Centre Number

Student Number

SCEGGS Darlinghurst

2004

Higher School Certificate
Trial Examination

Physics

This is a TRIAL PAPER only and does not necessarily reflect the content or format of the Higher School Certificate Examination for this subject.

General Instructions

- Reading time - 5 minutes
- Working time – 3 hours
- Write using blue or black pen.
- Draw diagrams using pencil.
- Use Multiple Choice Answer Sheet provided.
- Board-approved calculators may be used.
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper.
- Write your Centre Number and Student Number at the top of this page, the Multiple Choice Answer Sheet, pages 8 and 16 and the first page of your bundle of answers for Section II.

Section I Pages 1-19

Total marks **(75)**

- This section has two parts, Part A and Part B

Part A

Marks **(15)**

- Attempt Questions 1 – 15
- Allow about 30 minutes for this part.

Part B

Marks **(60)**

- Attempt Questions 16 – 27
- Allow about 1 hour and 45 minutes for this part.

Section II Page 20

Total marks (**25**)

- Attempt Question 28
- Allow about 45 minutes for this section.

Section I
75 marks

Part A – 15 marks

Attempt Questions 1 – 15
Allow about 30 minutes for this part

Use the multiple-choice answer sheet.

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

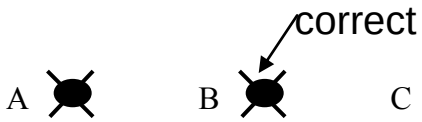
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.

A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

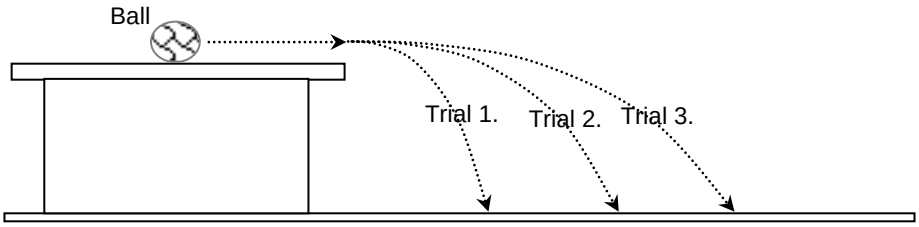
1. An 80 kg human was abducted by aliens and flown to the aliens' planet where the surface gravity is 2.5 times greater than on Earth. Which of the following would be true for the weight of the human on the surface of the alien planet?

   (A) The weight would still be 80 kg.
   (B) The weight would be 200 kg.
   (C) The weight would be (2.5 x 9.8 x 80) kg.
   (D) The weight would be 1960 N.

2. A satellite is in stable circular orbit at an altitude about 1000 km above the Earth's surface. When considering the velocity and acceleration of the satellite as it orbits, which of the following would be true?

   (A) The acceleration remains constant.
   (B) Both the acceleration and velocity remain constant throughout the orbit.
   (C) Only the magnitude of the acceleration and velocity remain constant.
   (D) The magnitude of both the velocity and acceleration change continuously.

3. During an experiment, a ball was rolled across a horizontal table at different speeds and the distance it travelled before hitting the floor was measured. The path followed by the ball for three trials is shown in the following diagram.



Considering this information, which of the following statements would be true as the ball leaves the table and falls to the floor?

(A) The change in the velocity of the ball is the same in each trial.

(B) The ball will take different times to hit the floor in each trial.

(C) The ball only accelerates vertically down in each trial.

(D) The ball gains the same amount of kinetic energy in each trial.

4. During the first stage of a rocket launch, the rocket engine consumes fuel at a constant rate of 12 tonnes per second. As the rocket gains speed the rate at which the fuel is being consumed is reduced. Which of the following is best to describe what happens to the rocket while the fuel burns at a constant rate?

(A) The acceleration of the rocket steadily increases.

(B) The thrust from the engine increases as the total mass of the rocket decreases.

(C) The acceleration of the rocket is constant.

(D) The g-forces on passengers become smaller requiring the rate to be reduced.

5. A particle is to be used in a linear accelerator. Measured at rest relative to the laboratory, it has a half-life of 2.5 μs. When measured at constant speed by an observer in the laboratory, its half life increases to 10 μs. What is the speed of the particle relative to the laboratory?

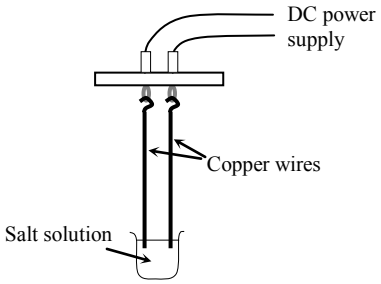
(A) 9.68×10^{-1} ms^{-1}

(B) 2.90×10^{-1} ms^{-1}

(C) 9.68×10^{7} ms^{-1}

(D) 2.90×10^{8} ms^{-1}

6. A student is conducting an investigation on the magnetic forces between current carrying wires. They have taken two equal, straight lengths of copper wire and suspended them from metal loops attached to a DC power supply, as shown in the diagram below.



When the power was switched on the student observed that the wires were weakly repelled from each other. The student then decided to try to modify the set-up so that the wires will now be attracted to each other and also to attempt to increase the size of the force acting.

Which of the following combinations of changes could the student make to the set-up to be sure they will achieve the desired result?

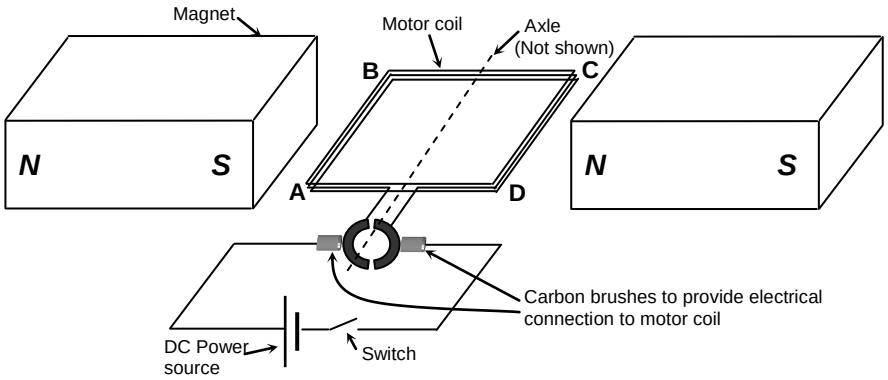
(A) Increase the length of the wires and reverse the connections to the DC power supply.

(B) Increase the length of the wires and increase the size of the current flowing.

(C) Reverse the direction of the current in one wire and use longer wires.

(D) Increase the current in the wires and reverse the connections to the DC power supply.

7. The diagram below represents a simple DC electric motor.



The magnets produce a field of 0.12 T in the region of the motor coil which consists of 10 square loops of 0.050 m side length. When the motor is switched on a current of 4.0 A flows into the motor coil. Which of the following alternatives correctly states the torque acting on the motor coil and the direction of the initial movement of the end of the motor coil AB?

