BOARD OF STUDIES
NEW SOUTH WALES

2003

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, 21 and 25

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 29–42

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.

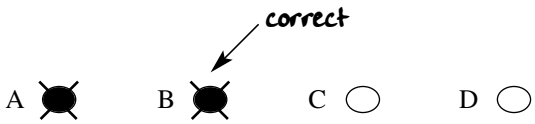
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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.

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.



1 The weight of an astronaut on the Moon is $\frac{1}{6}$ of her weight on Earth.

What is the acceleration due to gravity on the Moon?

(A) $\left(\frac{6}{9.8}\right) \text{m s}^{-2}$

(B) $\left(\frac{9.8}{6}\right) \text{m s}^{-2}$

(C) 9.8 m s^{-2}

(D) $(9.8 \times 6) \text{ m s}^{-2}$

2 A satellite moves in uniform circular motion around Earth.

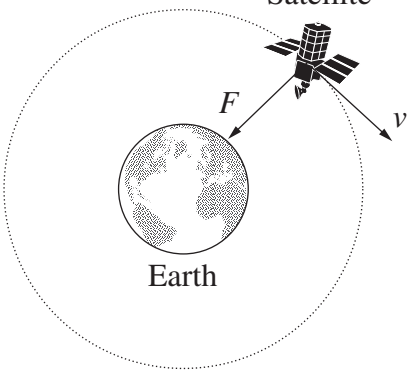
The following table shows the symbols used in the diagrams below.
These diagrams are NOT drawn to scale.

Key

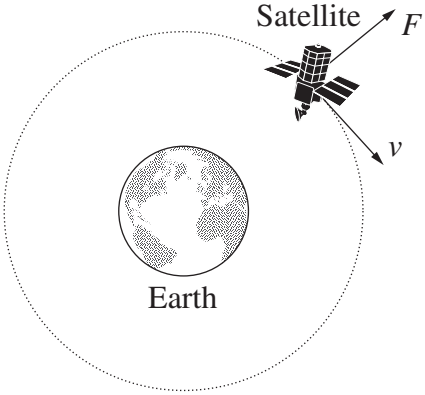
F	net force on satellite
v	velocity of satellite

Which diagram shows the direction of F and v at the position indicated?

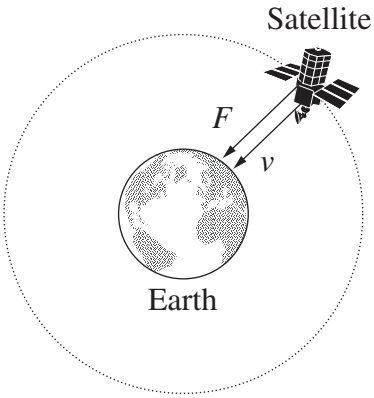
(A)



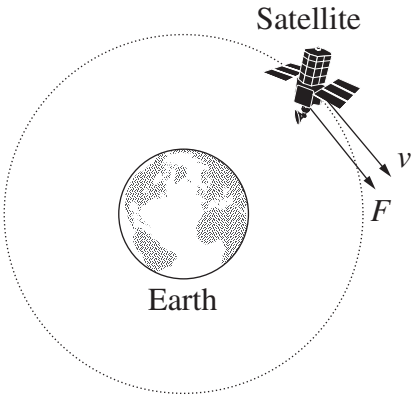
(B)



(C)



(D)



3 For a satellite moving in uniform circular motion around Earth, the centripetal force is provided by the gravitational force.

The mass of Earth is M_E.
The mass of the satellite is M_S.
The distance of the satellite from the centre of Earth is d.

Which of the following equations should be used to calculate the speed of this satellite?

(A) $v = \dfrac{GM_E}{d}$

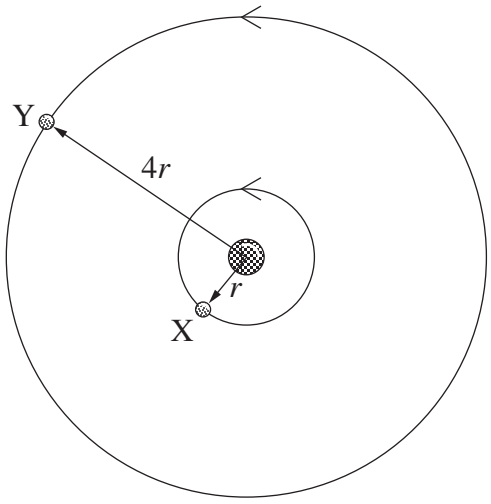
(B) $v = \sqrt{\dfrac{GM_E}{d}}$

(C) $v = \sqrt{\dfrac{GM_E}{d^2}}$

(D) $v = \sqrt{\dfrac{GM_E M_S}{d}}$

4 Two planets, X and Y, travel around a star in the same direction, in circular orbits.

Planet X completes one revolution about the star in time T. The radii of the orbits are in the ratio 1 : 4.



How many revolutions does planet Y make about the star in the same time T?

(A) $\frac{1}{8}$ revolution

(B) $\frac{1}{2}$ revolution

(C) 2 revolutions

(D) 8 revolutions

5 An astronaut set out in a spaceship from Earth orbit to travel to a distant star in our galaxy. The spaceship travelled at a speed of 0.8 *c*. When the spaceship reached the star the on-board clock showed the astronaut that the journey took 10 years.

An identical clock remained on Earth. What time in years had elapsed on this clock when seen from the astronaut's spaceship?

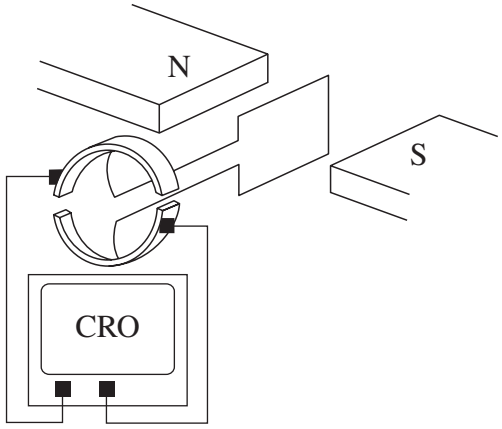
(A) 3.6

(B) 6.0

(C) 10.0

(D) 16.7

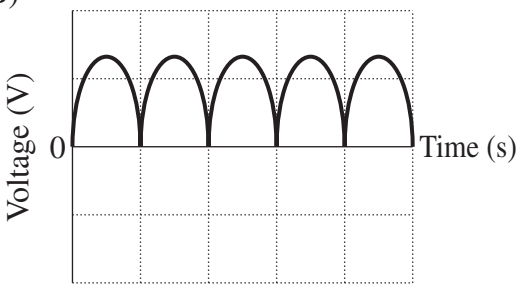
6 The diagram shows a DC generator connected to a cathode ray oscilloscope (CRO).



