2008

Higher School Certificate

Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and Periodic Table are provided separately
- Write your student number and/or name at the top of every page

Section I Pages 2 – 20
Total marks (75)
This section has two parts, Part A and Part B

Part A
Total marks (15)
Attempt questions 1-15
Allow about 30 minutes for this part

Part B
Total marks (60)
Attempt questions 16-29
Allow about 1 hour 45 minutes for this part

Section II Pages 21 – 29
Total marks (25)
Attempt ONE question from Questions 30-34
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

STUDENT NUMBER/NAME: .....

Section I
Total marks (75)

Part A
Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
2				
3				
4				
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9				
10				
11				
12				
13				
14				
15				

1. Planet X has twice the mass and half the radius of planet Y. What is the ratio of the weight of a 10 kg mass on planet X to its weight on planet Y?

(A) 1 : 1

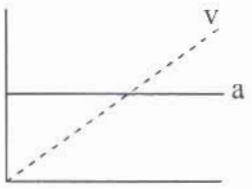
(B) 2 : 1

(C) 4 : 1

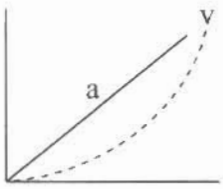
(D) 8 : 1

2. A rocket takes off from the launch pad with constant thrust. Which choice best shows how its acceleration and velocity change as it rises?

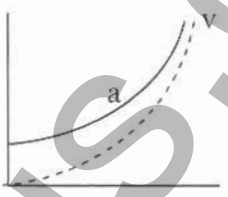
(A)



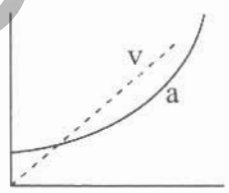
(B)



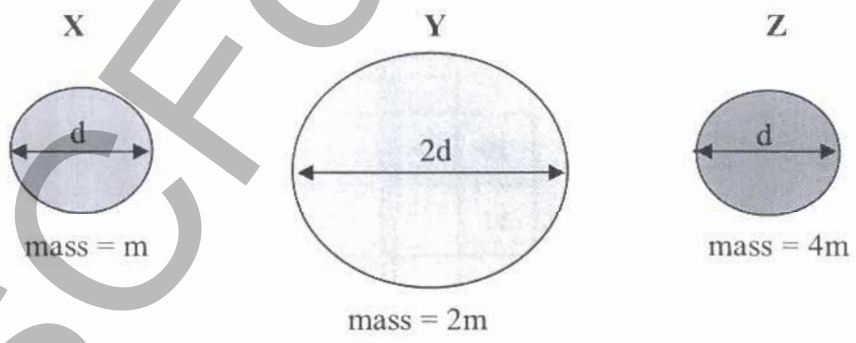
(C)



(D)



3. Consider the following planets, X, Y and Z.



What is the correct ratio of the escape velocity of these planets?

Note: $v_e = \sqrt{\frac{2GM}{r}}$

(A) X : Y : Z = 1 : 1 : 2

(B) X : Y : Z = 1 : 2 : 4

(C) X : Y : Z = 2 : 1 : 4

(D) X : Y : Z = 2 : 1 : 2

4. Two astronauts landed on a very small asteroid orbiting the Sun between Mars and Jupiter. They experienced almost negligible weight force. Which statement explains this?

(A) Because the asteroid is in a stable orbit around the Sun it will have zero mass.

(B) Because the asteroid is in a stable orbit around the Sun, the astronauts will apparently be weightless.

(C) Because the asteroid is very small it will have very small gravitational force.

(D) The gravitational force on the asteroid is balanced by an equal and opposite gravitational force on the astronauts.

5. Michelson and Morley expected to see a shift in an interference pattern in their experiment. They were destined to always get a null result. Why?

(A) A positive result would violate the principle of relativity.

(B) The Earth's speed through space is too small compared to the speed of light for the experiment to give a significant result.

(C) Any variation in the speed of light could be explained by experimental errors.

(D) Einstein had proven that the speed of light was constant in a particular medium.

6. Which of the following devices could be used to demonstrate the motor effect?

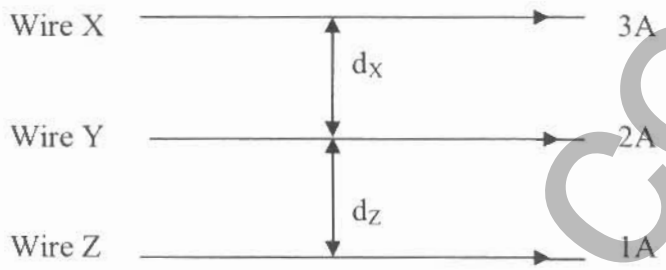
(A) Transformer

(B) Induction cooktop

(C) Generator

(D) Loudspeaker

7. Three long parallel wires X, Y and Z are positioned in the same plane and conduct different currents in the same direction as shown. The current in wire X is 3A, in wire Y is 2A and in wire Z is 1A. Wires X and Y are separated by a distance d_X and wires Y and Z are separated by a distance d_Z.