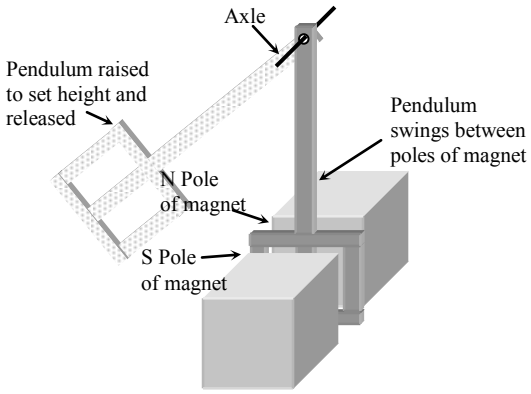
(A) Torque = 0.012 Nm, and end AB moves down

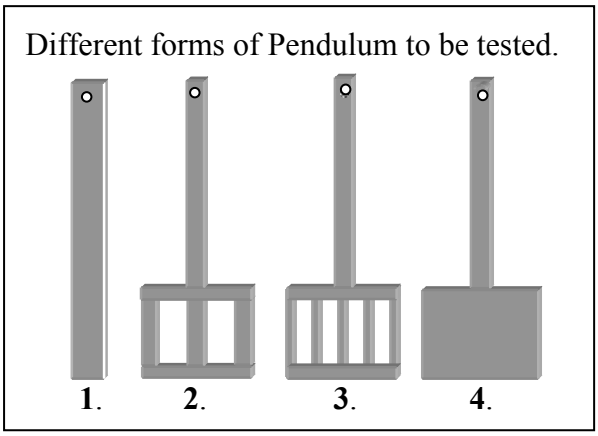
(B) Torque = 0.012 Nm, and end AB moves up

(C) Torque= 0.240 Nm, and end AB moves down

(D) Torque = 0.240 Nm, and end AB moves up

8. An apparatus has been constructed to investigate eddy currents. It consists of a large, very strong permanent magnet and several pendulum structures made of aluminium plate. The pendulums can be hung from an axle to allow them to swing between the poles of the large magnet. An example is represented in the following diagram.





Each of the FOUR different pendulums was tested. It was observed that the motion of each pendulum was slowed as it passed between the poles of the magnet.

Considering the shape of the FOUR pendulums, which of the following is most likely?

(A) Each of the four pendulums will come to rest at the same rate.

(B) The pendulum No. 1. will come to rest quicker than the others.

(C) The pendulum No. 3 will come to rest quicker than the others.

(D) The pendulum No. 4 will come to rest quicker than the others.

9. An ideal transformer is used to convert the 240 V AC power supply to 12 V DC to operate a slot car set. The transformer has 100 loops in the secondary coil and the power used by the slot cars when operating is 60 watts.

Which of the following correctly states the number of loops in the primary coil and the current flowing through them when the slot cars are operating?

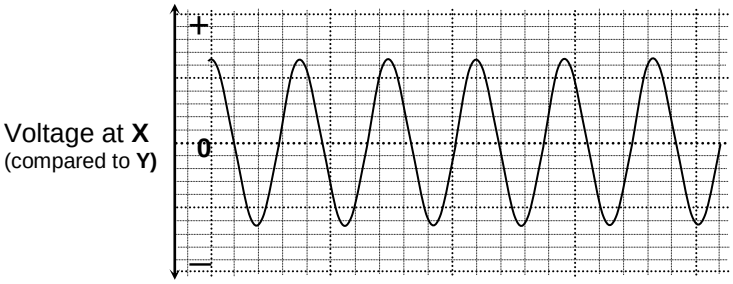
(A) 2000 loops and 0.25 A

(B) 5 loops and 5.0 A

(C) 2000 loops and 5.0 A

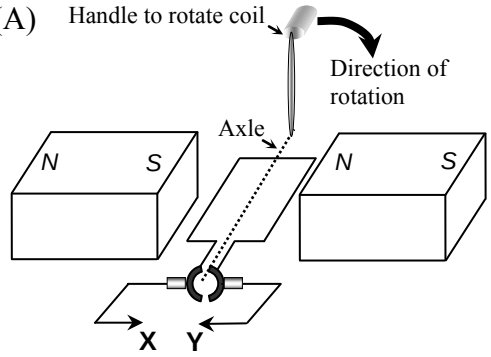
(D) 5 loops and 0.25 A

10. During an experiment, TWO forms of simple generator were each attached to a cathode ray oscilloscope. The handle of the generator was rotated at a steady rate and a plot of the voltage produced at the contact X, compared to Y, was recorded for each of the generators. The following graph shows the result for one of the generators tested.

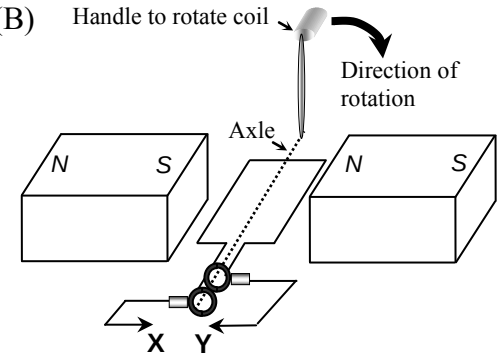


Considering the graph starts with the generators in the positions shown, which of the following alternatives would correctly represent the direction of rotation and form of generator that produced the plot shown.

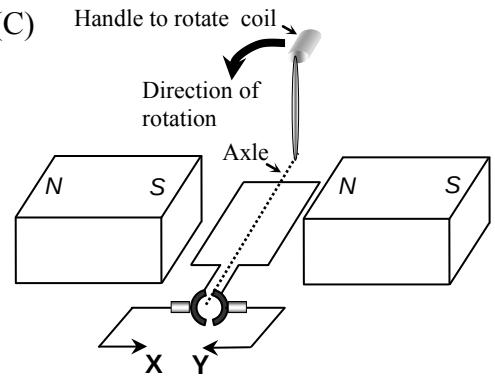
(A)



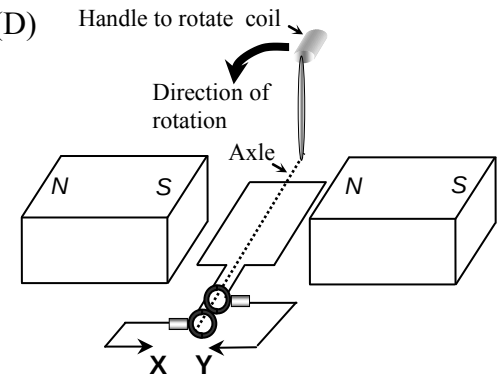
(B)



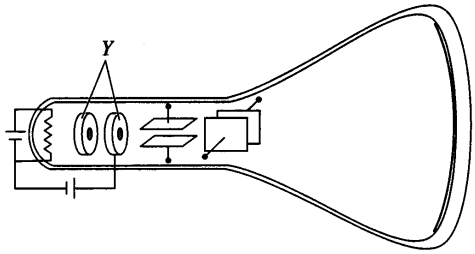
(C)



(D)



11. The following diagram shows a simple cathode ray tube from an oscilloscope.



The parts labelled Y have the function of:

(A) producing electrons.

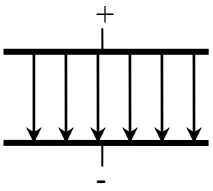
(B) accelerating the electrons.

(C) deflecting the beam horizontally.

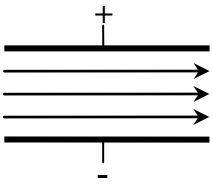
(D) indicating the path of the beam.

