BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

2000
PHYSICS
2 UNIT

Time allowed—Three hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- Board-approved calculators may be used.

Section I—Core

- Attempt ALL questions.
- **Part A** 15 multiple-choice questions, each worth 1 mark.
  Complete your answers in either blue or black pen on the Answer Sheet provided.
- **Part B** 10 questions, each worth 3 marks.
  Answer this Part in the Part B Answer Book.
- **Part C** 6 questions, each worth 5 marks.
  Answer this Part in the Part C Answer Book.
- Write your Student Number and Centre Number on the cover of each Answer Book.
- You may keep this Question Book. Anything written in the Question Book will NOT be marked.

Section II—Electives

- Attempt ONE question.
- Each question is worth 25 marks.
- Answer each Elective or Half-elective in a SEPARATE Elective Answer Book.
- Write your Student Number and Centre Number on the cover of each Elective Answer Book.
- Write the Course, Elective Name, and Question Number on the cover of each Elective Answer Book.
- You may ask for extra Elective Answer Books if you need them.

A Data Sheet and Periodic Table are provided as a tear-out sheet at the back of this paper.

SECTION I

(75 Marks)

Attempt ALL questions.

PART A

Instructions for answering multiple-choice questions

- Complete your answers in either blue or black pen.
- Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

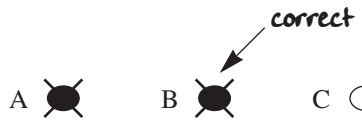
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

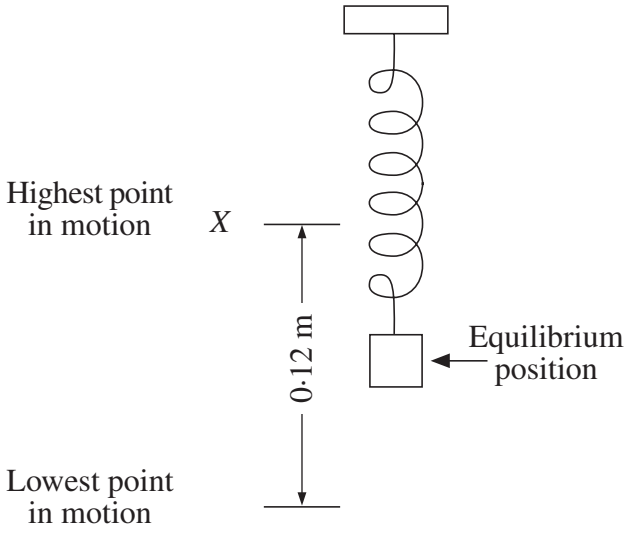
A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

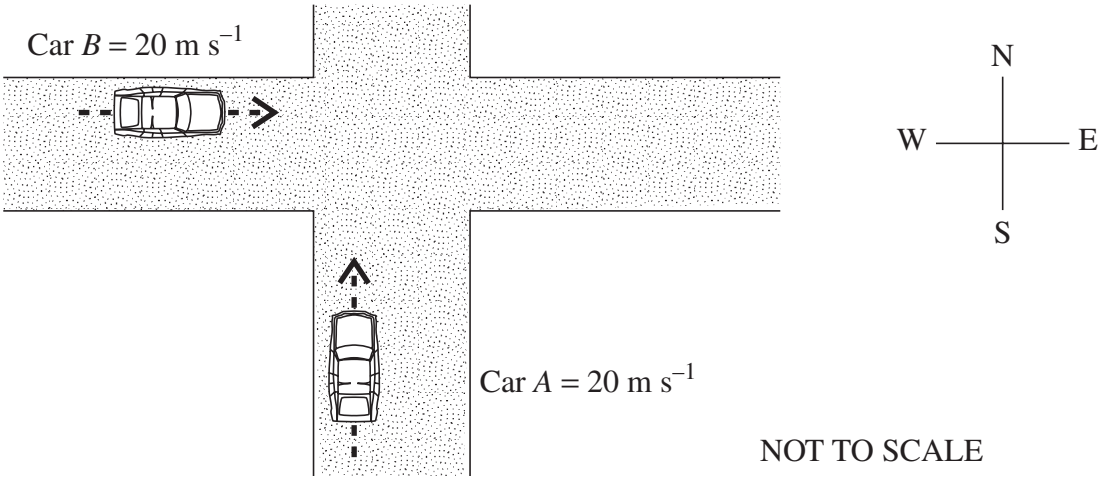
1 An object vibrates on the end of a spring as shown.



Which alternative gives the amplitude of the motion and the direction of the acceleration at point *X*?

	Amplitude (m)	*Direction of acceleration at X*
(A)	0·060	↓
(B)	0·060	↑
(C)	0·12	↓
(D)	0·12	↑

2 Car *A* and Car *B* approach an intersection as shown.



What is the approximate velocity of Car *B* relative to Car *A*?

(A) 28 m s^{-1} NE

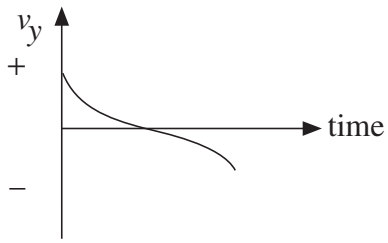
(B) 28 m s^{-1} NW

(C) 28 m s^{-1} SE

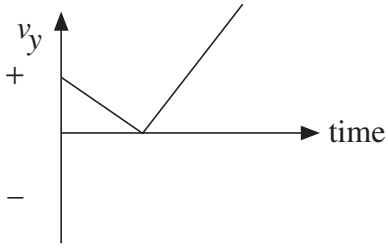
(D) 28 m s^{-1} SW

3 A stone is thrown upwards from the top of a cliff at an angle of 45° to the horizontal. Which graph of the vertical component (v_y) of the stone's velocity as a function of time best describes its motion? (Ignore air resistance.)

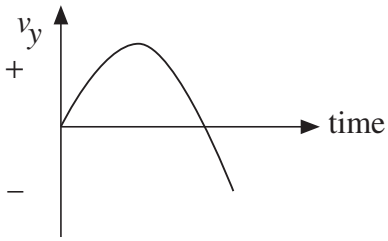
(A)



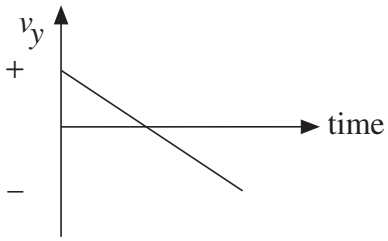
(B)



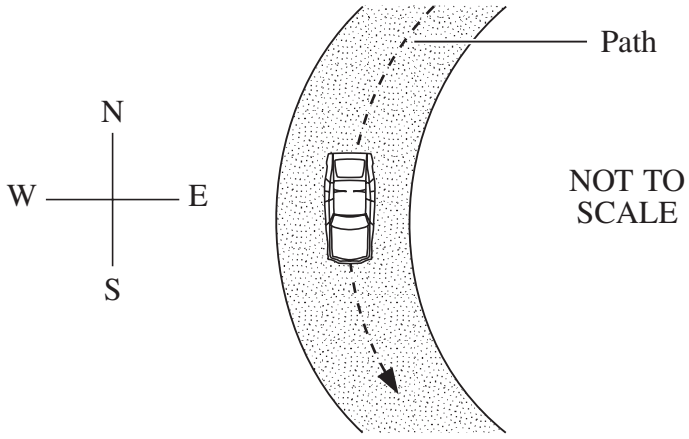
(C)



(D)



4 A car is moving at a *constant* speed along a circular path, as shown in the diagram.



At the instant shown, the car is moving south. Which statement best describes the acceleration at this instant?

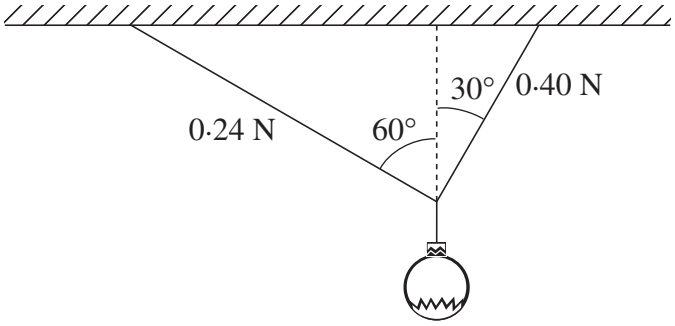
(A) The acceleration is directed to the south.

(B) The acceleration is directed to the west.

(C) The acceleration is directed to the east.

(D) The acceleration is zero.

5 A decoration is hung from two strings, as shown.



NOT TO SCALE

What is the approximate mass of the decoration?

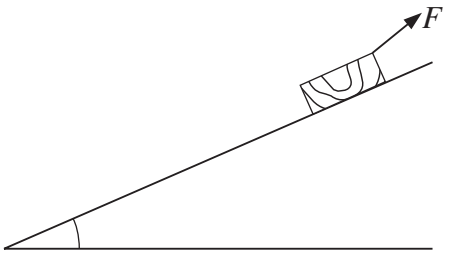
(A) $4{\cdot}2 \times 10^{-2}$ kg

(B) $4{\cdot}8 \times 10^{-2}$ kg

(C) $4{\cdot}1 \times 10^{-1}$ kg

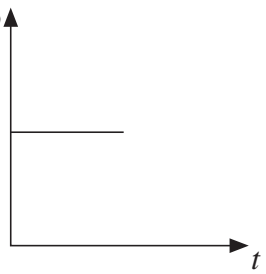
(D) $4{\cdot}7 \times 10^{-1}$ kg

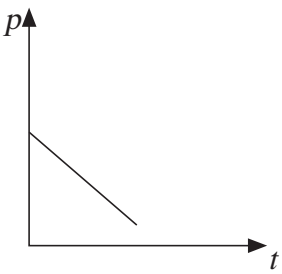
6 A block of wood is sliding down a smooth inclined plane. A constant force (F) is applied to the block, causing it to slow down.

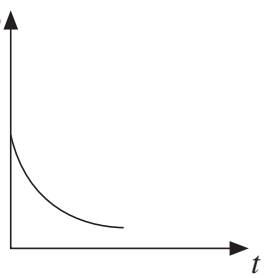


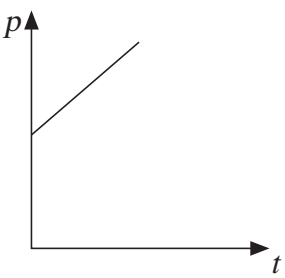
NOT TO SCALE

Which of the following momentum (p) versus time (t) graphs correctly describes the motion of the block?

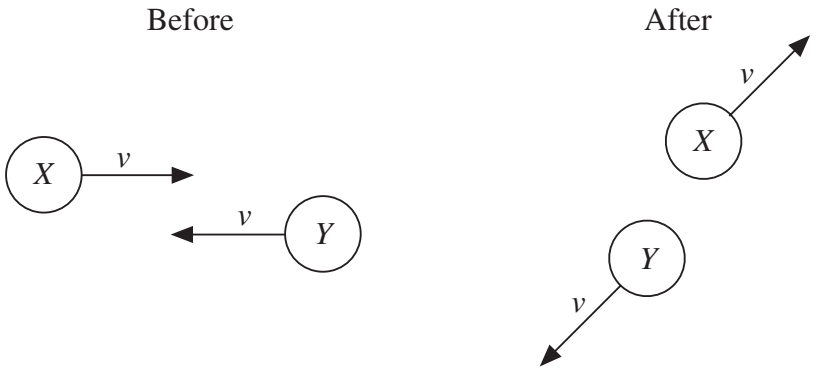
(A)


(B)


(C)


(D)


7 Two identical balls, *X* and *Y*, collide. The balls have the same speed *v* before and after the collision.



Which statement best describes the collision?

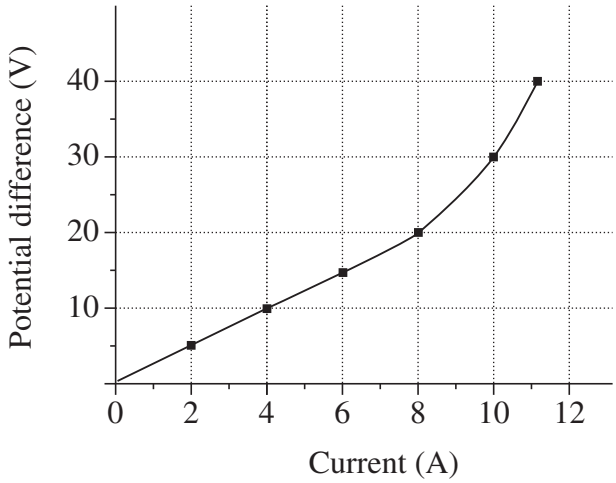
(A) The collision is inelastic and the momentum of the system is zero.

