BOARD OF STUDIES
NEW SOUTH WALES

2006

HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- 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 pages 13, 17, 19, 23, 25 and 27

Total marks – 100

Section I Pages 2–28

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks

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

Part B – 60 marks

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

Section II Pages 29–44

25 marks

- Attempt ONE question from Questions 28–32
- 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.

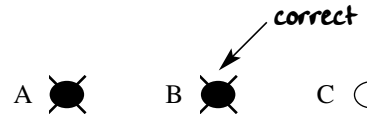
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 Given that G is the universal gravitational constant, and g is the magnitude of the acceleration due to gravity, which statement is true?

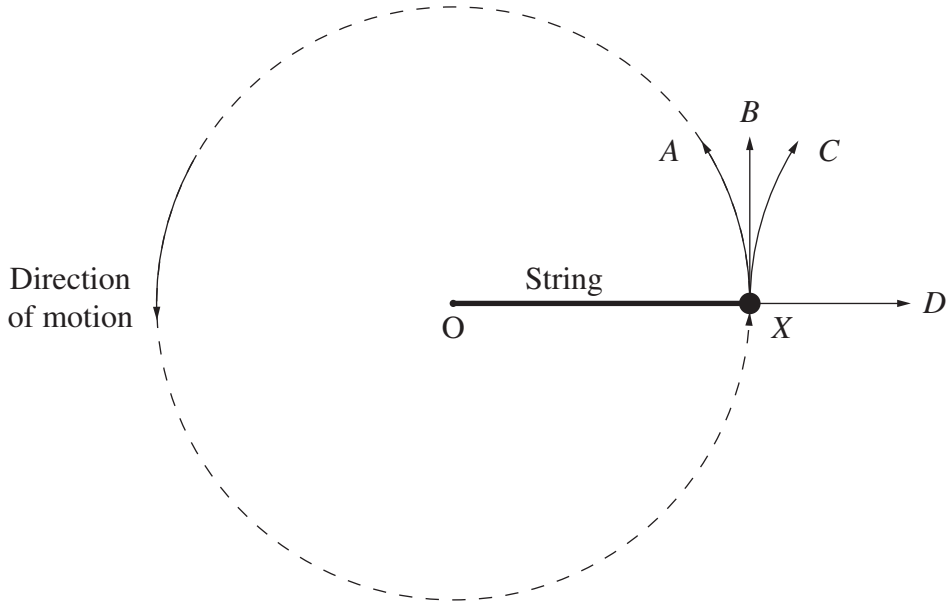
(A) The values of G and g depend on location.

(B) The values of G and g are independent of location.

(C) G is the same everywhere in the universe, but g is not.

(D) g is the same everywhere in the universe, but G is not.

2 A mass attached to a length of string is moving in a circular path around a central point, O, on a flat, horizontal, frictionless table. This is depicted in the diagram below. The string breaks as the mass passes point X.



Which line best depicts the subsequent path of the mass?

(A) Line A

(B) Line B

(C) Line C

(D) Line D

3 What is the main reason why the Michelson-Morley experiment is considered important?

(A) It shows the existence of the aether.

(B) It suggests that light is an electromagnetic wave.

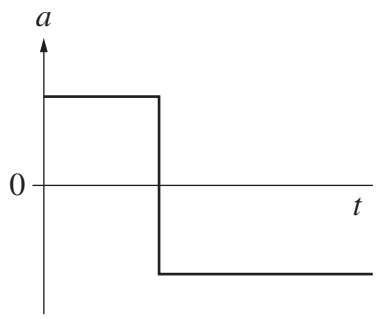
(C) It indicates that light can exhibit interference effects.

(D) It provides experimental support for the theory of relativity.

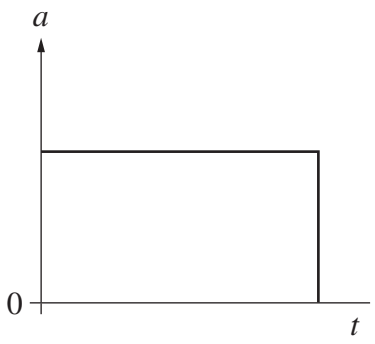
4 A stone is thrown horizontally from the top of a cliff and falls onto the beach below.

Which acceleration–time graph best describes the motion of the stone?

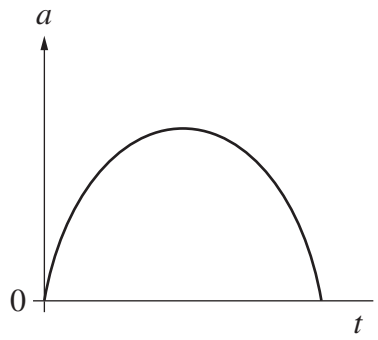
(A)



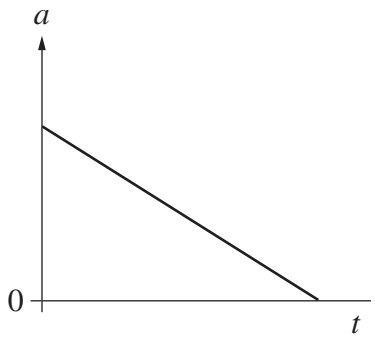
(B)



(C)



(D)



5 Two satellites, *X* and *Y*, are in circular orbits around Earth. Their masses are identical and their orbital radii are R and 16R, respectively.

What is the ratio of their orbital periods, $T_X : T_Y$?

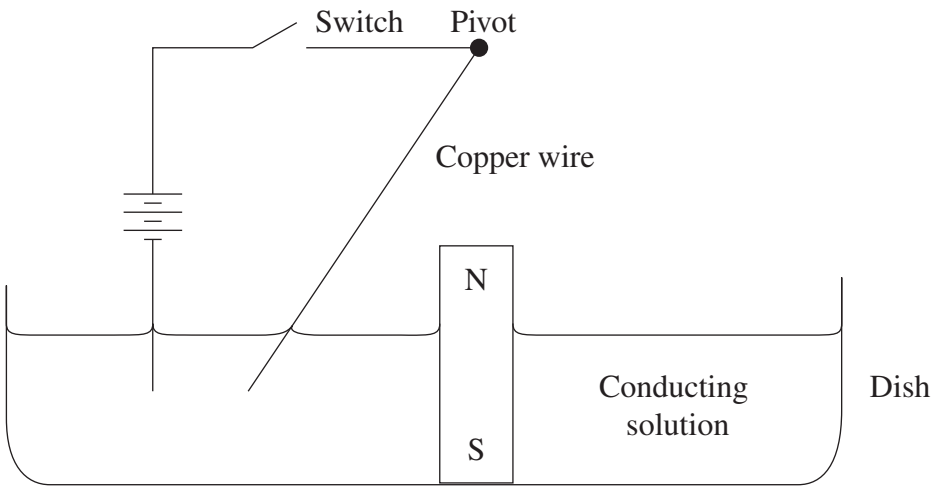
(A) 1 : 4

(B) 1 : 16

(C) 1 : 32

(D) 1 : 64

6 The diagram shows a magnet standing on the bottom of a dish filled with a conducting solution. A copper wire is suspended freely from a point above the magnet with its tip in the conducting solution. It is held in the position shown.



The switch is closed and the wire released.

Which of the following will be observed?

