BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1995
PHYSICS
2 UNIT

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

DIRECTIONS TO CANDIDATES

Section I—Core

- Attempt ALL questions.
- **Part A** 15 multiple-choice questions, each worth 1 mark.
  Mark your answers in pencil 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 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 Periodic Table and Data Sheet are provided as a tear-out sheet at the back of this paper.

SECTION I—CORE

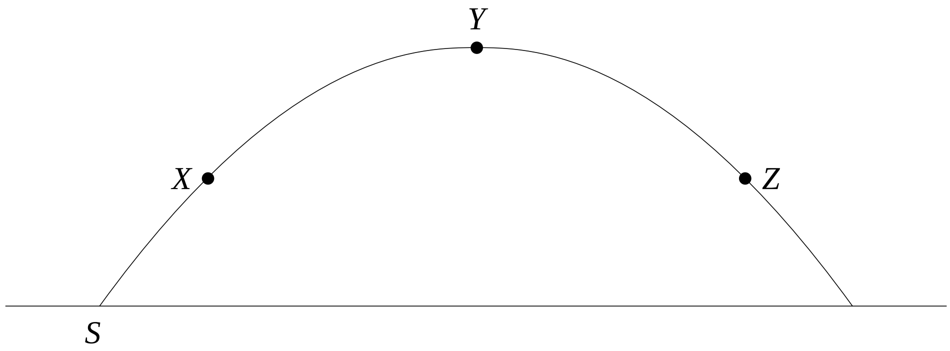
(75 Marks)

Attempt ALL questions.

PART A

Questions 1–15 are worth 1 mark each.
Mark your answers in pencil on the Answer Sheet provided.
Select the alternative A, B, C, or D that best answers the question.

1. A ball is thrown from *S* at an angle to the horizontal as shown in the diagram below.

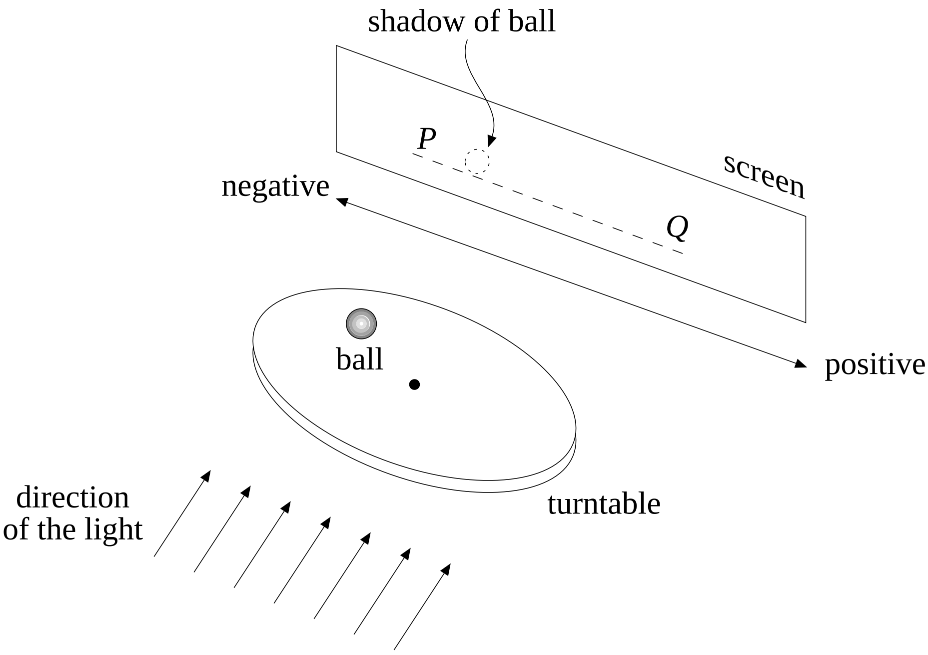


X, *Y*, and *Z* are different positions along the ball's trajectory.

Which of the following best represents the velocity and acceleration of the ball?

	VELOCITY			ACCELERATION		
	X	*Y*	*Z*	*X*	*Y*	*Z*
(A)	↑	zero	↓	↓	zero	↓
(B)	↗	→	↘	↑	zero	↓
(C)	↗	→	↘	↓	↓	↓
(D)	↗	→	↘	↗	zero	↘

2. A ball is attached to a rotating turntable as shown in the diagram below. Light shines horizontally at the turntable. The shadow of the ball moves in simple harmonic motion in a horizontal straight line on the screen. *P* and *Q* represent the extreme positions of the shadow while the turntable is rotating. The displacement of the shadow is measured from the midpoint of *PQ*.



Which statement correctly describes the motion of the ball's shadow when at point *P*?

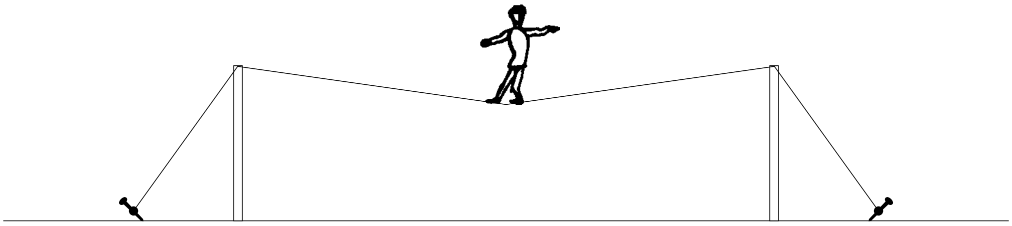
(A) The displacement is negative, the velocity is zero, and the acceleration is negative.

(B) The displacement is negative, the velocity is zero, and the acceleration is positive.

(C) The displacement is negative, the velocity is maximum, and the acceleration is positive.

(D) The displacement is zero, the velocity is zero, and the acceleration is negative.

3. An acrobat is walking along a tightrope as shown in the figure below. The acrobat has weight *W*.



The tension in the wire between the supporting posts is

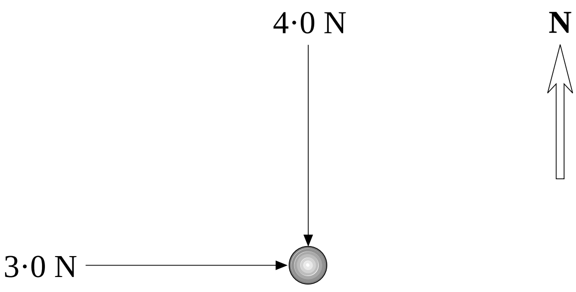
(A) much more than *W*.

(B) approximately *W*.

(C) approximately $\frac{W}{2}$.

(D) much less than $\frac{W}{2}$.

4. Two forces act on an object of mass 5·0 kg as shown in the diagram below.



The resultant acceleration of the object is

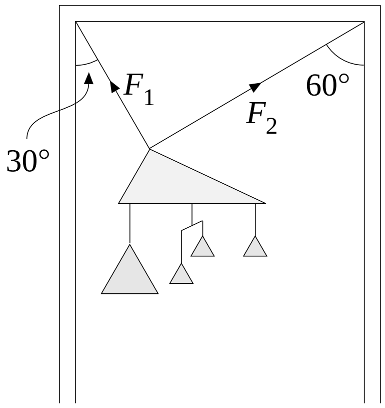
(A) 1·0 m s^{-2} directed at 37° east of north.

(B) 1·4 m s^{-2} directed at 53° east of north.

(C) 1·4 m s^{-2} directed at 37° south of east.

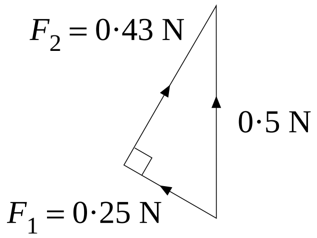
(D) 1·0 m s^{-2} directed at 53° south of east.

5. A child's mobile is hanging in a doorway as shown in the diagram below. The weight of the mobile is 0·5 newtons.

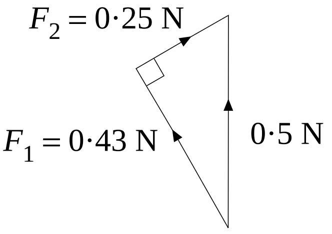


The correct vector diagram showing the three forces acting on the mobile is

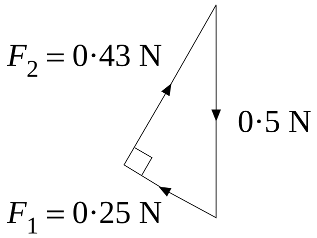
(A)



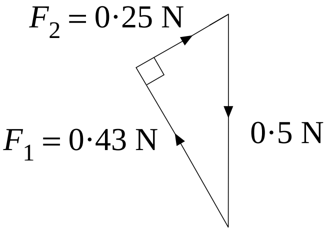
(B)



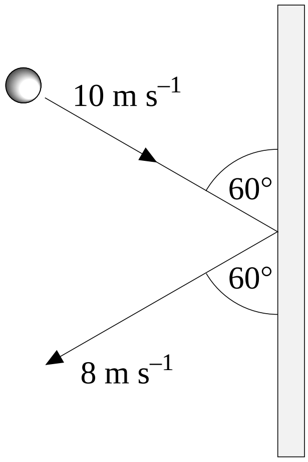
(C)



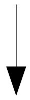
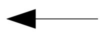
(D)



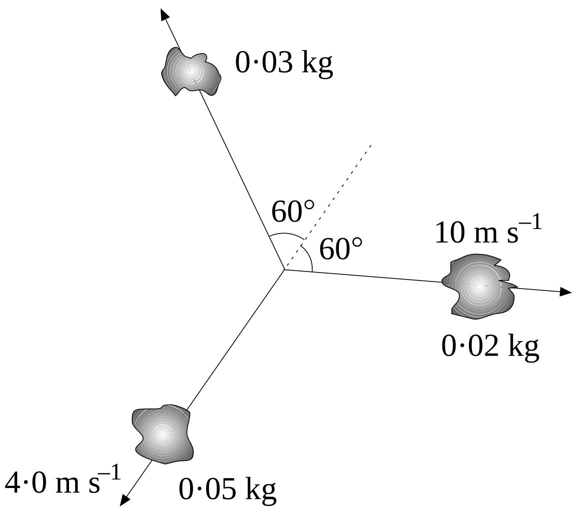
6. A ball bounces off a wall as shown in the diagram. The angles at which it strikes the wall and leaves the wall are both 60°. The initial speed of the ball is 10 m s^{-1} and the final speed is 8 m s^{-1}.



Which of the following best represents the type of collision and change in velocity of the ball?

	Type of collision	*Change in velocity*
(A)	Inelastic	
(B)	Inelastic	
(C)	Elastic	
(D)	Elastic	

7. An object initially at rest explodes into three fragments. The fragments have masses of 0·02 kg, 0·03 kg, and 0·05 kg. They fly off in the directions shown in the diagram.



The final velocity of the 0·03 kg fragment is

(A) 13·3 ms^{-1}.

(B) 6·7 ms^{-1}.

(C) 5·0 ms^{-1}.

(D) 0·0 ms^{-1}.

8. When two objects, *R* and *S*, collide head on they exert forces on each other. The force that *R* exerts on *S* is $F_{(R \text{ on } S)}$ and the force that *S* exerts on *R* is $F_{(S \text{ on } R)}$.