What is the relationship between the distances if the force on wire Y is zero?

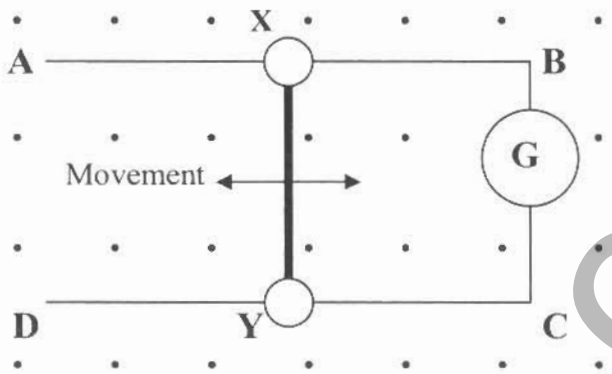
(A) $3\,d_X = d_Z$

(B) $d_X = 3d_Z$

(C) $5d_X = 2\,d_Z$

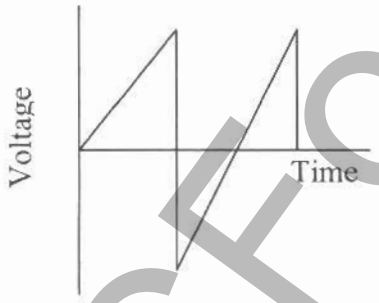
(D) $d_X = d_Z$

8. A conductor ABCD is situated in a magnetic field directed out of the page. The conductor has a galvanometer inserted in side BC and a conducting rod XY connects the sides AB and CD as shown. The rod XY is able to slide and is moved 5cm to the left, then10cm to the right and back to its initial position.

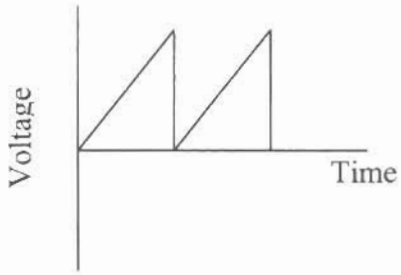


Which graph shows the possible voltage changes that could be observed on the galvanometer?

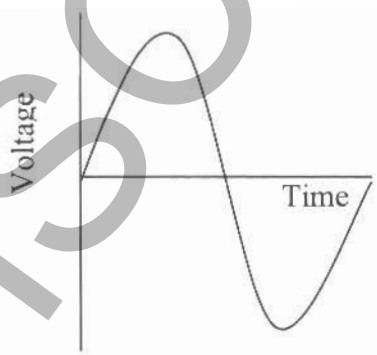
(A)



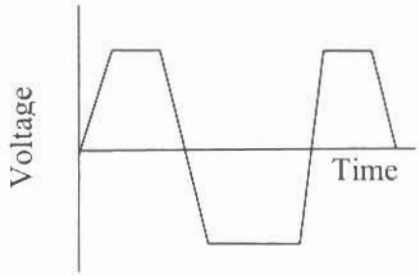
(B)



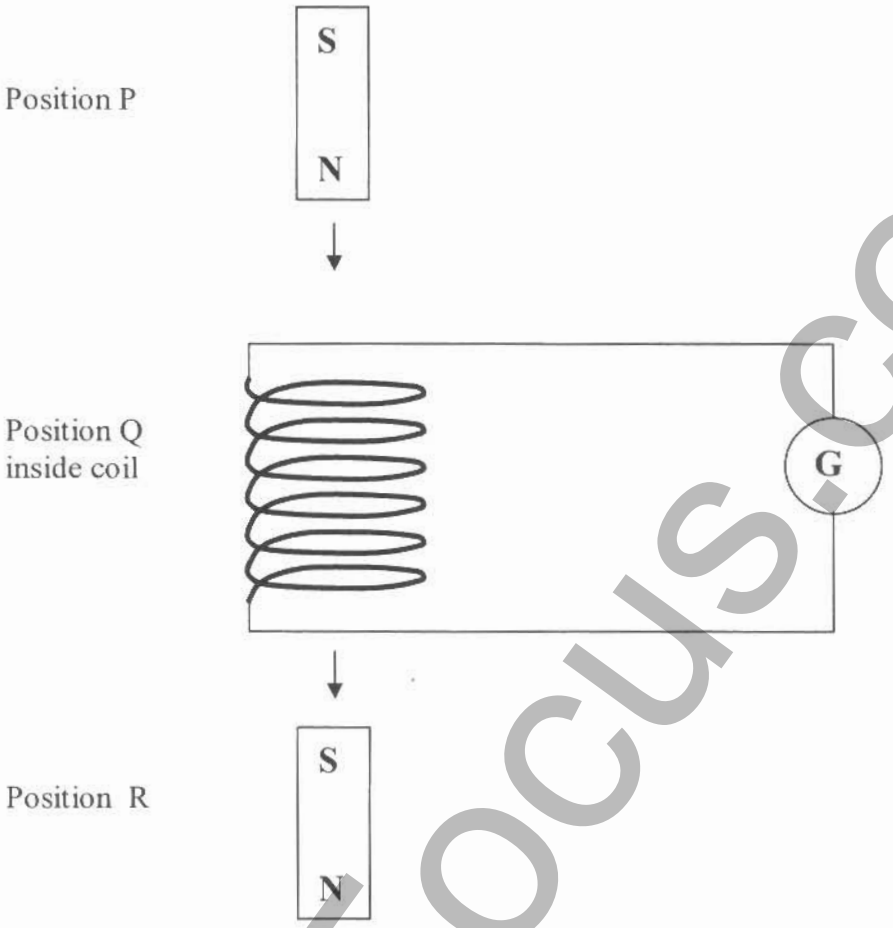
(C)