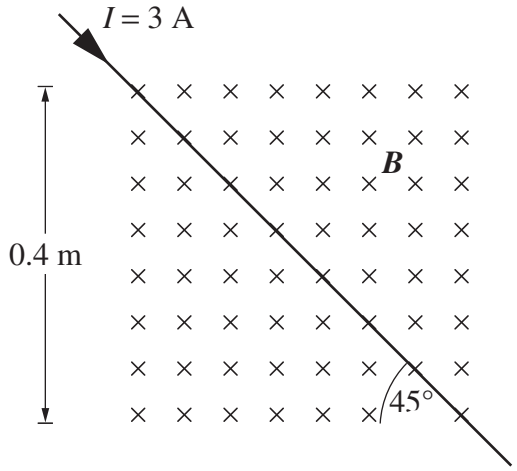
(A) The wire will rotate about the magnet.

(B) The wire will be attracted to the magnet.

(C) The magnet will rotate about its vertical axis.

(D) The solution in the dish will rotate about the magnet.

7 A current-carrying conductor passes through a square region of magnetic field, magnitude 0.5 T, as shown in the diagram. The magnetic field is directed into the page.



What is the magnitude of the magnetic force on the conductor?

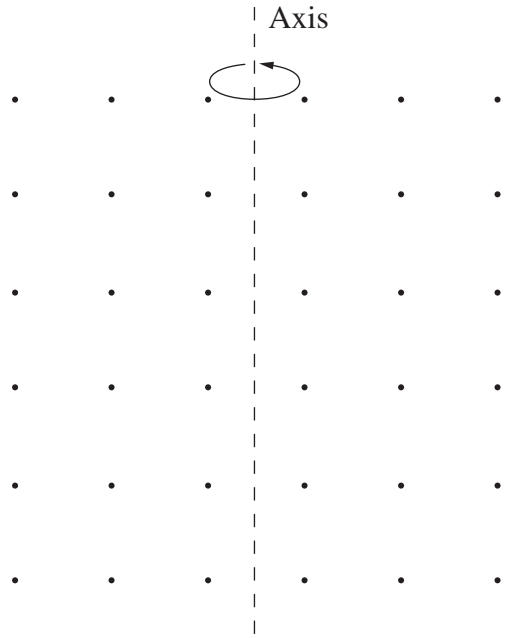
(A) 0.170 N

(B) 0.424 N

(C) 0.600 N

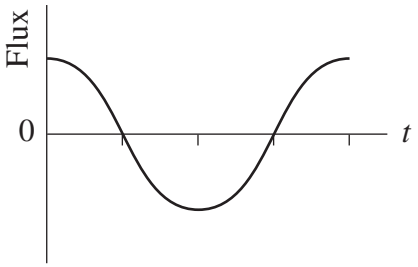
(D) 0.849 N

8 A square loop of wire, in a uniform magnetic field, is rotating at a constant rate about an axis as shown. The magnetic field is directed out of the plane of the page. At time $t = 0$ the plane of the loop is perpendicular to the magnetic field and side XY is moving out of the page.

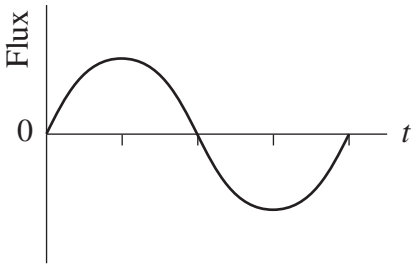


Which graph best represents the variation of the magnetic flux through the loop with time?

(A)



(B)



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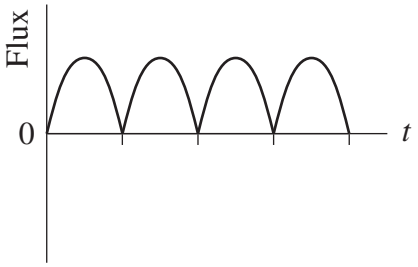
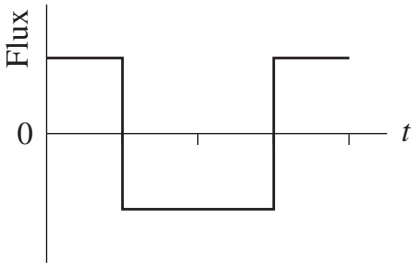
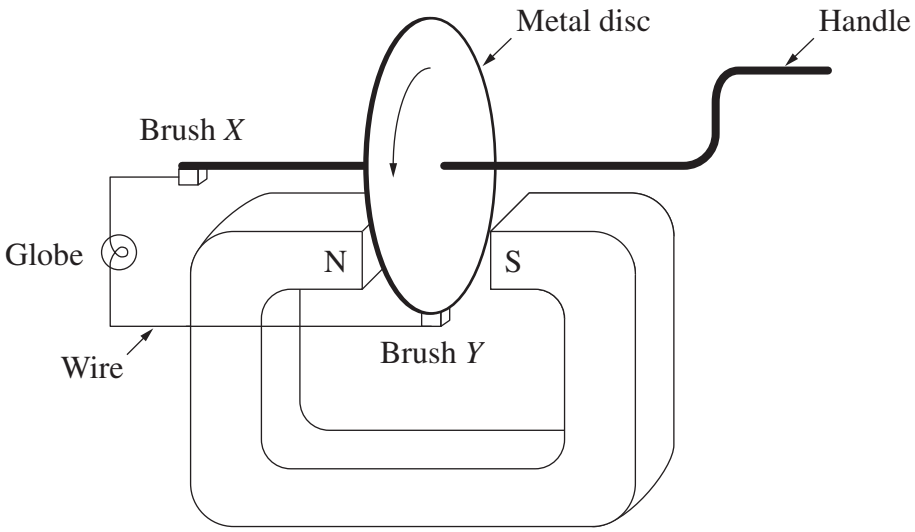


(D)



9 Early electric generators were often very simple. A hand-operated version is depicted below.



Brush *X* touches the metal axle and Brush *Y* touches the rim of the disc.

If the metal disc is rotated uniformly as shown, which statement about the current through the globe is correct?

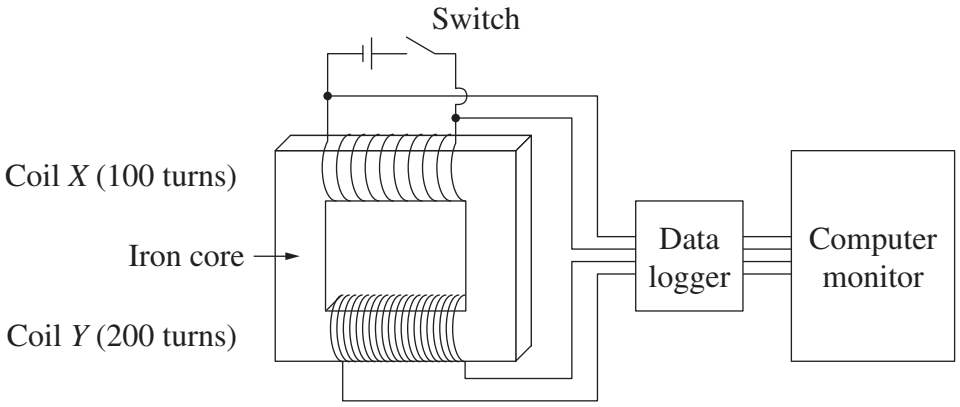
(A) No current flows.

(B) A direct current flows from *Y* to *X*.

(C) A direct current flows from *X* to *Y*.

(D) An alternating current flows between *X* and *Y*.

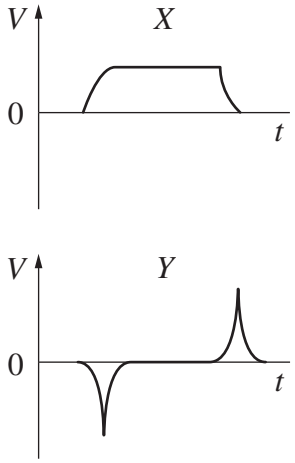
10 The apparatus shown is designed to investigate the operation of a transformer.