If the objects are identical and their speeds are equal, then

$$F_{(R \text{ on } S)} = -F_{(S \text{ on } R)}.$$

If *R* is heavier and faster than *S* and they collide at an angle, then

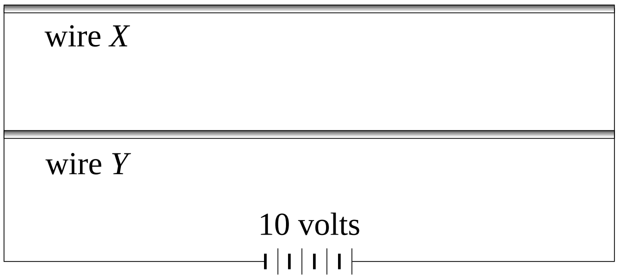
(A) $F_{(R \text{ on } S)}$ is greater than $-F_{(S \text{ on } R)}$.

(B) $F_{(R \text{ on } S)}$ is less than $-F_{(S \text{ on } R)}$.

(C) $F_{(R \text{ on } S)}$ is equal to $-F_{(S \text{ on } R)}$.

(D) More information is required to work out how the forces are related to each other.

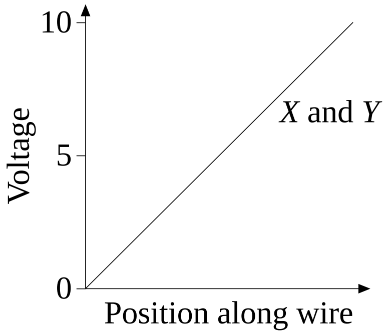
9. A circuit contains two resistance wires in parallel. A 10 V potential difference is applied to it as shown.



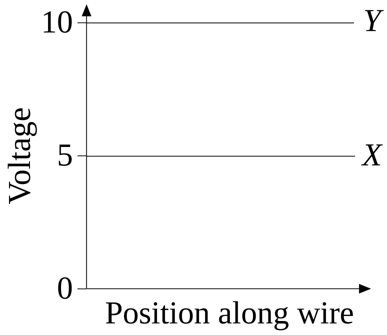
Wire *Y* has twice the resistance of wire *X*.

Which of the following graphs best represents the way the voltage varies along the length of each of the wires?

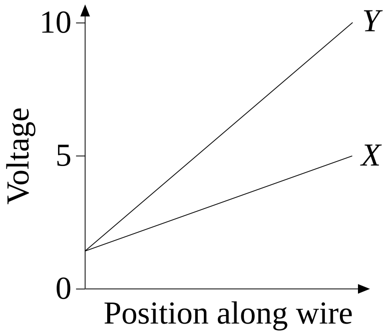
(A)



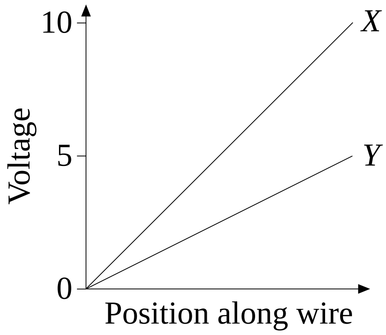
(B)



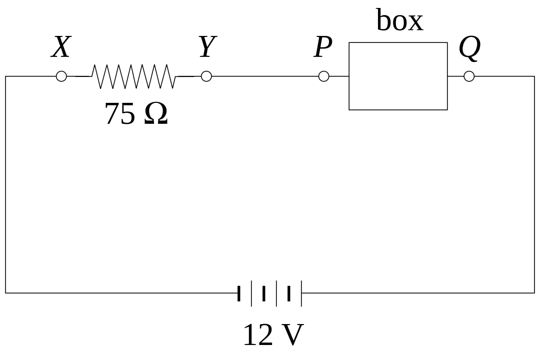
(C)



(D)

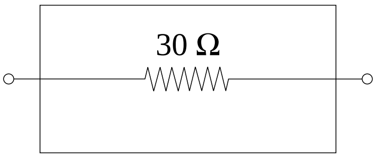


10. A student completes a circuit that includes a mystery box as shown below.

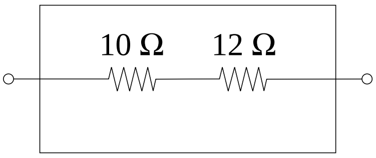


If the voltage between X and Y is 9·0 volts, which of the following boxes is in the circuit?

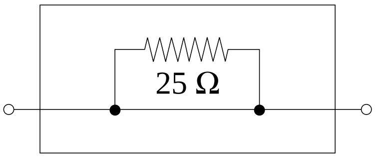
(A)



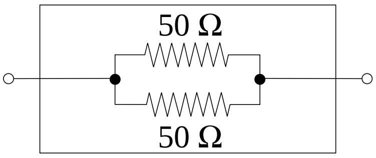
(B)



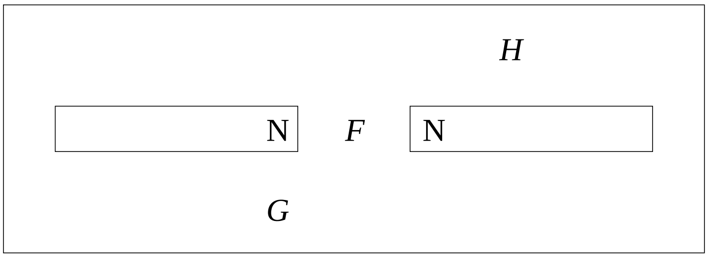
(C)



(D)



11. The diagram below shows the view from above of two identical permanent bar magnets. Their north ends are positioned close to each other. Points *F*, *G*, and *H* are in the same plane as the magnets. *F* is midway between the ends of the magnets.



Which of the following is a true statement?

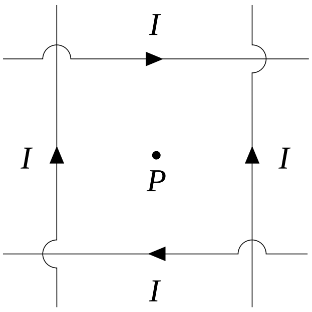
(A) A stationary alpha particle at *H* would experience a force to the right.

(B) An alpha particle moving to the right at *F* would experience a force upwards out of the page.

(C) A beta particle moving to the right at *G* would experience a force upwards out of the page.

(D) A beta particle moving to the left at *F* would experience a force upwards out of the page.

12. Four wires in a horizontal plane each carry a current *I* in the directions shown. They cross each other without touching to form a square as shown in the diagram below. Point *P* is at the centre of the square.



The strength of the magnetic field at *P* due to ONE wire only is *B*. The strength and direction of the magnetic field at *P* due to all four wires is

(A) 3*B* out of the page.

(B) 2*B* out of the page.

(C) 3*B* into the page.

(D) 2*B* into the page.

13. When waves travel across deep water, those with the longer wavelengths travel more rapidly than those with the shorter wavelengths.

This property of the waves is called

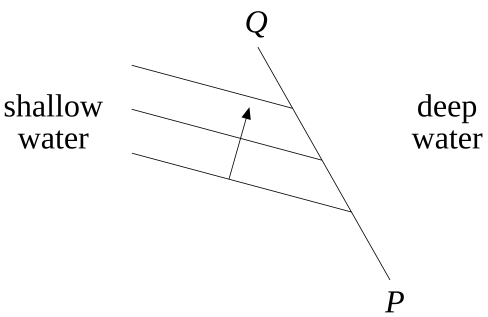
(A) diffraction.

(B) dispersion.

(C) interference.

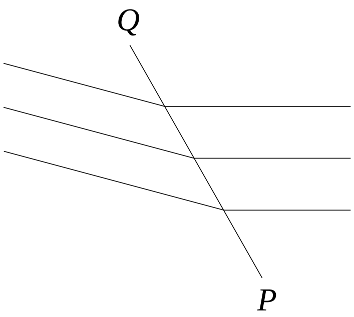
(D) refraction.

14. In the diagram, the line *PQ* marks the boundary between shallow and deep water in a ripple tank. Parallel water waves, travelling in the direction shown by the arrow, are incident on the boundary.

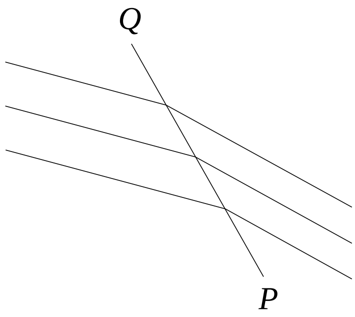


The diagram that shows the correct position of water waves after crossing the boundary is

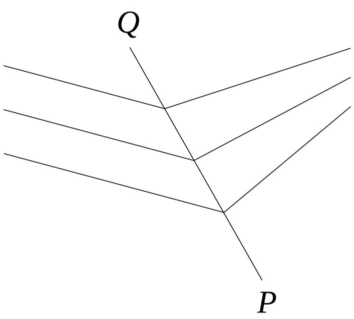
(A)



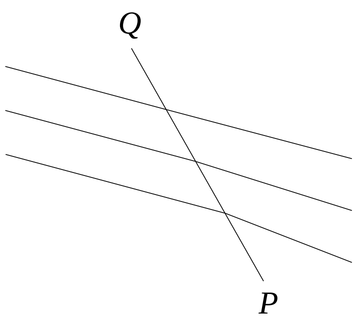
(B)



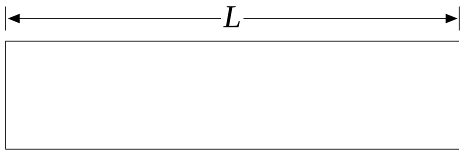
(C)



(D)



15. The diagram below shows an organ pipe of length L that is closed at one end and open at the other end. Ignore any end effects.



The velocity of sound in air is c. The frequencies of the fundamental and the first overtone are respectively

(A) $\frac{c}{4L}$ and $\frac{3c}{4L}$.

(B) $\frac{3c}{4L}$ and $\frac{c}{L}$.

(C) $\frac{c}{4L}$ and $\frac{c}{2L}$.

(D) $\frac{c}{2L}$ and $\frac{c}{L}$.

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. An aeroplane is flying in still air with a speed of 230 m s^{-1} on a heading of due north. It then encounters a wind from the south-west which has a speed of 35 m s^{-1}. From the point of view of an observer on the ground,

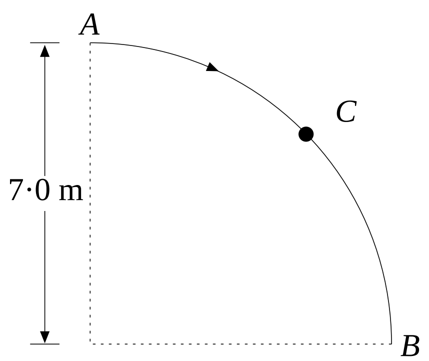
(a) draw ONE vector diagram that includes both:

(i) the velocity of the aeroplane relative to the air;

(ii) the velocity of the wind relative to the ground;

(b) calculate the velocity of the aeroplane relative to the ground.

17. A cyclist rides at a constant speed of 15 m s^{-1} round a quarter of a circle (A to B) as shown. The radius of the circle is 7·0 metres.

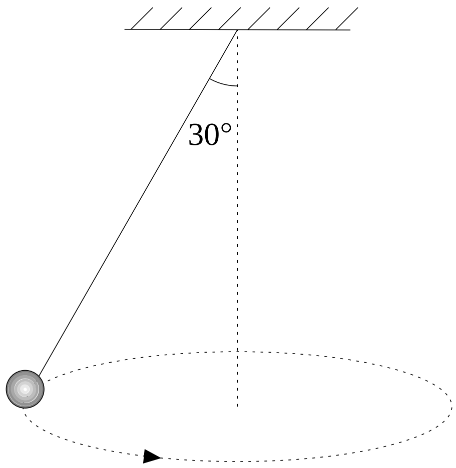


(a) How much time does the cyclist take to travel from A to B?