(B) The collision is inelastic and the momentum of the system is conserved.

(C) The collision is elastic and the momentum of ball *X* is conserved.

(D) The collision is elastic and the momentum of ball *X* is not conserved.

8 The graph shows the relationship between potential difference across and current through an electrical device.



Which statement best describes the behaviour of the electrical device at 10 V?

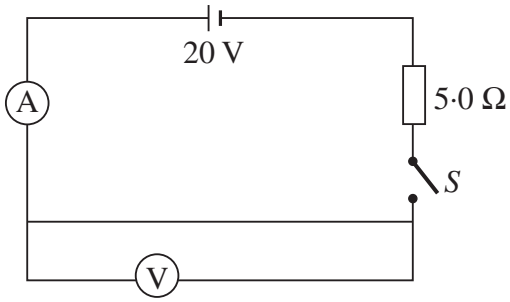
(A) It obeys Ohm's Law and has a resistance of 2·5 Ω.

(B) It obeys Ohm's Law and has a resistance of 3·0 Ω.

(C) It does not obey Ohm's Law and has a resistance of 2·5 Ω.

(D) It does not obey Ohm's Law and has a resistance of 3·0 Ω.

9 An ideal voltmeter and an ideal ammeter are connected into a circuit as shown.

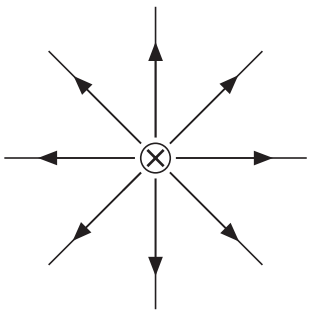


What are the readings on the voltmeter and ammeter when switch *S* is closed?

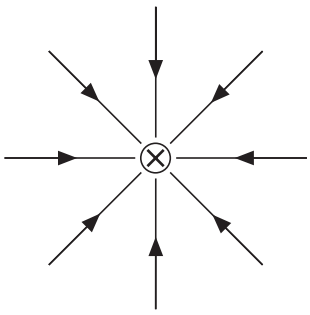
	Voltmeter (V)	*Ammeter* (A)
(A)	0	0
(B)	0	4·0
(C)	20	0
(D)	20	4·0

10 Which diagram shows the magnetic field around a straight wire carrying a current *into* the page?

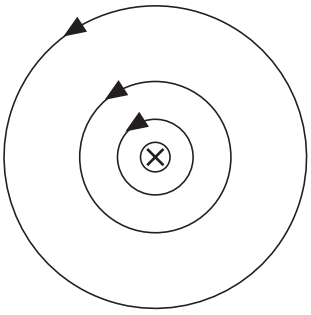
(A)



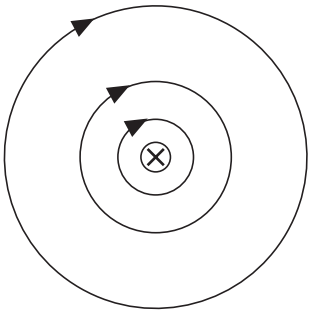
(B)



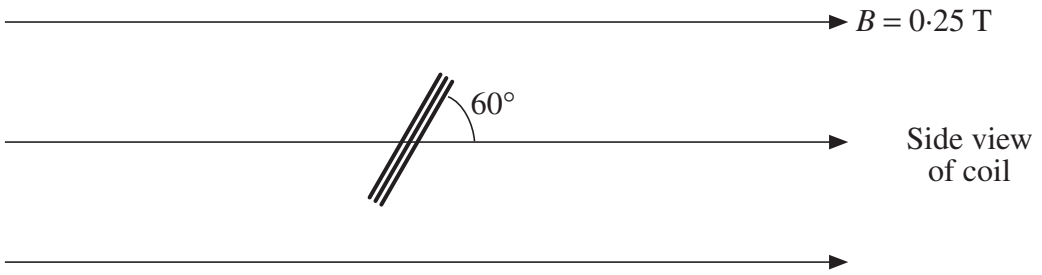
(C)



(D)



11 A coil consists of *three* turns of wire. Each turn encloses an area of $5{\cdot}0 \times 10^{-4}$ m^2. The plane of the coil is positioned at 60° to the direction of a magnetic field of 0·25 T.



What is the value of the magnetic flux through the coil?

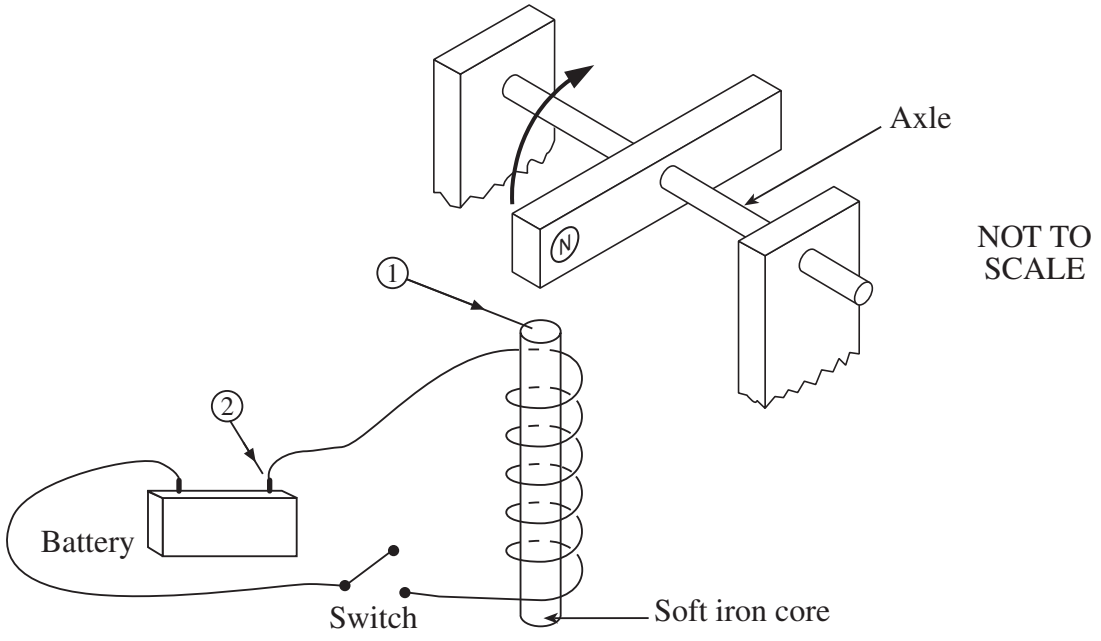
(A) $1{\cdot}1 \times 10^{-4}$ Wb

(B) $1{\cdot}9 \times 10^{-4}$ Wb

(C) $3{\cdot}2 \times 10^{-4}$ Wb

(D) $3{\cdot}8 \times 10^{-4}$ Wb

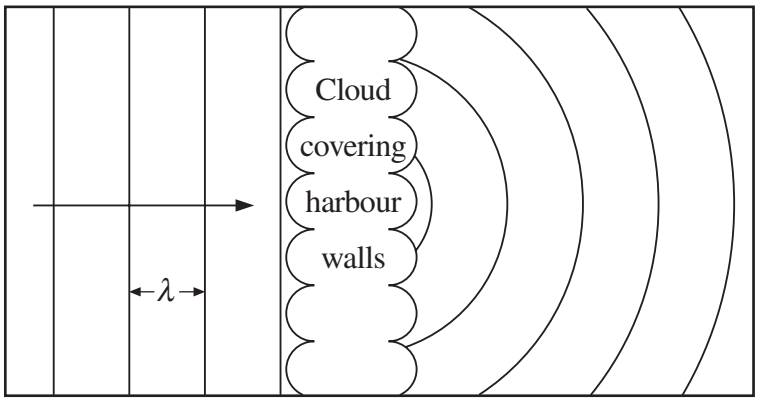
12 A magnet is free to spin. When the switch is closed, the magnet spins in the direction shown.



What is the magnetic polarity of the end of the soft iron core marked ① and the polarity of the battery terminal marked ②?

	Polarity of magnet ①	*Polarity of battery* ②
(A)	South	Positive
(B)	South	Negative
(C)	North	Positive
(D)	North	Negative

13 The diagram depicts a satellite photo of a harbour. The region in the photo is of uniform water depth. Ocean waves of wavelength λ are approaching the harbour walls which are covered by clouds.



The shape of the wavefronts inside the harbour is consistent with which of the following statements?

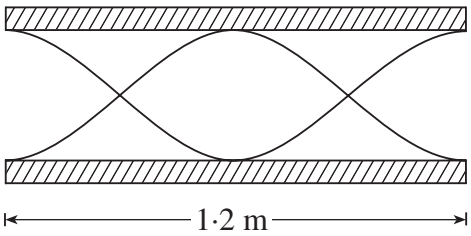
(A) The harbour has one entrance, the width of which is 10 λ.

(B) The harbour has one entrance, the width of which is $\frac{\lambda}{10}$.

(C) The harbour has two narrow entrances, separated by a distance of 10 λ.

(D) The harbour has two narrow entrances, separated by a distance of 2 λ.

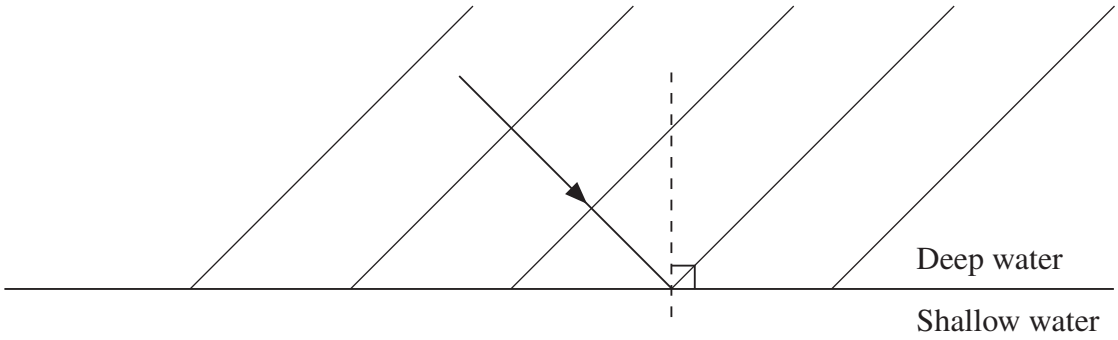
14 An organ is constructed so that it has open pipes. A note produced by one of these pipes has a frequency of 280 Hz. The length of this pipe is 1·2 m. A representation of a standing wave corresponding to this note is shown.



What are the frequency and wavelength of the fundamental resonance for this pipe?

	Frequency (Hz)	*Wavelength* (m)
(A)	140	1·2 m
(B)	140	2·4 m
(C)	560	1·2 m
(D)	560	2·4 m

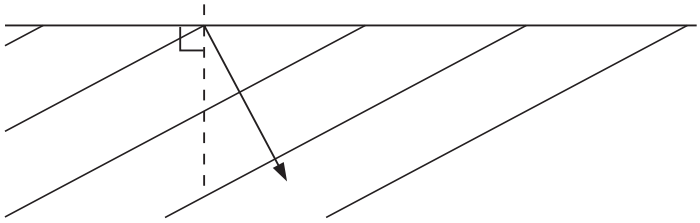
15 Successive waves in deep water are incident upon an interface with shallow water as shown.



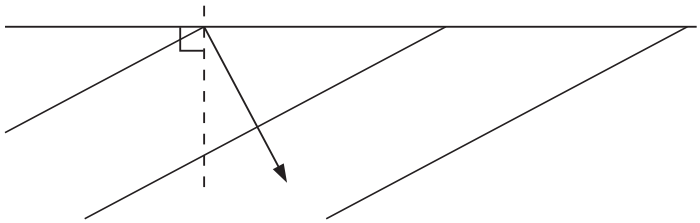
Note: All figures are drawn to the same scale.