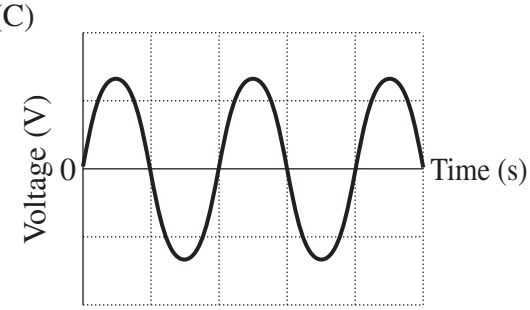
What output voltage would be observed for this generator on the CRO?

(A)

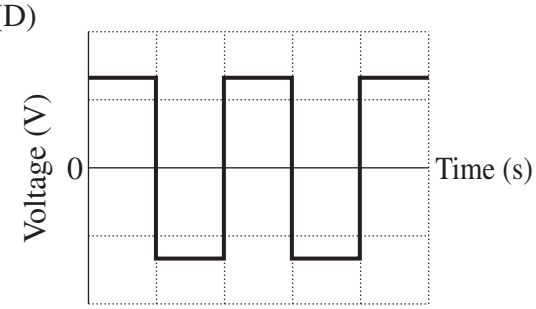
(B)



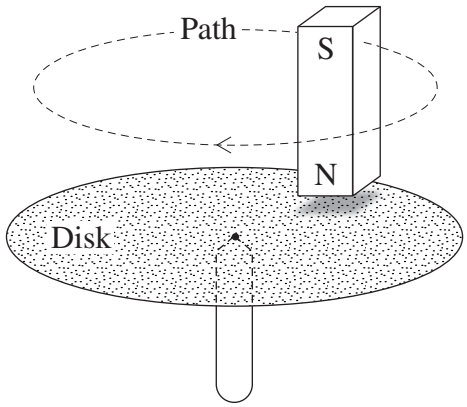
(C)



(D)



7 A non-magnetic metal disk is balanced on a support as shown in the diagram below. The disk is initially stationary. A magnet is moved in a circular path just above the surface of the disk, without touching it.



As a result of this movement the disk begins to rotate in the same direction as the magnet.

The observed effect demonstrates the principle *most* applicable to the operation of the

(A) DC motor.

(B) galvanometer.

(C) generator.

(D) induction motor.

8 A neon sign requires a 6000 V supply for its operation. A transformer allows the neon sign to operate from a 240 V supply.

What is the ratio of the number of secondary turns to the number of primary turns for the transformer?

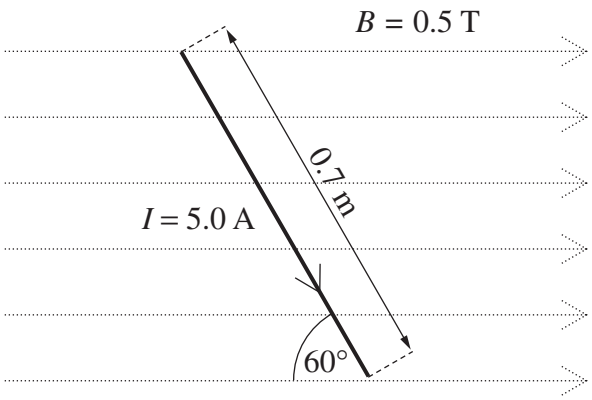
(A) 1 : 40

(B) 1 : 25

(C) 25 : 1

(D) 40 : 1

9 A current of 5.0 A flows in a wire that is placed in a magnetic field of 0.5 T. The wire is 0.7 m long and is at an angle of 60° to the field.



What is the approximate magnitude of the force on the wire?

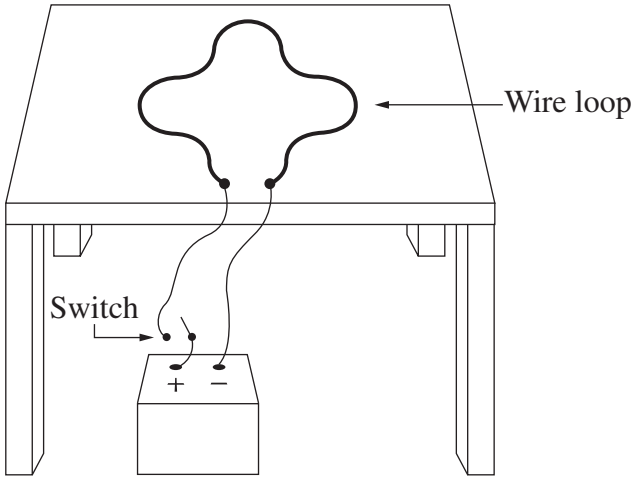
(A) 0 N

(B) 0.9 N

(C) 1.5 N

(D) 1.8 N

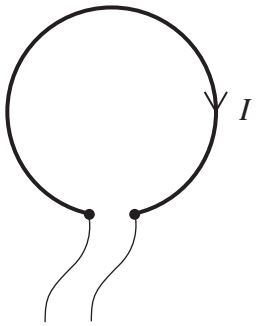
10 A flexible wire loop is lying on a frictionless table made from an insulating material. The wire can slide around horizontally on the table and change shape freely, but it cannot move vertically. The loop is connected to a power supply, a switch and two terminals fixed to the table as shown.



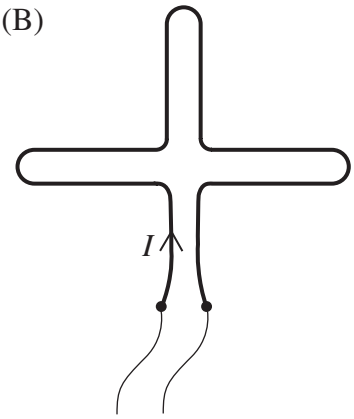
When the switch is closed, a current I flows around the loop.

Which of the following diagrams most closely represents the final shape of the loop after the switch is closed?

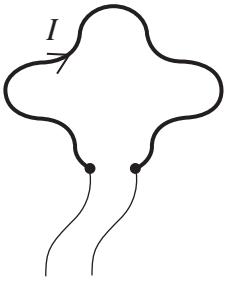
(A)



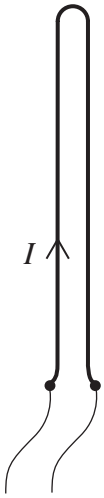
(B)



(C)



(D)



11 Which of the following did the Braggs investigate using X-ray diffraction?

(A) Cathode rays

(B) Crystal structure

(C) Photoelectric effect

(D) Superconductivity

12 In a first-hand investigation that you performed, you used a discharge tube containing a Maltese Cross. You would have observed an image similar to the one shown below.

Which of the following statements is a valid conclusion from the observations made in this Maltese Cross investigation?

(A) Cathode rays pass through glass.

(B) Cathode rays pass through metals.

(C) Cathode rays are charged particles.

(D) Cathode rays travel in straight lines.

13 An *n*-type semiconductor is produced when silicon crystal is doped with small quantities of phosphorus.

How will this doping change the crystal's electrical conductivity?