(b) What is the change of velocity between A and B?

(c) When the cyclist is at C, halfway between A and B, what is her instantaneous acceleration?

18. A ball of mass m hangs from a string and moves with a constant speed in a horizontal circle as shown. The string makes an angle of 30° with the vertical.



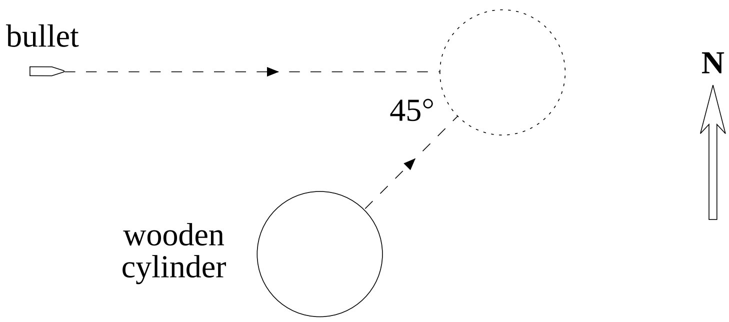
(a) Draw a vector diagram of the forces that act on the ball.

(b) What is the acceleration of the ball?

(c) Write an equation for the tension in the string under these conditions.

19. A 4·5 kg wooden cylinder is sliding across a horizontal sheet of ice from the south-west with a constant speed of 0·60 m s^{-1}.

A bullet of mass 0·020 kg is shot horizontally from the west with a speed of 350 m s^{-1} into the cylinder as shown in the diagram.



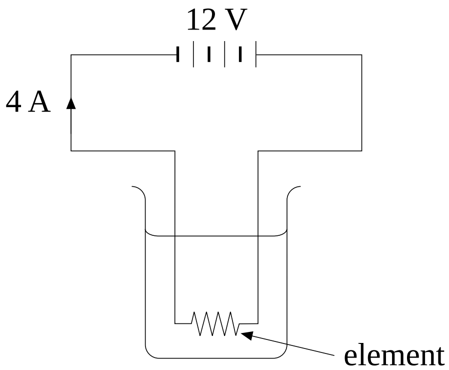
The bullet remains embedded in the cylinder after the impact.

(a) What is the kinetic energy of the bullet before the collision?

(b) In what direction will the cylinder move immediately after the collision?

(c) What is the speed of the cylinder immediately after the collision?

20. In a caravan, an electric jug is used to heat some water. It is connected to a 12-volt battery, which produces a current of 4·0 amperes through the element of the jug. The circuit is shown below.

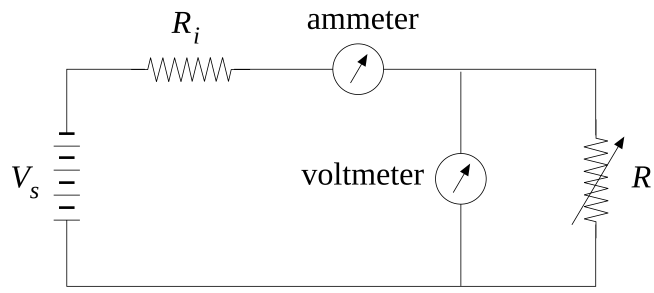


(a) In terms of energy, explain what it means to label the battery '12 volts'.

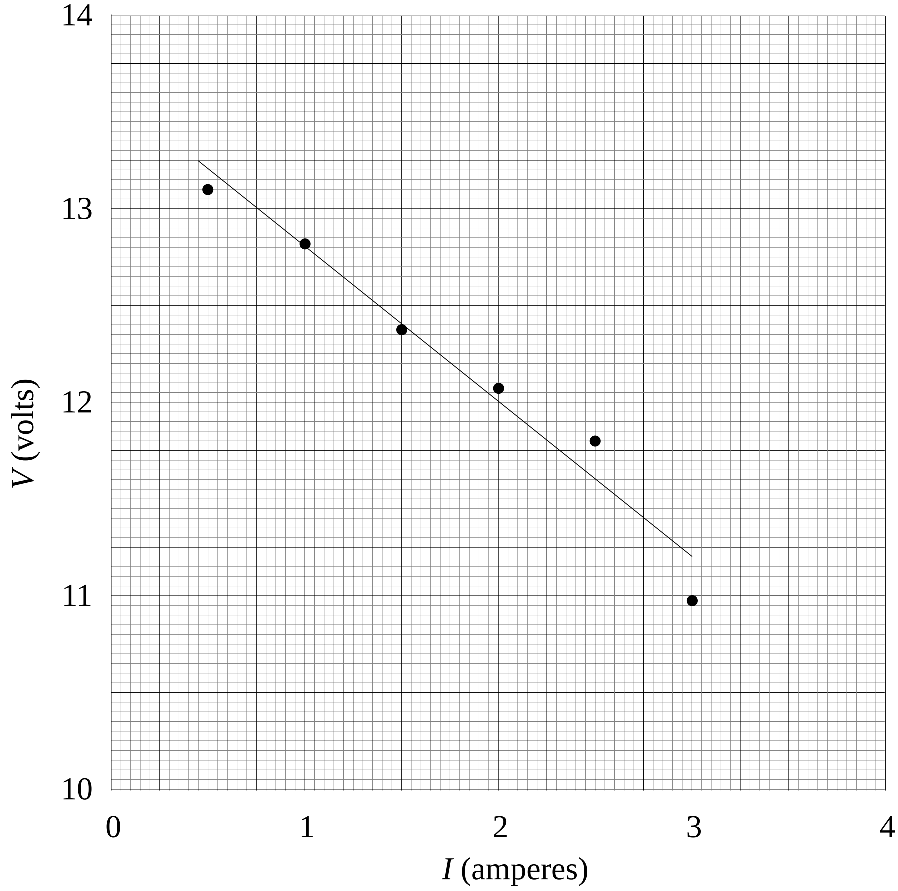
(b) Calculate the resistance of the element.

(c) How much energy does the element deliver to the water in 3 minutes?

21. The circuit shown below is set up in a laboratory. Both the power supply voltage, V_s, and the resistor R_i have fixed but unknown values, whilst the resistor R is variable.



The experimenter varies R and records the current, I, read by the ammeter, and the voltage, V, read by the voltmeter. The values are plotted on the graph as shown.



The relationship between V, V_s, R_i, and I is given by $V = V_s - IR_i$.

(a) Using the graph, determine the values of V_s and R_i.

(b) When R is set to 4 Ω, calculate the current read by the ammeter.

22. Two very long parallel wires each carry a current of 9·0 A in opposite directions. These wires are separated by a distance of 4·0 cm.

(a) Calculate the force per metre between these two wires, given that Ampère's constant, k, is 2×10^{-7} N s^{2} C^{-2}.

(b) On the diagram in the Answer Book, show the direction of the magnetic flux at a point, P, midway between the two wires.

23. A beam of electrons in a cathode-ray tube produces a bright spot in the middle of the screen. Diagram 1 shows the view from the front of the screen, with the electrons coming out of the page.

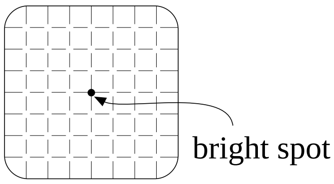


DIAGRAM 1

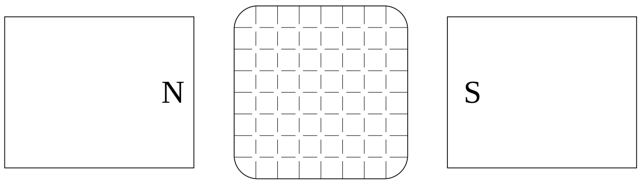


DIAGRAM 2

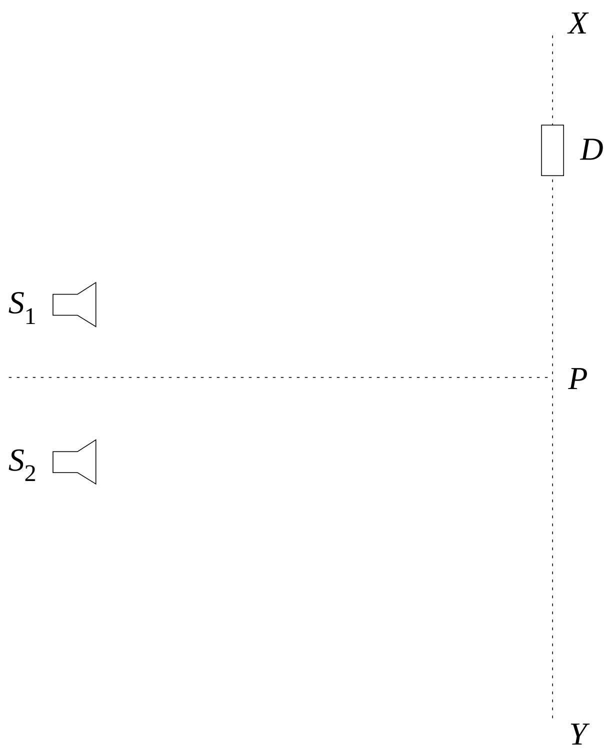
Magnets are then placed on either side, as shown in Diagram 2.

(a) On the diagram in the Answer Book, show the direction in which the bright spot will move with the magnets in place.

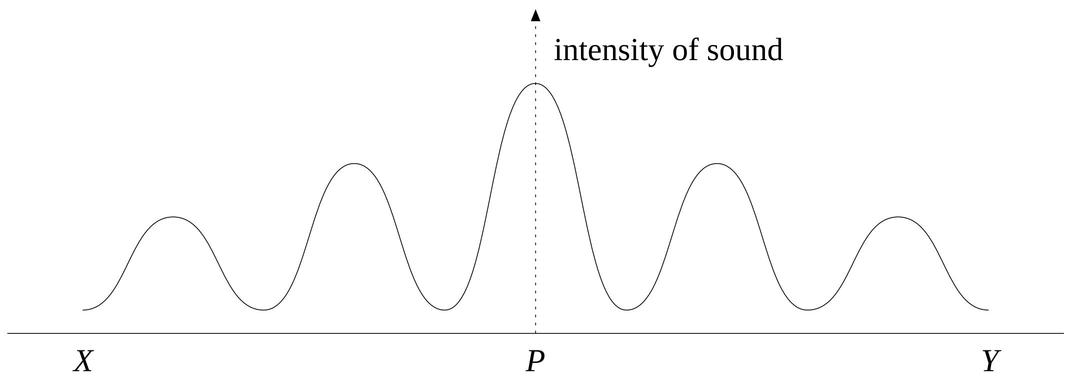
(b) On the diagram in the Answer Book, draw the positions of positive and negative plates that could return the spot to the centre.

(c) When the spot is at the centre of the screen, the electric force due to the positive and negative plates balances the magnetic force due to the magnets. If the electric force on each electron is $5{\cdot}2 \times 10^{-15}$ N and the magnetic flux density is $4{\cdot}0 \times 10^{-2}$ T, calculate the speed of the electrons.

24. Two sources of identical sound waves, S_1 and S_2, are separated by a small distance as shown in the diagram below.



A detector, *D*, is set up so that it moves between *X* and *Y*. A graph of the intensity of the sound measured by the detector is shown below.