(D)



9. A magnet is dropped so that it moves through a coil that is suspended vertically. The coil is connected to a galvanometer.



Which alternative could describe the galvanometer needle deflection as the magnet moves from position P through Q to R?

	Position P	Position Q	Position R
(A)	To the right	No deflection	To the right
(B)	To the right	To the right	No deflection
(C)	To the right	No deflection	To the left
(D)	To the right	To the right	To the right

10. Electrical power was first transmitted by Edison in 1882 and soon afterwards a competition developed between Edison and Westinghouse to supply electricity to cities.

What is the main reason that Westinghouse was successful?

(A) He was able to use transformers to change the transmission voltage.

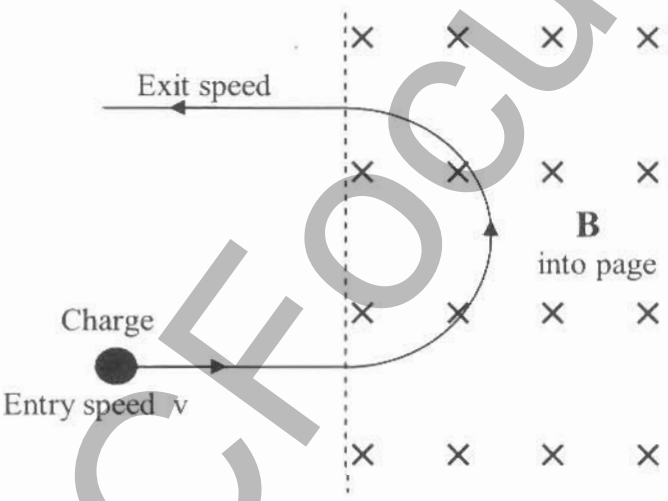
(B) He spent more money on advertising.

(C) He developed a safer system of electricity supply.

(D) The Westinghouse company was better known.

Use the following information to answer Questions 11 and 12.

The diagram shows a charged particle entering a magnetic field (**B**) directed into the page. The charge is moving with a speed (v) perpendicular to the boundary of the magnetic field and moves in a semi-circle in time (T) before it leaves the magnetic field.



11. Which alternative describes the charge and exit speed of the particle?

	Charge	Exit speed
(A)	Positive	v
(B)	Negative	v
(C)	Positive	Less than v
(D)	Negative	Less than v

Question 12 refers to the diagram on page 8.

12. What will be the time to complete the semi-circular motion if the entry speed is doubled?

(A) 0.5 T

(B) T

(C) 2 T

(D) 4 T

13 What is the energy (in joules) of a light photon with a wavelength of 5.0×10^{-7} m?

(A) 6.0×10^{14} J

(B) 4.0×10^{-19} J

(C) 3.3×10^{-41} J

(D) 1.1×10^{-48} J

14 Which factors were responsible for the invention of transistors?

(A)	Increased research into the structure of the atom	The need for satellite communication
(B)	The ability to produce pure silicon	The limitations of previous technologies
(C)	Increased research into the structure of the atom	The limitations of previous technologies
(D)	The ability to produce pure silicon	The need for satellite communication

15 Which of the following describes the band structure of a semiconductor?

(A) There is a forbidden band with a large energy gap between the filled band and the next allowed band.

(B) The partially filled band valence overlaps the conduction band.

(C) On cooling, the band structure changes to allow electrons to cross the energy gap more easily.

(D) There is a small energy gap between the almost filled valence band and the conduction band.

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 29
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (5 marks)

The period (T) of a pendulum is given by the equation:

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

where ℓ is the length of the pendulum and g is Earth's gravitational acceleration.

A group of scientists conducted an experiment on Earth to check the relationship between the period of the pendulum and its length. They then took their apparatus to the Moon and repeated the experiment.