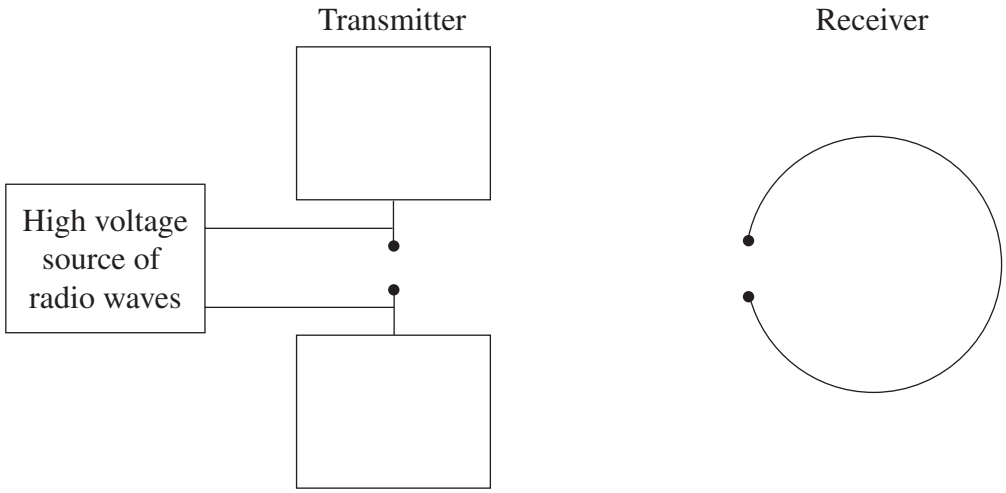
(A) The conductivity will decrease because there are fewer holes in the valence band.

(B) The conductivity will increase because there are more holes in the valence band.

(C) The conductivity will decrease because there are fewer electrons in the conduction band.

(D) The conductivity will increase because there are more electrons in the conduction band.

14 Heinrich Hertz used a set-up similar to the one shown below to investigate the production and detection of electromagnetic radiation.



A glass sheet was placed between the transmitter and receiver.

Which of the following observations is consistent with the photoelectric effect that Hertz produced?

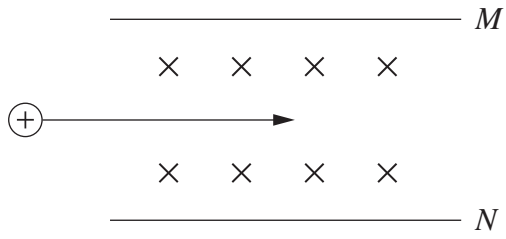
(A) Radio waves were blocked when the glass sheet was in place.

(B) Ultraviolet waves were blocked when the glass sheet was in place.

(C) The maximum spark length was longer when the glass sheet was in place.

(D) The maximum spark length was shorter when the glass sheet was in place.

15 A positively-charged ion travelling at 250 m s^{-1} is fired between two parallel charged plates, *M* and *N*. There is also a magnetic field present in the region between the two plates. The direction of the magnetic field is into the page as shown. The ion is travelling perpendicular to both the electric and the magnetic fields.



The electric field between the plates has a magnitude of 200 V m^{-1}. The magnetic field is adjusted so that the ion passes through undeflected.

What is the magnitude of the adjusted magnetic field, and the polarity of the *M* terminal relative to the *N* terminal?

	Magnitude of magnetic field (teslas)	*Polarity of M relative to N*
(A)	0.8	positive
(B)	0.8	negative
(C)	1.25	positive
(D)	1.25	negative

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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)

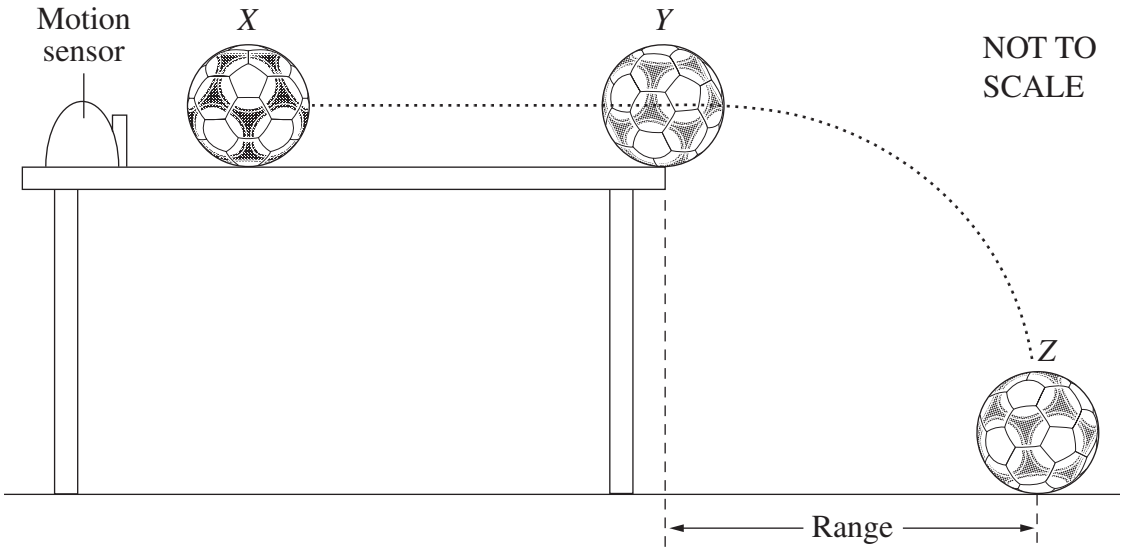
Please turn over

Marks

Question 16 (6 marks)

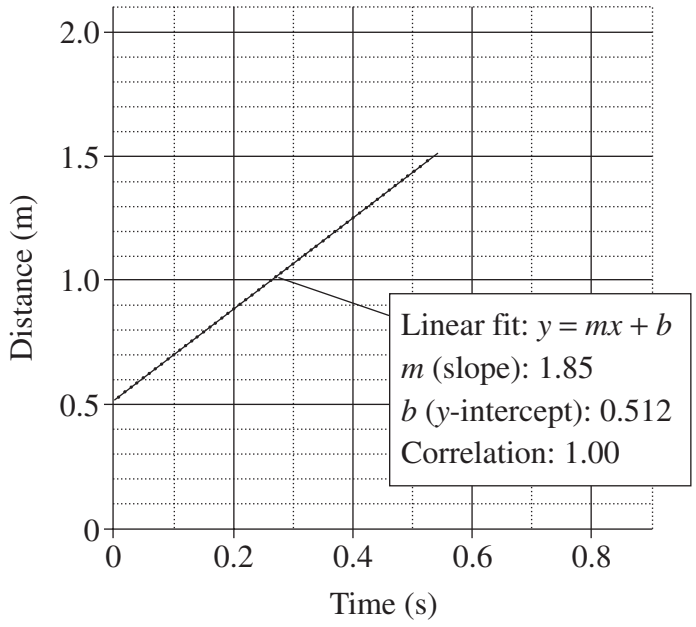
A student performed a first-hand investigation to examine projectile motion.

A ball resting on a horizontal table was given an initial push at *X*, resulting in the ball following the path *XYZ* as shown.