(a) Explain why such a pattern is observed.

(b) Describe how a minimum rather than a maximum intensity of sound can be produced at *P* without moving the sources or altering the frequency.

25. A tube is 0·60 m long and open at both ends. Air inside the tube is made to vibrate so that a musical note is produced. The speed of sound in air is 340 m s^{-1}.

(a) What is the lowest frequency note that the tube can produce?

(b) Some of the air particles in the tube do NOT move when this lowest frequency note is produced. On the diagram in the Answer Book, clearly indicate all the points inside the tube where the air particles do NOT move.

(c) If one end of the tube is closed, what is the lowest frequency it can now produce?

PART C

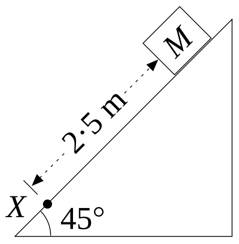
Questions 26–31 are worth 5 marks each.

Answer this Part in the Part C Answer Book.

Show all necessary working.

Marks may be awarded for relevant working.

26. A block M of mass 3·0 kg is placed 2·5 m from the point X on a frictionless plane as shown below. The plane is inclined at an angle of 45°.



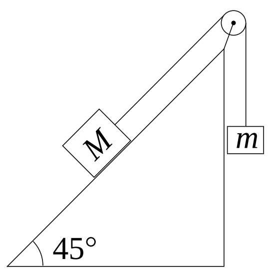
Calculate:

(a) the force acting on M down the plane;

(b) the acceleration of M;

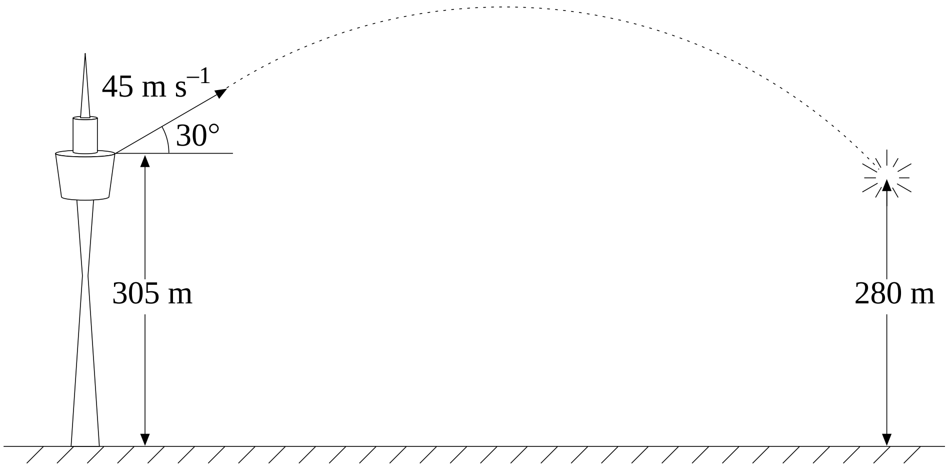
(c) the velocity of M at point X, assuming that it starts from rest.

(d) M is once again placed on the inclined plane. A second block, m, of mass 1·5 kg is now attached to it using a frictionless pulley and a massless string as shown below.



Calculate the magnitude of the acceleration of the masses.

27. A bundle of fireworks is launched from Centrepoint Tower in Sydney, 305 m above the ground. It is launched with a velocity of 45 m s^{-1} at an angle of 30° above the horizontal. The fireworks explode at a safe height of 280 m above the ground.



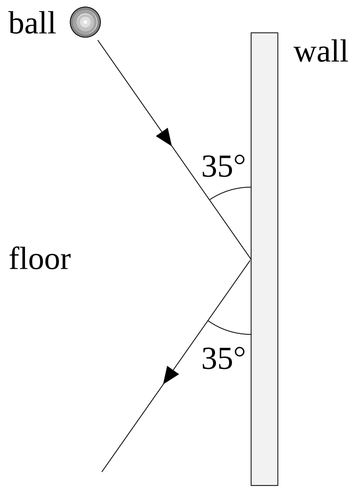
(a) What is the initial vertical component of the velocity?

(b) What is the maximum height reached by the fireworks before they explode?

(c) How long after the launch do the fireworks explode?

(d) What is the horizontal distance from the tower to the fireworks when they explode?

28. A ball of mass 0·30 kg rolls across a floor and makes a perfectly elastic collision with a wall as shown in the diagram.



The speed of the ball before it hits the wall is 2·8 m s^{-1}. The average force of the wall on the ball during the collision is 33 N.

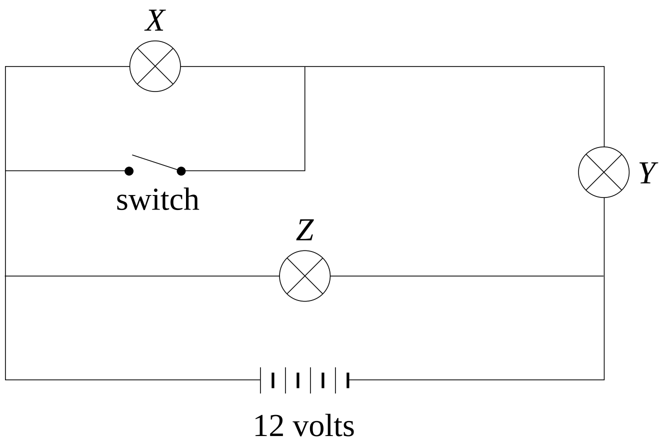
(a) Calculate the magnitude of the momentum of the ball before the collision.

(b) Determine the magnitude and direction of the change in momentum of the ball.

(c) Calculate the time during which the ball is in contact with the wall.

(d) Explain what happens to the kinetic energy of the ball during the short time that it is in contact with the wall.

29. Three 36 Ω globes, *X*, *Y*, and *Z*, are set up in a circuit as shown below.



(a) An ammeter is used to measure the total current in the circuit. On the diagram in the Answer Book, draw the ammeter. Show the positions of its positive and negative terminals.

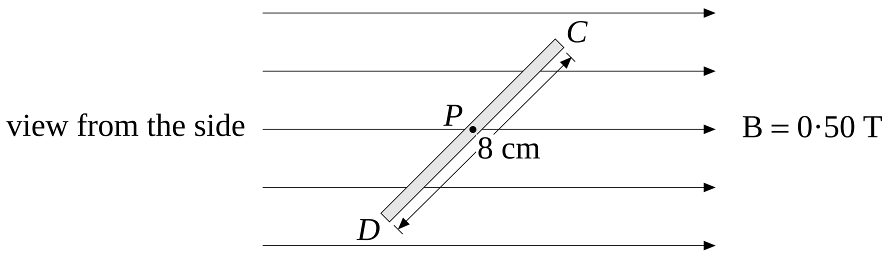
(b) When the switch is open, as shown, calculate:

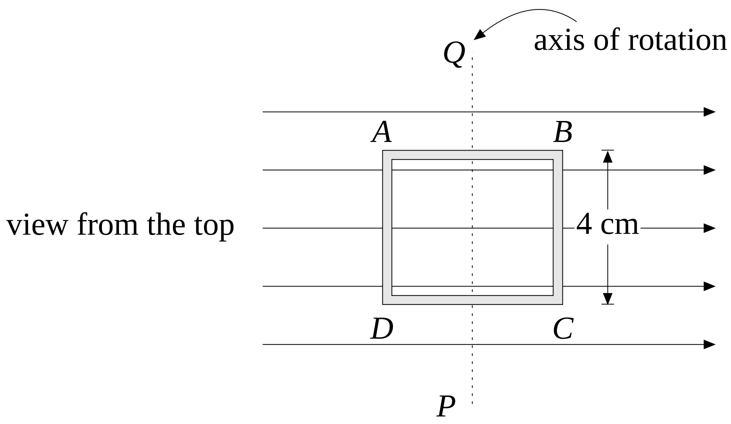
(i) the total resistance of the circuit;

(ii) the total current drawn from the battery.

(c) What will happen to the brightness of each of the globes when the switch is closed? Explain your answer.

30. A rectangular coil *ABCD* of dimensions 8·0 cm by 4·0 cm is made up of 250 turns of wire. It is placed in a uniform magnetic field with a flux density of 0·50 T. It is free to rotate about an axis, *PQ*, as shown in the diagrams below. A current of 9·0 μA flows through the coil.





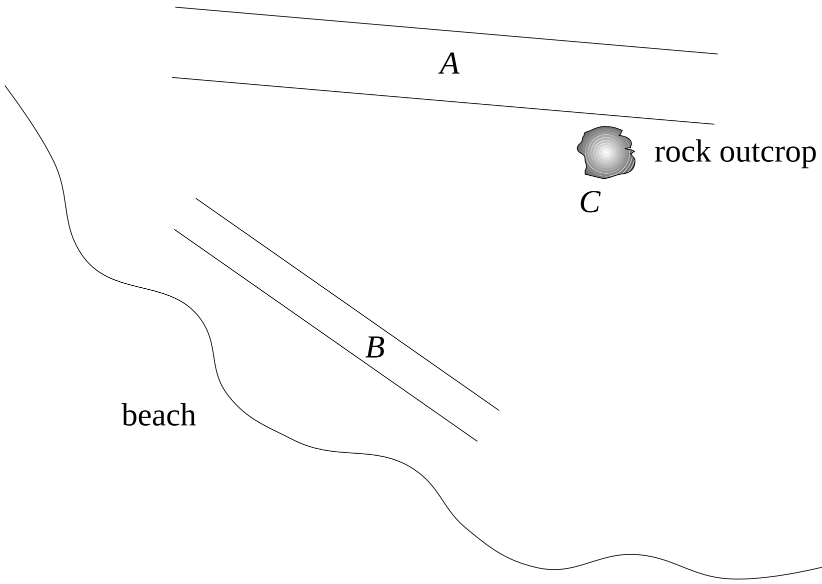
(a) Complete the diagram in the Answer Book by drawing a sketch from the side showing the angle of the coil in the field when the torque is maximum.

(b) The coil is then rotated 180° around axis *PQ* from the position of maximum torque. Compare the torque in this position with that described in part (a).

(c) What is the magnitude of the maximum torque?

(d) What is the magnitude of the force on side *DC* of the coil when the torque is maximum?

31. Two adjacent wavefronts in a train of waves are shown at position A in the diagram below. A short time later, the waves have moved towards the beach to the position marked *B.*



The distances between the wavefronts are 5·0 m at *A* and 2·0 m at *B*. The speed of the waves at *B* is 3·2 m s^{-1}.

(a) What is the frequency of the waves at *A*?

(b) What is the speed of the waves at *A*?

(c) Explain why the waves change as they move from *A* to *B.*

(d) Explain why waves from *A* striking the outcrop of rock cause waves at position *C* behind the outcrop.

(e) In terms of the displacement of particles, describe how water waves differ from sound waves.

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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)

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) (i) Aristarchus, who lived around 240 BC, believed that the Earth orbited the Sun, even though most people believed that the Sun orbited the Earth. **7**

How did Aristarchus explain the motion of the stars?

(ii) Ptolemy produced an improved geocentric model that more accurately predicted the position of the planets. With the use of a clearly labelled diagram, show what Ptolemy meant by the 'deferent', 'eccentric', and 'epicycle'.

(iii) What observation made the eccentric necessary?

(iv) The equant was a further modification of the geocentric model. What was it used to explain?