(a) How would their results on the Moon be similar to those they obtained on Earth? **1**

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(b) Explain why their results would be similar in this way. **1**

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(c) How would their results on the Moon be different to those they obtained on Earth? **1**

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(d) Explain why their results would be different in this way. **1**

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Question 16 continues on page 11

Marks

Question 16 (continued)

(e) Sketch TWO graphs on the axes below to compare the results the scientists would obtain for the relationship between the square of the period and the length of the pendulum on Earth and the Moon. Be sure to label EACH graph. **1**

Question 17 (5 marks)

Two students are 130 m apart. One holds a paint ball gun 1.2 m above the ground and fires a paint ball at the other. The ball leaves the gun at 40 ms^{-1} at an angle of elevation of 20°.

(a) Calculate the maximum height of the paint ball above its firing position. **2**

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(b) Calculate whether or not the ball hits the second student. **3**

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Marks

Question 18 (4 marks)

(a) Give TWO reasons to explain why the concept of g-force is useful. **2**

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(b) How would our exploration of the solar system be different if the slingshot effect did not exist? **2**

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Question 19 (6 marks)

A group of students did two experiments to determine the acceleration due to gravity.

Firstly, they dropped a ball from a vertical height of 3.0 m and measured the time of fall using a stopwatch. From this they calculated the average speed of the ball and hence its final speed and acceleration.

Next they set up a 3.0 m length of board with an angle of elevation of 20^{o}. The board had a groove cut along its length the same curvature as the ball. They measured the time it took the ball to roll down the board. From this they calculated the average speed of the ball and hence its final speed and its acceleration down the slope. They then calculated a value for the acceleration due to gravity.

(a) Compare the accuracy of the time measurements in the experiments. **2**

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Question 19 continues on page 13

Marks

Question 19 (continued)

(b) Compare the validity of EACH experiment. **2**

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Question 20 (2 marks)

(a) After being created in the upper atmosphere by cosmic rays, mu mesons have speeds that exceed 2.95×10^8 ms^{-1}. An observer on Earth measures their lifetime as 1.221×10^{-5} s.
Calculate the lifetime of such a meson in its own frame of reference. **1**

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(b) Define an inertial frame of reference. **1**

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Question 21 (2 marks)

Describe TWO different ways in which motors are used in industry or the home to convert electrical energy into more useful forms of energy. **2**

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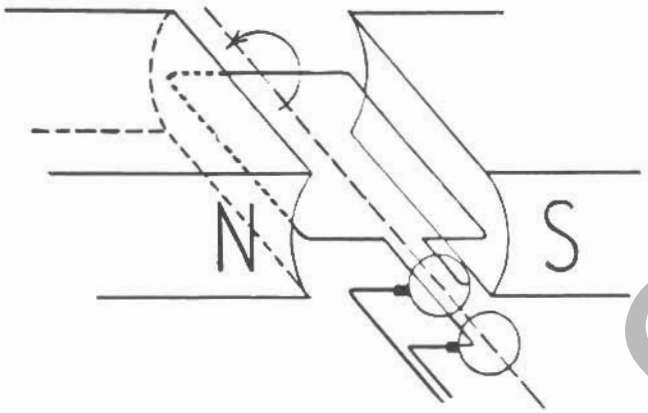
Marks

Question 22 (6 marks)

A rectangular coil of conducting wire is rotated in the magnetic field between the poles of magnets as shown.



(a) Propose ONE change to the experimental set up that would increase the electromotive force generated. **1**

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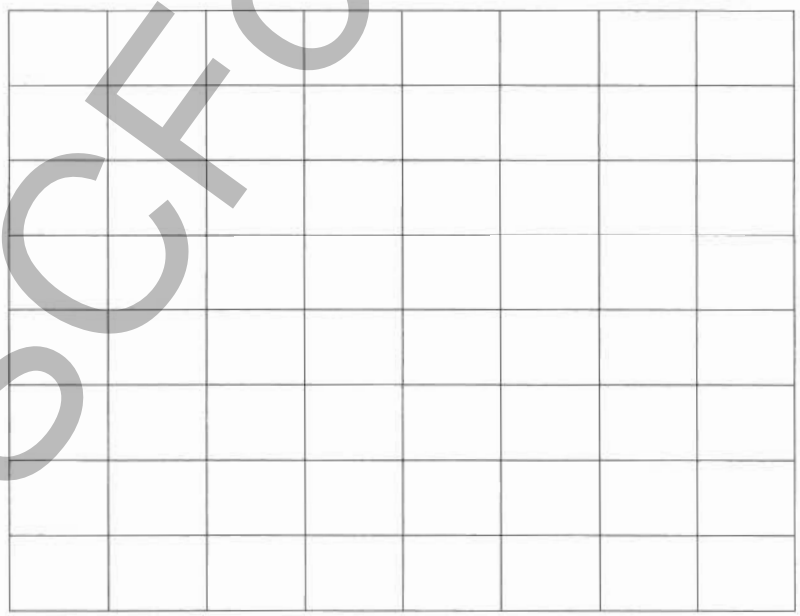
(b) Sketch a graph of the emf generated as the coil is rotated through one revolution beginning from the position shown at time t = 0. **1**



Question 22 continues on page 15

Marks

Question 22 (continued)

(c) Analyse the relationship between emf generated and the flux through the coil. **2**