A data logger used the motion sensor to measure the horizontal distance to the ball. When the ball was at position *Y*, a distance of 1.50 m from the motion sensor, it left the edge of the table.

In the first trial, the range was 0.60 m. The graph below was obtained from the data logger.



Question 16 continues on page 15

Marks

Question 16 (continued)

(a) For this trial, determine the horizontal speed of the ball as it left the edge of the table. **1**

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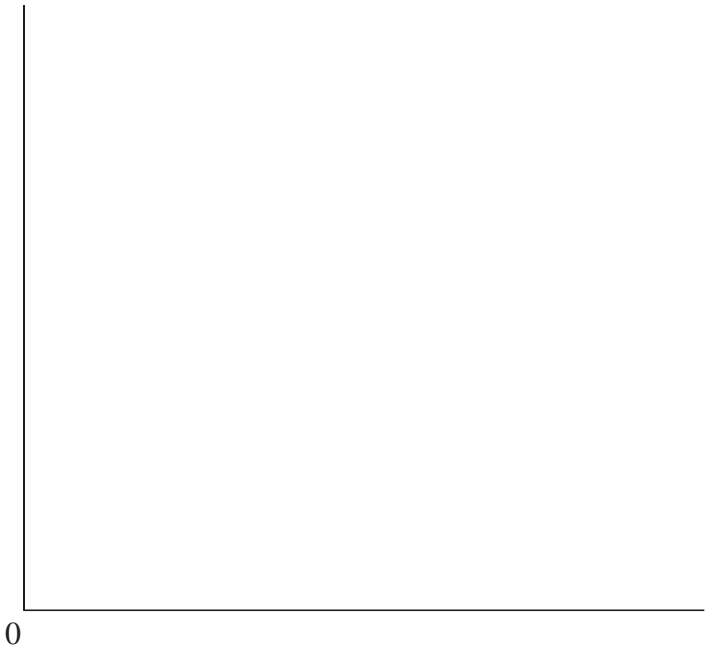
(b) The experiment was repeated with the ball leaving the table at different speeds. Graph the relationship between the range and the horizontal speed at *Y*. Identify on your graph the results from the first trial. **3**



(c) The apparatus described in this first-hand investigation was used to carry out an identical experiment on another planet where the acceleration due to gravity is less than that on Earth. **2**

The horizontal speed of the ball as it left the table on the planet was the same as in part (a). Compare the range of the ball on the planet to that on Earth. Explain your answer.

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End of Question 16

Marks

Question 17 (6 marks)

A satellite of mass 150 kg is launched from Earth's surface into a uniform circular orbit of radius 7.5×10^6 m.

(a) Calculate the magnitude of the gravitational potential energy E_p of the satellite. **1**

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(b) From this uniform circular orbit, the satellite can escape Earth's gravitational field when its kinetic energy is equal to the magnitude of the gravitational potential energy. **3**

Use this relationship to calculate the escape velocity of the satellite.

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(c) Discuss the effect of Earth's rotational motion on the launch of this satellite. **2**

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Marks

Question 18 (6 marks)

Michelson and Morley set up an experiment to measure the velocity of Earth relative to the aether.

(a) Outline TWO features of the aether model for the transmission of light. **2**

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(b) Recount the Michelson and Morley experiment, which attempted to measure the relative velocity of Earth through the aether, and describe the results they anticipated. **4**

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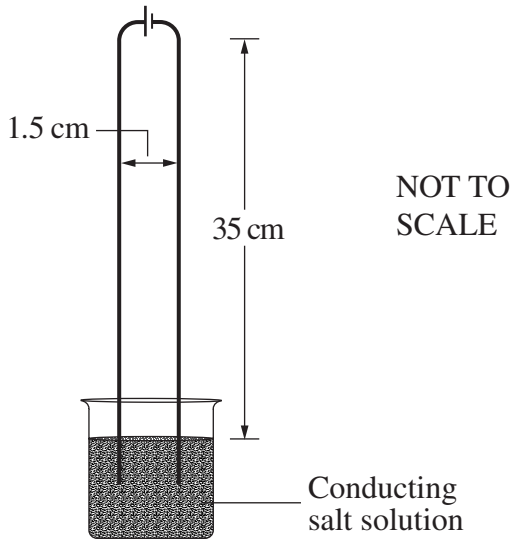
Marks

Question 19 (3 marks)

Two straight copper wires are suspended so that their lower ends dip into a conducting salt solution in a beaker as shown. The length of the straight section of each wire above the conducting salt solution is 35 cm and they are placed 1.5 cm apart. The ends of the wire do not touch the bottom of the beaker. The two wires are connected to a DC power supply. **3**



A current of 2 amperes flows from the battery. Calculate the magnitude and direction of the initial force on each wire.

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Marks

Question 20 (4 marks)

Two solenoids (coils) with hollow cores are suspended using string so that they are hanging in the positions shown below. The solenoids are free to move in a pendulum motion. **4**

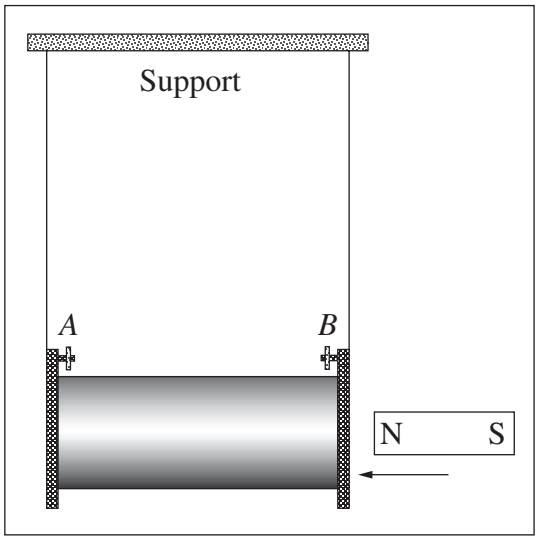

Figure 1 – First investigation

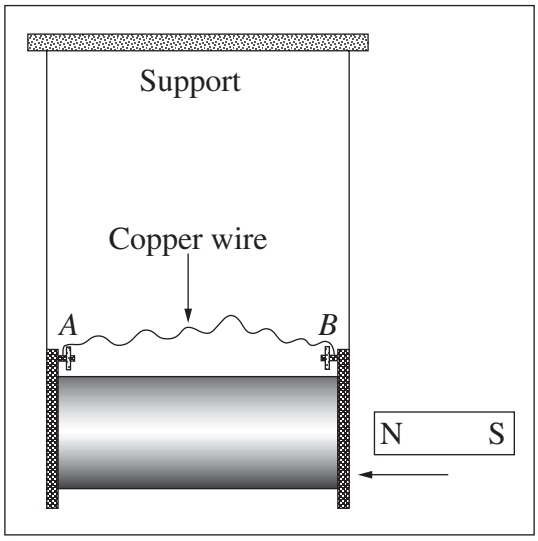

Figure 2 – Second investigation

In the first investigation shown in Figure 1, a strong bar magnet is moved towards the solenoid until the north end of the magnet enters the solenoid and then the motion of the magnet is stopped.