12. Which of the diagrams below is the best to represent the electric field between two charged, parallel metal plates?

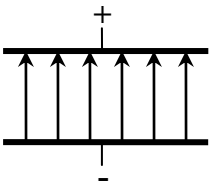
(A)



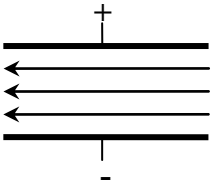
(B)



(C)



(D)



13. Which area of physics knowledge was used by the Braggs in their experimental work?

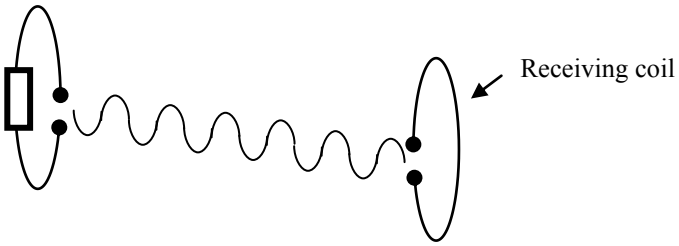
(A) particle nature of light

(B) law of refraction

(C) interference of waves

(D) forces on charged particles

14. Hertz used a high voltage source to generate a spark and realised that when another spark was produced at a receiving coil, energy must have been transferred somehow.



Early in his experiments Hertz made a chance observation when he found he could increase the strength of the spark in the receiving coil. Which of the following correctly describes what Hertz had done that led to this observation?

(A) He shone a source of ultraviolet light on the receiving coil.

(B) He slightly increased the gap between the terminals of the receiving coil.

(C) He placed a glass panel between the transmitting coil and the receiving coil.

(D) He placed a flat metal sheet behind the transmitting coil which reflected energy to the receiving coil.

15. A small magnet can be made to hover above a superconducting material that is cooled below its critical temperature. Which of the following alternatives provides the best explanation for why this occurs?

(A) Below the critical temperature superconductors produce their own magnetic fields.

(B) The superconductor responds to the magnetic field of the small magnet by producing internal currents that produce magnetic fields to repel the small magnet.

(C) The magnetic field of the small magnet cannot enter the superconductor and is perfectly reflected from the surface of the superconductor causing the magnet to repel itself.

(D) Below the critical temperature all the electrons in the superconductor attract each other to form Cooper Pairs that repel magnetic fields.

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Section I (continued)

Part B – 60 marks

Attempt Questions 16 – 27
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.

Show ALL relevant working in questions involving calculations.

Question 16 (3 marks) **Marks**

A satellite with a mass of 200 kg maintains its orbit at an altitude of 300 km above the surface of the Earth. Given that the Earth has a radius of 6.38×10^6 m, calculate the gravitational potential energy of the satellite at this altitude. **3**

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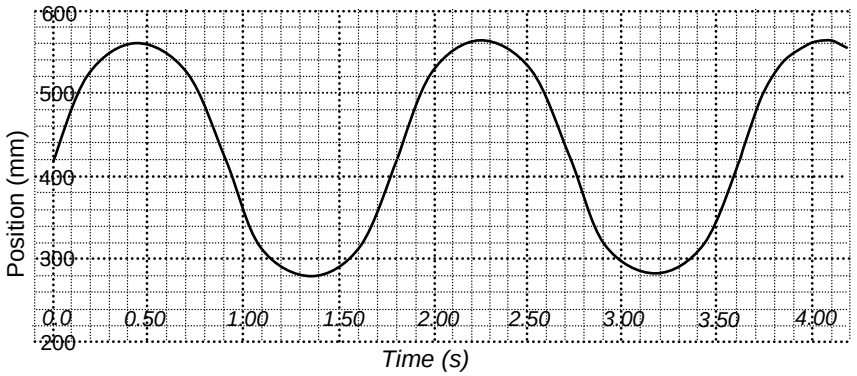
Question 17 (6 marks) **Marks**

A simple pendulum and motion sensor were used in an experiment to determine the size of acceleration due to gravity. The motion sensor was attached to a computer and set up to record the horizontal motion of the simple pendulum. The following graph shows the result for the 'Position' of the pendulum bob vs. 'Time', for a pendulum of length 0.800 m.



(a) Use the graph to determine the period and amplitude of the pendulum's motion. **3**

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(b) Based on the result from the graph and the length of the pendulum used, calculate the magnitude of acceleration due to gravity using the equation, $T = 2\pi\sqrt{L/g}$. **1**

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(c) Describe a possible technique that could be used with the same apparatus to improve the accuracy of the value of gravity calculated in part (b). **2**

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Question 18 (5 marks) **Marks**

At launch, a rocket and its payload have a total mass of 4.80×10^5 kg. The thrust produced by the rocket engines in the first second as the rocket begins to move is 1.43×10^7 N.

(a) Calculate the magnitude of the average acceleration of the rocket during the first second of launch. **2**

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(b) The rocket can be used to place a satellite into a stable circular orbit with a specific orbital velocity. Providing full detail, explain how the orbital speed can be used to calculate the altitude above Earth of the satellite's circular orbit. **3**

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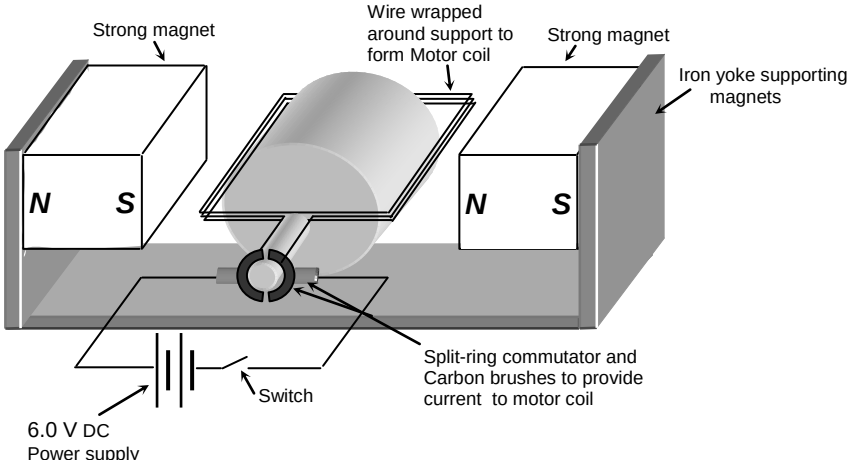
Question 19 (6 marks) **Marks**

The experiments carried out by Albert Michelson and Edward Morley won Michelson a U.S national prize in Physics in 1888 for, as it was described, "Not only for what he has established but also for what he has unsettled." With detail on the basis for the Michelson-Morley, experiment discuss what was shown by the experiments and what was unsettled. **6**

Question 20 (4 marks) **Marks**

As part of their studies a group of students successfully constructed a simple D.C electric motor, represented in the diagram below. **4**



The students conducted tests on the motor and found that it operated best using a 6.0 V power supply, with the motor coil rotating at a frequency of about 3 Hz. Considering when the switch is closed the motor begins at the position shown in the diagram, explain how the torque acting on the motor coil will vary as the coil begins to rotate and reaches its full speed.