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(d) Justify the difference in the energy required to rotate the coil when the coil is connected to a light globe compared to an open circuit as shown. **2**

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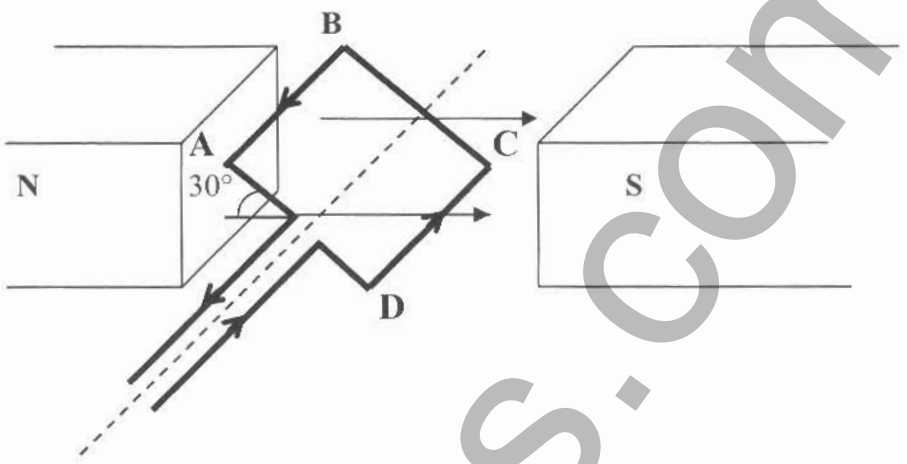
Marks

Question 23 (5 marks)

A rectangular coil of 20 loops is positioned between the poles of bar magnets and its plane makes an angle of 30° with the direction of the magnetic field as shown. The side AB measures 15 cm while the side BC measures 18 cm. The magnetic field between the poles of the magnets is 5.0 mT and the current through the coil is 25 mA.



(a) Calculate the magnitude and direction of the force on side AB when the coil is at an angle of 30° with the direction of the magnetic field as shown. **2**

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(b) Define *torque*. **1**

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(c) Calculate the torque acting on the coil when it is at an angle of 30° with the direction of the magnetic field as shown. **1**

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(d) Many motors do not contain permanent magnets. State how the magnetic field is produced. **1**

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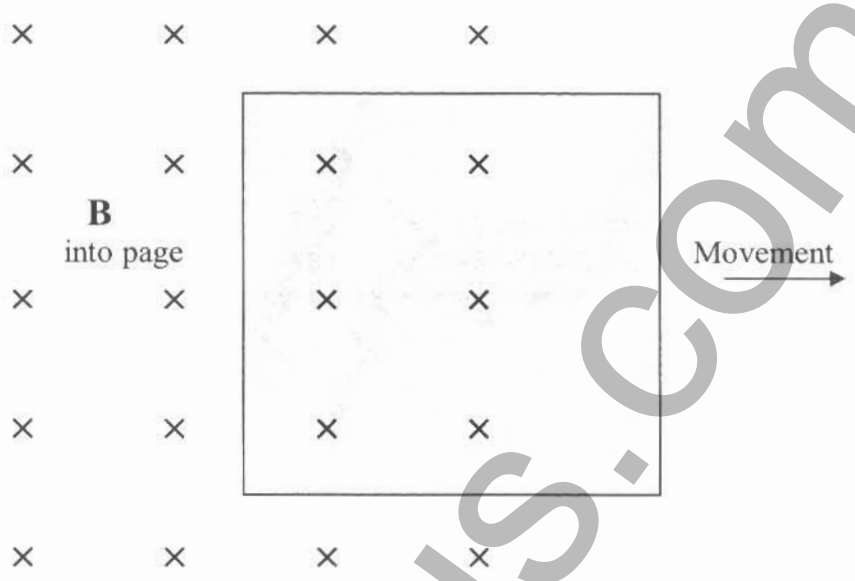
Marks

Question 24 (4 marks)

Part of a flat horizontal metal sheet is perpendicular to a magnetic field into the page, as shown. The sheet is moved out of the magnetic field at constant speed.



(a) Draw on the diagram the eddy current that is produced in the sheet as it moves out of the magnetic field. Include the direction of the current. **2**

(b) Using Lenz's Law, explain the production of the eddy current in the sheet. **2**

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Marks

Question 25 (3 marks)

Describe a first-hand school laboratory investigation to model the structure of a transformer to demonstrate how secondary voltage is produced. **3**

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Question 26 (6 marks)

(a) Describe the main components of the apparatus used by Thomson to determine the charge to mass ratio of electrons. **3**

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(b) *Explain how Thomson was able to calculate the speed of the charges moving* through his apparatus by measuring two quantities once the magnitude of the magnetic field had been determined. **3**

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Marks

Question 27 (4 marks)

(a) Describe the quantum model of radiation put forward by Max Planck. **2**

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(b) Identify the contribution made by Einstein to quantum theory. **2**

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Question 28 (4 marks)

(a) Account for the occurrence of "holes" in semiconductors and their involvement in the flow of current in semiconductors. **3**

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(b) Outline the use of heat in thermionic devices. **1**

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STUDENT NUMBER/NAME: .....