In the second investigation, shown in Figure 2, a thick copper wire is connected between the two terminals, *A* and *B*, at the ends of the solenoid. The motion of the magnet is repeated exactly in this second investigation.

Explain the effect of the motion of the magnet on the solenoid in the two investigations.

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Question 21 (5 marks)

(a) Explain the relationship between the current in the primary coil and the current in the secondary coil of an ideal step-down transformer in relation to the conservation of energy. **3**

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(b) Explain why a transformer will work in an AC circuit but not in a DC circuit. **2**

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Marks

Question 22 (5 marks)

Describe a first-hand investigation to demonstrate the effect on a generated electric current when the strength of the magnet is varied. **5**

In your description, include:

- a labelled sketch of the experimental set-up;
- how you varied the magnetic field strength;
- how other variables were controlled.

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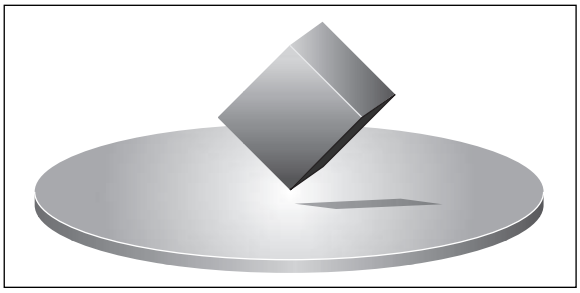
Marks

Question 23 (6 marks)

(a) The following image shows a magnet hovering above a superconducting disk. **3**



Explain why the magnet is able to hover above the superconductor.

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(b) Compare the model for the conduction of electricity in metals at room temperature with the model for conduction of electricity in superconductors below the critical temperature. **3**

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Centre Number

Section I – Part B (continued)

Student Number

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Question 24 (4 marks)

Outline Thomson's experiment to measure the charge/mass ratio of an electron. **4**

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Marks

Question 25 (5 marks)

A physics student was conducting an investigation on the photoelectric effect. The student used an infrared laser with a wavelength of 1.55×10^{-6} m for this investigation.

(a) Calculate the energy of a photon from this laser. **2**

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(b) When the laser light was shone onto a photo-cell, no current was detected. The student increased the intensity of the light but still detected no current. **3**

Explain this observation.

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Marks

Question 26 (6 marks)

Describe Einstein's contributions to Special Relativity and to Quantum Theory and how these contributions changed the direction of scientific thinking in the Twentieth Century. **6**

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Marks

Question 27 (4 marks)

In a particle accelerator called a synchrotron, magnetic fields are used to control the motion of an electron so that it follows a circular path of fixed radius. **4**

Describe the changes required in the magnetic field to accelerate an electron to near the speed of light. Support your answer with appropriate mathematical relationships.

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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.

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Marks

Question 28 — Geophysics (25 marks)

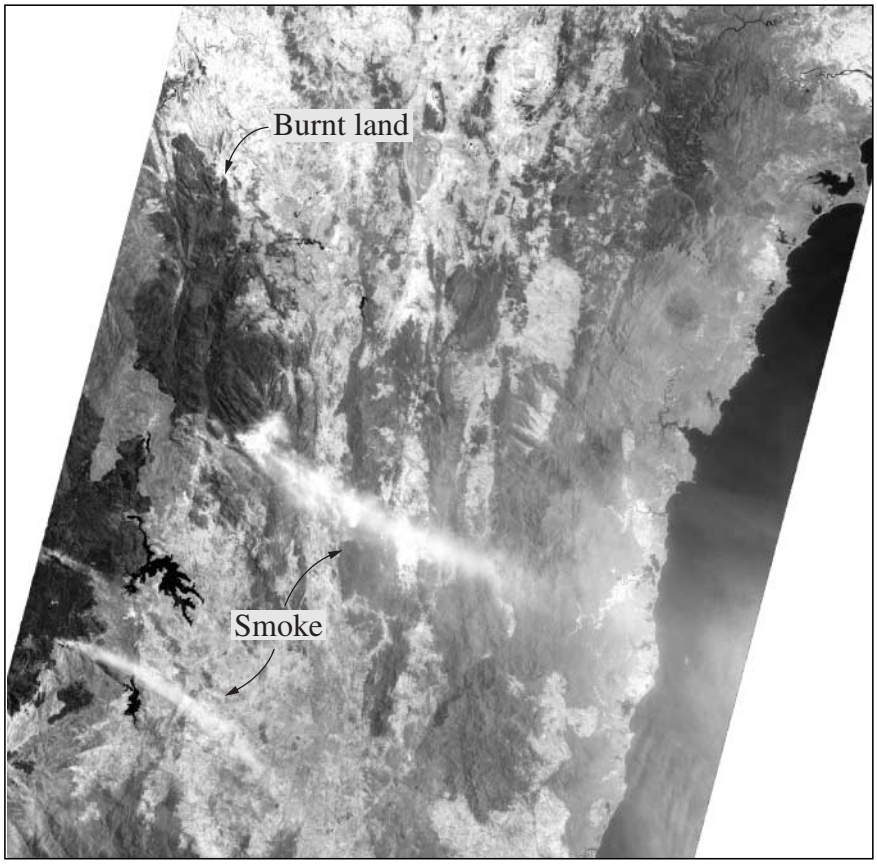
(a) (i) Identify THREE principal methods used by geophysicists to investigate the structure of Earth and the properties of Earth materials. **1**

(ii) Describe the role that geophysicists play in the monitoring of nuclear test-ban treaties. **2**

(b) Summarise the geophysical evidence that supports the theory of plate tectonics. **3**

(c) (i) Describe how absorption and reflection of radiation can provide information about a reflecting surface. **2**

(ii) The picture below shows a satellite image of a bushfire burning in a forested area. Images such as the one below can be used as a part of the process of monitoring changes in vegetation. **3**



Explain how remote-sensing techniques can be used to monitor the spread of a bushfire, and the regrowth of vegetation in regions affected by a bushfire.

Question 28 continues on page 32

Marks

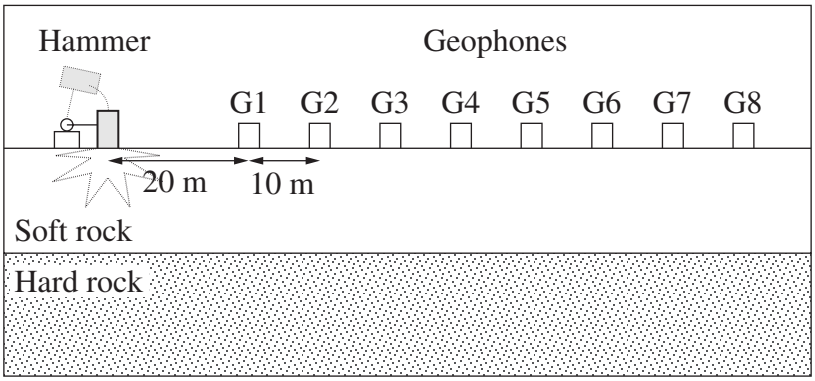
Question 28 (continued)

(d) (i) Outline the structure and function of a geophone. **2**

(ii) The method of seismic refraction is depicted in the diagram below. A series of eight geophones, G1 to G8, are arranged in a straight line along level ground. They are each separated by a distance of 10 m.