A student closes the switch for a short time, then opens it. The data logger records values of voltage for both coils for the duration of the investigation. The data logger software displays the results as a pair of voltage–time graphs on a computer monitor.

Which pair of graphs best depicts the student's results?

(A)



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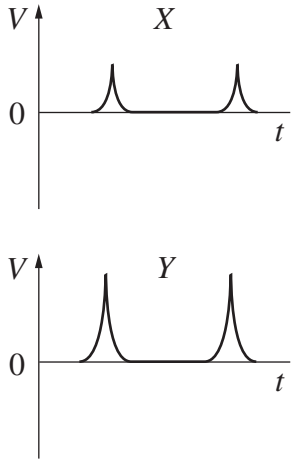
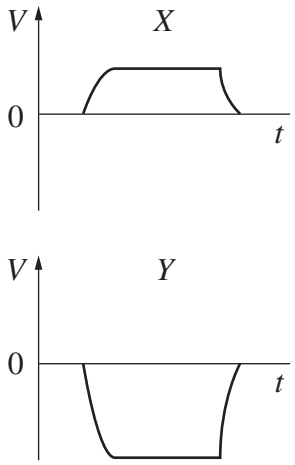
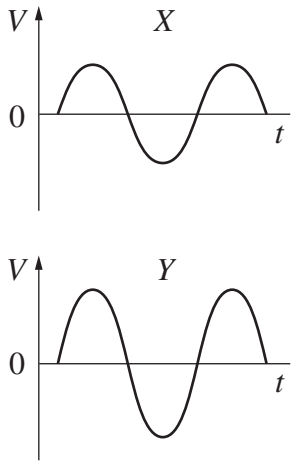


(C)



(D)



11 Lawrence and William Bragg used X-rays to determine the crystal structure of materials.

Which property of waves was the basis of their technique?

(A) Diffraction

(B) Dispersion

(C) Polarisation

(D) Rarefaction

12 A charged non-magnetic particle is moving in a magnetic field.

What would NOT affect the magnetic force on the particle?

(A) The strength of the magnetic field

(B) The magnitude of the charge on the particle

(C) The velocity component parallel to the magnetic field direction

(D) The velocity component perpendicular to the magnetic field direction

13 The temperature of a metal is reduced.

Which statement correctly identifies the change in its electrical resistance and the reason for this change?

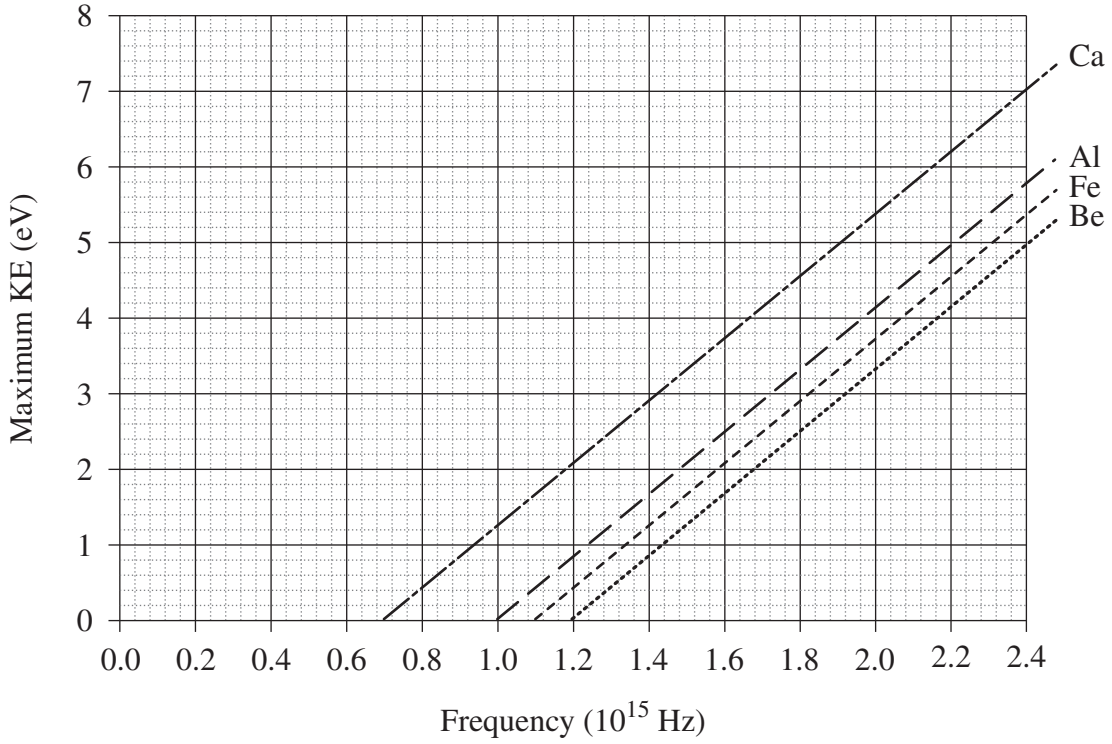
	Electrical resistance	*Reason*
(A)	Increases	Metal freezes
(B)	Decreases	More free electrons available
(C)	Increases	Electrons move more slowly
(D)	Decreases	Reduced metal lattice vibrations

14 A potential difference of 50 V is applied between two identical, parallel aluminium plates which are separated by a distance of 10 mm.

In order to double this electric field strength, which new arrangement should be used?

	Separation (mm)	*Potential difference* (V)	*Plates*
(A)	20	100	Aluminium
(B)	5	50	Perspex
(C)	10	100	Copper
(D)	20	50	Aluminium

15 When electromagnetic radiation shines on metals, photoelectrons may be emitted. The maximum kinetic energy of emitted photoelectrons is plotted against radiation frequency for four metals as shown in the graph.



Electromagnetic radiation of wavelength 187 nm shines upon an unknown metal and the maximum kinetic energy of the photoelectrons is found to be 2.5 eV.

Based on this information, what is the unknown metal?

(A) Al

(B) Be

(C) Ca

(D) Fe

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Physics

Centre Number

Student Number

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.

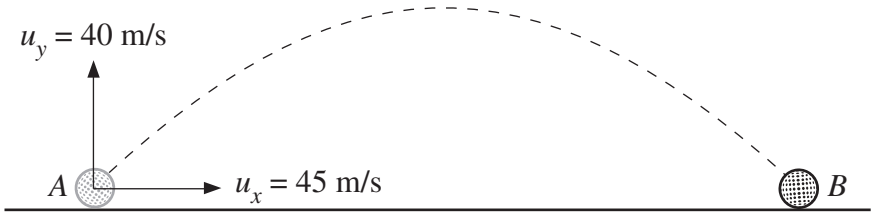
Question 16 (6 marks)

Please turn over

Marks

Question 16 (6 marks)

A projectile leaves the ground at point *A* with velocity components as shown in the diagram. It follows the path given by the dotted line and lands at point *B*.



(a) State the horizontal component of the projectile's velocity when it lands. **1**

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(b) Find the magnitude of the initial velocity of the projectile. **1**

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(c) Calculate the maximum height attained by the projectile. **2**

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(d) Calculate the range of the projectile, if it lands level with its starting position. **2**

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Marks

Question 17 (6 marks)

Parts of a space mission involve a spacecraft spending time in geostationary orbit, and then returning safely to Earth. **6**

Analyse the forces acting on this spacecraft during these parts of the mission.

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Marks

Question 18 (3 marks)

An object is stationary in space and located at a distance 10 000 km from the centre of a certain planet. It is found that 1.0 MJ of work needs to be done to move the object to a stationary point 20 000 km from the centre of the planet. **3**

Calculate how much more work needs to be done to move the object to a stationary point 80 000 km from the centre of the planet.