Which diagram best represents the correct arrangement of successive wavefronts in the shallow water?

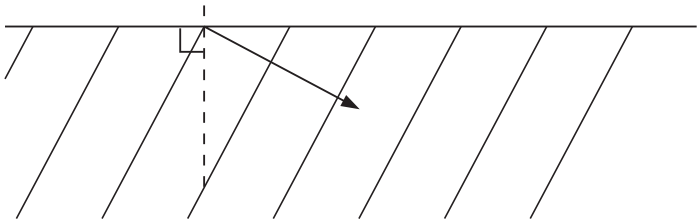
(A)



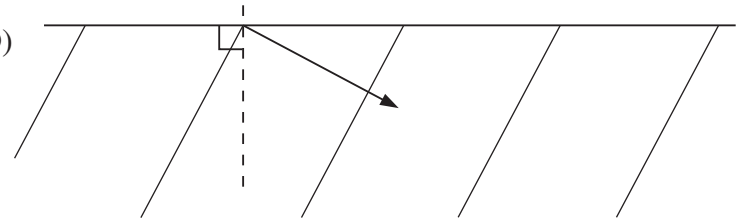
(B)



(C)



(D)



PART B

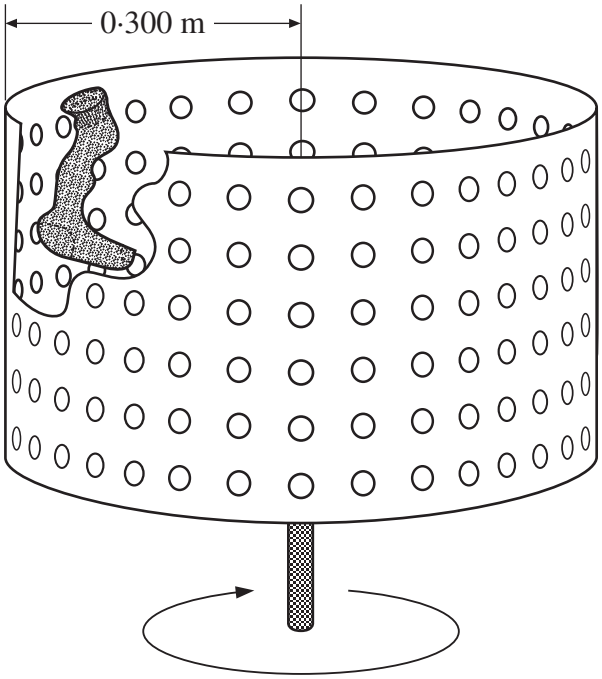
Questions 16–25 are worth 3 marks each.

Answer this Part in the Part B Answer Book.

Show all necessary working.

Marks may be awarded for relevant working.

16 A washing machine has a drum of radius 0·300 m. The drum spins at 525 revolutions per minute. A sock of mass 0·0250 kg is observed to be spinning in a horizontal circle against the wall of the drum.

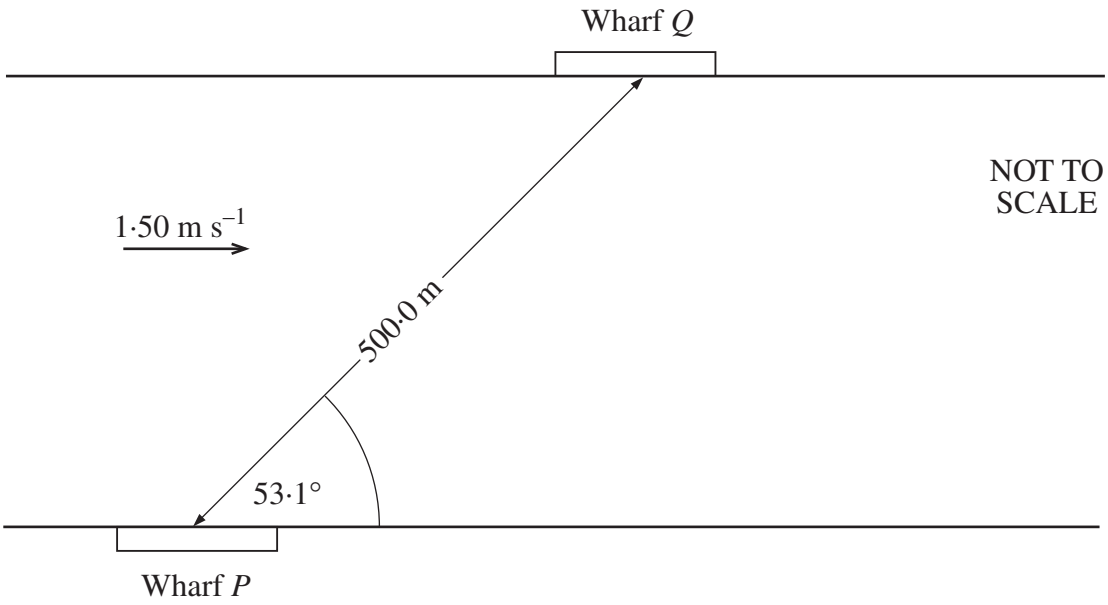


(a) What is the angular speed of the sock, in rad s^{-1}?

(b) Calculate the magnitude of the centripetal force on the sock.

(c) What is the value of the horizontal component of the force of the drum on the sock?

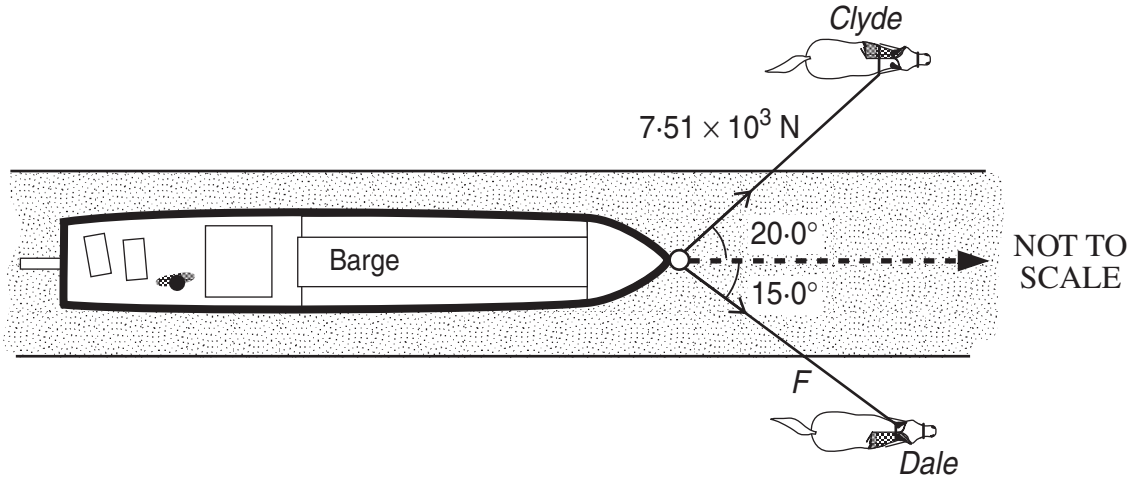
17 A ferry travels across a river in 200·0 seconds from Wharf *P* to Wharf *Q*. The river flows at $1{\cdot}50\ \text{m s}^{-1}$ in the direction shown. The banks of the river are parallel.



(a) Calculate the average speed of the ferry along its path *PQ*.

(b) What is the velocity of the ferry *relative* to the water? Show working.

18 The figure shows a barge being pulled along a straight canal by two horses, *Clyde* and *Dale*. Both of the horses and the barge are moving parallel to the banks of the canal. *Clyde* exerts a force of $7{\cdot}51 \times 10^3$ N on the tow-rope, which makes an angle of 20·0° to the direction of motion of the barge. *Dale* exerts a force *F* on the tow-rope, which makes an angle of 15·0° to the direction of motion of the barge.

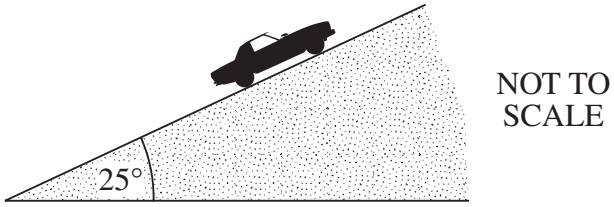


(a) What force *F* must *Dale* exert on the tow-rope for the barge to move parallel to the banks of the canal?

(b) The barge continues to move parallel to the canal banks.
The opposing force exerted by the water on the barge is $1{\cdot}62 \times 10^4$ N. The mass of the barge is $1{\cdot}28 \times 10^5$ kg.

What is the acceleration of the barge?

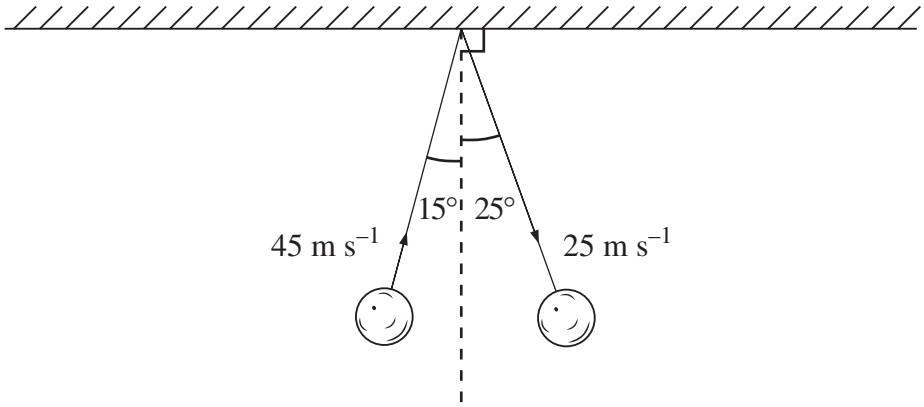
19 A car of mass 1540 kg is stationary on a hill that has a slope of 25°.



(a) In the space provided in your Part B Answer Book, sketch and label the forces acting on the stationary car.

(b) Calculate the force that is necessary to stop the car from moving.

20 A squash ball strikes the wall of a court horizontally with a speed of 45 m s^{-1} and at an angle of 15° as shown. It bounces off the wall at an angle of 25°, with a speed of 25 m s^{-1}. The mass of the squash ball is 25 g.

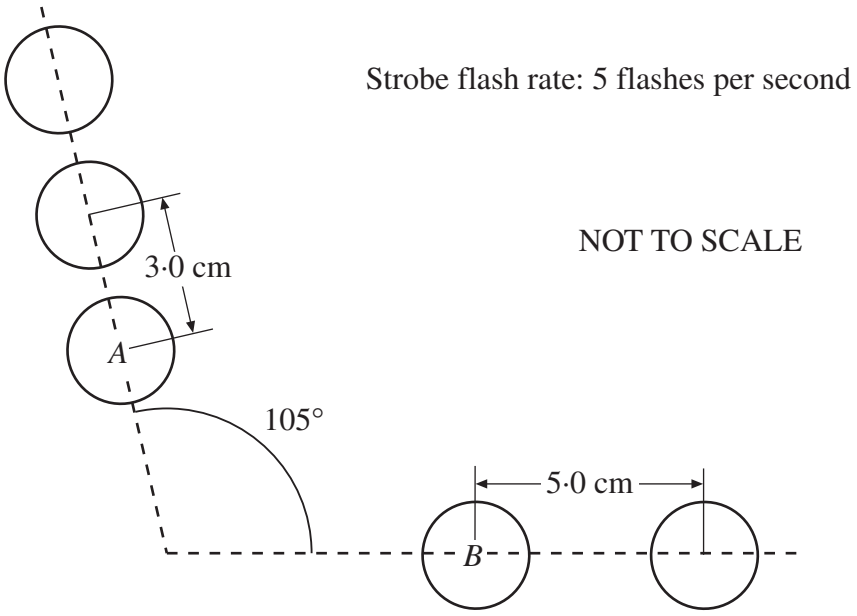


(a) Calculate the *change* in the component of the momentum of the ball normal to the wall.

(b) The collision of the ball with the wall takes place over a time interval of $5{\cdot}0 \times 10^{-3}$ s.

Calculate the average component of the force (normal to the wall) exerted by the ball on the wall.