At a distance of 20 m from the first geophone, a hammer is used to strike the ground to produce seismic waves.

The geophones are attached to a seismograph that records the time of arrival of the waves after the hammer strikes the ground.

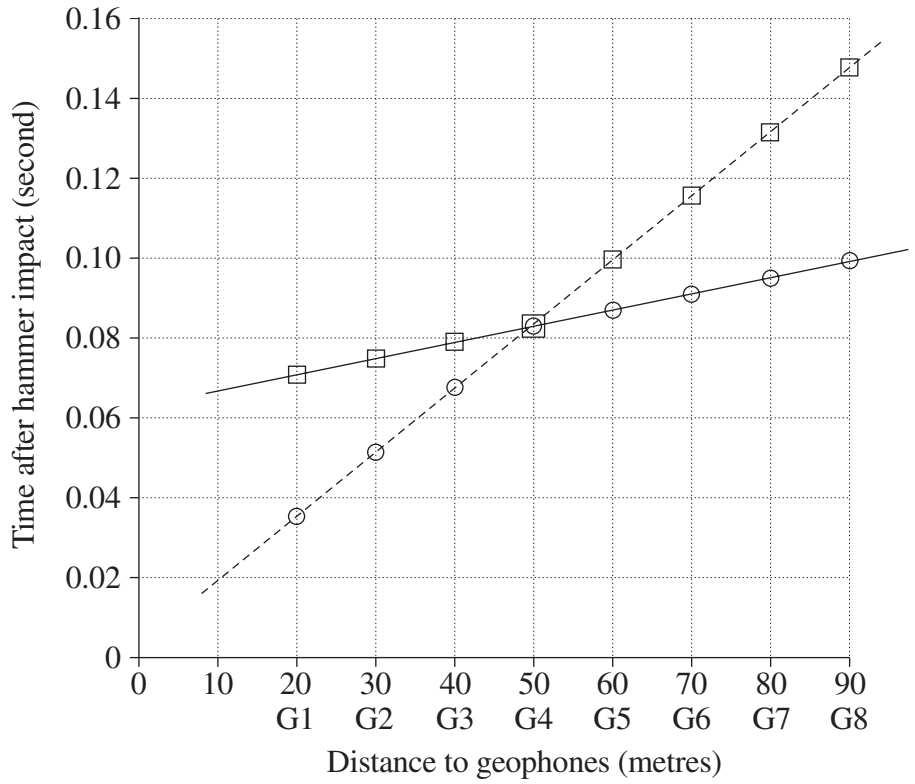


The data from the geophones are analysed and the arrival times of the direct and refracted waves that reach each geophone are recorded. These data are shown in the graph on page 33. On the graph, a circle represents the arrival of the first wave to reach a geophone, and a square represents the arrival time of the second wave to reach a geophone. The points on the graph associated with the direct seismic wave and the refracted seismic wave are shown.

Question 28 continues on page 33

Marks

Question 28 (continued)



Legend

○ Time of arrival of first wave at geophone

□ Time of arrival of second wave at geophone

——— Refracted wave

------ Direct wave

(1) Explain why the line for the refracted wave crosses the line for the direct wave on the graph. **2**

(2) From the graph, calculate the speed of the direct wave in the soft rock layer. **2**

(e) Outline the application of Newton's theory of universal gravitation to the field of geophysics, and discuss how information obtained from gravity surveys has led to a greater understanding of the structure of Earth. **8**

End of Question 28

Marks

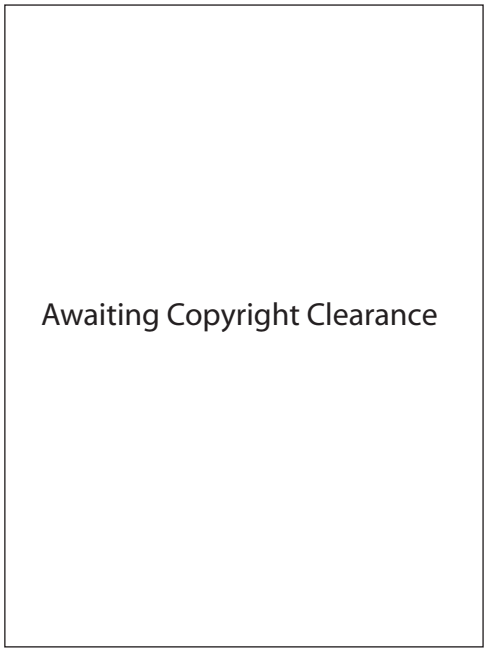
Question 29 — Medical Physics (25 marks)

(a) (i) Identify the property of the hydrogen nucleus that makes it useful in magnetic resonance imaging. **1**

(ii) Describe how X-rays are produced when electrons strike the anode in an X-ray tube. **2**

(b) Outline the production of gamma rays and their use in the diagnostic procedure of positron emission tomography (PET). **3**

(c) This question refers to the bone scan of a person with cancer, and a chest X-ray of a healthy person.



Bone-scan image

X-ray image

(i) Compare how radiation is used to produce a bone scan image and an X-ray image. **3**

(ii) Describe how a bone scan is able to provide information that an X-ray cannot provide. **2**

Question 29 continues on page 35

Question 29 (continued)

(d) The table below shows the speed of sound in, and density of, several different tissues.

Tissue	*Speed of sound in tissue* (m s^{-1})	*Density* (kg m^{-3})
Fat	1450	952
Blood	1570	1025
Kidney	1560	1038
Liver	1550	1065
Muscle	1580	1076

(i) Calculate the acoustic impedance of kidney tissue. **1**

(ii) Ultrasound travelling through kidney tissue in the body encounters a different type of tissue. Identify the type of tissue that will result in the greatest proportion of the incident pulse being reflected at the boundary between the kidney and the other tissue. Justify your choice. **2**

(iii) Describe the properties of ultrasound that led to its use in the measurement of bone density. **3**

(e) An understanding of the properties of electrons, and our ability to control their behaviour, have played key roles in the development of CAT scans and positron emission tomography imaging technologies. **8**

Justify this statement with reference to the production and display of images used for medical diagnosis.