(v) Give ONE reason why Copernicus still needed epicycles in his model of the solar system.

(b) Newton's law of universal gravitation can be expressed mathematically as **3**

$$F = \frac{Gm_1 m_2}{r^2}.$$

(i) Draw a clearly labelled diagram to show the meaning of the symbols used in this equation.

(ii) If the mass of Jupiter is $1{\cdot}87 \times 10^{27}$ kg and its radius is $7{\cdot}18 \times 10^7$ m, what is the value of the acceleration due to gravity at the surface of Jupiter?

(c) In 1572, Tycho Brahe observed a 'new star' in the constellation Cassiopeia. In 1577, he showed that comets travelled through the crystalline spheres of the planets. What was the importance of these observations? **2**

(d) State Kepler's law of periods. $\mathbf{\frac{1}{2}}$

QUESTION 32. (Continued)

Answer this half-elective in a *new* Elective Answer Book.

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

(a) Both the corpuscular and wave theories of light could explain the refraction of light. What is the major difference between the two explanations? **1**

(b) Between 1802 and 1804, Thomas Young used a black screen with a small hole to produce a narrow beam of light in a dark room. In the narrow beam of light, he then placed a second black screen with two narrow slits. Beyond this screen he placed a white screen. **4**

(i) What was the function of the screen with the small hole?

(ii) What was Young able to calculate using this equipment?

(iii) Augustin Fresnel repeated Young's experiment using different apparatus. What was the major difference between the equipment used by Young and Fresnel?

(iv) Poisson challenged Young's wave theory of light. Fresnel produced experimental results to answer this challenge.

What was the challenge that Poisson made?

(c) In 1669, Erasmus Bartholinus found that crystals of Iceland spar (calcite) could split a ray of light in two. **2**

(i) Why was this difficult to explain using the wave model assumed by Hooke and Huygens?

(ii) What information about the wave nature of light is provided by polarization but not interference?

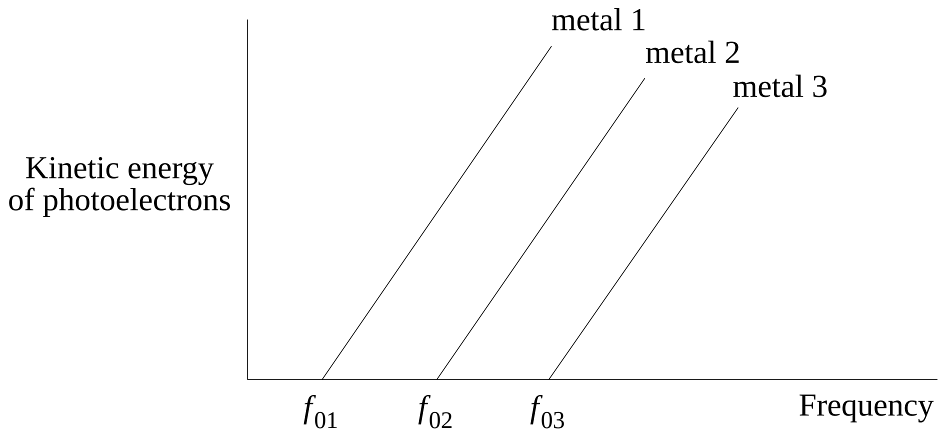
(d) (i) Describe TWO things that led Maxwell to suggest that light was a form of electromagnetic radiation. $\mathbf{2\frac{1}{2}}$

(ii) What is ONE difference between gamma rays and radio waves?

Question 32 continues on page 30

QUESTION 32. (Continued)

(e) Below is a graphical representation of the results of a photoelectric experiment for three different metals. **3**



(i) Why are the slopes of the lines identical?

(ii) What does the point f_{01} represent?

(iii) How did Einstein explain that, below a certain frequency, emission of photoelectrons did not occur, no matter how intense the light?

QUESTION 32. (Continued)

Answer this half-elective in a *new* Elective Answer Book.

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

(a) About 400 BC, Democritus taught that matter was made up of atoms. In about 300 BC, Epicurus used these ideas to establish a more detailed philosophy. Subsequently, the atomic ideas fell into disuse for about 2000 years. **2**

Describe TWO ways in which modern views about atoms differ from those held by the ancient Greek philosophers.

(b) In 1799, Proust formulated the law of definite proportions, which states: *In every sample of any compound substance, formed or decomposed, the proportions by weight of the constituent elements are always the same.* **$1\frac{1}{2}$**

Explain how Dalton's concept of the atom provided a straightforward way of accounting for Proust's law.

(c) Describe how J.J. Thomson discovered isotopes. **2**

(d) Rutherford's model of the atom was developed after he considered the results of an experiment carried out by Geiger and Marsden. **5**

(i) Describe, using a labelled diagram, how the experimental apparatus was used by Geiger and Marsden.

(ii) State ONE significant result of the experiment. Explain how this result was accounted for by Rutherford's model of the atom.

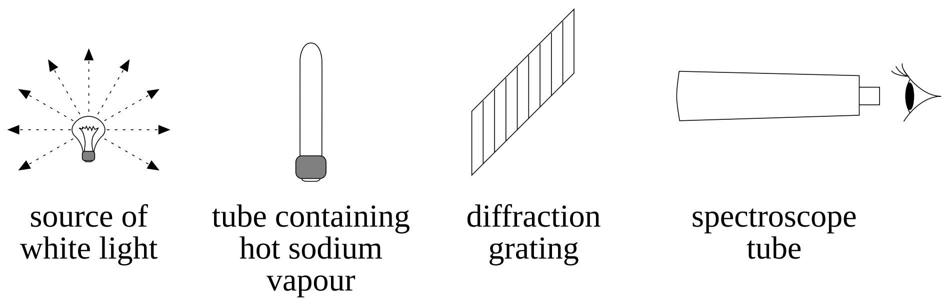
(iii) State the major difficulty with Rutherford's model of the atom.

(iv) Describe how Bohr modified Rutherford's model of the atom.

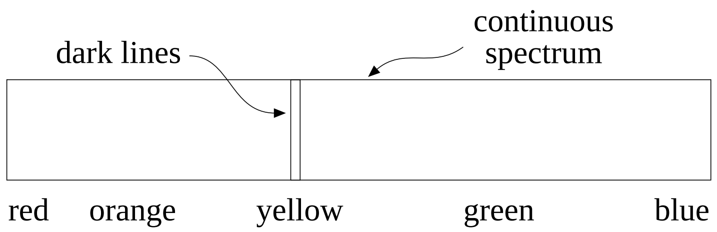
Question 32 continues on page 32

QUESTION 32. (Continued)

(e) White light is passed through hot sodium vapour and then through a diffraction grating as shown in the diagram below. **2**



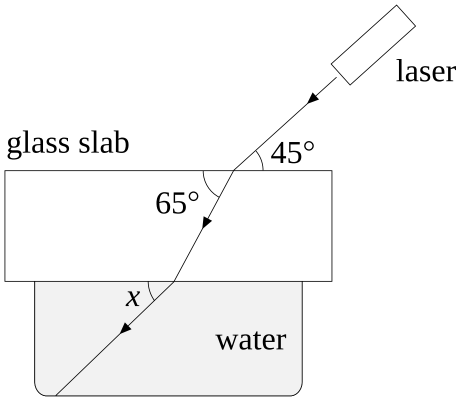
The light is viewed through a spectroscope. Two distinct parallel dark lines are seen in an otherwise continuous spectrum as shown below.



Explain how the dark lines are formed.

QUESTION 33. Wave Properties of Light (25 marks)

(a) A student passed a beam of laser light (λ = 633 nm) through a glass slab into some water. He recorded the information shown in the diagram below. **4**



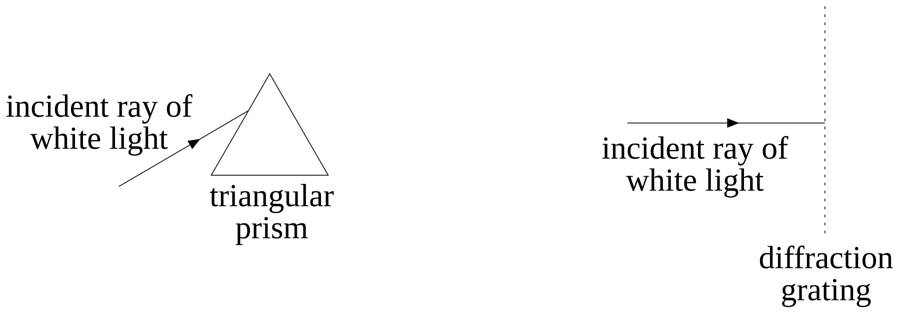
(i) Calculate the refractive index of glass for the laser light.

(ii) Determine the wavelength of the laser light in the glass slab.

(iii) The water has a refractive index of 1·33. Calculate the angle *x*, showing all working.

(b) Use Huygens's principle to explain the law of refraction. **2**

(c) A student conducted an experiment to show the difference in the spectra produced by a triangular prism and a diffraction grating. **6**



(i) Copy the diagrams above into your Answer Book. Complete them to show the formation of spectra by each piece of apparatus. (Label the positions of red and violet in each case.)

(ii) Briefly explain how the spectra are formed by:

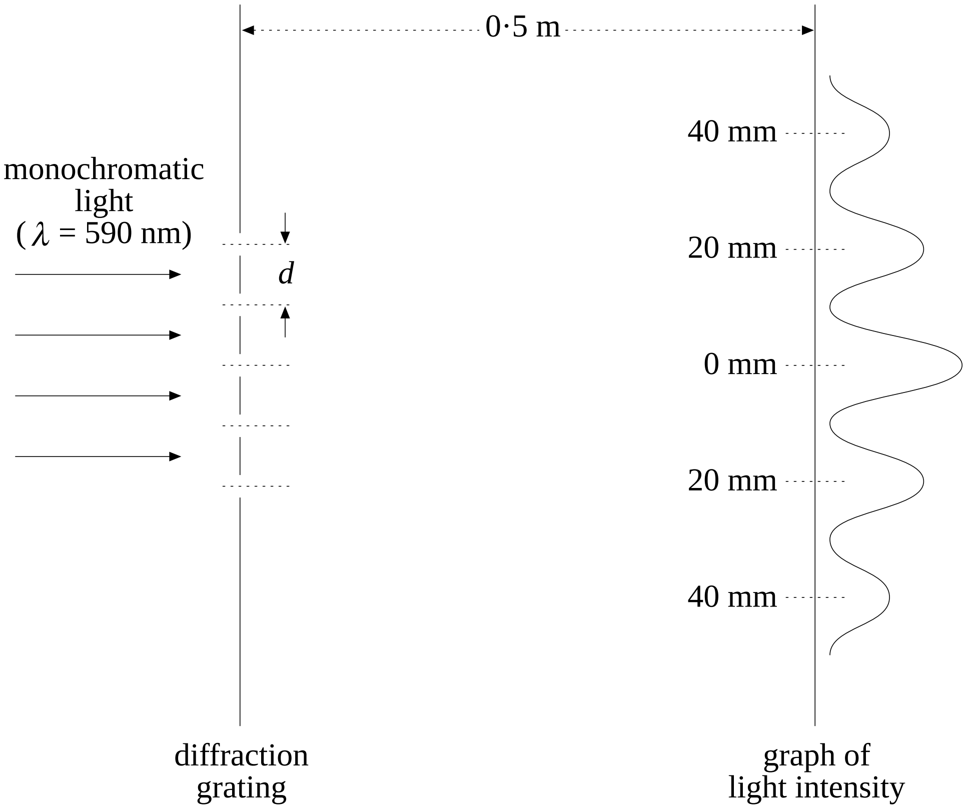
1. the triangular prism;

2. the diffraction grating.