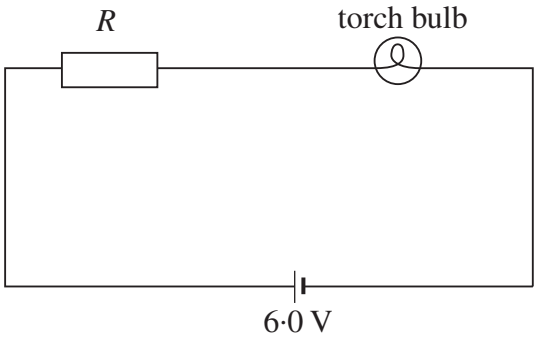
21 Three identical pucks, *A*, *B* and *C*, are initially in contact and at rest on a frictionless table. The pucks move away from each other after an explosion. The motion of pucks *A* and *B* is recorded, using strobe photography, as shown in the diagram.



(a) Determine the speed of puck *B* after the explosion.

(b) Calculate the speed of puck *C* after the explosion.

22 A current of 0·30 A flows through a torch bulb when operated at its *rated* voltage of 1·5 V. The circuit shown is used to light this torch bulb from a 6·0 V battery.

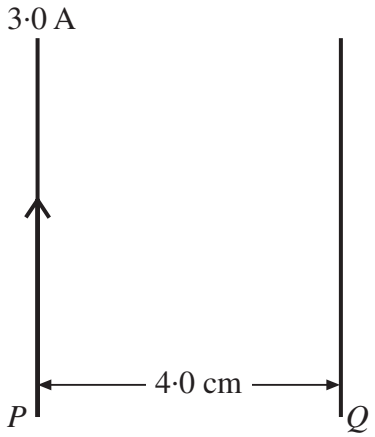


(a) What is the electrical power dissipated in the torch bulb when operated at its *rated* voltage?

(b) What is the potential difference across the resistor *R* if the torch bulb is to operate at its *rated* voltage?

(c) What is the required value of the resistance *R* for the torch bulb to operate at the *rated* voltage?

23 Two parallel conductors *P* and *Q* are shown in the diagram.



(a) A repulsive force per unit length of $3{\cdot}6 \times 10^{-5}\,\text{N m}^{-1}$ acts between the conductors.

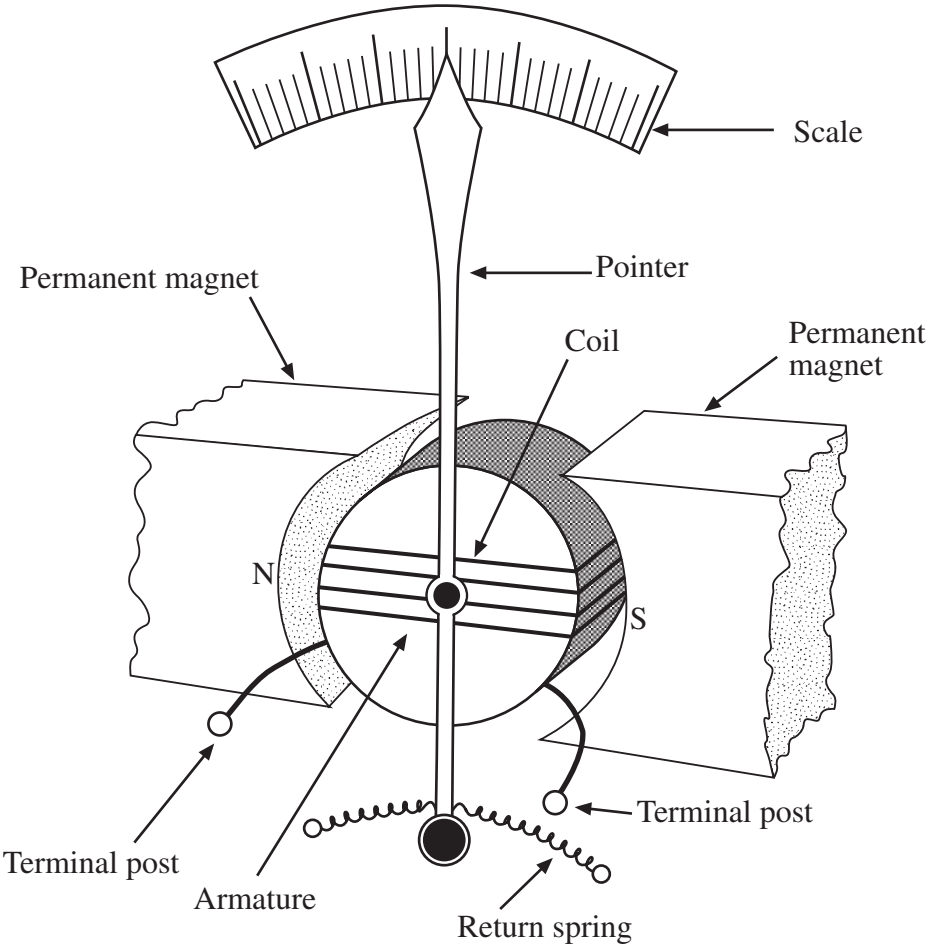
(i) Calculate the magnitude of the current flowing in conductor *Q*.

(ii) What is the direction of the current flowing in conductor *Q*?

(b) The distance between the conductors is doubled.

Calculate the new magnitude of the force per unit length between the conductors.

24 The diagram shows an application of the motor effect in a simple electrical meter.

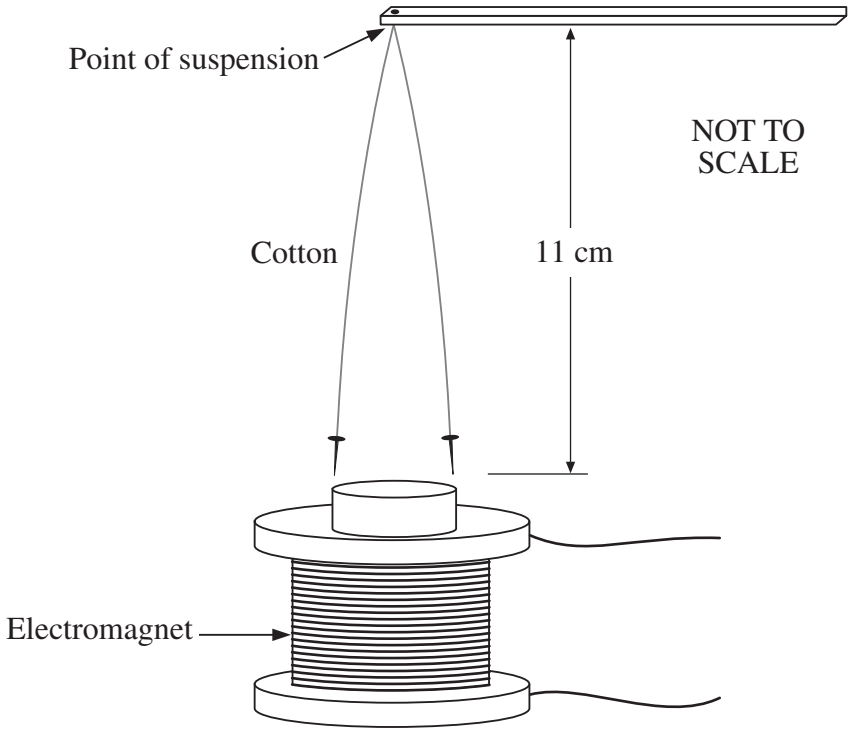


Laundry, G et al, Physics: An Energy Introduction, Laundry et al, McGraw Hill (Toronto) 1979, p 345. Reproduced with the permission of the McGraw-Hill Book Company

(a) Using the motor effect, explain briefly how this meter operates.

(b) Why are the poles of the permanent magnet curved around the armature?

25 A pin is suspended by a piece of cotton above an electromagnet, as shown. The electromagnet has an AC power supply that causes the pin to vibrate at 50 Hz. This sets up a fundamental mode of vibration for the string, with the pin acting as a free end.



(a) Calculate the wavelength of this fundamental mode of vibration.

(b) In the space provided in your Part B Answer Book, draw a diagram of the standing wave pattern that is observed when the frequency is 150 Hz.

(c) Explain briefly why no standing wave pattern is observed when the frequency is 100 Hz.

PART C

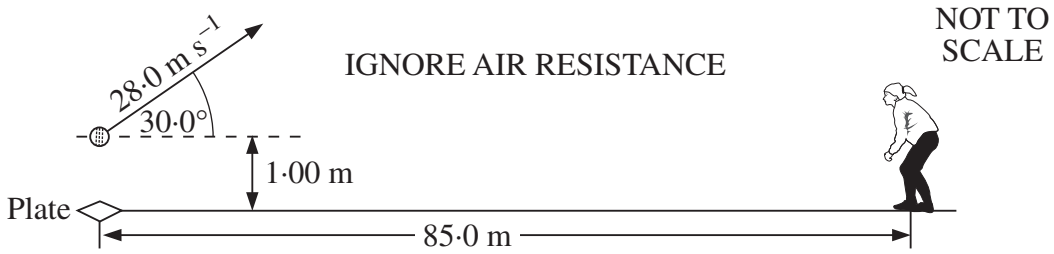
Questions 26–31 are worth 5 marks each.

Answer this Part in the Part C Answer Book.

Show all necessary working.

Marks may be awarded for relevant working.

26 A baseball is hit with a velocity of 28·0 m s^{-1} at an angle of 30·0° to the horizontal at an initial height of 1·00 m above the plate.



(a) What is the magnitude of the vertical component of the initial velocity?

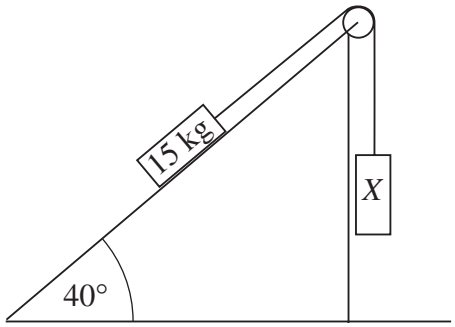
(b) How long does it take the ball to return to the initial height above the ground?

(c) What is the horizontal distance the ball travels before returning to the initial height above the ground?

(d) The ball is hit directly towards a stationary outfielder who is 85·0 m from the plate. At the instant the ball is hit, she begins to run towards the plate with constant acceleration.

What is the magnitude of her acceleration if she is to catch the ball when it is 1·00 m above the ground?

27 A 15 kg block is placed on a smooth inclined plane. It is attached by a light inextensible string over a frictionless pulley to block *X*.



(a) The 15 kg mass accelerates down the slope at 0·50 m s^{-2}.

(i) What is the magnitude of the resultant force acting on the 15 kg mass?

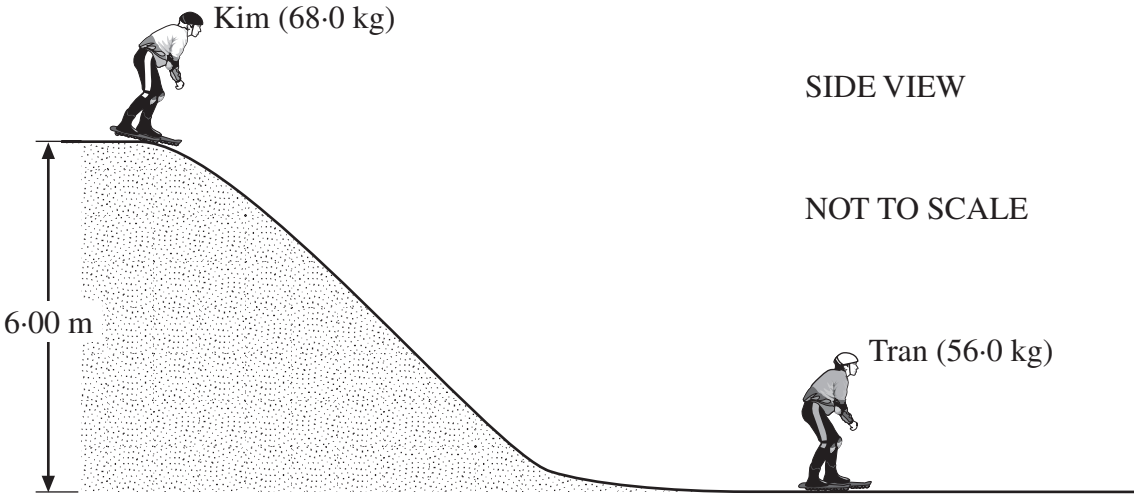
(ii) Calculate the tension in the string.