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Question 21 (4 marks) **Marks**

With reference to an "ideal" situation, describe the requirements to change the voltage of a source of electrical energy to a different value to operate a second circuit. **4**

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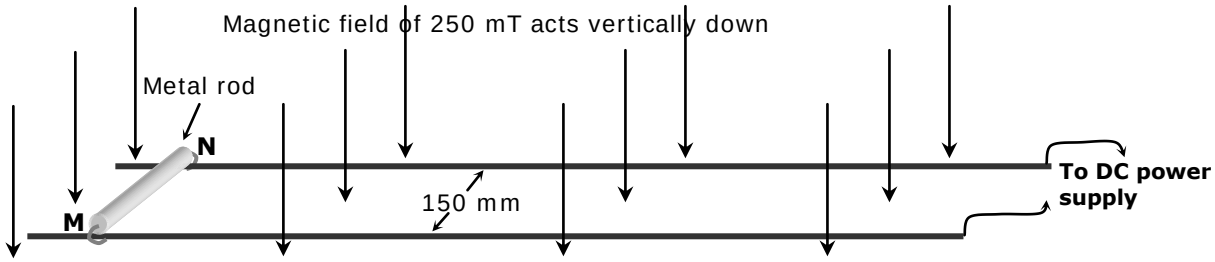
Question 22 (5 marks) **Marks**

In a demonstration device a light metal rod, MN, sits loosely attached with hooks on two parallel metal rails of negligible electrical resistance, a distance 150 mm apart. A uniform magnetic field of 250 mT acts vertically down as shown. When a DC power supply attached to the ends of the metal rails is switched on, a current of 8.40 A flows through the rails and rod. This results in a magnetic force acting on the rod and it is observed to move to the right, sliding easily along the horizontal rails.



(a) State the direction of current flow through the metal rod and calculate the magnitude of the magnetic force that acts on the rod when the power is first switched on. **2**

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(b) With reference to the physical principles involved, explain how the motion of the rod will affect the magnetic force that is pushing it along the rails. **3**

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Question 23 (7 marks) **Marks**

The early quest to provide "large scale electrical power" to consumers saw Westinghouse and Edison pitted in a very expensive battle to try to convince others of the suitability of their own system when compared to the others. Discuss reasons why the Westinghouse system was eventually to win and how the development of large scale electrical power supply has affected society and the environment. **7**

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Question 24 (4 marks) **Marks**

A student studying the photoelectric effect has a weak UV light source and a laser that produces red light of wavelength 6.35×10^{-7} m. The student placed a polished zinc sheet on the surface of an electroscope and then charged the electroscope negatively. They then tested each light source, one at a time, by directing the beam onto the zinc sheet on top of the charged electroscope.

(a) Calculate the energy for each photon of red light produced by the laser. **2**

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(b) With reasons for your answer, describe what the student is likely to have observed. **2**

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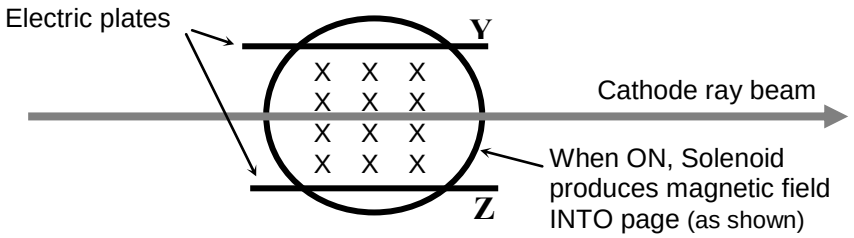
Question 25 (5 marks) **Marks**

A cathode ray beam was manipulated in a Thomson-like apparatus. Part of this apparatus is shown below with the beam shown indicating the path followed when NO fields are acting.



The speed of the particles in the cathode ray beam was known to be 2.0×10^5 ms^{-1}. The cathode ray beam was slightly deflected when the magnetic field was turned on. From the amount of deflection, the magnetic force on the particles in the cathode ray was determined to be 2.2×10^{-15} N.

(a) Calculate the magnitude of the magnetic field acting. **1**

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With the magnetic field still operating, it was found that when the electric field was turned on, the voltage applied to the plates could be adjusted so that the cathode ray beam went through without being deflected.

(b) State which of the electric plates (Y or Z) would be positively charged. **1**

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(c) The distance between the plates producing the required electric field is 2.00 cm. With reference to the physical principles involved, calculate the voltage that must be applied to the plates so the beam is not deflected. **3**

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Question 26 (5 marks) **Marks**

Assess Einstein's contribution to quantum theory and its relation to black body radiation. **5**

Question 27 (6 marks) **Marks**

Discuss how superconductors and the effects of magnetic fields have been applied to develop a Maglev train. **6**

Section II
25 marks

Attempt Question 28 – Medical Physics
Allow about 45 minutes for this section

Answer the question on the writing paper provided. Write your student number at the top of each page and staple the bundle together when you have finished the option.

Show all relevant working in questions involving calculations.

Question 28 – Medical Physics (25 marks) **Marks**

(a) The endoscope used in medical procedures contains two bundles of optical fibres to allow the surgeon to view internal structures.

(i) Name the physical principle employed in an endoscope. **1**

(ii) Contrast the role of the coherent bundle of optical fibres with that of the incoherent bundle. **2**

(b) The table below gives values for the density and speed of sound in a variety of body tissues.

Tissue	Density (kgm^{-3})	Speed of sound (ms^{-1})
heart muscle	1080	1580
fat	950	1450
blood	1025	1570

(i) Calculate the acoustic impedance of heart muscle and blood. **2**

(ii) Some of an ultrasound pulse is reflected when it passes from heart muscle into a blood-filled chamber. Calculate the percentage intensity reflected. **2**

(c) Certain radioactive isotopes are commonly used to obtain scans of organs. Identify ONE specific radioactive isotope used to obtain scans and outline the properties that enable it to be useful. **3**

(d) Compare the situations in which phase and sector scans would be used. **2**

(e) The images produced by a PET scan can be very useful to assist in diagnosing certain medical problems.

(i) Outline one advantage and one disadvantage of PET scans. **2**

(ii) Describe how PET scans are produced. **4**

(f) Compare the techniques employed to produce a CAT scan with those of a MRI scan including information on the possible effects of each technique on the patient. **7**

End of Paper

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Multiple Choice Answer Sheet

PART A
Total Marks (15)
Allow about 30 minutes for this part

1. A ○ B ○ C ○ D ○
2. A ○ B ○ C ○ D ○
3. A ○ B ○ C ○ D ○
4. A ○ B ○ C ○ D ○
5. A ○ B ○ C ○ D ○
6. A ○ B ○ C ○ D ○
7. A ○ B ○ C ○ D ○
8. A ○ B ○ C ○ D ○
9. A ○ B ○ C ○ D ○
10. A ○ B ○ C ○ D ○
11. A ○ B ○ C ○ D ○
12. A ○ B ○ C ○ D ○
13. A ○ B ○ C ○ D ○
14. A ○ B ○ C ○ D ○
15. A ○ B ○ C ○ D ○

TOTAL Part A =

SCEGGS Physics Trial 2004 – Marking Guidelines

Part A

1. D 2. C 3. C 4. A 5. D 6. C 7. B 8. D 9. A 10. D 11. B 12. A 13. C 14. A 15. B

16.