Question 33 continues on page 34

QUESTION 33. (Continued)

(d) The diagram below shows a diffraction grating and a light-intensity pattern. The incident light has a wavelength of 590 nm. **4**



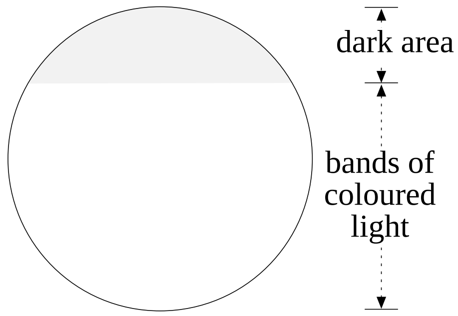
(i) Determine *d*, the spacing of the gaps in the diffraction grating.

(ii) Calculate the distance between two adjacent maxima if the wavelength of the incident light is increased to 633 nm.

QUESTION 33. (Continued)

(e) A soap film can be made by placing a metal ring into a saucer containing soapy water. When the ring is held vertically and viewed by reflected light, a horizontal pattern of coloured bands can be seen on the soap film. **4**

The coloured bands move downwards and a dark area appears at the top, as shown in the diagram, just before the film breaks.



(i) Explain, using a diagram, how the coloured bands are produced.

(ii) Explain why the coloured bands move downwards.

(iii) Explain why the top of the soap film goes dark just before it breaks.

(f) A student reported on a polarization experiment. The following is a section of notes from the report. **3**

> 'I held up a piece of Polaroid film and looked up through it at the blue sky. As I rotated the film through 360°, the light intensity varied.'

(i) Describe the variation in light intensity that the student would have seen.

(ii) Explain why this variation occurs.

(g) The relative speed of a light source and an observer along a line of sight is v. The speed of light is c. When v is small compared with c, the relationship between the emitted frequency, f_0, and the observed frequency, f, of the light is given by **2**

$$f = \frac{f_0}{\left(1 \pm \frac{v}{c}\right)}.$$

Yellow light from a sodium lamp has a wavelength of $5{\cdot}9 \times 10^{-7}$ m when measured in the laboratory.

A distant galaxy that is moving away from the Earth with a speed of $3{\cdot}0 \times 10^{7}$ m s^{-1} is emitting light from sodium atoms.

Calculate the wavelength of this light as measured by an observer on Earth.

QUESTION 34. Rotation (25 marks)

(a) Define each of the following: **3**

(i) angular displacement;

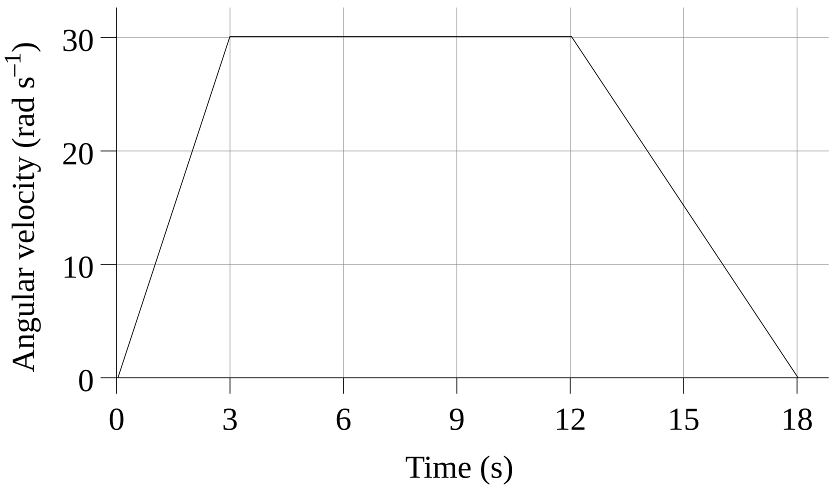
(ii) angular velocity;

(iii) angular acceleration.

(b) Newton's second law for translational motion can be written as $F = ma$. In this equation, the mass, m, does not depend on the point of application of the force. The corresponding equation for rotational motion is $\tau = I\alpha$ where I is the moment of inertia of the object about the axis of rotation. **2**

Explain why I depends on the axis of rotation.

(c) The angular velocity of a dentist's drill bit is shown in the graph below. **4**



The mass of the drill bit is 6·0 g and its average radius is 0·5 mm.

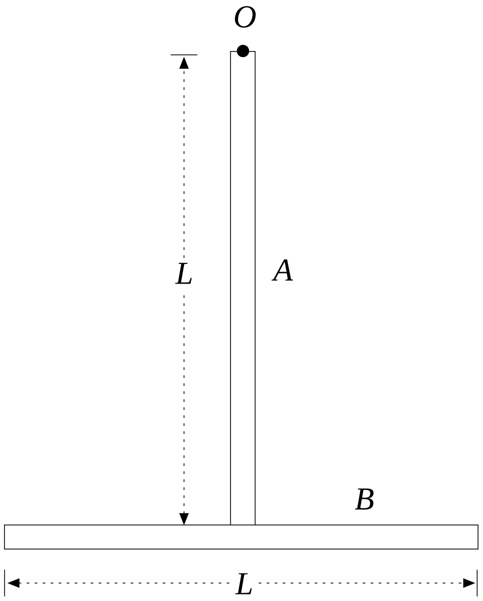
(i) Calculate the average angular acceleration of the drill bit over the first 3 seconds.

(ii) How many revolutions does the drill bit make during the 18-second interval?

(iii) The drill bit can be regarded as a uniform cylinder with moment of inertia $\frac{1}{2}Mr^2$. Calculate its moment of inertia. Calculate the torque required to bring the drill bit to rest in the final 6-second time interval.

QUESTION 34. (Continued)

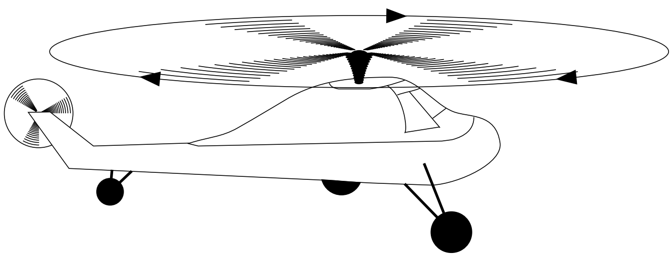
(d) A thin uniform rod of mass M and length L has a moment of inertia about its centre of mass of $\frac{1}{12}ML^2$. Two identical rods, A and B, are connected in a T-shape as shown in the diagram. The T-shape is suspended from the point O so that it is free to rotate about an axis through O. The axis is perpendicular to the plane of the T-shape. **3**



(i) Calculate the moment of inertia about O of rod A only.

(ii) Calculate the moment of inertia of the whole T-shape about O.

(e) Explain why a helicopter, which has a large rotor overhead, needs to have a smaller rotor mounted on a horizontal axis at the rear as shown. **2**

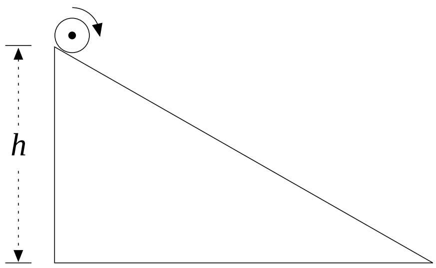


Airflow, Martin Simons, AE Press, 1984, p 89.

Question 34 continues on page 38

QUESTION 34. (Continued)

(f) A cylinder and a hoop roll down an inclined plane from the same height above the ground. They have identical masses, m, and radii, r. The moment of inertia about the rolling axis is mr^2 for the hoop and $\frac{1}{2}mr^2$ for the cylinder. **2**



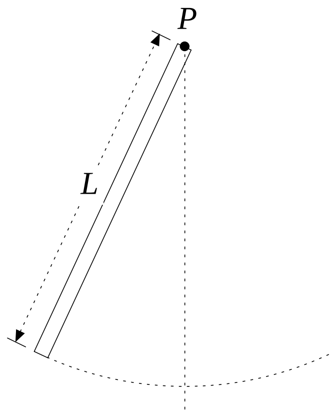
Which one will reach the bottom first? Explain your answer.

(g) An increase in the greenhouse effect could result in significant melting of the polar ice-caps. This would cause ocean levels to rise. **2**

How would this affect the length of the day?

Explain your answer.

(h) The diagram below shows a uniform rod of length L and mass m suspended from one end, P. Its moment of inertia about its centre of mass is $\frac{1}{12}mL^2$. **3**



(i) When the rod is used as a pendulum, the period of its motion is given by

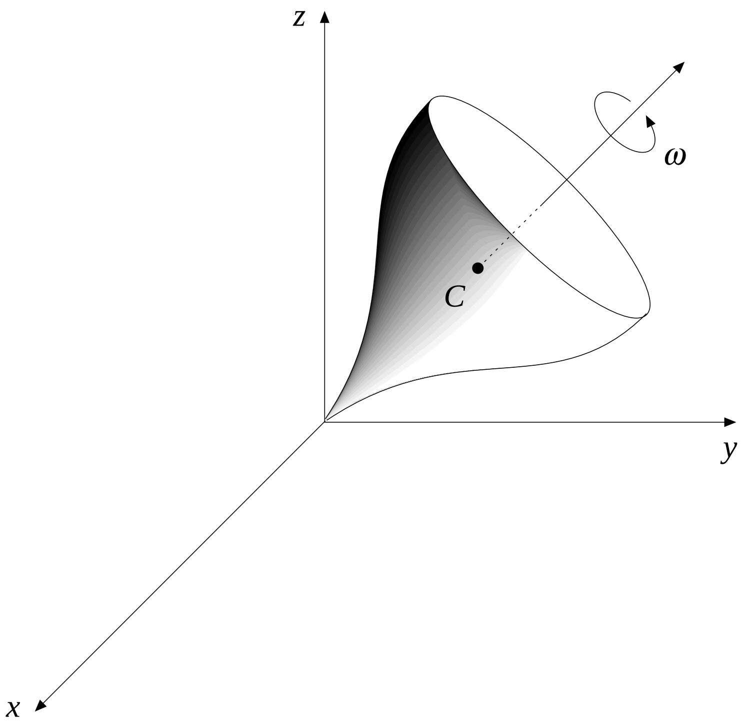
$$T = 2\pi\sqrt{\frac{2I}{mgL}}.$$

Determine the length of the rod if the period of its motion is 2 seconds.

(ii) The rod is pulled aside to make an angle of 30° to the vertical. Calculate the maximum velocity of the centre of mass of the rod after it is released.

QUESTION 34. (Continued)

(i) As shown in the diagram below, a top is spinning with angular velocity ω about its axis of symmetry. The centre of gravity of the top is at the point C on the axis of symmetry. At the instant shown in the diagram, the axis of the top lies in the yz plane. **4**



(i) Draw ONE vector diagram showing:

- the angular momentum of the top;
- the gravitational torque acting on it;
- the direction of the instantaneous change in the angular momentum of the top.

(ii) Explain the motion of the top by referring to your diagram.