(iii) Calculate the mass of block *X*.

(b) The mass of block *X* is changed so that the resultant force acting on the 15 kg mass is zero.

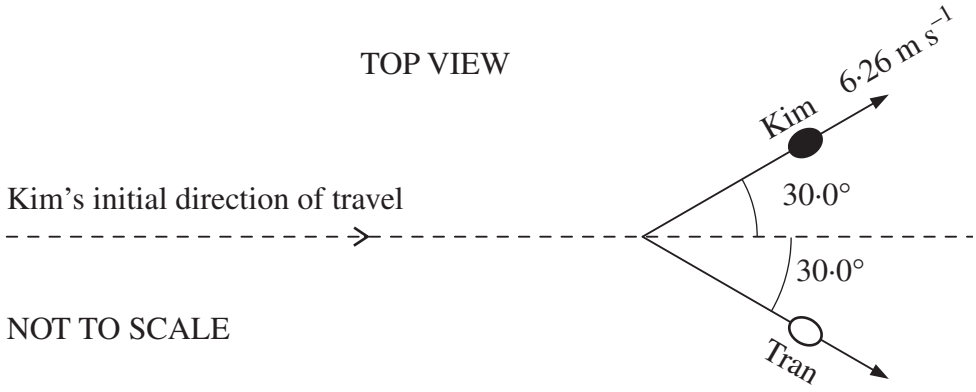
Calculate the new mass of block *X*.

28 Two HSC students, Kim and Tran, are at a grass ski slope that is 6·00 m high. Both Kim and Tran are wearing frictionless grass skis. Kim has a mass of 68·0 kg (including skis). Tran has a mass of 56·0 kg (including skis). Initially they are both at rest, Kim at the top of the slope and Tran at the bottom. Kim slides down the slope and collides with Tran.



(a) Calculate Kim's speed immediately before the collision.

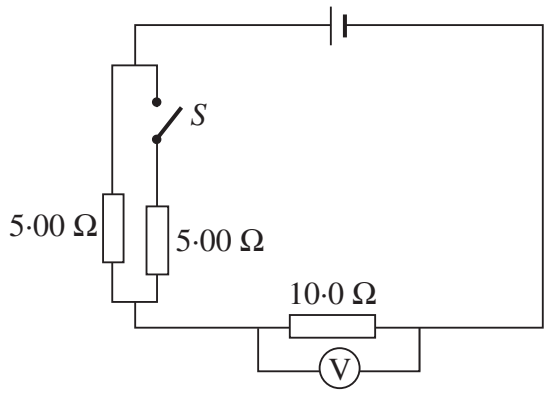
(b) After the collision, Kim moves with a speed of 6·26 m s^{-1} at an angle of 30·0° from his initial direction of travel, and Tran moves off at an angle of 30·0° on the other side of Kim's initial direction of travel, as shown in the diagram.



(i) Calculate Tran's speed after the collision.

(ii) Is the collision elastic or inelastic? Use calculations to justify your answer.

29 A current of 1·25 A flows through the circuit shown when the switch *S* is in the open position. Both the voltmeter and battery are ideal.



(a) (i) Calculate the voltage supplied by the battery.

(ii) Calculate the rate at which heat is dissipated in this circuit.

(b) The switch *S* is now closed.

(i) What will be the reading on the voltmeter?

(ii) Does the circuit dissipate more, the same, or less heat when the switch *S* is closed? Explain your answer.

30 A beam of moving charged particles represents a current of 3·2 μA.

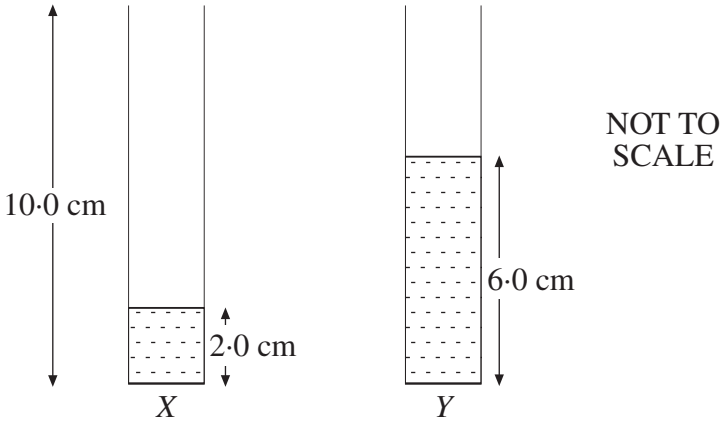
(a) Calculate the energy transferred per second to the charged particles by a voltage of $1{\cdot}2 \times 10^6$ V.

(b) These charged particles are alpha particles (He^{2+}).

(i) How many of these particles per second would need to pass a point to make up the 3·2 μA current?

(ii) These particles are directed at right angles to a region of uniform magnetic field. On the diagram in your Part C Answer Book, sketch the path that the beam of particles would follow in the magnetic field.

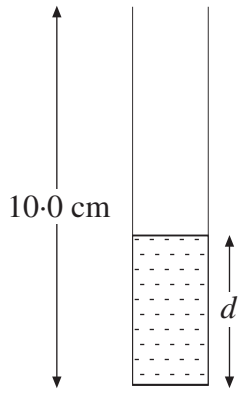
31 Two 10·0 cm high, flat-bottomed cylinders contain water. The depth of water in cylinder *X* is 2·0 cm. The depth of water in cylinder *Y* is 6·0 cm. The speed of sound in water is 1493 m s^{-1}.



(a) Resonances are produced when a student blows over the top of cylinder *X*. Calculate the frequency of the fundamental mode of these resonances.

(b) When the student blows over the top of cylinder *Y,* she determines that the fundamental resonant frequency produced in *Y* is double the frequency produced in *X*. Briefly explain why this occurs.

(c) The student observes that resonances can be excited in the water column by tapping the base of the cylinder.



At what water depth *d* will the fundamental frequency of the resonance in the water (produced by tapping the base) equal the fundamental frequency of the resonance in the air (produced by blowing over the top)?

SECTION II—ELECTIVES

(25 Marks)

Attempt ONE question.

Each question is worth 25 marks.

Answer each Elective or Half-elective in a SEPARATE Elective Answer Book.

Show all necessary working.

Marks may be awarded for relevant working.

QUESTION 32 History of Ideas in Physics (25 marks) **Marks**

If you are attempting this elective, you must do TWO half-electives.

Answer each half-elective in a SEPARATE Elective Answer Book.

A Half-elective: Gravitation ($12\frac{1}{2}$ marks)

(a) The ancient Greeks had many ideas about astronomy. **3**

(i) Why did ancient Greek astronomers classify some objects in the sky as planets and some as stars?

(ii) Aristotle and Aristarchus were two famous Greek astronomers.

1 How did their ideas about the solar system differ?

2 Why was Aristarchus' view rejected?

(b) Ptolemy and Copernicus both presented theories to explain the motion of the planets. **4**

(i) What are TWO features common to both the Ptolemaic and Copernican theories?

(ii) What are TWO features that differ in the Ptolemaic and Copernican theories?

(c) Galileo was one of the first people to use a telescope to look up at the Moon and planets. His observations led to changes in ideas about the solar system. **2**

(i) State ONE important observation that Galileo made using his telescope.

(ii) How did this observation challenge earlier views about the solar system?

(d) Long-period comets, such as Comet Kohoutek, are believed to come from the Oort Cloud that lies far beyond the outermost planets. In our solar system, Kohoutek travels in an elliptical orbit around the Sun and spends most of its time beyond the outermost planets. **2**

Use a diagram to explain how the orbit of Comet Kohoutek supports Kepler's Second Law.

(e) The mass of the Moon is 0·0123 times the Earth's mass, and the average radius of the Moon's orbit around the the Earth is $3{\cdot}80 \times 10^8$ m. **$1\frac{1}{2}$**

Calculate the gravitational force between the Earth and the Moon.

Question 32 continues on page 25

QUESTION 32 (Continued) **Marks**

Answer this half-elective in a SEPARATE Elective Answer Book.

B Half-elective: The Nature of Light ($12\frac{1}{2}$ marks)

(a) When white light is passed through a prism it splits into a spectrum of colours. **2**

(i) Use the corpuscular model of light to explain this effect.

(ii) Use the wave model of light to explain this effect.

(b) At the beginning of the nineteenth century, Young performed the 'double slit' experiment demonstrating interference. **3**

(i) Describe briefly, using words or a diagram how this experiment was performed.

(ii) Young's observations were confirmed by Fresnel. Why was their work the subject of intense debate?

(c) Maxwell published his electromagnetic theory in 1872. **4**

(i) List THREE properties of electromagnetic waves.

(ii) What is the frequency of X-rays of wavelength $3{\cdot}6 \times 10^{-10}$ m?

(d) When a clean zinc plate is illuminated with a weak beam of ultraviolet light, photoelectrons are emitted from its surface. When the plate is illuminated with red light, no photoelectrons are emitted, even when the light intensity is very high. **2**

Explain these observations in terms of the quantum model of light.

(e) The energy required to remove an electron from metallic sodium is 2·28 eV. Will photoelectrons be ejected from metallic sodium when it is illuminated with yellow light that has a wavelength of 580 nm? Justify your answer. **$1\frac{1}{2}$**

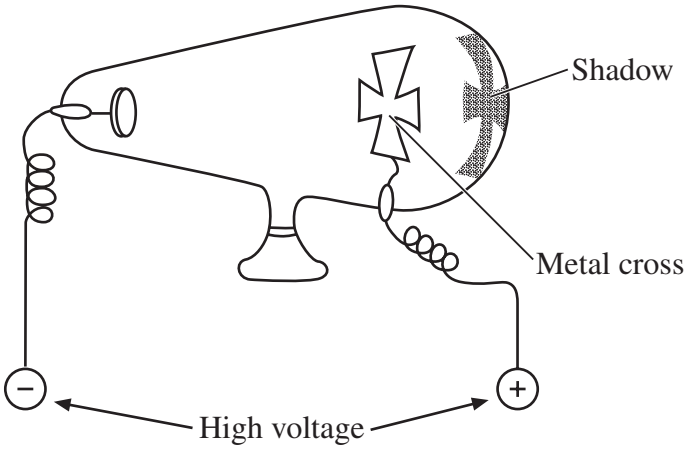
Question 32 continues on page 26

QUESTION 32 (Continued) **Marks**

Answer this half-elective in a SEPARATE Elective Answer Book.

C Half-elective: Atomic Structure ($12\frac{1}{2}$ marks)

(a) Crookes developed a gas discharge tube to investigate the electrical nature of matter. When a high voltage is applied to this tube, the glass behind the metal cross glows (fluoresces) and a shadow of the cross appears as shown. **3**



Christian D & Crossley W, Studymate HSC Physics, McGraw-Hill 1991, p 167.
Reproduced with permission of Science Press.

(i) Briefly explain how this shadow is formed.

(ii) When a magnet is moved towards this gas discharge tube, the shadow of the cross is observed to move across the glass.

Briefly explain this observation.

(iii) Briefly describe ONE way that work involving gas discharge tubes contributed to our understanding of atomic structure.

Question 32 C continues on page 27

QUESTION 32 (Continued) **Marks**

(b) In 1911, Rutherford and his colleagues performed an experiment using thin gold foil and a beam of alpha particles. One of the observations was that some alpha particles scattered back from the foil towards the source. **3**

(i) Describe Rutherford's model of the atom.

(ii) How does this model explain the experimental observation that some of the alpha particles are scattered back from the foil?

(c) The Rydberg equation is given by **4 $\frac{1}{2}$**

$$\frac{1}{\lambda} = R_H\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$$

(i) To what do each of the terms, λ, R_H, m and n, refer, respectively?

(ii) In the Balmer series, $m = 2$.

Calculate the wavelength of the first line in the Balmer series.

(iii) Use a diagram to show the *four* transitions that make up the part of the Balmer series that is in the visible spectrum.