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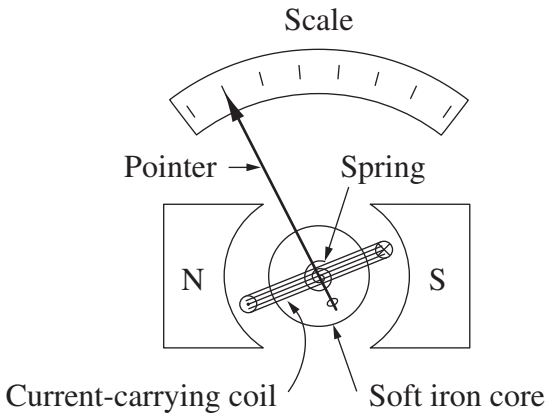
Marks

Question 19 (3 marks)

The diagram shows the structure of a typical galvanometer. **3**



Describe how the galvanometer operates as an application of the motor effect.

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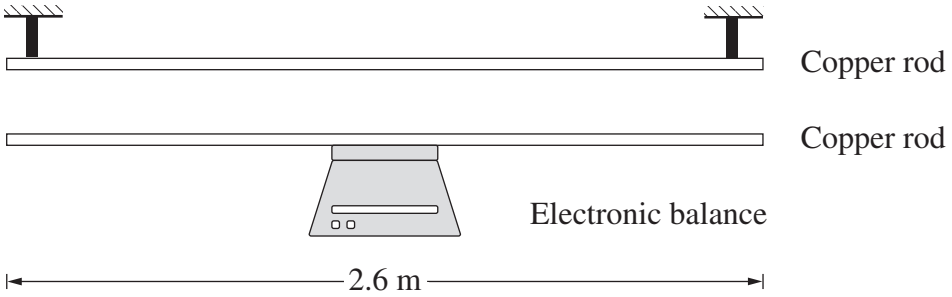
Question 20 (8 marks)

Please turn over

Marks

Question 20 (8 marks)

A balance was used to investigate the relationship between current and force. The balance was set up with one copper rod fixed to it and a second rod fixed above it, as shown in the diagram. Each rod was connected to a source of current. The diagram is not to scale.



The copper rods were rigid, each was 2.6 m long, and they were parallel. The current in the upper rod was kept constant at 50 A. Different currents were passed through the lower rod and the balance reading recorded for each current. The readings are given in the table below.

Current in lower rod (A)	*Balance reading* (kg)
2.8	0.5485
8.0	0.5480
12.2	0.5474
16.8	0.5470
20.0	0.5465

(a) Identify the relative directions of the currents in both rods, and justify your answer. **2**

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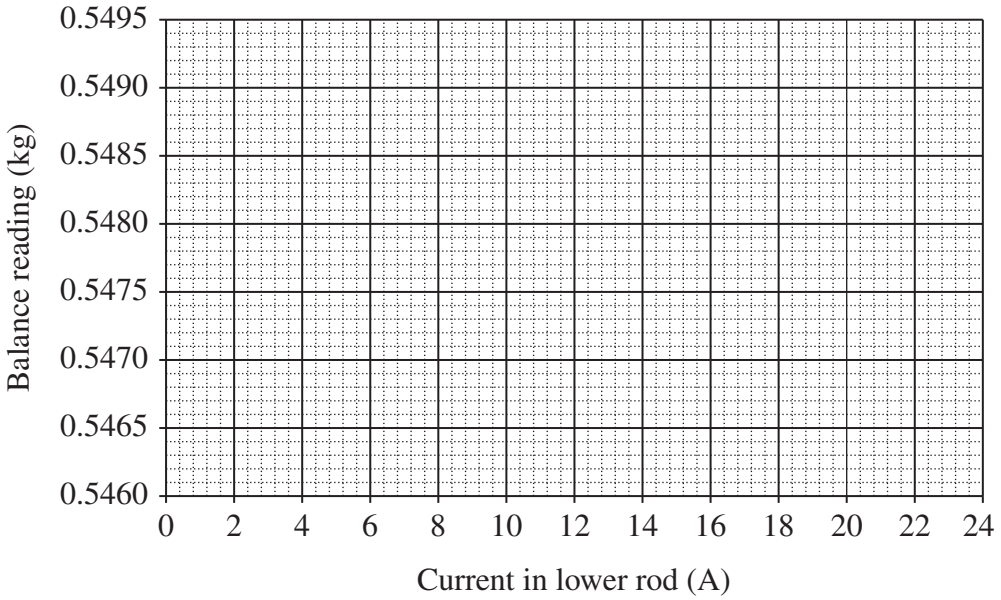
Question 20 continues on page 21

Marks

Question 20 (continued)

(b) Plot the data from the table onto the graph, using the scales and axes as indicated, and add the line of best fit (trend line). **2**



(c) Find the mass of the copper rod on the balance. **1**

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(d) Calculate the distance between the two copper rods. **3**

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End of Question 20

Marks

Question 21 (6 marks)

Assess the impact on society and the environment of the potential applications of superconductors. **6**

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Marks

Question 22 (5 marks)

A student drops a bar magnet onto a large block of copper resting on the floor. The magnet falls towards the copper, slowing down as it comes close, then landing gently.

(a) Explain the physics responsible for this observation. **3**

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(b) Predict what will happen if the experiment is repeated with a copper block cooled to approximately –50°C. Justify your prediction. **2**

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Marks

Question 23 (6 marks)

(a) Draw labelled diagrams of the band structures of an insulator, a semiconductor, and a conductor. **2**

(b) With reference to your diagrams, describe the differences in electrical resistance between insulators, semiconductors and conductors. **2**

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(c) Explain how the addition of trace amounts of certain elements, such as phosphorus, can change the electrical resistance of semiconductors at a given temperature. **2**

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Marks

Question 24 (3 marks)

Discuss the origins of unwanted heat production in transformers and ways in which these can be overcome. **3**

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Please turn over

Marks

Question 25 (6 marks)

A simplified cathode ray oscilloscope is depicted below.

(a) Outline the roles of the deflection plates and the electrodes in the electron gun. **2**

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(b) In a special investigation, the voltage between the cathode and the anode is increased so that an electron gains a velocity of 0.60 c, where c is the speed of light. The electron starts from rest at the cathode. **2**

Calculate the mass of this electron in the laboratory frame of reference.

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(c) The distance between the anode and the screen, as measured in the electron's frame of reference, is 0.24 m. **2**

Calculate this distance as measured in the laboratory frame of reference.

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Marks

Question 26 (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. **4**

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

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Marks

Question 27 (4 marks)

J. Plücker was the first to observe cathode rays within gas discharge tubes. He inferred that the rays were a form of electromagnetic radiation.

(a) Describe ONE subsequent observation that led other scientists to argue that cathode rays were charged particles. **2**

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(b) Identify ONE potential hazard associated with performing discharge tube investigations, and outline ONE safe work practice which addresses this hazard. **2**

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Physics

Section II

25 marks
Attempt ONE question from Questions 28–32
Allow about 45 minutes for this section

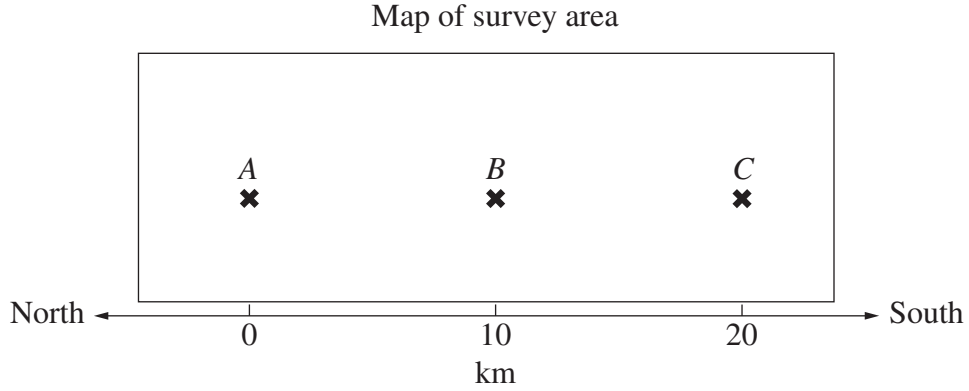
Answer the question in a writing booklet. Extra writing booklets are available.