Marks

Question 29 (6 marks)

(a) Name TWO of the three groups of substances that have been identified as exhibiting superconductivity and name an example for EACH group. **2**

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(b) Name the group of superconductors with the highest critical temperature. **1**

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(c) Discuss the BCS theory proposed to explain superconductivity. **3**

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STUDENT NUMBER/NAME: .....

Section II

Total marks (25)

Attempt ONE question from Questions 30 – 34
Allow about 45 minutes for this section

Answer the question on your own paper or writing booklet, if provided.

Show all relevant working in questions involving calculations

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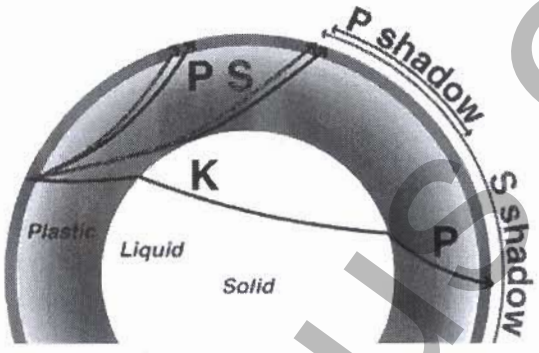
Marks

Question 30 — Geophysics (25 marks)

(a) During your study of geophysics you carried out a first-hand investigation to model the principles of reflection and refraction of seismic waves.

Many trial runs of this investigation are recorded by a group of students and the data is not consistent. What is the best classification for the overall result; a reliable result or an unreliable result or a null result? Justify your answer by addressing all three terms. **3**

(b) The dimension of the Earth's core was determined precisely and its state was shown to be liquid due to its failure to support S-type earthquake-waves. By 1935, the inside of the Earth was thought to consist of a fluid iron core surrounded by a solid rock mantle.



(i) State whether the determination of the Earth's structure or the Earth's composition is addressed most directly through studies of earthquakes. Identify the most reliable source of information about the Earth's composition. **2**

(ii) The diagram shows the path of seismic waves through Earth. Account for the features shown such as the curved path followed by all the waves and the difference in the behavior of the S-type wave and the P-type wave. **4**

(iii) By 1936 Inge Lehmann discovered the inner core by carefully studying the shadow zone. Describe how this was done. **2**

Question 30 continues on page 23

Marks

Question 30 (continued)

(c) The Hamersley Ranges are important because some of the largest known deposits of iron ore are mined there. The picture shows folded rocks in a gorge east of the town of Newman in the Hamersley Ranges.

(i) Describe how this formation occurred. **2**

(ii) State possible impacts of geology research in this area on science and the community. **2**

(d) A satellite orbits the Earth with a period of 6.5 hours.

(i) Calculate the radius of the orbit of this satellite. **1**

(ii) Describe how this satellite could detect changes in the density of the crust below, as it orbits the planet. **2**

(e) The geosciences are not a purely quantitative science; it is still heavily dependent upon observation, careful deductive reasoning and interpretation of data. These types of skills are often critical for effective problem solving or producing accurate conclusions.

Discuss how this was applied to the magnetic surveys of oceanic ridges and to the theory of plate tectonics. **7**

End of Question 30

Marks

Question 31 – Medical Physics (25 marks)

(a) The following table shows the density and the speed of sound in different parts of the body.

Body part	Density (kg/m^3)	Speed of sound (m/s)
fat	0.93 x 1000	1480
blood	1.00 x 1000	1560
brain	1.04 x 1000	1521
kidney	1.04 x 1000	1561
muscle	1.06 x 1000	1570
liver	1.07 x 1000	1549

(i) Does the data show that density is directly proportional to the speed of sound? Justify your response. **2**

(ii) Calculate the ratio of reflected intensity to initial intensity when the ultrasound reflects from the boundary between fat and muscle. **2**

(b) X-rays and CT scans are both important types of scans in medical physics.

(i) Identify TWO advantages and TWO disadvantages of CT scans over X-ray images. **3**

(ii) Identify ONE way a bone scan can provide better information than a CAT scan. **1**

(iii) Explain how the contrast of a standard CT scan can be improved. **2**

(c) Doctors and medical physicists can make use of radioactive isotopes to image a patient.

(i) Explain how this process works. **2**

(ii) Describe how radioisotope scans can be used to improve patient care and to carry out research. **2**

(d) Describe the use of particular types of electromagnetic waves that are involved in the production and interpretation of an MRI scan. **4**

(e) Science involves identifying a problem, designing a program of investigation to address that problem, collecting data, developing a hypothesis, and then undertaking a course of action.

Discuss how this applies to the case of using a PET scan to assist a patient who is sick because of a tumour. **7**

End of Question 31

Marks

Question 32 – Astrophysics (25 marks)

(a) The telescope was first used by Galileo to observe objects in the night sky.