End of Question 29

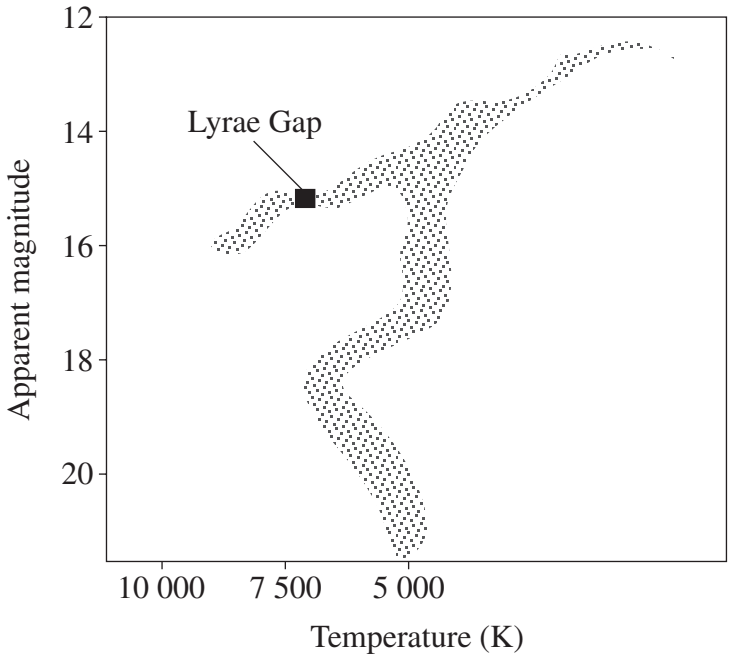
Marks

Question 30 — Astrophysics (25 marks)

(a) (i) Define the term *resolution* of a telescope. **1**

(ii) Describe ONE method by which the resolution of a ground-based system can be improved. **2**

(b) An H-R diagram for the globular cluster M3 is shown below. **3**



The stars in the Lyrae gap have an absolute magnitude of 0.6. Use this information and their position on the H-R diagram to determine the distance of M3 from Earth.

Question 30 continues on page 37

Marks

Question 30 (continued)

(c) The diagram below is a comparison of the spectrum of quasar 3C 273 and a spectrum from a light source on Earth.

(i) From this comparison, identify the feature of the quasar spectrum that is representative of the spectra produced by quasars. **1**

(ii) The spectra above are both examples of absorption spectra.

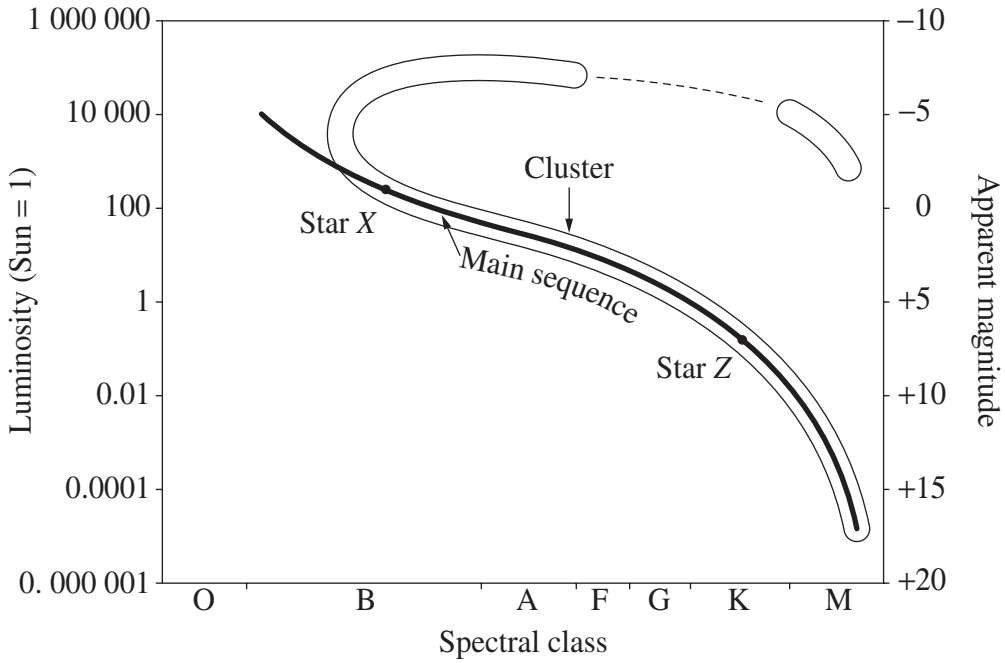
(1) Account for the production of a star's absorption spectrum. **2**

(2) Describe how a spectrum from a star can provide information on the surface temperature of that star. Give a specific example to illustrate your answer. **2**

Question 30 continues on page 38

Question 30 (continued)

(d) The H-R diagram for a cluster is shown below.



(i) Why is the cluster considered young? **1**

(ii) Stars *X* and *Z* are both part of the same cluster but have different main sequence nuclear reactions and different evolutionary pathways.

(1) Contrast the fusion reactions in star *X* and star *Z*. **2**

(2) Predict TWO possible evolutionary pathways for star *X*. **3**

(e) Evaluate the impact of studying the visible spectrum of light on our understanding of celestial objects. **8**

End of Question 30

Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) (i) Identify the structure of the Rutherford model of the atom. **1**

(ii) Describe how Bohr refined Rutherford's model of the hydrogen atom. **2**

(b) The table below shows the different types of quarks and their charge. **3**

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

The standard model of matter says that protons and neutrons are composed of up and down quarks. There are three quarks in each particle.

Compare protons and neutrons in terms of their quark composition.

(c) The equations shown below describe three different types of transmutation reactions involving uranium.

(1) $^{238}_{92}\mathrm{U} + {}^{1}_{0}n \rightarrow {}^{239}_{92}\mathrm{U}$

(2) $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$

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

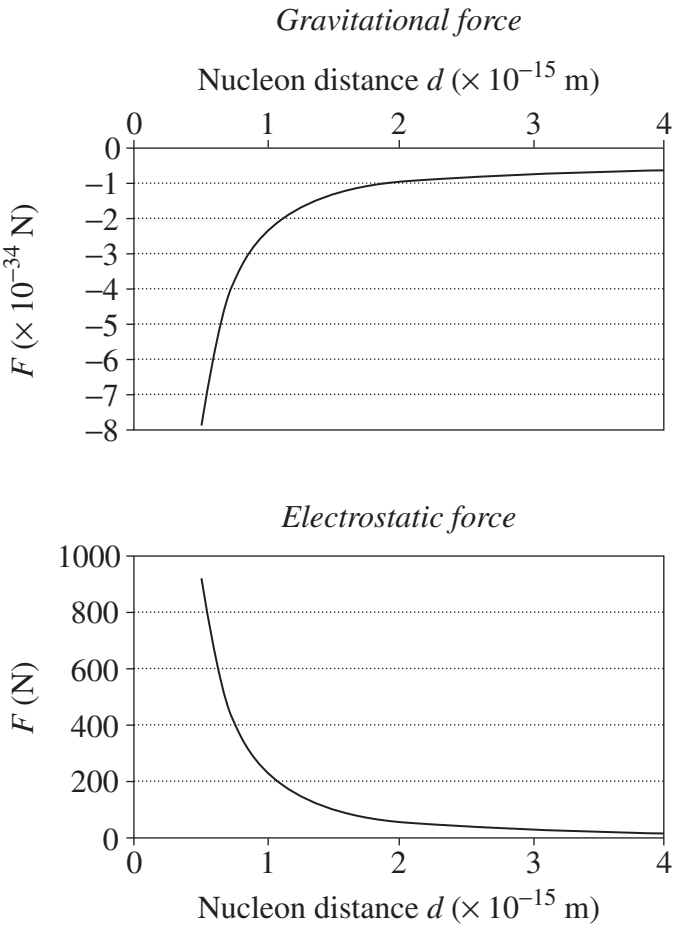
(i) Identify which reaction is naturally occurring, and justify your answer. **2**

(ii) Identify ONE transmutation reaction above that has a practical application, and describe the application. **3**

Question 31 continues on page 40

Question 31 (continued)

(d) The two graphs below show the gravitational and electrostatic forces acting between two protons in the nucleus of an atom.