Correctly calculates E_p of satellite in Joules or Nm using the radius of the Earth and the altitude in metres and substituting data sheet values for *G* and the mass of the Earth.	3
Calculates E_p but with one or more errors	1-2

Specimen Answer:

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

$\Rightarrow$ - 6.67 x 10^{-11} x 200 x 6.0 x 10^{24}/6.38 x 10^{6} + 3 x 10^{5} = -1.19 x 10^{-10} J

17. (a)

correctly calculates the period and the amplitude of the pendulum with correct units and shows appropriate working	3
calculates the period and the amplitude of the pendulum but makes one or more errors	1-2

Specimen Answer:

T $\approx$ 2.75 – 0.95 $\approx$ 1.80s

A = (560 – 280)/2 = 280/2 = 140mm

17. (b)

Correctly calculates answer based on values used.	1

Specimen Answer:

The acceleration due to gravity can be determined using;

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \therefore g = \frac{4\pi^2 l}{T^2} \quad \therefore g = \frac{4\pi^2 \times 0.80}{1.8^2}$$

$g = 9.75\ ms^{-2}$.

17. (c)

Adequately describes a possible technique that could be used with the same apparatus to improve accuracy.	3
Describes a possible technique that could be used to improve accuracy, but with insufficient detail	2
Identifies a possible technique that could be used to improve accuracy	1

Specimen Answer:

The accuracy of the result could easily be improved by repeating the collection of the results using several different pendulum lengths. Using the data from the different lengths, a graph of T^2 vs *l* can be drawn. Then, the gradient can be calculated from the line of best fit from the graph, and used with the relationship

$$g = \frac{4\pi^2 l}{T^2}$$ to calculate a more accurate value for 'g'.

OR

The accuracy of the result could easily be improved by repeating the collection of the results using several different pendulum lengths to obtain different graphs. Using the results for T from the different lengths and the relationship $T = 2\pi\sqrt{\frac{l}{g}}$ different values of 'g' can be calculated and averaged.

18. (a)

Correctly calculates acceleration	2
Applies F=ma but fails to consider weight	1

Specimen Answer:

$\Sigma F = T - W \Rightarrow a = (T - W)/m$ = (1.43 x 10^7 – (4.80 x 10^5 x 9.8))/4.80 x 10^5 = 20 ms^{-2}

Average acceleration of rocket over first second = 20.0 ms^{-2}

18. (b)

Explains how gravity provides centripetal force, showing relationship using appropriate equations, and clearly indicating how orbital velocity and known values allow the altitude to be calculated	3
Explains how gravity provides centripetal force and shows relationship using appropriate equations, but does not fully indicate how orbital velocity allows radius of orbit to be calculated correctly	2
States required centripetal force found using speed and radius of orbit and this is created by gravity OR Provides some description of relationship using relevant equations	1

Specimen Answer:
The centripetal force to maintain the circular orbit of the satellite is provided by its gravitational attraction to the Earth, i.e. $F_c = F_g$. Equating these forces:

$$G\frac{m_E m_s}{r_s^2} = \frac{m_s v_s^2}{r_s} \quad \text{or} \quad r_s = G\frac{m_E}{v_s^2}$$

where r_s is the radius of the satellites circular orbit.
Now $r_s = r_E + \text{h}$, where h is the altitude of the satellite above the surface of the Earth of radius r_E. Thus by using the known value for G the Universal Gravitation constant, and the data for the mass, m_E, and radius, r_E, of the Earth, these values and the known orbital velocity, v_s , can be substituted in to the equations shown to allow h, the altitude of the satellites orbit, to be calculated.

19.

The response is coherent and includes the following points: • describes why the aether was proposed as a medium for the propagation of light and reasons for the supposed aether wind. • substantially describes how a sensitive interferometer (or draws an accurate diagram) was used to compare the speed of light along two identical perpendicular paths including the direction of movement or direction of aether wind • describes how the apparatus would detect a change in the speed of light through an observable change in interference pattern as the apparatus is rotated • identifies the null result due to repeated experiments in different situations producing no change in interference pattern • states that the null result was what was 'unsettled' as this showed there was no change in the speed of light through the aether wind (implied there was no aether wind) therefore suggested no aether which went against the prevailing model of light	6
The response contains most of the above points but lacks coherence and/or detail	4-5
The response contains some of the above points	2-3
Identifies that the experiment used a sensitive device (interferometer) to detect the aether and there was "null" result.	1

Specimen Answer:
The Michelson-Morley experiment was a determined effort, using a very sensitive interferometer as part of the apparatus, in an attempt to detect the hypothesised "aether wind". According to classical wave theory and Maxwell's electromagnetism, there should exist an all pervading medium occupying all free space, in order for light waves to be able to travel through the vacuum of space. This mysterious medium termed the aether had long been looked for, with it suggested that, because of the movement of the Earth on its axis and around the Sun, there should be an observable change in the speed of light created as the aether swept over the surface of the moving Earth creating the so called " aether wind". Michelson's interferometer allowed the speed of light along two identical perpendicular paths to be compared. Any change in the speed of the light along one path would produce a clearly observable change in the interference pattern the interferometer produced, as the apparatus is rotated through 90°. Despite the experiment being repeated many times in varied locations, there was never any change observed in the interference pattern. This "null" result which suggested no aether, was the issue "unsettled" by Michelson as many scientists, including Michelson, were confident that, based on what they thought was a complete understanding of light, the aether did exist and that the apparatus used would be sensitive enough to detect any aether wind. What the experiment did show, although at that stage it wasn't fully realised, was that the speed of light did not change and remained the same irrespective of the frame of reference from which it is observed. The issue was finally settled by Einstein as part of his Special Relativity theory in 1905.

20.

The response includes the following points: • uses appropriate equations to correctly explain why torque begins at a maximum • explains why torque reduces as it moves through 90°, with specific reference to the component of force perpendicular to the coil or angle of the plane of the coil that is parallel to the magnetic field • identifies when torque is zero and states that the coil continues moving in the clockwise direction because of the inertia or momentum of the coil • identifies that torque will again be at a maximum at 180° • describes the induction of a back-emf (and current) using the concepts of Faraday and Lenz • identifies the decrease of the magnitude of the original current as the speed of the coil increases • describes that torque is reduced until the motor reaches full speed	4
The response includes all of the above points but fails to include the concept of back-emf OR includes all of the above points, but the answer lacks coherence	3
The response includes some of the above points OR includes most of the above points, but the answer lacks coherence	2
Correctly identifies how torque changes as the coil goes through one rotation	1

Specimen Answer:
The torque applied to the coil of a simple DC motor varies according to the equation $\tau = Fd$ where F is the component of force perpendicular to the coil and d is the perpendicular distance. As the force is at right angles to the coil when the motor is first switched on, the torque acting will be at a maximum value and cause clockwise rotation (left side moves up). As the motor coil moves, the torque will begin to reduce as only a component of the force is perpendicular to the coil. When the plane of the coil is at right angles to the magnetic field, torque reaches a minimum because (i) there is no longer a component of force perpendicular to the coil and (ii) the current is zero. The torque is zero, but the inertia of the moving coil maintains the rotation and at this point the split-ring commutator switches contacts and current begins to flow in the opposite direction in the coil. This causes the torque on the coil to act in the same direction. As the rotation continues the torque increases until, having completed 180°, it will again be a maximum value. This pattern, of torque rising to a maximum when the force is perpendicular to the coil and then reducing to zero will be maintained as the coil speeds up. However, because the conductor of the motor coil is cutting magnetic flux an emf is induced causing an induced current to flow in the direction to oppose the motion that caused the change in flux (according to Faraday's and Lenz's laws). This back-emf increases as the speed of the rotating motor coil increases. This reduces the size of the current that flows through the coil. This leads to the maximum value of the torque reducing as the motor speeds up and then having a steady value once the motor achieves full speed.