(i) Outline ONE feature of the Moon identified by Galileo using the telescope. **1**

(ii) Define the terms resolution and sensitivity. **2**

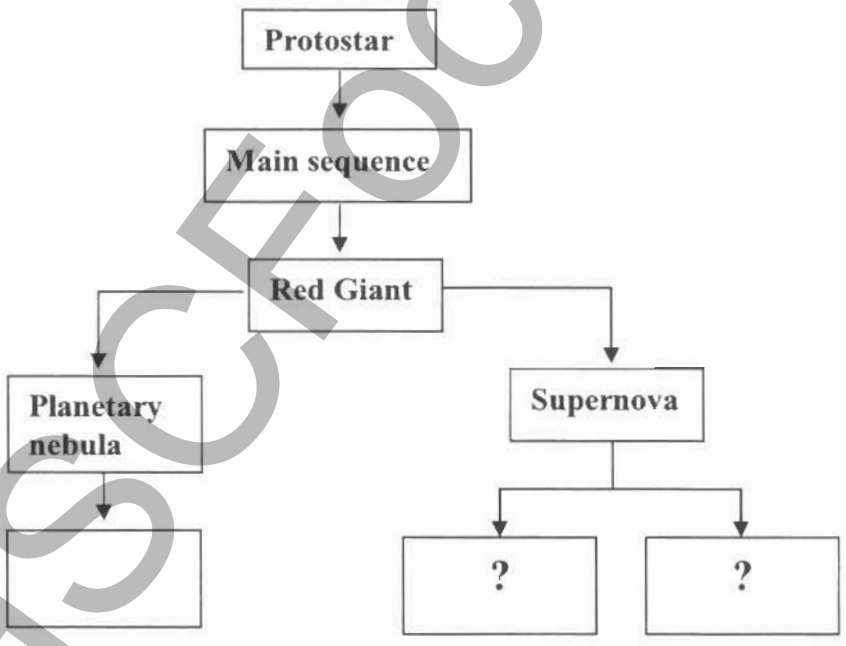
(b) (i) Describe TWO different pieces of equipment used to produce TWO different spectra in a school laboratory. **2**

(ii) Contrast the TWO different spectra produced by the pieces of equipment described above and account for the differences. **2**

(iii) Identify a method to increase the intensity of short wavelengths of visible light in a spectrum being emitted by a black body radiator. **1**

(c) Compare the relative limits to trigonometric parallax distance determinations using ground-based and space-based telescopes. **3**

(d) The flow chart shows the key stages in the life of a star.



(i) Depending on the mass of the red giant star, there are two possible remnants after a supernova explosion. Identify the TWO remnants. **1**

(ii) Outline the physical processes involved as a red giant star becomes a supernova. **2**

Question 32 continues on page 26

Marks

Question 32 continued.

(e) The star Arcturus has an apparent magnitude of -0.06 and an absolute magnitude of -0.31. Calculate its distance from Earth in parsecs. **2**

(f) (i) Sketch an H-R diagram, with the axes appropriately labelled, for the stars in a young open cluster. **1**

(ii) Sketch an H-R diagram for the stars in a globular cluster. **1**

(iii) Explain why the H-R diagrams are different for a young open cluster and a globular cluster. **1**

(g) Binary stars are classed as visual, eclipsing, spectroscopic or astrometric binaries.

Discuss the techniques used to identify binary stars and a limitation for EACH technique that makes it unable to be used to identify some stars as binaries. **6**

End of Question 32.

Marks

Question 33 – From Quanta to Quarks (25 marks)

(a) Bohr's mathematical model of the atom was an important breakthrough in developing a model that would better explain the observed phenomena.

(i) Describe the observed phenomena that could not be accounted for by the Rutherford model of the atom. **3**

(ii) Calculate the energy of a photon emitted by an electron moving from the energy state n = 4 to n = 3. **2**

(iii) Justify the need for physicists to improve on the Bohr model of the atom. **2**

(b) (i) Explain how de Broglie's hypothesis accounted for the stability of the electron orbits in the Bohr model of the atom. **2**

(ii) Describe the confirmation of de Broglie's proposal by Davisson and Germer. **3**

(c) (i) Evaluate the relative contributions of the THREE forces acting on nucleons inside the nucleus of the atom. **2**

(ii) Identify TWO properties of the nuclear force. **2**

(d) Fermi and his team were the first group to cause nuclear fission but failed to recognize it. Describe his experiment. **3**

(e) Outline the Manhattan Project and assess its significance to society. ***6***