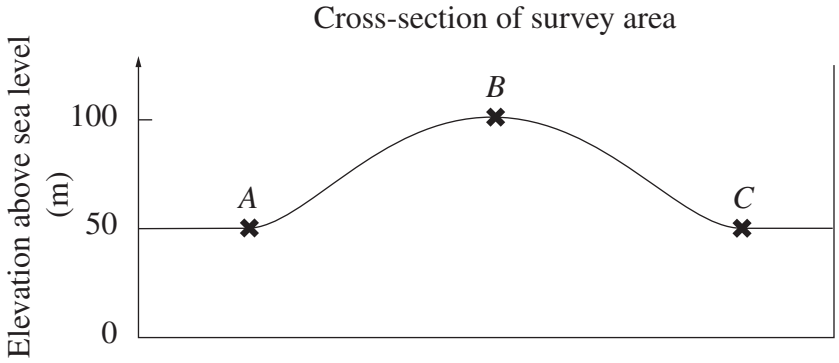
Show all relevant working in questions involving calculations.

Question 28 — Geophysics (25 marks)

(a) Gravimetric surveys collect raw gravity data which must be further processed by the application of a number of corrections. The following data table, map, and cross-section are the result of a small-scale gravimetric survey.

Station	*Gravitational reading (raw data)* (mgal)
A (datum station)	979158.1
B	979161.6
C	979174.2





Question 28 continues on page 31

Question 28 (continued)

Gravity data reduction involves the application of the following corrections:

Quantity	*Correction*	*Application comment*
Latitude correction	0.8 mgal/km	Subtract a correction for each kilometre south of datum
Free air correction	0.3 mgal/m	Add a correction for each elevation metre above sea-level
Bouguer correction	0.1 mgal/m	Subtract a correction for each metre above the datum station

The data for station *A*, the datum station, has been processed as below:

Correction or calculation item	*Station A (datum)*
Latitude correction	$-(0 \times 0.8)$
Free air correction	$+(50 \times 0.3)$
Bouguer correction	$-(0 \times 0.1)$
Total correction	+15.0
Observed *g* at station	979158.1
Corrected *g* at station	979173.1
Corrected *g* at datum station	979173.1
Gravity anomaly at station (corrected *g* – corrected datum *g*)	0

(i) Outline the role of the Bouguer correction in the reduction of gravity data. **1**

(ii) Using a table format and the information provided, reduce the gravity data for stations *B* and *C*, and draw an inference about the geology of the survey data. **4**

Question 28 continues on page 32

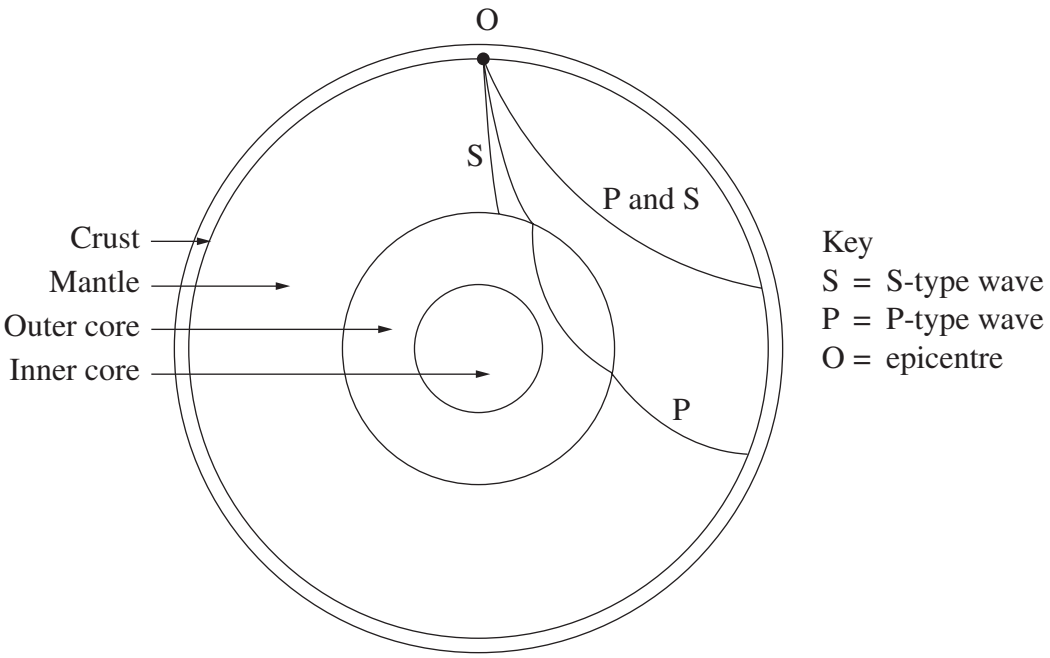
Question 28 (continued)

(b) (i) During your study of geophysics you carried out a first-hand investigation to model the principles of reflection and refraction of seismic waves. **2**

Describe how you ensured that the data obtained in your investigation were reliable.

(ii) The diagram shows the path of seismic waves through Earth. **4**

Account for the curved path followed by all the waves, and justify why the S-type wave stops at the outer core and the P-type wave does not.