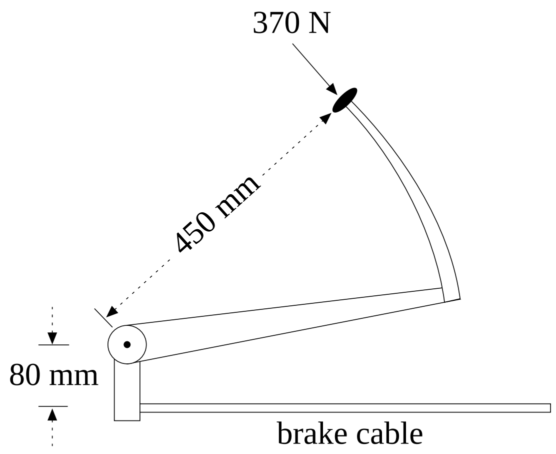
QUESTION 35. Physics in Technology (25 marks)

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

Answer each half-elective in a *separate* Elective Answer Book.

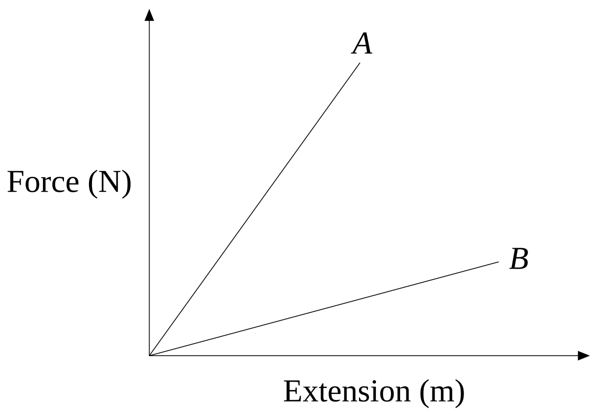
A. Half-elective: Engineering Materials and Structures ($12\frac{1}{2}$ marks)

(a) The diagram below shows the brake pedal of a truck. **2**



The driver applies a force of 370 N to the pedal. Find the tension in the brake cable.

(b) A force–extension graph for two wires, *A* and *B*, is shown below. **3**



The wires have the same length but are made of different materials. The diameter of *B* is twice that of *A*. The gradient of graph *A* is 730 N m^{-1} and the gradient of graph *B* is 250 N m^{-1}.

(i) Find the ratio of the cross-sectional areas of the wires.

(ii) Find the ratio of the Young's modulus of wire *A* to that of wire *B*.

QUESTION 35. (Continued)

(c) Two identical metal blocks are shaped as shown in Diagram 1 below. **$3\frac{1}{2}$**

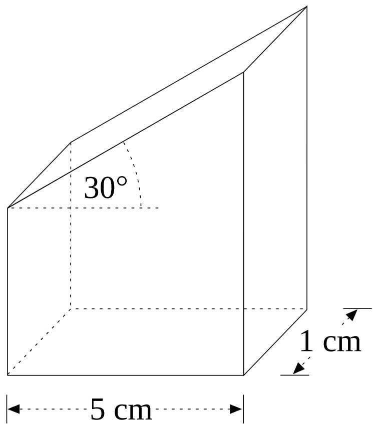


DIAGRAM 1

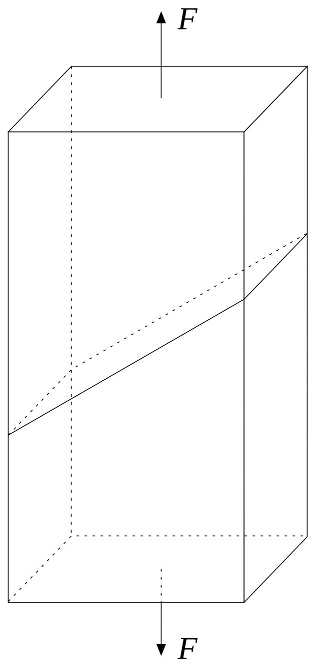


DIAGRAM 2

The two pieces are joined together to form a rod. A tensile load, *F*, is applied to the rod as shown in Diagram 2.

The joint has a tensile strength of $1{\cdot}4 \times 10^8$ N m^{-2}.

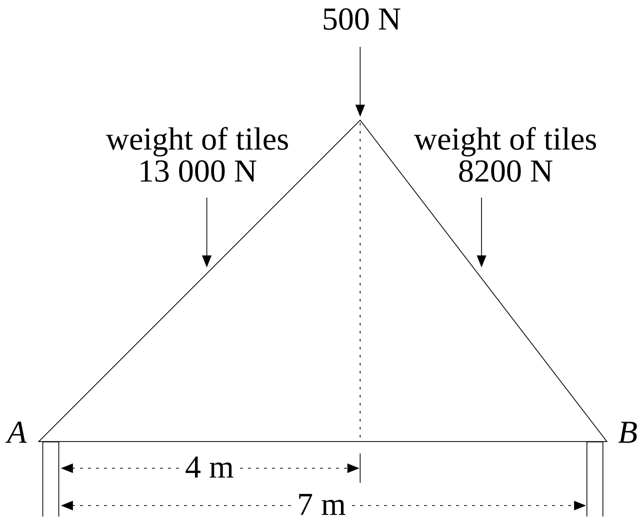
(i) Calculate the tensile stress across the joint in terms of *F*.

(ii) Calculate the load required to make the joint fail in tension.

Question 35 continues on page 42

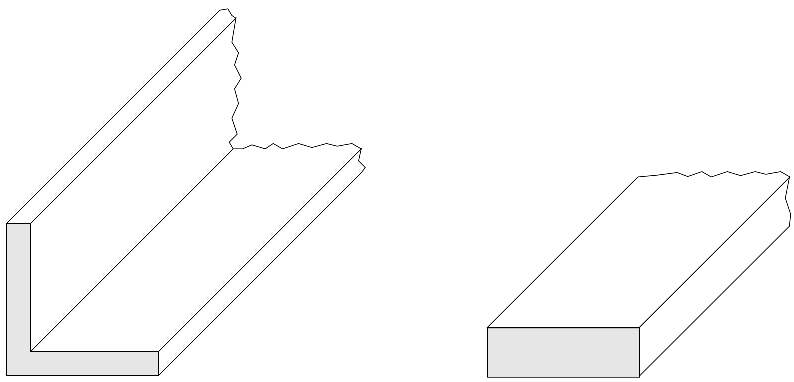
QUESTION 35. (Continued)

(d) A roof truss is shown in the diagram below. The truss supports roof tiles whose weight can be assumed to act half way down each side as shown. A 500 N load acts at the apex of the truss. **2**



Calculate the forces exerted on the truss by the supports at *A* and *B*.

(e) The diagrams below show the ends of two steel beams, *A* and *B*. They have the same cross-sectional area and the same length. **2**



beam *A*

beam *B*

(i) Compare the suitability of the two beams as struts. Explain your answer.

(ii) Compare the suitability of the two beams as ties. Explain your answer.

QUESTION 35. (Continued)

Answer this half-elective in a *new* Elective Answer Book.

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

(a) A simple refracting telescope consists of an objective lens and an eyepiece lens. **4**

(i) What is the object for the eyepiece lens?

(ii) Why is the focal length of the objective much longer than the focal length of the eyepiece?

(iii) The diameter of the objective should be as large as possible. Explain why.

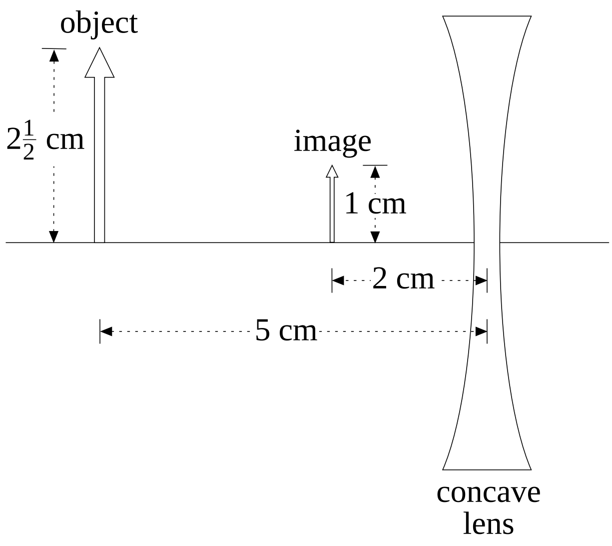
(iv) The largest telescopes in the world are reflecting telescopes rather than refracting telescopes. Give ONE reason for this.

(b) A dentist's concave mirror, placed 15 mm from a tooth, produces a magnified image of the tooth 60 mm behind the mirror. **$2\frac{1}{2}$**

(i) What is the focal length of the mirror?

(ii) The image of a hole in the tooth is 3·6 mm in diameter. What is the actual diameter of the hole?

(c) The following diagram shows a concave lens with an object and its image. **2**



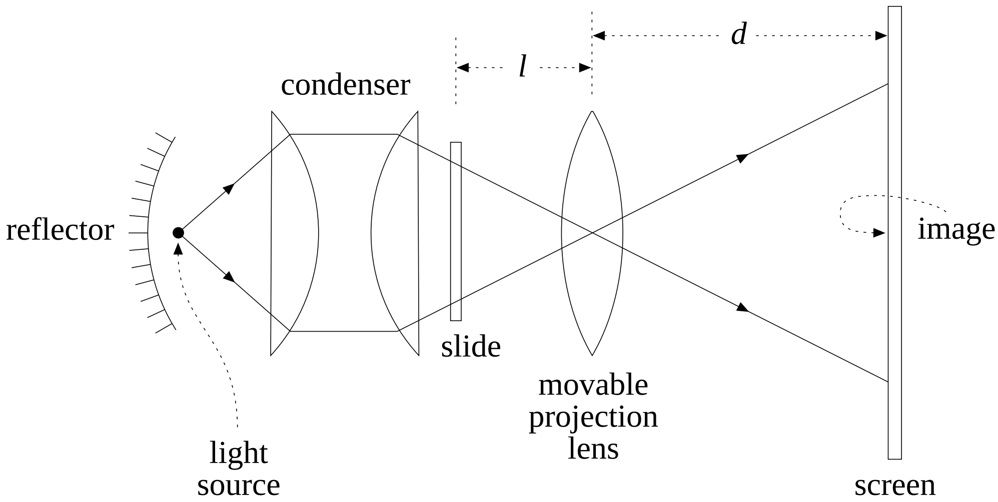
(i) Carefully draw a ray diagram, in your Answer Book, to show how the image is formed.

(ii) Label the position of a principal focus of the lens.

Question 35 continues on page 44

QUESTION 35. (Continued)

(d) The diagram below shows the components of a slide projector. **4**



(i) Describe the function of:

1. the condenser;

2. the projection lens.

(ii) In a typical slide projector, the projection lens has a focal length of 50 mm. It can be moved so that the distance *l* can be varied between 51 mm and 60 mm.

Determine the minimum distance *d* required for a sharp image.

QUESTION 35. (Continued)

Answer this half-elective in a *new* Elective Answer Book.

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

(a) In a hydroelectric power station, the vertical height from the generator to the reservoir is 560 m. **5**

(i) When the station is providing its maximum output, $4{\cdot}3 \times 10^5$ kg of water passes through the turbines every second. What is the power input to the turbines?

(ii) The station can feed a maximum current of 5500 A at 330 kV into the electricity distribution grid. What is the maximum power output of the station?

(iii) What is the efficiency of the power station?

(iv) The generators produce electrical energy at a low voltage, which is then stepped up to 330 kV.

Explain why it is more efficient to transmit the energy at a high voltage.