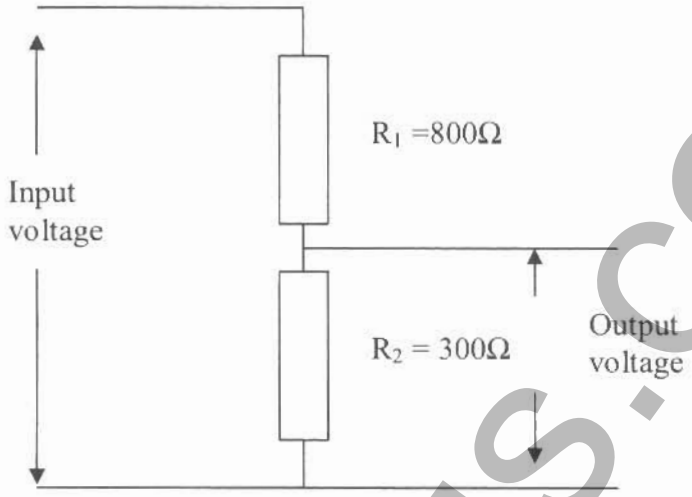
End of question 33

Marks

Question 34 – The Age of Silicon (25 marks)

(a) The potential divider is a very useful component found in many circuits.

(i) Evaluate the ratio of output voltage to input voltage for the potential divider shown in the diagram if $R_1 = 800\ \Omega$ and $R_2 = 300\ \Omega$. **2**



(ii) LDR devices may be used in a potential divider. Explain why the amount of light falling on the LDR device determines its resistance. **1**

b) (i) Recall the TWO types of thermistor and describe how they respond differently to heat. **2**

(ii) Explain why thermistors are considered analogue devices. **1**

(c) Outline the series of events when an electro-mechanical switch or relay is triggered. **3**

(d) The development of electronics resulted in major changes to life during the twentieth century.

(i) Distinguish between silicon chips, transistors and integrated circuits. Explain how the invention of these components improved electronic devices available to society. **5**

(ii) Explain how quantum effects are causing problems for electronic engineers. **1**

Question 34 continues on page 29

Marks

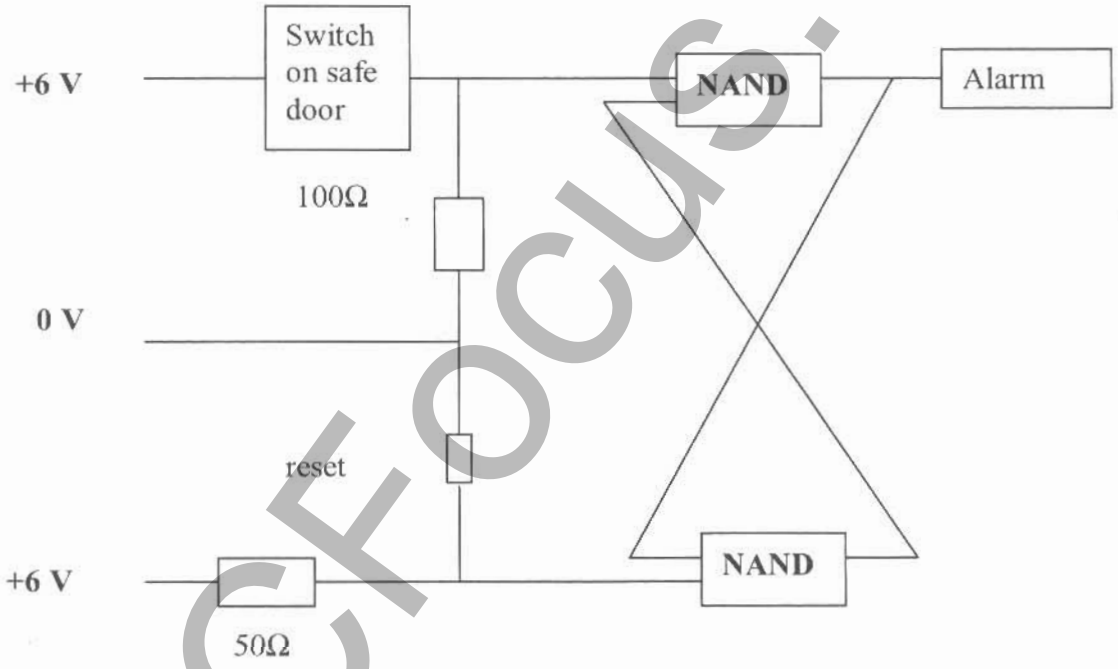
Question 34 (continued)

(e) (i) Sketch a graph to show the transfer characteristics of an inverting amplifier. **2**

(ii) On your graph, identify the voltage range over which the amplifier acts as a linear device. **1**

(iii) Describe the TWO properties of an ideal amplifier. **2**

(f) A burglar alarm on the door of a safe uses two NAND gates in its circuit shown below. When the safe door is closed and the alarm set, there is a current flowing to the top input of the upper NAND gate.



(i) Construct a truth table for a NAND gate. **1**

(ii) Predict the sequence of changes in the inputs and outputs of the NAND gates when the safe door is opened. **2**

(iii) The alarm continues to ring after the safe door is shut until the reset is pressed, closing the open circuit at that point. Outline the changes to the gate inputs and outputs when the reset button is pressed. **2**

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