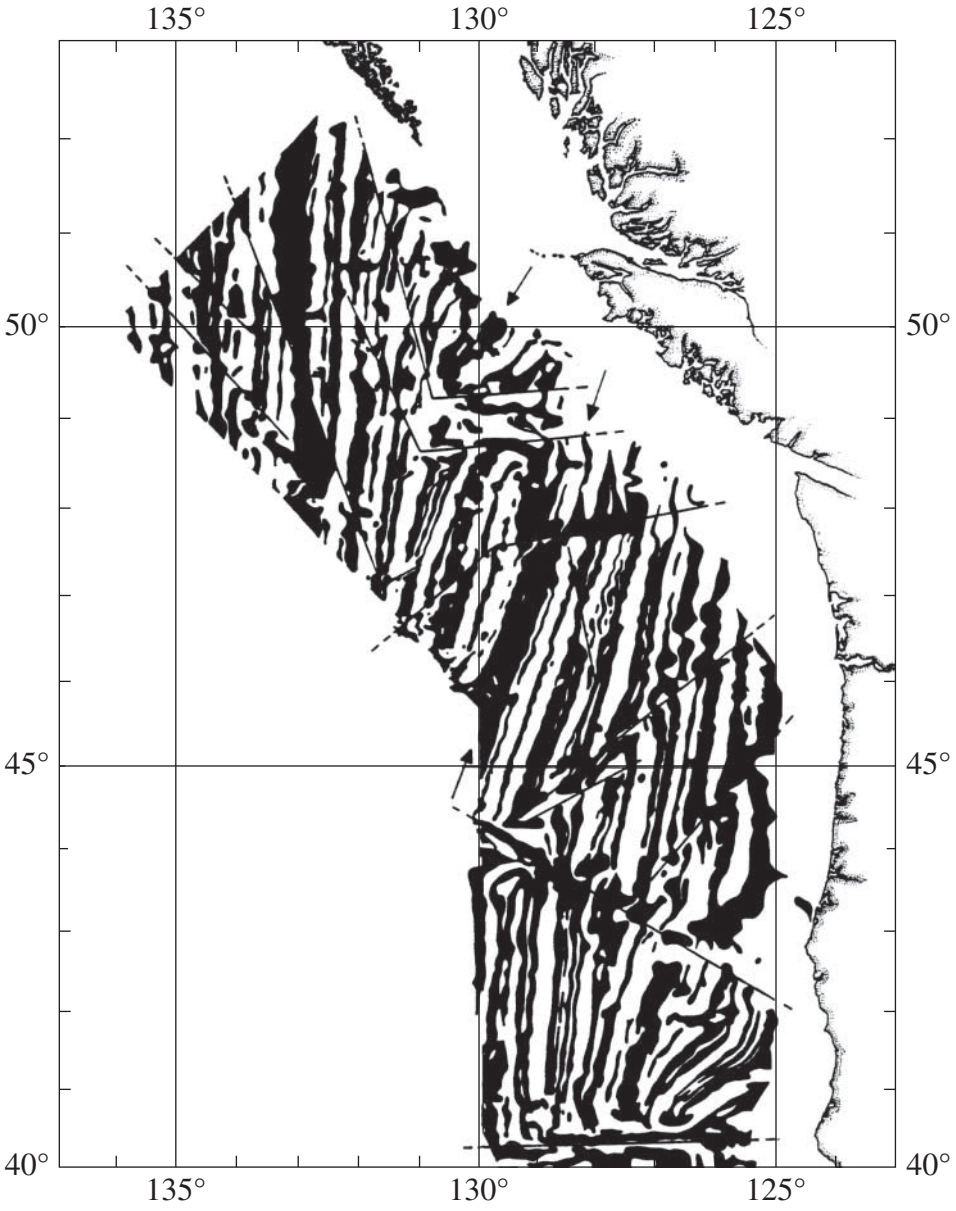
(c) 'Our understanding of Earth has changed as a result of developments in geophysics.' **7**

Discuss this statement with reference to the geophysical methods you have studied.

Question 28 continues on page 33

Question 28 (continued)

(d) (i) The map below shows a pattern of magnetic anomalies recorded in the rocks of the seabed. The stripes represent areas of positive and negative magnetic anomaly. **4**

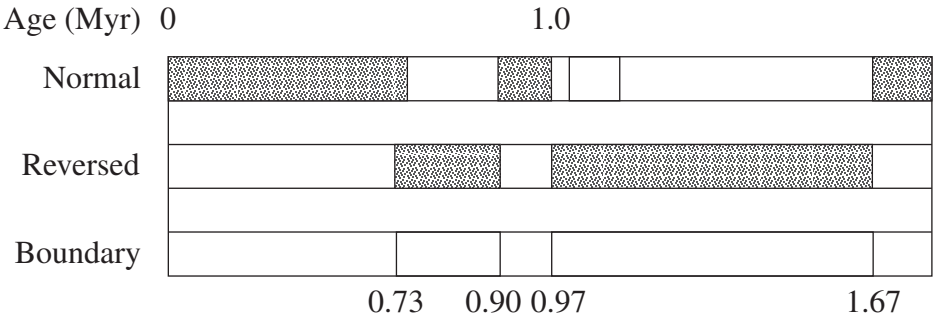


Explain the formation of these paleomagnetic patterns.

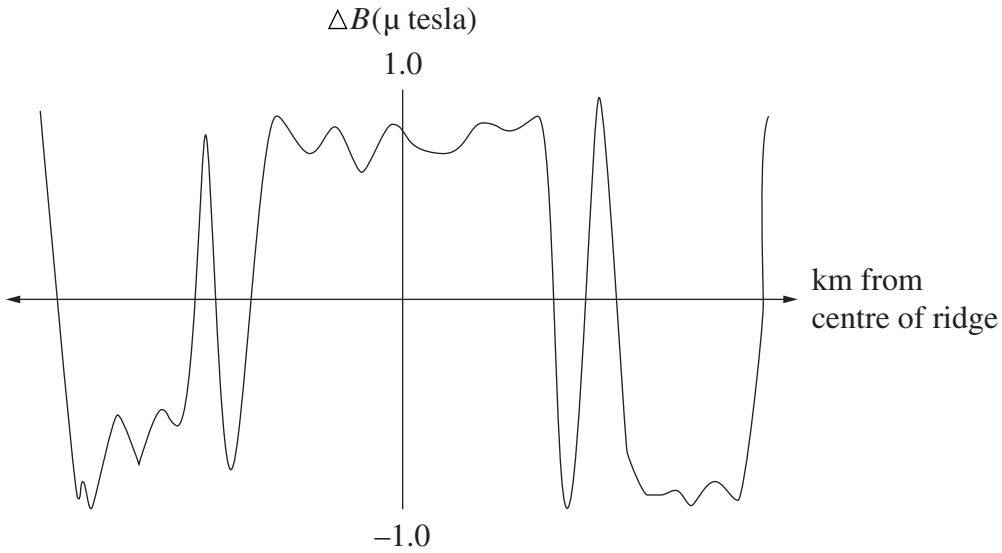
Question 28 continues on page 34

(ii) The spreading rate of an ocean can be calculated using paleomagnetic data as shown. **3**

Use the information provided to calculate the spreading rate of the ocean, in units of mm/yr.

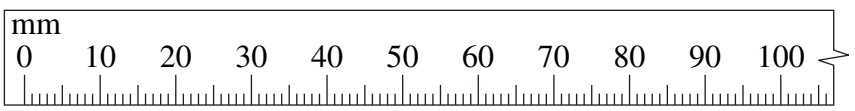


Magnetic polarity time scale



Magnetic anomaly profile across the mid-ocean ridge

This diagram is to scale.



1 mm = 1 km

End of Question 28

Marks

Question 29 — Medical Physics (25 marks)

(a) The acoustic impedance and density of a number of different types of body tissue, ultrasound gel and air are shown in the table:

Material	*Acoustic impedance* ($kg\ m^{-2}\ s^{-1} \times 10^6$)	*Density* ($kg\ m^{-3}$)
Fat	1.38	9.25×10^2
Skin	1.52	1.00×10^3
Ultrasound gel	1.54	1.01×10^3
Air	0.0004	1.3

(i) Calculate the velocity of sound in fat tissue. **2**

(ii) Ultrasound gel is used to overcome the excessive reflection from the skin during a scan. **3**

Explain why this is necessary, justifying your response with calculations.

(b) During your study of Medical Physics you identified data sources, and gathered, processed and presented information to explain why MRI scans can be used to detect abnormalities in the body.

(i) Describe the criteria you would use to determine the reliability of a data source for this purpose. **3**

(ii) Explain why MRI scans can be used to detect cancerous tissues. **3**

(c) Advances in our understanding of the electromagnetic spectrum have allowed scientists to investigate the human body in more detail. **7**

Assess the impact of these advances on the development of medical technologies.

Question 29 continues on page 36

Question 29 (continued)

(d) Bones can be viewed with a range of different medical imaging techniques. The images shown below were obtained using three different techniques.

A *B* *C*

(i) The images shown above are an X-ray, a CAT scan and a bone scan (in no particular order). **1**

Identify the images labelled *A*, *B* and *C*.