(b) (i) Calculate the minimum amount of electrical energy required to bring 1·2 litres of water to the boiling-point if the initial temperature of the water is 16°C. $\mathbf{3\frac{1}{2}}$

(ii) The actual amount of energy needed to bring any amount of water to the boiling-point is always greater than the calculated minimum.

Give TWO reasons for this.

(c) In a nuclear-fission power station, 1·0 kg of ^{235}U loses 0·01% of its mass during one month of operation. **4**

(i) How much energy is released by 1·0 kg of uranium in the month?

(ii) Describe how this energy is transformed into electrical energy.

(iii) Much research into nuclear-fusion reactors continues at great expense despite limited success.

What has limited the large-scale production of energy using nuclear fusion?

QUESTION 36. Astronomy (25 marks)

(a) The following is information about four different stars as given in an astronomy handbook. **9**

Name	*Apparent magnitude*	*Spectral class*	*Distance* (parsecs)
Sirius	–1·58	A0	2·5
Alpha Centauri	0·06	G0, K5	1·6
Beta Crucis	1·50	B1	
Polaris	2·12	F8	339

(i) What is the brightness ratio of Polaris over Beta Crucis?

(ii) What is the absolute visual magnitude of Alpha Centauri?

(iii) Sirius has an absolute visual magnitude of +1·3. If Sirius and Alpha Centauri were viewed from the same distance, which one would be brighter? Explain your answer.

(iv) Explain why Alpha Centauri has two spectral classes.

(v) What colour is Polaris?

(vi) Which of the stars in the table would have the lowest colour index? Explain your answer.

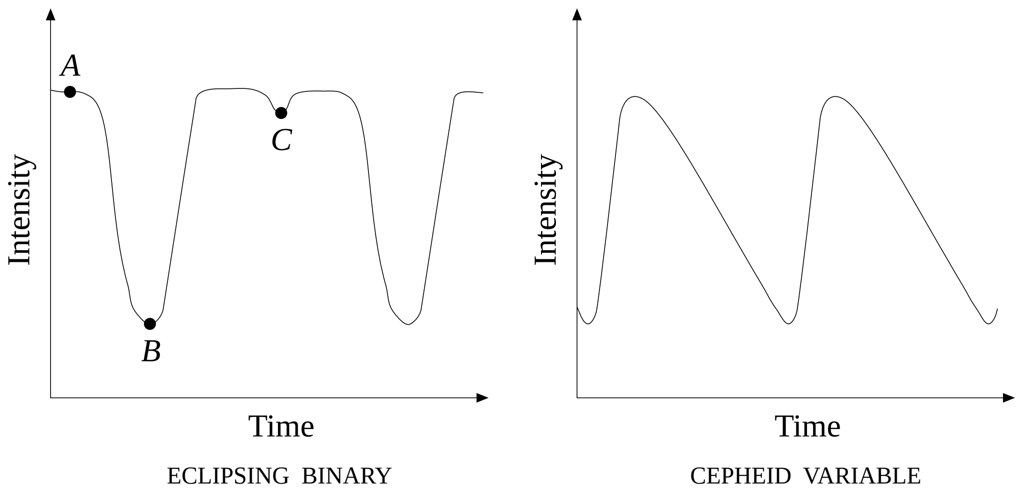
(vii) Which of the stars in the table would have the hottest surface temperature? Explain your answer.

(viii) Beta Crucis has an absolute magnitude of –5·0. What is the distance to Beta Crucis in parsecs?

(ix) Sirius has a parallax of 0·38 seconds of arc. Use a diagram to show what is meant by this.

QUESTION 36. (Continued)

(b) The diagrams below give the variation in the intensity of light reaching the Earth from two different types of variable stars. **6**



(i) Describe the process by which the light output of the eclipsing binary system changes. In your answer, you should refer to points *A*, *B*, and *C* on the diagram above.

(ii) Explain why the intensity of light from the Cepheid variable changes.

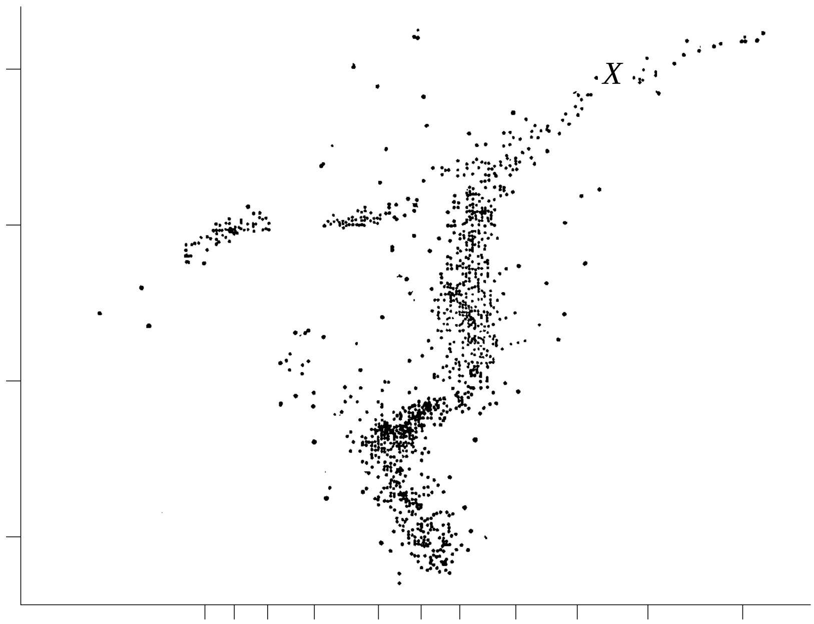
(iii) Cepheid variables have a certain property that makes them very useful for determining how far they are from the Earth. Describe this property.

Question 36 continues on page 48

QUESTION 36. (Continued)

(c) (i) Stars *A* and *B* are both white stars. Star *A* has an absolute magnitude of $-0{\cdot}5$ and Star *B* has an absolute magnitude of $+6{\cdot}2$. Which of the two stars is more likely to be found in a globular cluster? Explain your answer. **5**

(ii) Stars in the globular cluster M3 are plotted on a Hertzsprung–Russell diagram, shown below.



Frontiers of Astronomy,
F Hoyle, Heinemann, 19955.

1. What characteristic of the stars is plotted on the horizontal axis?

2. What characteristic of the stars is plotted on the vertical axis?

3. What is the name given to stars in region *X* of the diagram?

QUESTION 36. (Continued)

(d) The proton–proton chain and the CNO cycle are thought to be the major sources of energy in main-sequence stars. **5**

(i) What, besides energy, is the major product of the proton–proton chain?

(ii) What is the process commonly known as the 'helium flash'? When does it occur in the evolution of a star?

(iii) The following equation is part of the CNO cycle.

$$^{12}_{6}\text{C} + {}^{1}_{1}\text{H} \rightarrow {}^{13}_{7}\text{N} + \gamma$$

Determine, in MeV, the amount of energy released in this reaction, given that:

- mass of $^{12}_{6}\text{C}$ is 11·9967 u
- mass of $^{1}_{1}\text{H}$ is 1·0072 u
- mass of $^{13}_{7}\text{N}$ is 13·0019 u.

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HIGHER SCHOOL CERTIFICATE EXAMINATION

1995
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.

EXAMINER'S USE ONLY

PART	Mark	Examiner	Check
B			

EXAMINER'S USE ONLY

Questions 16 to 25 (3 marks each).

Attempt ALL questions.

Answer Questions 16 to 25 in the spaces provided below.

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

16. (a)

(b) ....

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17. (a) ....

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(b) ....

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(c) ....

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EXAMINER'S USE ONLY

18. (a)

(b) ....

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(c) ....

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EXAMINER'S USE ONLY

19. (a) ....

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(b) ....

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(c) ....

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20. (a) ....

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(b) ....

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(c) ....

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EXAMINER'S USE ONLY

21. (a) ....

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(b) ....

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22. (a) ....

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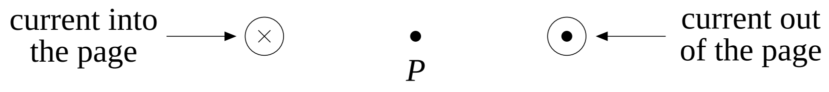
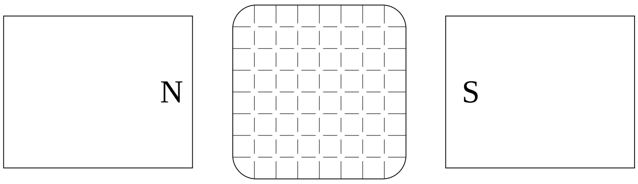
(b)

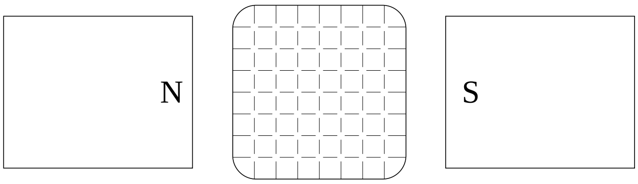


EXAMINER'S USE ONLY

23. (a)



(b)



(c) ....

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24. (a) ....

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(b) ....

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EXAMINER'S USE ONLY

25. (a) ....

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(b)

(c) ....

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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.

EXAMINER'S USE ONLY

PART	Mark	Examiner	Check
C			

EXAMINER'S USE ONLY

Questions 26 to 31 (5 marks each).

Attempt ALL questions.

Answer Questions 26 to 31 in the spaces provided below.

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

26. (a) ....

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(b) ....

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(c) ....

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(d) ....

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EXAMINER'S USE ONLY

27. (a) ....

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(b) ....

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(c) ....

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(d) ....

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EXAMINER'S USE ONLY

28. (a) ....

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(b) ....

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(c) ....

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(d) ....

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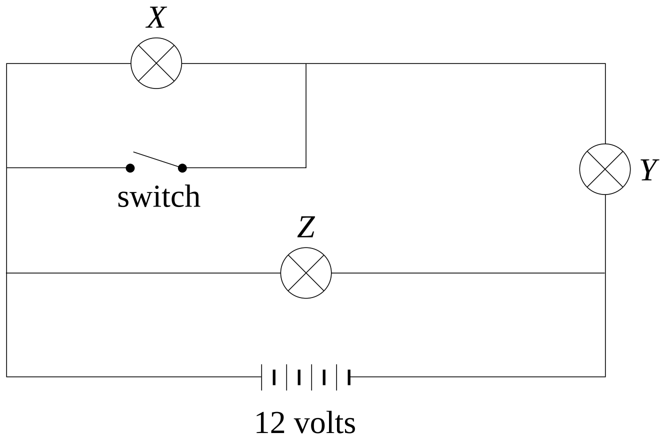
EXAMINER'S USE ONLY

29. (a)



(b) (i) ....

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(ii) ....

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(c) Globe *X*

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Globe *Y*

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Globe *Z*

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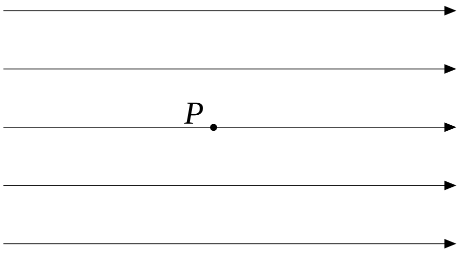
EXAMINER'S USE ONLY

30. (a)

view from the side



(b) ....

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(c) ....

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(d) ....

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EXAMINER'S USE ONLY

31. (a) ....

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(b) ....

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(c) ....

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(d) ....

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(e) ....

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