21.

Answer includes the following points: • A description or a labelled diagram of the appropriate components of a transformer • The need for the primary coil to be attached to an alternating current or changing DC current supply • Describes how flux is linked between the coils via the soft iron core • Reference to an ideal situation: $P_p = P_s$ (or flux fully linked) and laminations in the core to reduce eddy currents • Makes reference to step-up and/or step-down transformers and the relationship between voltage and number of turns.	4
Describes how the components of a transformer operate to step-up or step-down the voltage, but with insufficient description of an ideal situation and/or relationship between voltage and number of turns OR inadequately describes how the components of a transformer operate to step-up or step-down the voltage, but with sufficient description of an ideal situation and/or relationship between voltage and number of turns	2-3
Identifies a transformer or its components as the apparatus required to change the voltage from a primary source	1

Specimen Answer:
A transformer is required to change the voltage of a source of electrical energy to a different voltage. A transformer consists of two coils of wire: the primary coil, attached to the source of electrical energy (voltage), and the secondary coil, which provides a different voltage to operate a second circuit. The primary and secondary coils have their flux linked via a soft iron core. In an ideal transformer the output power from the secondary coil is equal to the input power to the primary coil, i.e. $P_p = P_s$ ($V_p I_p = V_s I_s$). Furthermore, the iron core should be

laminated to reduce eddy currents. To operate, the transformer must have the primary coil attached to an alternating power supply or a constantly changing DC power supply. This change in current produces a changing magnetic field which leads to the primary coil producing a change in flux ($\phi = BA_{\perp}$). If the purpose of the transformer is to increase the voltage, it is called a step-up transformer. This is done by having a greater number of turns in the secondary coil, and vice versa for a step-down transformer.

22. (a)

Identifies current flow from N to M and shows equation with substitution of correct values.	2
Shows equation and substitution of data into equation OR identifies current flow from N to M.	1

Specimen Answer:
The current flows N to M through the rod (using the Right Hand Palm Rule and considering the rod moves to the right).
The magnitude of the force given by $F = B\,I\,l\,\sin\theta = 0.25 \times 8.4 \times 0.15 \times \sin 90° = \underline{0.315\ \text{N}}$.

22. (b)

Uses the concept of Faraday's law to explain how the motion of a conductor through a magnetic field will induce an emf and, according to Lenz's law, this opposes the motion by reducing the size of the current and as a result the magnetic force pushing the rod.	3
States that motion induces emf and, according to Lenz's law this emf opposes the motion (or produces an opposing force) by reducing the size of the current and as a result the magnetic force.	2
Describes how motion induces emf according to Lenz's law and this opposes the motion, reducing the net force.	1

Specimen Answer:
As the rod moves to the right due to the magnetic force, it will cut lines of flux. This leads to an increase in the area through which the magnetic field flows so the rod experiences a change in flux. This change in flux induces an emf across the ends of the rod according to Faraday's Law. As there is a complete circuit, the emf will give rise to an induced current that flows in the direction that will minimise the change in flux that caused it (Lenz's Law) ie M to N. As this current opposes the original direction of current flow (back emf), the current through the rod due to the applied emf will decrease, leading to a decrease in the magnetic force that is pushing it along the rails ($F = BIl \sin\theta$).

23.

Response includes the following points: • identifies Westinghouse as a supporter of AC and Edison as a supporter of DC • provides at least three advantages of AC over DC (easy transformation, the reliability and efficiency of AC generators and the production of higher currents) • identifies what is meant by large scale power (ie provision of electricity to large populations) • provides at least one significant point for and against the effect of the development of large scale electrical power on society • provides at least one significant point for and against the effect of the development of large scale electrical power on the environment • the response is coherent and succinct • the response is comprehensive (ie clarifies the majority of the points made)	7
The response includes most of the points above	5-6
The response includes some of the points above	3-4
Identifies that the Westinghouse AC system prevailed over the Edison DC system and/or states one relevant issue	1 - 2

Specimen Answer:
The Westinghouse system used alternating current (AC) whereas the Edison system used direct current (DC). The three main reasons that the Westinghouse system prevailed was:

a. the ability of AC to be efficiently transformed as opposed to the DC system. The use of a step-up transformer to increase the voltage allowed the energy to be transmitted over longer distances more cheaply, due to decreased line loss. (As P = V x I, increasing voltage leads to reduced current. As P = I^2R, decreased current results in a reduction of energy loss through transmission wires)

b. AC generators are more reliable and efficient because the contact between slip rings is continuous as opposed to the split ring commutators in the DC system.
c. AC systems are able to produce higher currents because there need not be electrical connection between the stator and the rotor (ie functions of the stator and the rotor are interchangeable).

The development of large-scale electrical power supply has had both positive and negative effects on society and the environment; mainly due to how much is now being used.
Society:

Positive effects	Negative effects
Convenient power source to supply the needs of industry, business, commerce, scientific research facilities which can lead to improved technologies being used. Life is made easier with the ever-growing array of electrical devices, lighting, heating and transportation systems. In conjunction with the development of computers and communication technologies, electricity has allowed for the information revolution and the rapid transmission of information around the world. Overcrowding in cities is reduced as people can live further away due to the ability to transmit electricity over long distances	Increased redundancies and unemployment as manual labour is replaced. Sedentary lifestyle brought about by less active home and work places due to increased automation/machines to do work. This could lead to health problems due to lack of exercise (such as obesity) and increased exposure to EM radiations. Higher work expectations. Due to the availability of electricity to the home and office, workdays are getting longer and impacting the family environment.

Environment:

Positive effects	Negative effects
The use of wood for burning for cooking and heating decreased as less is now used because electricity is used for heating. This meant reduced logging of forests and less pollution produced from the burning of wood. The previously local power stations were moved to more remote locations significantly reducing the amount of pollution in cities	The burning of coal/fossil fuels to produce greater amounts of electricity produces greenhouse gas emissions, which may lead to global warming. Depending on the level of sulfur in coal, burning of coal to produce larger amounts of electricity can lead to sulfur dioxide emissions which dissolve in water in the air to produce acid rain Land clearing in order to build transmission lines and towers

24. (a)

uses $c = f\lambda$ and $E = hf$ to correctly calculates energy of red photon using data sheet values	2
correctly uses $E = hf$ OR $c=f\lambda$	1

Specimen Answer:
$c = f\lambda \Rightarrow 3.0 \times 10^{8} = f \times 6.35 \times 10^{-7} \Rightarrow f = 4.72 \times 10^{14}$ Hz $\therefore E = hf = 6.626 \times 10^{-34} \times 4.72 \times 10^{14} = \underline{3.13 \times 10^{-19}\ \text{J}}$

24. (b)

states that electroscope will discharge through photoelectric effect if energy of photons is large enough AND distinguishes between lower energy of laser compared to UV source	2
states electroscope will discharge through photoelectric effect OR relates effect to energy	1

Specimen Answer:
The students are likely to observe that the electroscope discharges rapidly when illuminated with UV light but experiences no difference in its rate of discharge when illuminated with red laser light. This is because photons of UV light have a higher frequency and thus have greater energy than photons of red light. This means that the UV light photons are likely to have enough energy to release electrons from the zinc by the photoelectric effect (ie. have energy greater than the work function of zinc) but the red light photons do not.
NB. The photoelectric effect **cannot** be directly observed neither can you observe the speed of the electrons. The weak (low intensity) UV light means that it will discharge more slowly than if a strong source were used.