(i) If the distance between protons in a nucleus is 1.0×10^{-15} m, determine both the gravitational and the electrostatic force at this distance. **2**

(ii) Explain why these two forces cannot explain the stability of the nucleus, and why there is a need for the strong nuclear force. **2**

(iii) Describe TWO properties of the strong nuclear force. **2**

(e) Describe the requirements for a nuclear fission explosion, and describe how these are controlled in a nuclear reactor. **8**

End of Question 31

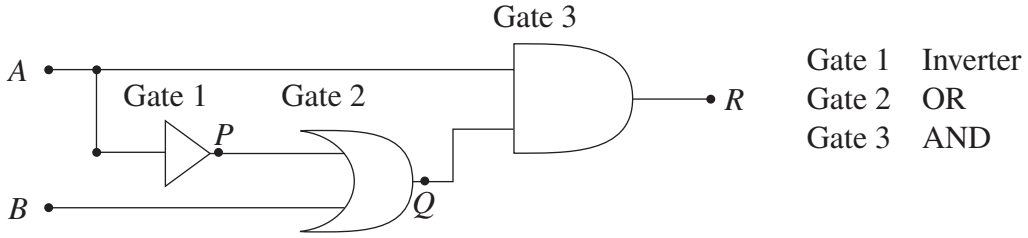
Marks

Question 32 — The Age of Silicon (25 marks)

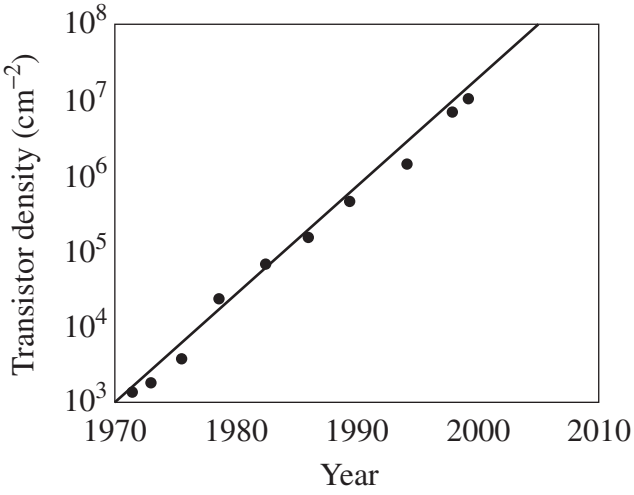
(a) (i) Identify ONE electronic system that is digital, and ONE electronic system that is analogue. **1**

(ii) Use diagrams to describe the variation between digital and analogue voltage outputs with time. **2**

(b) Construct a truth table showing the outputs at P, Q and R for each of the possible input states of A and B in the following circuit. **3**



(c) The graph below shows how the density of transistors on a silicon chip has increased over the last 30 years.



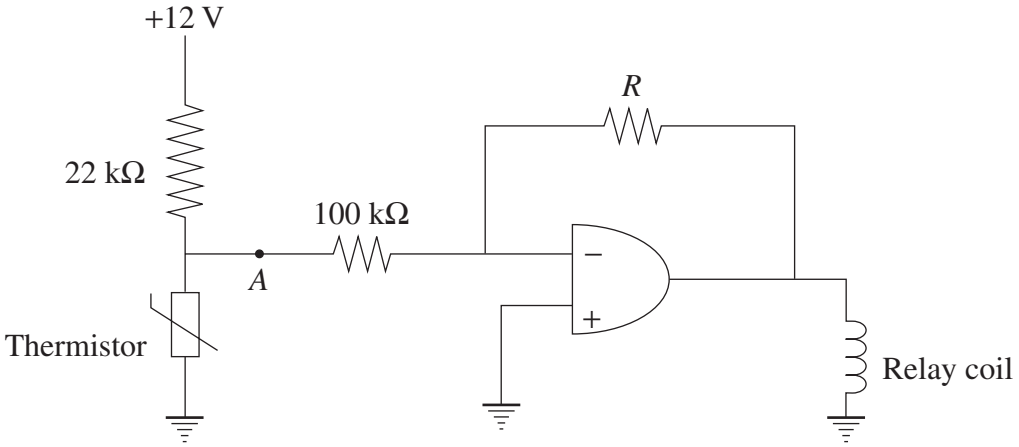
(i) Use the data in the graph to predict the change in computer performance from 1970 to 2005. Justify your answer. **3**

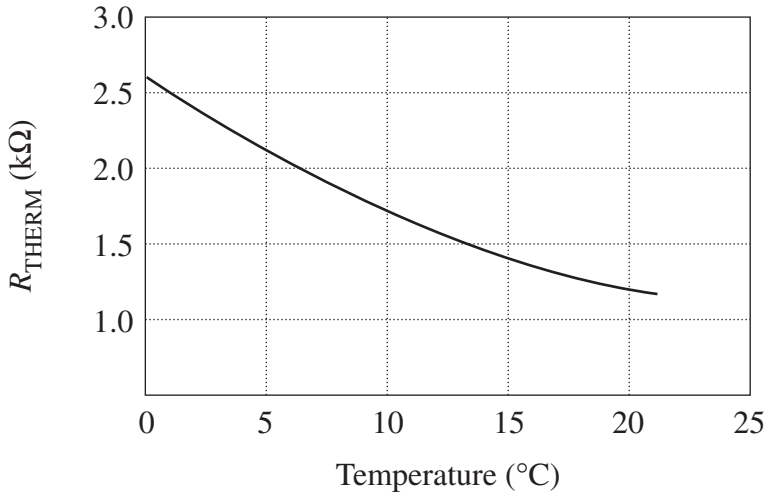
(ii) Discuss the validity of using the graph to predict computer performance up to 2060. **2**

Question 32 continues on page 42

Question 32 (continued)

(d) The circuit below uses a thermistor as a temperature sensor to control the operation of a relay. The relay will close when the voltage across the relay coil is greater than 6 volts. The resistance of the thermistor, R_{THERM}, is given in the graph.





(i) Calculate the voltage at point *A* at a temperature of 15°C. Neglect the effect of the 100 kΩ resistor and the operational amplifier on the voltage at point *A*. **3**

(ii) Determine the value of *R* so that the relay will close only when the temperature falls below 15°C. **3**

(e) Describe and compare the physical principles underlying the operation of input and output transducers. Use an analogue ammeter and a solar cell as examples. **8**

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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

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

$$Z = \rho v$$

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

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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

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

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

Lanthanides

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

Actinides

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

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