(d) Bohr developed a model of the atom using new ideas to overcome the problems of classical theory. **2**

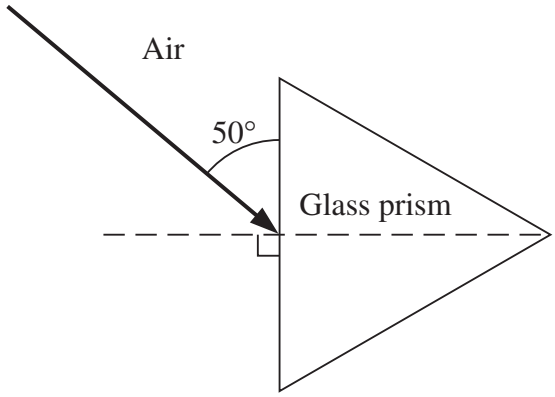
(i) Describe ONE of the problems of classical theory.

(ii) Outline how Bohr overcame this problem.

End of question

QUESTION 33 Wave Properties of Light (25 marks)

(a) A ray of blue light strikes a 60° triangular glass prism of refractive index 1·54 as shown. **7**



(i) Calculate the angle of refraction of the ray of blue light as it enters the glass prism.

(ii) If the speed of the blue light in air is $3{\cdot}00 \times 10^8$ m s^{-1}, what is the speed of the blue light in the glass prism?

(iii) Calculate the angle of refraction of this ray of blue light as it emerges from the glass prism.

(iv) Briefly explain what you would expect to observe if the ray of blue light was replaced by a ray of white light?

(b) A narrow single slit, of width $2{\cdot}0 \times 10^{-6}$ m, is illuminated with a single narrow beam of green light. The wavelength of this light is approximately $0{\cdot}52 \times 10^{-6}$ m. **5**

(i) Describe the diffraction pattern observed on a screen that is about 1 m from the slit.

(ii) Sketch a graph to show how the intensity of light varies across the screen.

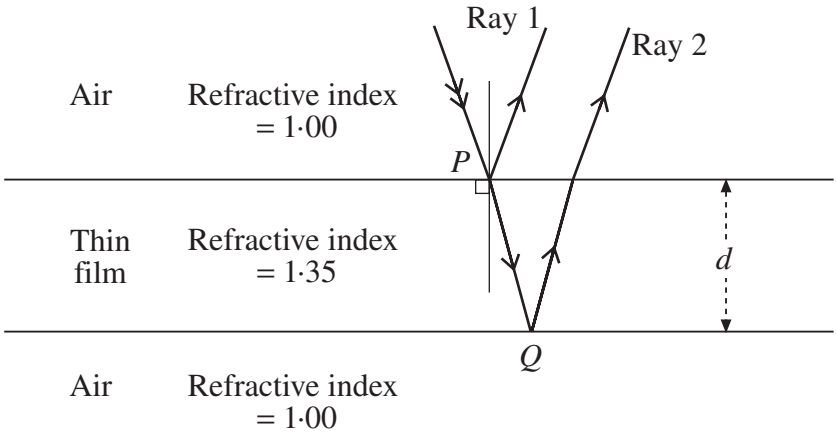
(iii) How would the original diffraction pattern change if the slit was illuminated with orange light of wavelength approximately $0{\cdot}60 \times 10^{-6}$ m?

(iv) How would the original diffraction pattern change if the width of the slit was halved?

Question 33 continues on page 29

QUESTION 33 (Continued) **Marks**

(c) Light of wavelength 630 nm is incident normally on a thin film. Some of the light reflects at points *P* and *Q*. **4**



(*Note*: The angles of incidence and reflection of the rays shown in the diagram are exaggerated for clarity.)

(i) 1 What is the phase difference between ray 1 and the incident ray as a result of reflection at *P*?

2 What is the phase difference between ray 2 and the incident ray as a result of reflection at *Q*?

(ii) Calculate the wavelength of the light in the thin film.

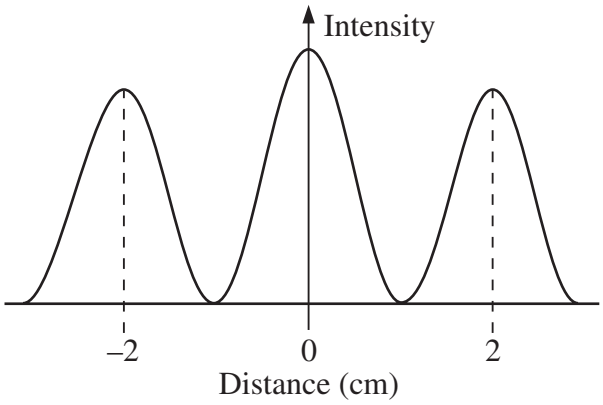
(iii) What is the minimum thickness (*d*) of the thin film that results in the maximum reflection of light?

Question 33 continues on page 30

QUESTION 33 (Continued) **Marks**

(d) A monochromatic light source consists of a laser light of wavelength 640 nm. The light beam passes through two narrow slits before falling on a screen. **4**

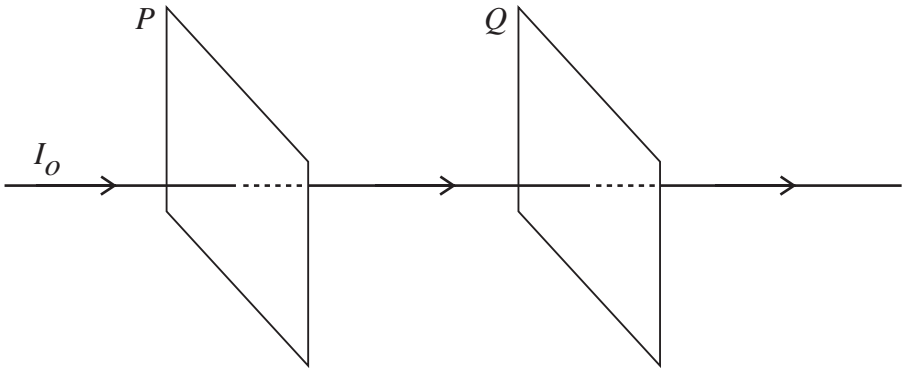
The pattern of the light falling on the screen is represented by the following graph, showing the intensity of light plotted against distance along the screen. The screen is at a distance of 1·60 m from the double slit.



(i) Explain how the pattern observed on the screen is formed.

(ii) Determine the separation of the centre of the two slits. Show all working.

(e) Unpolarised light is incident on two polarising filters, *P* and *Q*, as shown. **2**



(i) What percentage of the incident light (I_O) is transmitted through the polariser, *P*?

(ii) The polarisation axis of polariser *Q* is at an angle of 30° to that of polariser *P*. What percentage of incident light (I_O) is transmitted through this pair of polarisers?

Question 33 continues on page 31

QUESTION 33 (Continued) **Marks**

(f) Many galaxies show a *red shift* of their spectra. Calculations based on this *red shift* are used to produce data on the velocities of galaxies relative to the Earth. **3**

The table shows the data for three galaxies.

Galaxy	*Velocity* (10^4 km s^{-1})
A	0·12
B	1·40
C	2·14

(i) Explain the cause of the *red shift*.

(ii) Which of the galaxies listed above indicates the greatest *red shift*? Briefly explain your answer.

End of question

QUESTION 34 Rotation (25 marks) **Marks**

(a) A food processor has blades that rotate at 1·5 Hz on the 'fold' setting. **5**

(i) How long does it take for a blade to complete one revolution on the 'fold' setting?

(ii) What is the angular velocity of the blade?

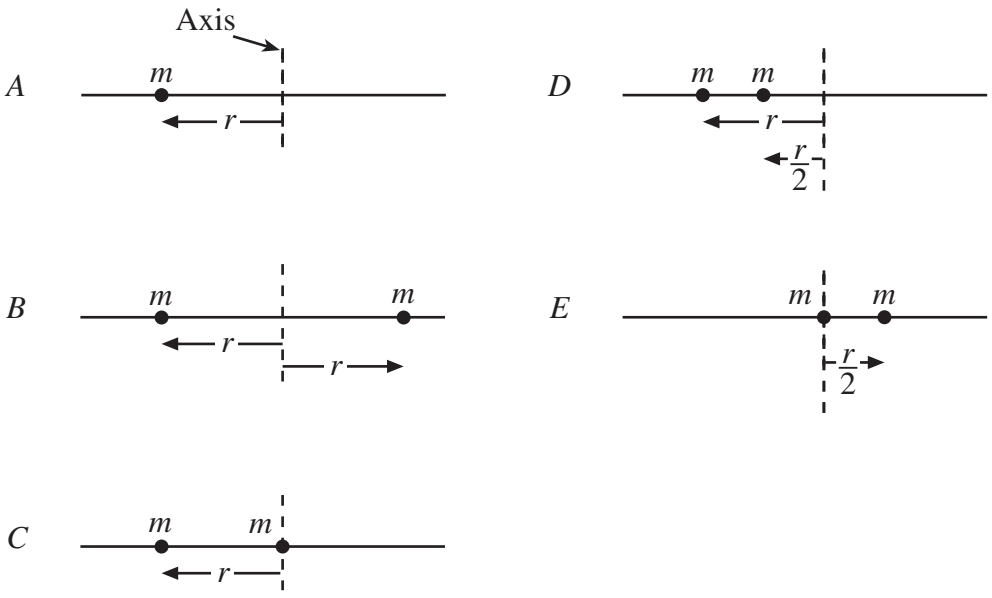
(iii) If the blades have a diameter of 6·0 cm, what is the linear velocity of the outer tip of the blade?

(iv) When the food processor is switched to the 'blend' setting, the blades take 0·60 s to accelerate to the new frequency of 7·0 Hz.

1 Calculate the angular acceleration of the blades during this time.

2 Calculate the angular displacement during this acceleration.

(b) Consider the following arrangements of point masses attached to a rod of negligible mass. The arrangement rotates about the vertical axis shown. **4**



(i) Explain why arrangements *A* and *C* have the same moment of inertia.

(ii) Calculate the ratio of moments of inertia of arrangement *A* to arrangement *E*.

(iii) Rank the arrangements *B*, *C*, *D* and *E* in order of decreasing moments of inertia. Show your working.

Question 34 continues on page 33

QUESTION 34 (Continued) **Marks**

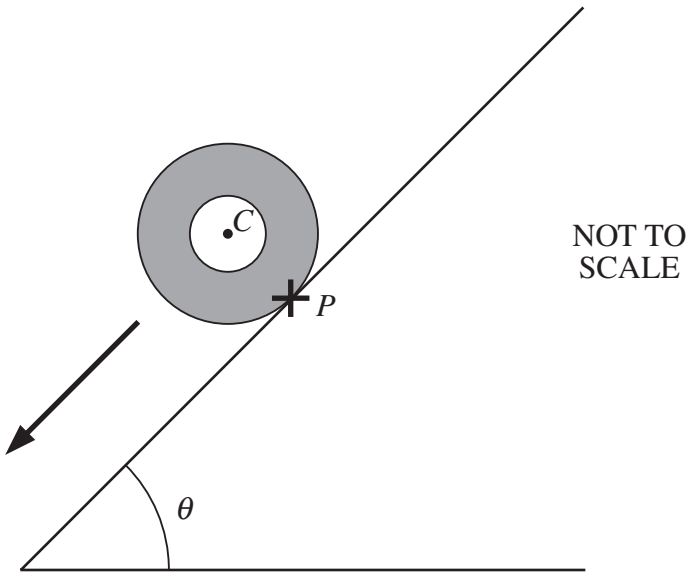
(c) The moment of inertia of a cylindrical annulus (such as a metal washer) about an axis through the centre, C, is given by **6**

$$I = \frac{1}{2}M(r_o^2 + r_i^2)$$

where r_o and r_i are the outer and inner radii, respectively.

A metal washer of mass 5·50 grams has an inner radius of 5·00 mm and an outer radius of 12·0 mm.

The washer rolls, without slipping, down an incline as shown.



(i) Calculate the moment of inertia about the centre C.

(ii) Calculate the moment of inertia about the instantaneous point of contact P.

(iii) The centre of the mass of the washer is observed to accelerate down the incline at 3·78 m s^{-2}. Calculate the torque about the instantaneous point of contact P.