25. (a)

correctly calculates the magnitude of the magnetic field	1

Specimen Answer:
$F = qvBsin\theta \Rightarrow 2.2 \times 10^{-15} = 1.602 \times 10^{-19} \times 2.0 \times 10^{5} \times B \times sin\ 90° \quad \therefore B = \underline{6.9 \times 10^{-2}\ T}$

25. (b)

states plate Y	1

Specimen Answer:
Plate Y will be positive.

25. (c)

states that electric and magnetic forces are equal AND shows the relationship between electric field strength and separation of plates AND correctly calculates voltage in volts using the data sheet value of electron charge	3
correctly calculates the voltage in volts using data sheet values with no explanation OR states that electric force equals magnetic force and uses the relationship between electric field strength and separation of plates in attempt to calculate voltage.	2
infers or shows by equation that the electric force must equal the magnetic force OR correctly calculates the voltage or electric field strength with no explanation or units	1

Specimen Answer:
No deflection of cathode ray means that the electric force on the electron, F_E, must equal the magnetic force, F_B.
$F_E = F_B \Rightarrow qE = 2.2 \times 10^{-15} \Rightarrow 1.602 \times 10^{-19} \times E = 2.2 \times 10^{-15} \therefore E = 1.37 \times 10^{4}\ NC^{-1}$
$E = V/d \Rightarrow 1.37 \times 10^{4} = V/2.00 \times 10^{-2} \therefore V = \underline{275V}$

26.

response includes the following points and is expressed clearly: • describes what is meant by the term 'black body radiation' • relates the introduction of concept of packets of energy (quanta) to Planck's effort to explain/solve the experimentally determined black body radiation curves • distinguishes between classical and quantum theory • refers to Einstein's application of Planck's quanta to explain the photoelectric effect • extends Planck's idea of quanta being due to specific vibrations to the radiation itself • explains the photoelectric effect in terms of each electron absorbing a quantum of light (photon) and being released from the surface of a metal only if the energy of the photon exceeded the work function of the metal • outlines way/s in which Einstein hindered progress in our modern quantum theory • makes an appropriate judgement about Einstein's contribution to quantum theory	5
response includes most of the above points	3-4
response includes some of the above points	1-2

Specimen Answer:
Black bodies are ones that absorb and radiate all energy that is incident on them. Black body radiation refers to the radiation emitted from the cavity of a black body that is considered to have reached thermal equilibrium. Experimental results had yielded black body radiation curves that were temperature dependent but could not be explained with classical theory. Planck was the first to introduce the concept of a quanta (bundle of energy with E = hf) as he found a mathematical relationship that explained the black body radiation curves but he thought that his solution was just a mathematical trick. Einstein extended Planck's idea of quantised vibrations produced by atomic oscillators to the radiation itself being quantised. Classical theory was also unable to explain the results of photoelectric effect experiments that indicated that a threshold frequency of light was required. Einstein's used the concept of light quanta (later called photons) to explain these results. He explained that an electron can only absorb one photon at a time (never part of it) and if its energy is less than the work function of the metal (ie.. the energy required to release the electron from the surface of the metal), then it would not be liberated regardless of the intensity of the light and that excess energy would contribute to the KE of the photoelectron (KE = hf – W). Unfortunately, Einstein still tried to explain wave-particle duality in terms of classical theory because he, like Planck, did not really believe in quantum theory. Whilst Einstein's contribution to quantum theory was significant in that he was able to explain the photoelectric effect and back up Planck's black body explanations in term of quanta, it was limited because he did not contribute any more to the development of the modern quantum theory.

27.

response includes the following points: • maglev trains rely on magnetic levitation to minimise friction between train and track and allow them to reach very high speeds • DC superconducting (ie. zero resistance) coils on train produce large magnetic fields • magnetic levitation produced by repulsion between superconducting coils on train and magnetic fields produced by electromagnets in the track (guideway) • train is propelled forward by magnetic forces of attraction and repulsion produced by continually changing the polarity of alternate magnets along the track (ie. interaction of magnetic fields caused by DC superconducting coils and AC coils in track) • magnets are also used to reduce instability (that arises when train movement leads to varying distances between the superconducting magnets and those in the guideway) • large expense involved in cooling superconductors below their critical temperature • huge amount of electrical power required by maglev trains prohibit their wider use • at least one point for and against maglev trains • answer is coherent, well-organised and succinct	5-6
response includes most of the above points	3-4
response includes some of the above points	1-2

Specimen Answer:
The Maglev train relies on the use of onboard "supermagnets" made from superconductor loops carrying large currents and producing very powerful magnetic fields. The interaction of the these onboard magnetic fields, and those produced by currents in an arrangement of coils in the special track (guideway), allow the train to be levitated, propelled, and stabilised on the track. In order for the superconductors to operate they must be cooled below their critical temperature. This requires the Maglev train to have onboard refrigeration units using liquid nitrogen (and liquid helium where Type I superconductors are used). For operation the Maglev train requires: a very large supply of electrical energy; A number of onboard refrigerated superconducting coils producing very strong magnetic fields (~ 5 teslas); A system of specially arranged metal coils lining a guideway (track) and large guidance magnets attached to the underside of the train. There have been different forms of Maglev train developed but the basic operating principles are: - onboard superconductor magnets produce a very strong magnetic field using DC current. - the levitation coils in the guideway are engaged to repel (or attract depending on model) the train causing it to levitate just above the track. (rubber wheels are used on one model until sufficient speed is produced to allow induced currents in coils in the track to create magnetic fields large enough to allow their interaction with the onboard magnets to fully levitate the train.) – the propulsion coils in the guideway are supplied with AC to produce a unique magnetic field that both attracts and repels the onboard magnets. By controlling the frequency of the AC in the coils these magnets interact with the onboard magnets to accelerate the train to very high speeds, both pushing and pulling the train along the track. There are also stabilisation coils that act to attract or repel the train as it travels along the track, keeping it stable and allowing it to negotiate curves. Maglev trains are very expensive to build and operate but they have shown that they can work very effectively. With their ability to hover just above the track they are very efficient when moving and have achieved very high speeds (over $500 kmh^{-1}$), relying for levitation, propulsion and stability, on the interactions of the magnetic fields produced by the onboard superconductor loops and the coils in the track.

Question 28 Medical Physics – Marking Guidelines Total 25 Marks

(a) (i)

identifies total internal reflection	1

Specimen answer:
The physical principle used is total internal reflection of light.

(a) (ii)

correctly identifies the role of both coherent and incoherent bundle	2
correctly identifies role of either bundle	1

Specimen answer:
The coherent bundle of optical fibres has the role of collecting light and passing that light in a coherent arrangement to allow an image to be created. The incoherent bundle acts to transmit light into the region of study to illuminate the subject, i.e. it provides the light that reflects off the internal structures to allow the coherent bundle to collect the reflected light.