(ii) Compare the advantages and disadvantages of CAT scans to X-ray images. **3**

(iii) Contrast the information provided by bone scans with that obtained by CAT scans and X-ray images. **3**

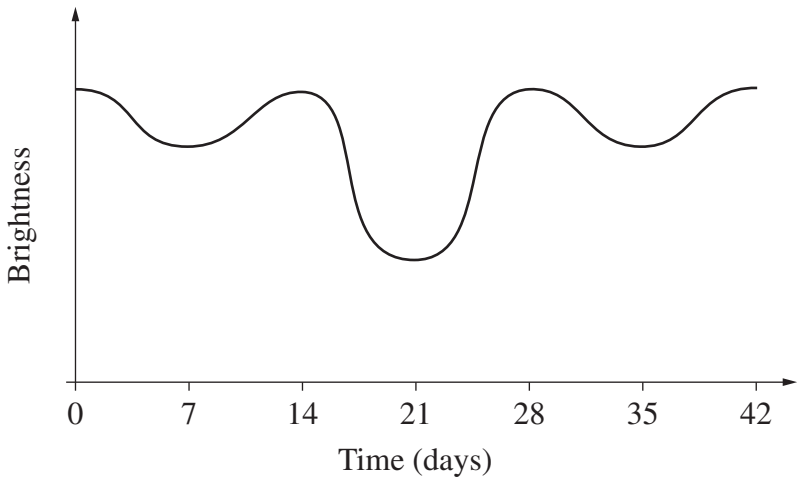
End of Question 29

Marks

Question 30 — Astrophysics (25 marks)

(a) (i) Describe the spectroscopic observations that would determine whether a particular star is really a binary star system. **2**

(ii) The graph represents the variation in brightness of a binary star system. **3**



Given that the mass of the system is determined to be 6×10^{32} kg, calculate the average distance between the stars within the system.

(b) During your study of Astrophysics you performed a first-hand investigation into the spectra produced by different objects under different conditions.

(i) Explain how you determined that the data you obtained were reliable. **2**

(ii) Explain how the absorption spectrum of a star is produced, and how it can be used to determine the star's composition. **4**

(c) Astronomers employ a range of instruments and techniques to observe celestial objects. **7**

Assess the impact of technological advances on our understanding of the cosmos.

Question 30 continues on page 38

Question 30 (continued)

(d) The Hertsprung-Russell (H-R) diagram depicts a possible life cycle path of a known star.

(i) Describe the reactions that occur in stars at the points marked **A**, **B** and **C** in its life cycle. **3**

(ii) Explain what type and mass of star is most likely to be formed at point **A**. **2**

(iii) Compare the life cycle of a star that has a mass greater than 10 solar masses with the one depicted at point **A**. **2**

End of Question 30

Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) The Bohr picture of the atom explains the energy of the photons emitted when an electron falls from an initial orbit n_i to find an orbit of n_f.

The various energies depend upon the quantity $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ and the values for this term are given in the table.

Table of values of $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ for values of n_i and n_f from 1 to 6

n_f \ n_i	1	2	3	4	5	6
1	–	0.7500	0.8889	0.9375	0.9600	0.9722
2	–	–	0.1389	0.1875	0.2100	0.2222
3	–	–	–	0.0486	0.0711	0.0833
4	–	–	–	–	0.0225	0.0347
5	–	–	–	–	–	0.0122
6	–	–	–	–	–	–

(i) Identify the physical reason for about one-half of the table appearing blank. **1**

(ii) Calculate the energy of the photon emitted when an electron falls from $n_i = 4$ to $n_f = 3$. **4**

(b) You have gathered, processed and analysed information related to the development of atomic theory.

(i) Describe how you ensured that the information you gathered was reliable. **2**

(ii) The atomic theory changed as a result of the contributions of both Heisenberg and Pauli. **4**

Analyse how the work of both scientists modified the atomic theory at that time.

Question 31 continues on page 40

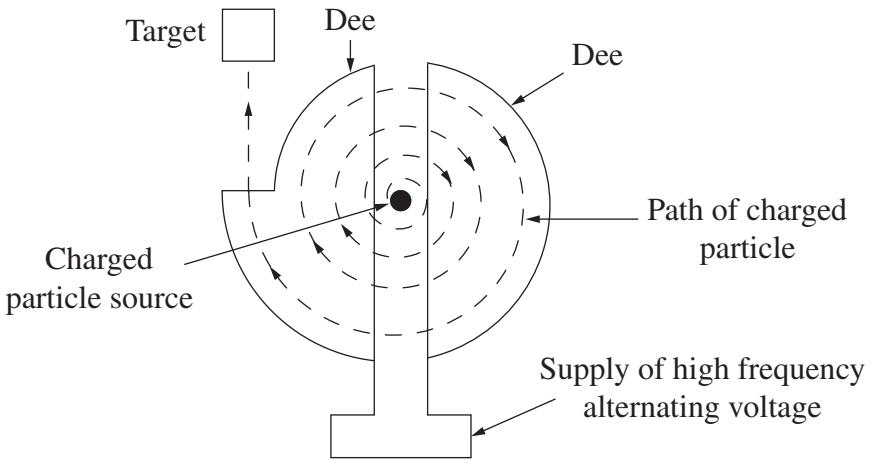
Question 31 (continued)

(c) Australia has a large supply of uranium which may be used in fission reactors to create energy. The equation describes the relevant transmutation reaction: **7**

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3{}^{1}_{0}\text{n}$$

Analyse how the process described in this equation has been developed into a technology which produces a sustained and controlled amount of energy.

(d) The cyclotron, invented in 1932, accelerates charged particles to a very high speed. The diagram shows the basic design of a cyclotron. The Dees provide a strong magnetic field into the plane of the page.



(i) Explain the physical principles involved in the design of the cyclotron. **3**

(ii) Account for the use of the cyclotron (or other accelerator) in the development of our understanding of matter. **2**

(iii) Quarks are an important part of the Standard Model of Matter. The table shows the six types of quark and their charge (in units of e, the charge on an electron). **2**

Quark	Up	Down	Strange	Charm	Bottom	Top
Charge	$+\frac{2}{3}e$	$-\frac{1}{3}e$	$-\frac{1}{3}e$	$+\frac{2}{3}e$	$-\frac{1}{3}e$	$+\frac{2}{3}e$

Identify the quark composition of the proton and the neutron.

End of Question 31

Marks

Question 32 — The Age of Silicon (25 marks)

(a) Lately, traffic control authorities in NSW have been replacing the incandescent bulbs in traffic lights with arrays of light emitting diodes (LEDs).

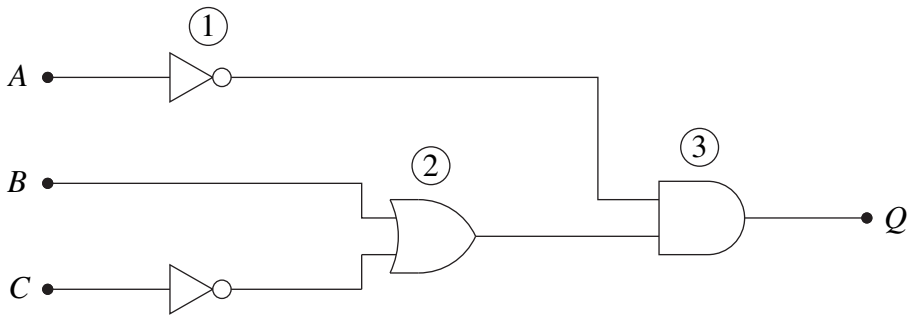
(i) Describe the structure and operation of an LED. **2**

(ii) Explain why LEDs are preferable to ordinary light bulbs when used in traffic lights. **3**

(b) (i) During your study of the Age of Silicon you identified data sources, and gathered, processed and analysed information to outline the rapid development of electronics. **3**

Describe the criteria you would use to determine the reliability of a data source for this purpose.