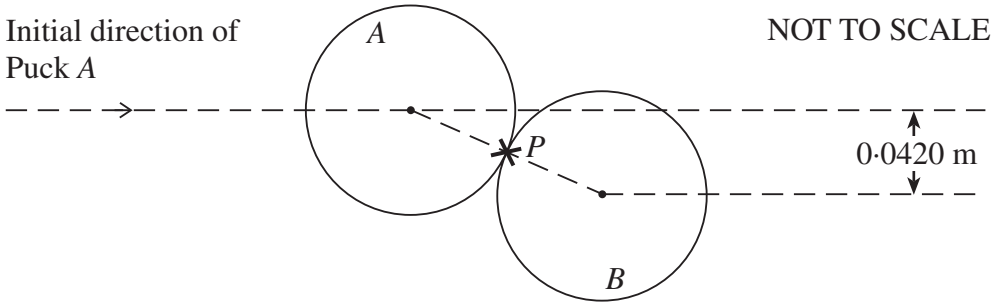
(iv) Calculate the angle of the incline, θ.

Question 34 continues on page 34

QUESTION 34 (Continued) **Marks**

(d) Puck *A* collides with, and sticks to, an identical puck *B* at rest on a frictionless surface. Each puck has a radius of 0·0500 m and mass of 0·125 kg. The initial velocity of puck A is 0·250 m s^{-1} to the right. The diagram shows the two pucks at the instant of collision. **7**

The moment of inertia of a disc about its axis of symmetry is $I = \frac{1}{2}Mr^2$.



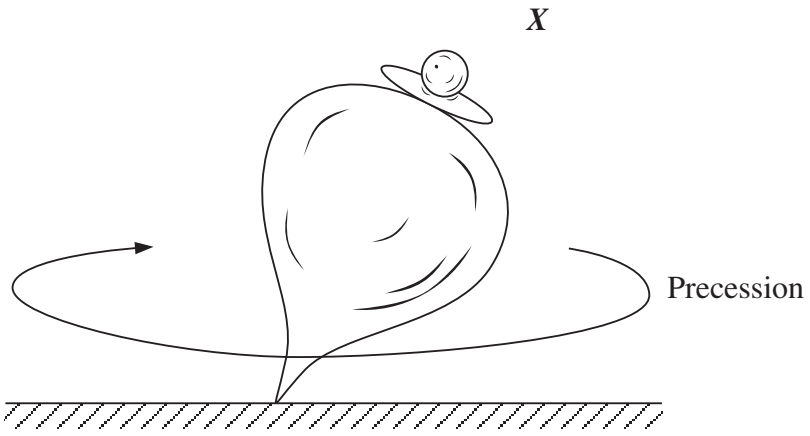
(i) Calculate the angular momentum of the system about the point of contact *P* before the collision.

(ii) Calculate the angular velocity of the pucks after collision.

(iii) Describe the motion of the pucks after collision.

(iv) Calculate the change in kinetic energy due to the collision.

(e) A spinning top is observed to precess in a clockwise direction when viewed from above. **3**



(i) Explain why the axis of rotation of a spinning top precesses.

(ii) What is the direction of rotation of the top, as viewed from *X*? Justify your answer.

End of question

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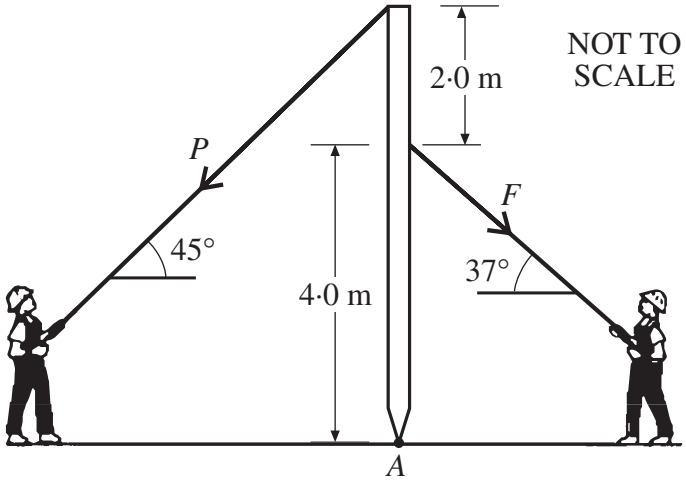
QUESTION 35 Physics in Technology (25 marks) **Marks**

If you are attempting this elective, you must do TWO half-electives.

Answer each half-elective in a SEPARATE Elective Answer Book.

A Half-elective: Engineering Materials and Structures ($12\frac{1}{2}$ marks)

(a) Two workers apply forces $P = 250\,\text{N}$ and $F = 400\,\text{N}$ to a pole with ropes as shown. **3**

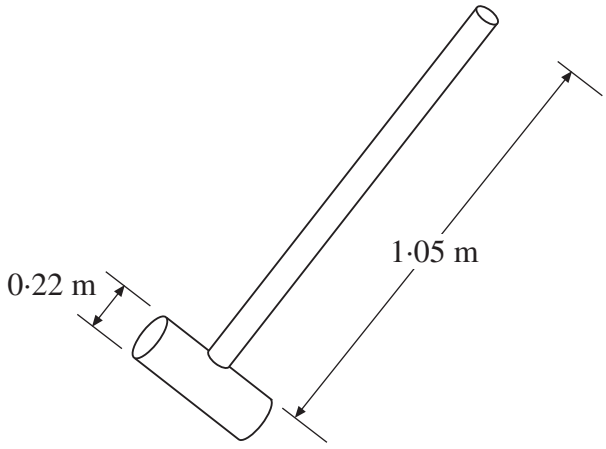


Hibbeler R C, Engineering Mechanics: Statistics & Dynamics, 4th ed 1986, Macmillan NY, P 109

(i) Calculate the moment of each force about the point A.

(ii) Does the pole rotate clockwise, anticlockwise or remain vertical? Justify your answer.

(b) A croquet mallet can be considered as a cylindrical handle glued into a cylindrical head. The handle (mass 0·25 kg) and the head (mass 0·85 kg) are made of the same uniform material. **$1\frac{1}{2}$**



Calculate the position of the centre of mass of the mallet.

Question 35 A continues on page 37

QUESTION 35 (Continued) **Marks**

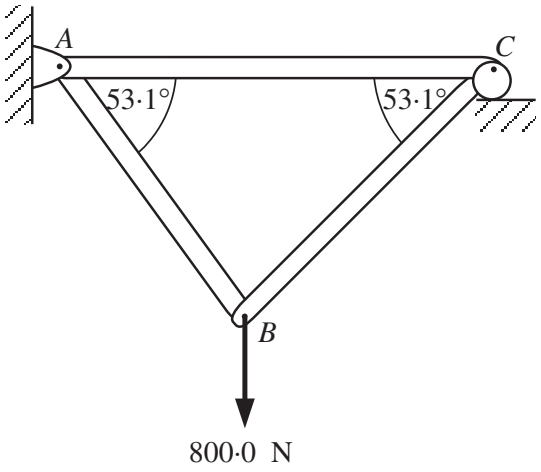
(c) Two materials of cross-sectional area $5{\cdot}00 \times 10^{-6}\,m^2$ were compared. Material *P* has a Young's Modulus of $4{\cdot}00 \times 10^{6}\,N\,m^{-2}$ and material *Q* has a Young's Modulus of $2{\cdot}00 \times 10^{11}\,N\,m^{-2}$. **3**

(i) What is the stress within material *Q* if it supports a load of 2·0 kg?

(ii) What is the strain within material *Q* under these conditions?

(iii) Which material, *P* or *Q*, is most likely to be used in making elastic bands? Justify your choice.

(d) The structure *ABC* is constructed of light, rigid members *AB*, *BC* and *CA*. **5**



Hibbeler R C, Engineering Mechanics: Statistics & Dynamics, 4th ed 1986, Macmillan, NY, p 225

Member *CA* is horizontal. Each joint, *A*, *B* and *C*, is a pivot, and the joint *C* is free to move horizontally on the platform as shown. A load of 800·0 N is applied vertically at pivot point *B*.

(i) Calculate the force in the members *AB* and *BC*.

(ii) Calculate the force in the member *CA*.

(iii) Is *CA* in tension or compression? Justify your choice.

Question 35 continues on page 38

QUESTION 35 (Continued) **Marks**

Answer this half-elective in a SEPARATE Elective Answer Book.

B Half-elective: Optical Instruments ($12\frac{1}{2}$ marks)

(a) Convex mirrors are used to observe customers in different parts of shops. **3**

A convex mirror with a focal length of 0·60 m is used to observe a customer of height 1·5 m. The customer is 1·2 m from the mirror.

Determine the:

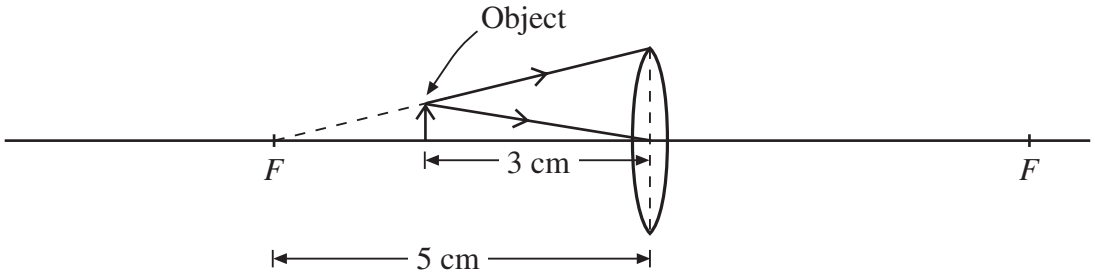
(i) position of the image;

(ii) size of the image;

(iii) nature of the image.

(b) Describe an advantage of using a parabolic mirror instead of a spherical mirror in a telescope. **1**

(c) (i) Copy the diagram below into your Elective Answer Book. Complete the diagram to show the location and height of the image formed by the convex lens shown. **4**

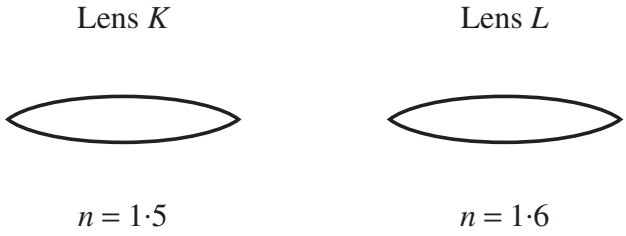


(ii) Describe the image formed in part (c) (i).

Question 35 B continues on page 39

QUESTION 35 (Continued) **Marks**

(d) Two identically shaped convex lenses are made of different types of glass. The lenses have different refractive indices (n) as shown. **1½**



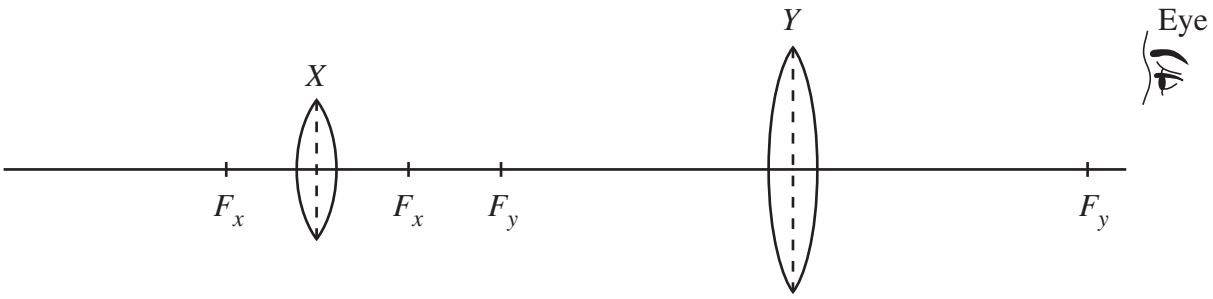
Which lens has the shorter focal length? Explain your answer.

(e) Optical instruments such as the: **3**

- refracting telescope
- microscope
- slide projector

use arrangements of convex lenses to produce images.

The diagram shows the arrangement of lenses in ONE of the instruments named.



(i) Name the instrument. Explain why the lenses are arranged in this way.

(ii) Describe the image that would be observed.

Question 35 continues on page 40

QUESTION 35 (Continued) **Marks**

Answer this half-elective in a SEPARATE Elective Answer Book.

C Half-elective: Transformation of Energy ($12\frac{1}{2}$ marks)

(a) For which physical quantity is the kilowatt hour a correct unit? **$\frac{1}{2}$**

(b) A student is investigating the energy-collecting capability of a simple solar collector used in hot water systems. The solar collector is a rectangle of 0·60 m by 0·30 m and is 60% efficient. The collector contains 2·0 L of water that has a density of 1·0 kg L^{-1}. During a particular three-minute period, the intensity of solar radiation incident upon the collector measures 0·85 kW m^{-2}. **4**

(i) Calculate the amount of energy that falls on the solar collector during this three-minute period.