Examiners' comment:
Students should answer the question rather than 'brain dump'. The question asked for information about the 'role' of the two types of bundles and it was inappropriate to describe their thickness etc. Students run the risk of being unnecessarily penalised for including incorrect information when they go beyond what is required.

(b) (i)

correctly calculates the value and units of acoustic impedance of heart muscle and blood	2
correctly calculates value of acoustic impedance of heart muscle and blood OR correctly calculates the value and units of acoustic impedance of heart muscle or blood	1

Specimen answer:
$Z = \rho v \quad \Rightarrow$ for heart muscle, Z_{HM} = 1080 x 1580 = $\underline{1.706 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}}$
For blood, Z_B = 1025 x 1570 = $\underline{1.609 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}}$

(b) (ii)

correctly calculates the percentage intensity reflected using values from part (a)	2
substitutes values from part (a) into the correct equation OR calculates percentage from incorrect substitution into the correct equation	1

Specimen answer:
The intensity of the reflection of the ultrasound at a boundary is given by the equation:

$$\frac{I_r}{I_0} = \left[\frac{Z_2 - Z_1}{Z_2 + Z_1}\right]^2 = \frac{\left[1.706 \times 10^6 - 1.609 \times 10^6\right]^2}{\left[1.706 \times 10^6 + 1.609 \times 10^6\right]^2} = 8.547 \text{ x } 10^{-4} = 0.085\ \%$$

(c)

response includes the following points: • correctly identifies an appropriate radioisotope • relates half life to both patient exposure time and/or imaging time • refers to at least two other relevant properties that enable it to be useful • clear, coherent and succinct	3
response includes some of the above points	1-2

Specimen answer:
Iodine-123 is the radioisotope of choice for scanning the thyroid as it can be easily attached to compounds that concentrate (are metabolised) in the thyroid. It emits gamma rays of an appropriate intensity for detection outside the body. It only emits gamma radiation making it less harmful to patients than the more ionising beta emitters. It is easily produced in a cyclotron and has a half-life of just 13 hours which means it is long enough to use for imaging purposes but short enough that it is not causing the patient subsequent problems. (Students may have referred to the versatile technicium-99m (half life = 6 h) that can be attached to many different compounds.)

(d)

describes a correct similarity of AND a correct difference between the types of situations	2
provides a correct similarity of OR difference between the types of situations	1

Specimen answer:
Phase and sector scans are both used to produce ultrasound images that involve minimal risk to the patient. Sector scans provide two dimensional information but can be observed in real time and so can show movement of such things as a foetus. Phase scans, due to their direction nature, can build up three dimensional information and thus provide greater detail of such things as abdominal organs.

(e) (i)

correctly outlines an appropriate advantage and disadvantage of PET scans	2
correctly outlines either an advantage or disadvantage of PET scans	1

Specimen answer:
A significant advantage of PET scans is that an appropriate radioisotope can be attached to certain biologically active molecules to allow it to be targeted at particular organs or tissue and reveal. A disadvantage of the PET scan is that the patient is exposed to increased levels of radiation (and there is a potential risk involved in the production and handling of any radioisotope).

(e) (ii)

clear description that includes details of radio pharmaceuticals, metabolism into target organs, positron emission by radioisotope, positron-electron annihilation , gamma rays at 180° to each other, gamma detectors, image produced by computer	3-4
correct reference is made to some of the details above	1-2

Specimen answer:
A radioisotope (such as F-18 that is unstable because it is too rich in protons compared with neutrons) can be incorporated into certain molecules (ie. to produce a radiopharmaceutical) that, when inhaled, ingested or injected, accumulate in the organ or region of the body to be studied (such as a tumour which is metabolically more active). The radioisotope decays by emission of positrons that travel no more than a few millimetres before colliding with electrons in the organ. In these collisions, a positron and an electron are annihilated producing two γ-rays that travel at 180° to each other. The γ-rays produced in these annihilations are detected by a ring of detectors that surrounds the patient and turned into an image by a computer by the analysis of different times of arrival of the γ-rays. Metabolic activity is indicated by different brightnesses on the image produced in the PET scan.

(f)

A coherent, well organised answer using appropriate language and terminology providing a good outline of both MRI and CAT scans highlighting similarities and differences between the actual techniques used and the information produced. Gives clear indication of the possible effects of both scans on the patient.	7
Provides a good and organised outline of how both MRI and CAT scans are conducted. Shows at least one similarity and including suitable comment on the differences between the techniques. Gives an indication of the possible effects of both scans on the patient.	6
Includes a fair description of both techniques including a least one similarity and two differences. Comments on the effects of the scans on patient.	5
Clearly outlines one or both techniques and includes at least one similarity and two differences (or vice versa) between the techniques and/or effects on patients OR provides many similarities and differences but insufficient detail on actual techniques	4
Offers some/sketchy detail on one or both of the scanning techniques and includes a least one similarity or two differences between techniques and/or effects on patients	3
Weak answer but provides at least two differences OR one similarity and one difference in the techniques and/or effects on patients	2
Very weak answer but offers at least one appropriate piece of information to show a similarity or difference in the techniques used to collect CAT and MRI scans or an effect	1

Specimen answer:

CAT scans	**MRI scans**
Both techniques involve electromagnetic waves.	
Both techniques require patient to rest inside a gantry which may cause claustrophobia in patients.	
Neither technique involves invasive surgery and thus harm to patient is minimised.	
Both detect radiation around patient and use this information to build up a cross-sectional image/slice.	
Both utilise a computer (complex algorithms) to produce an image from the detected radiation.	
rely on X-rays	rely on B-fields and radio frequency pulses
require high potential difference to accelerate and tungsten target to decelerate electrons in an evacuated chamber to produce X-rays	require superconducting electromagnet and cooling mechanism to produce strong B-field that causes nuclei with net spin such as hydrogen to precess and thus be able to resonate when RF pulses are applied
radiation detected by scintillations of sensors	radiation detected by induction in coils
X-ray machine and detectors rotated 360° around patient and array of sensors detect the X-rays that pass through the patient and send this information to a computer for analysis	Precessing nuclei in body absorb energy and change state when they are subjected to RF pulses (resonate). As these nuclei relax, receiver coils around the patient detect the RF pulses that are reradiated by these nuclei and send this information to a computer for analysis
position of slice determined by position of patient within the gantry	position of slice determined by gradient B-fields (consequently slice does not have to be axial like CAT)
image dependent on attenuation of X-rays	image dependent on number of hydrogen nuclei, their bonding and surrounding environment as these affect the rate at which the nuclei relax
less complicated processes and so cheaper and scan takes patient less time	more complicated processes and so more expensive and scan takes patient longer
less claustrophobic for patient	more claustrophobic for patient
more likely to harm patient permanently (X-rays are ionising radiation that may cause cancer)	less likely to harm most patients permanently (effects of strong B-fields thought to be harmless)
no difference in effect of CAT scans on patients with pacemakers or metal implants	MRI scans should not be done on patients with pacemakers or metal implants because of likely damage due to heating and/or magnetic effects

Examiners' comment:
Student responses generally needed to provide more detail on the actual techniques employed so that appropriate similarities and differences could be given. In some cases, students did not make their similarities of and differences between techniques employed and effects on patients sufficiently explicit. The answers that scored well tended include a description of each of the techniques as well as a table or list of similarities and differences. Students were penalised if they included incorrect information about aspects of either of the techniques.