(ii) Circuits containing logic gates are an integral part of modern electronics. An example of such a circuit is given below. **3**



Identify each gate labelled ①, ② and ③ and, using a truth table, determine the value of Q when $A = 0$, $B = 1$ and $C = 1$.

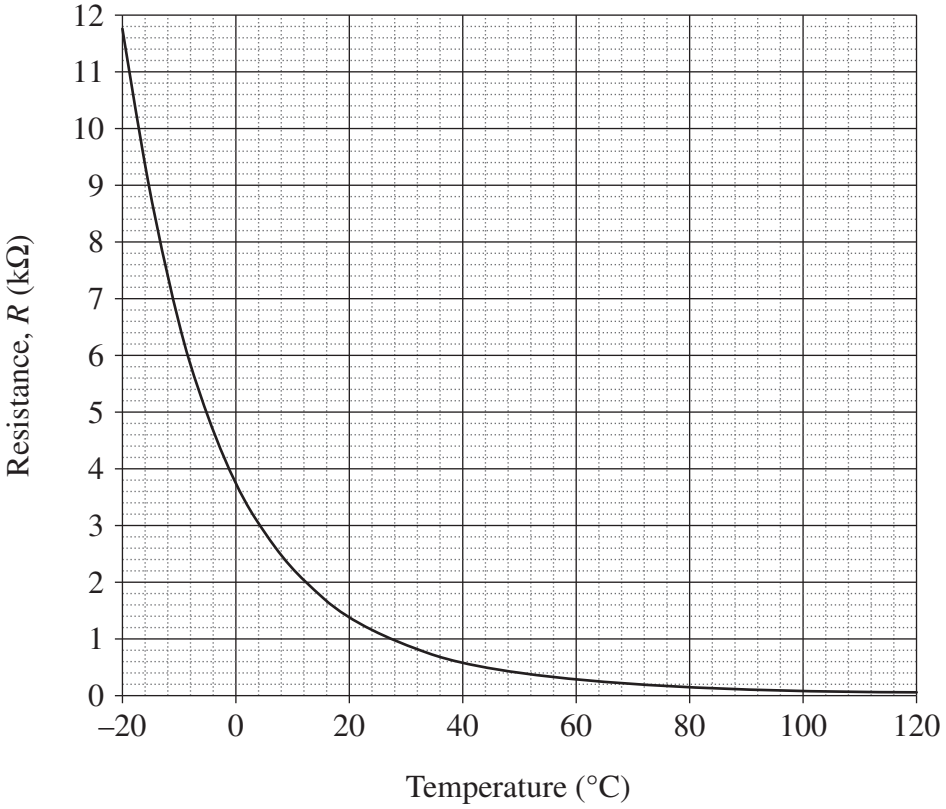
(c) Computer developments since World War II (1945) have been characterised by increasing performance at decreasing cost. This trend may or may not continue in the future. **7**

Assess this statement.

Question 32 continues on page 42

Question 32 (continued)

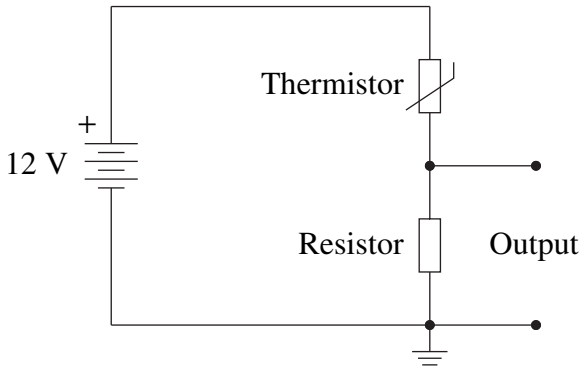
(d) The resistance of a thermistor as a function of temperature is as shown.



(i) Deduce the sign of the temperature coefficient of the thermistor. Explain your answer. **1**

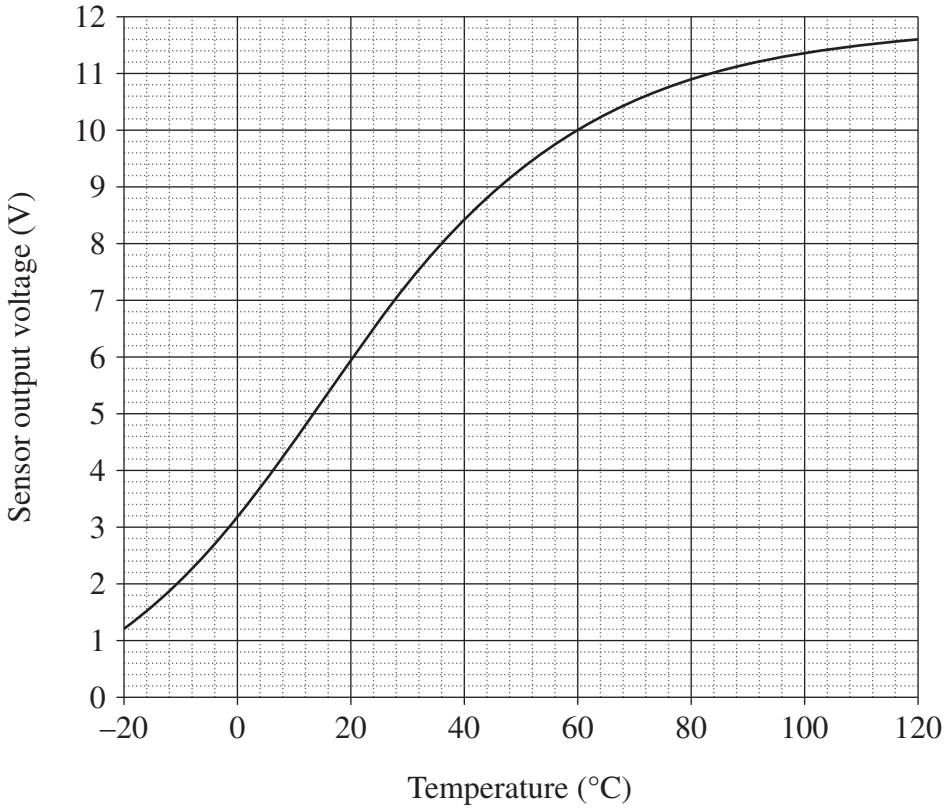
Question 32 continues on page 43

(ii) A potential divider sensor circuit using this thermistor and a fixed resistor is built as shown. **2**



A chamber temperature of +20°C is required. On connecting a resistor, the sensor output voltage as a function of temperature is measured and plotted as below.

Determine the approximate sensitivity of the potential divider sensor in the temperature range 6°C to 20°C.



Question 32 continues on page 44

Question 32 (continued)

(iii) The output of the potential divider sensor is to be converted to give a –10.0 V signal at 20°C. **4**

Design a suitable feedback amplifier to achieve this conversion. Base your circuit on an operational amplifier and assume a ±15 V power supply. Show, using a fully labelled diagram, how your circuit should be connected to the temperature sensor.

End of paper

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

$$v = f\lambda$$

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

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

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

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

$$P = VI$$

$$\text{Energy} = VIt$$

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

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

$$\Sigma F = ma$$

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

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

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

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

$$F = mg$$

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

$$v = u + at$$

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

$$\Delta x = u_x t$$

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

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

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

$$E = mc^2$$

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

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

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

FORMULAE SHEET

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

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

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

$$Z = \rho v$$

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

PERIODIC TABLE OF THE ELEMENTS

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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 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 [97.91] 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 [209.0] 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 [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

KEY

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

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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.