal X-ray is processed by an ordinary 1-dimensional detection process, and so is obviously limited to that single view.