(ii) What is the temperature rise of the water over this three-minute period?

(c) A current of 0·50 A flows through an electric motor when a potential difference of 2·0 V is applied to it. This motor can lift a block of 250 g to a height of 1·5 m in 8·0 s. **4**

(i) What is the electrical power supplied to the motor?

(ii) Calculate the energy needed to lift the block in the 8·0 s.

(iii) What is the efficiency of this electric motor?

(d) At present, countries such as France and Japan rely on nuclear power stations for the production of significant quantities of their energy. **4**

(i) Using a flowchart, or in another way, outline the general physical processes involved in the conversion of nuclear energy to electrical energy in these power stations.

(ii) Outline TWO disadvantages of the energy conversion processes described in part (d) (i) compared with the conversion of gravitational energy to electrical energy in Australia's hydro-electric power stations.

End of question

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QUESTION 36 Astronomy (25 marks) **Marks**

(a) Consider the following stellar data. **5**

Name of star	*Apparent magnitude*	*Absolute magnitude*
Procyon *A*	+0·37	+2·6
Pollux	+1·16	+1·0
Betelgeuse	+0·41	–5·5
Canopus	–0·72	–3·1
ϵ Erindi	+3·73	+6·1

(i) Which is the brightest star when viewed from Earth?

(ii) What is the ratio of the observed brightness of Betelgeuse to that of Procyon *A*?

(iii) Of the stars listed, Pollux is the one that is closest to 10 parsecs from Earth. Justify this conclusion.

(iv) Calculate the distance in parsecs to ϵ Erindi.

(b) Emission and absorption spectra provide information about stars. **2**

(i) Briefly describe ONE difference in the appearance of these two types of spectra.

(ii) Explain briefly how an emission spectrum is produced.

Question 36 continues on page 43

QUESTION 36 (Continued) **Marks**

(c) The tables show information about stars. **4**

Class	*Example*	*Spectra*	*Surface temperature*
05	None visible to the naked eye	Ionized helium, nitrogen, oxygen	50 000 K
B3	Achernar	H, He strong	15 000 K
A1	Sirius	H lines at maximum Ca lines weak	11 000 K
A3	Formalhaut	H lines strong Ca lines stronger Metals weak	9 000 K
F0	Canopus	H lines weak Ca lines strong	7 600 K
F5	Procyon	Ca lines very strong Neutral metals	6 600 K

Colour index	*Colour*	*Surface temperature*
–0·6	Blue-white	50 000 K
–0·3	Blue	20 000 K
0·0	White	10 000 K
+0·2	White	7 000 K

Deneb is an A2 class star with a blue magnitude of 1·26.

Use the information in the tables to find:

(i) the chemical composition of Deneb;

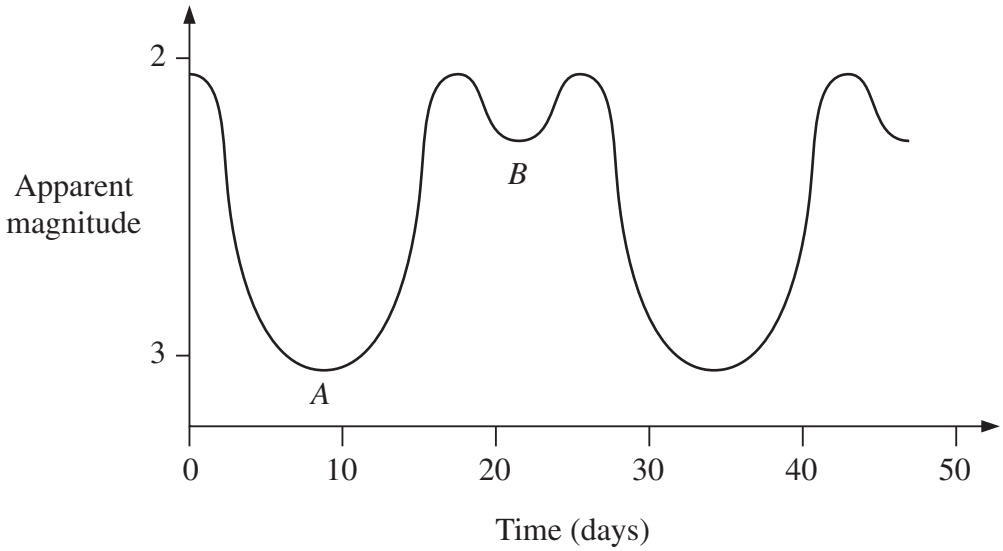
(ii) the colour index of Deneb;

(iii) the apparent visual magnitude of Deneb.

Question 36 continues on page 44

QUESTION 36 (Continued) **Marks**

(d) The light curve for a binary star system is shown in the graph. **2**



Briefly describe what is happening at points *A* and *B*. You may use diagrams to support your answer.

(e) The Jewel Box is an example of an open cluster in the constellation Crux. **2**

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What are TWO characteristics of open clusters?

Question 36 continues on page 45

QUESTION 36 (Continued) **Marks**

(f) The Magellanic Clouds are galaxies. To earlier astronomers, however, these clouds looked like concentrated areas of dust. In fact, most galaxies contain dust and gas. Dust clouds are thought to be involved in the 'birth' and 'death' of many stars. **2**

(i) List the energy changes involved when a main sequence star forms from a dust cloud.

(ii) Describe ONE of the ways in which dust clouds are thought to form during the 'death' of certain stars.

(g) (i) Sketch a Hertzsprung-Russell diagram in your Elective Answer Book. Include the following on the diagram: **6**

- labels on the vertical and horizontal axes (only one label per axis);
- the main sequence, showing the relative position of the sun;
- the region in which white dwarfs are likely to be found.

(ii) Stars are stable while on the main sequence. What is ONE reason for this stability?

(h) The triple alpha process produces energy in the core of red giant stars. It is a two-stage process as shown. **2**

(i) What is the missing component in the triple alpha process?

$$^{4}_{2}\text{He} + {}^{4}_{2}\text{He} + {}^{4}_{2}\text{He} \rightarrow {}^{4}_{2}\text{He} + \boxed{} \rightarrow {}^{12}_{6}\text{C} + \gamma$$

(ii) What is the source of the helium used to start this process?

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PHYSICS DATA SHEET

Numerical values of several constants

Charge on the electron, q_e	$-1{\cdot}602 \times 10^{-19}$ C
Mass of electron, m_e	$9{\cdot}109 \times 10^{-31}$ kg
Mass of neutron, m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of proton, m_p	$1{\cdot}673 \times 10^{-27}$ kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9·80 m s^{-2}
Speed of light, c	$3{\cdot}00 \times 10^{8}$ m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	$2{\cdot}0 \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	$6{\cdot}67 \times 10^{-11}$ N m^2 kg^{-2}
Mass of Earth	$6{\cdot}0 \times 10^{24}$ kg
Planck's constant, h	$6{\cdot}626 \times 10^{-34}$ J s
Rydberg's constant, R_H	$1{\cdot}097 \times 10^{7}$ m^{-1}
Atomic mass unit, u	$1{\cdot}661 \times 10^{-27}$ kg 931·5 MeV/c^2
1 eV	$1{\cdot}602 \times 10^{-19}$ J
Density of water, ρ	$1{\cdot}00 \times 10^{3}$ kg m^{-3}
Specific heat capacity of water	$4{\cdot}18 \times 10^{3}$ J kg^{-1} K^{-1}

PERIODIC TABLE

				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 47·88 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 72·59 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 Cesium	56 Ba 137·3 Barium	57 La 138·9 Lanthanum	72 Hf 178·5 Hafnium	73 Ta 180·9 Tantalum	74 W 183·9 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 — Polonium	85 At — Astatine	86 Rn — Radon
87 Fr — Francium	88 Ra 226·0 Radium	89 Ac — Actinium	104	105	106												

KEY

Atomic Number — 79 — Symbol of element

Atomic Mass — 197·0 — Name of element

Au — Gold

58 Ce 140·1 Cerium	59 Pr 140·9 Praseodymium	60 Nd 144·2 Neodymium	61 Pm — 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
90 Th 232·0 Thorium	91 Pa 231·0 Protactinium	92 U 238·0 Uranium	93 Np 237·0 Neptunium	94 Pu — Plutonium	95 Am — Americium	96 Cm — Curium	97 Bk — Berkelium	98 Cf — Californium	99 Es — Einsteinium	100 Fm — Fermium	101 Md — Mendelevium	102 No — Nobelium	103 Lr — Lawrencium

This sheet should be REMOVED for your convenience.

BOARD OF STUDIES
NEW SOUTH WALES

STUDENT NUMBER

CENTRE NUMBER

HIGHER SCHOOL CERTIFICATE EXAMINATION

2000
PHYSICS
2 UNIT
PART B ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right-hand corner of this page.
- You should receive this Answer Book with a Part A Answer Sheet, a Part C Answer Book, and two Elective Answer Books.
- Answer Questions 16 to 25 in this Answer Book.
- Each question is worth 3 marks.

MARKER'S USE ONLY

PART	Mark	Marker	Check
B			

PART B

MARKER'S USE ONLY

Questions 16 to 25 are worth 3 marks each.

Attempt ALL questions.

Answer the questions in the spaces provided below.

You should show sufficient working to allow the marker to follow your method.

16 (a) .....

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MARKER'S USE ONLY

17 (a) .....

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MARKER'S USE ONLY

18 (a) .....

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MARKER'S USE ONLY

19 (a)

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20 (a) .....

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22 (a) .....

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MARKER'S USE ONLY

23 (a) (i) .....

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(ii) .....

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24 (a) .....

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MARKER'S USE ONLY

25 (a) .....

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(b)

(c) .....

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BOARD OF STUDIES
NEW SOUTH WALES

STUDENT NUMBER

CENTRE NUMBER

HIGHER SCHOOL CERTIFICATE EXAMINATION

2000
PHYSICS
2 UNIT
PART C ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right-hand corner of this page.
- You should receive this Answer Book with a Part A Answer Sheet, a Part B Answer Book, and two Elective Answer Books.
- Answer Questions 26 to 31 in this Answer Book.
- Each question is worth 5 marks.

MARKER'S USE ONLY

PART	Mark	Marker	Check
C			

PART C

MARKER'S USE ONLY

Questions 26 to 31 are worth 5 marks each.

Attempt ALL questions.

Answer the questions in the spaces provided below.

You should show sufficient working to allow the marker to follow your method.

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(c) .....

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(d) .....

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MARKER'S USE ONLY

27 (a) (i) .....

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(ii) .....

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(iii) .....

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MARKER'S USE ONLY

28 (a) .....

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MARKER'S USE ONLY

29 (a) (i) .....

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MARKER'S USE ONLY

30 (a) .....

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(b) (i) .....

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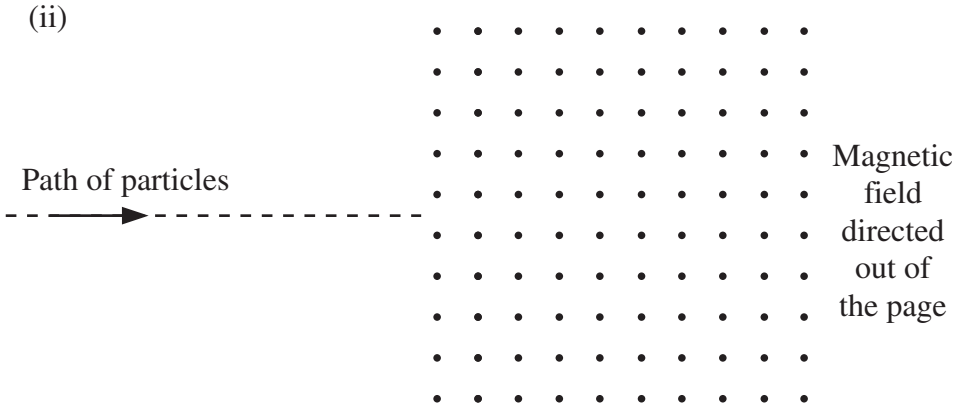
(ii)



MARKER'S USE ONLY

31 (a) .....

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(b) .....

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