**TERTIARY ENTRANCE EXAMINATION, 1993**

**QUESTION/ANSWER BOOKLET**

# PHYSICS

Please place one of your student identification labels in this box

SEA STUDENT NUMBER – In figures

In words _____

_____

**TIME ALLOWED FOR THIS PAPER**

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

**MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER**

*TO BE PROVIDED BY THE SUPERVISOR*

This Question/Answer Booklet comprising 35 pages (Section A - 30 questions, Section B - 8 questions)
Physical Constants (inside front cover of this Question/Answer Booklet)

*TO BE PROVIDED BY THE CANDIDATE*

*Standard Items:* Pens, pencils, eraser or correction fluid, ruler

*Special Items:* A calculator satisfying the conditions set by the Secondary Education Authority, compass, protractor and set square.

**IMPORTANT NOTE TO CANDIDATES**

**No other items may be taken into the examination room.**

**It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you hand it to the supervisor BEFORE reading any further.**

**SEE PAGE 3**

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SEE PAGE 3

**INSTRUCTIONS TO CANDIDATES**

This paper consists of **TWO (2)** sections

In SECTION A, answer **ALL** thirty questions, and **write your answers in the spaces provided below or next to each question.** This section is worth 48% of the marks for the examination. Each of these questions is of equal value.

In SECTION B, answer **ALL** eight questions, and write your answers in the spaces provided beneath each question in the Question/Answer Booklet provided. This section is worth 52% of the marks for the examination.

Note that (where appropriate) answers should be given numerically and that they should be evaluated and not left in fractional or radical form. Give all answers to an appropriate number of significant figures.

A calculator satisfying the conditions set by the Secondary Education Authority may be used to evaluate numerical answers.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

At the commencement of this examination, attach your STUDENT IDENTIFICATION label to the front cover of this Question/Answer Booklet. Write your SEA Student Number in the spaces provided in the Question/Answer Booklet.

**SEE PAGE 4**

## SECTION A

**MARKS ALLOTTED : 48**

Attempt all thirty (30) questions in this section. All questions are worth equal marks. **Answers are to be written in the spaces below or next to the question.**

Evaluate answers numerically where possible. Credit will be given for working, if shown.

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1. Express in scientific notation (e.g. 567 kJ = $5.67 \times 10^5$ J) :

   22.5 mPa = _____ 363 nm = _____

   Express, using an appropriate prefix (e.g. $3.41 \times 10^{-11}$s = 34.1 ps) :

   $4.47 \times 10^{-4}$ A = _____ $1.87 \times 10^7$ eV = _____

2. How many protons and neutrons are there in one atom of the uranium isotope $^{238}_{92}U$ ?

   Number of protons _____ Number of neutrons _____

3. (a) Briefly describe the phenomenon of resonance.

   (b) List three examples of resonance :

   1. _____

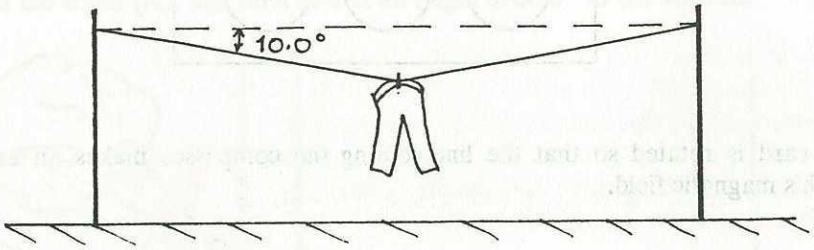
   2. _____

   3. _____

SEE PAGE 5

4. A small dust particle with a charge of -3e is held stationary between two horizontal plates between which an electric field of 50.0 kV $m^{-1}$ is applied. Briefly explain how this is possible. What is the mass of the particle?

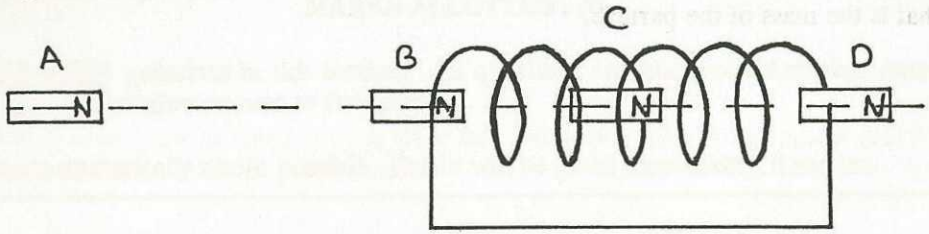
5. A pair of wet jeans is hung on a light clothes line using a single peg at the midpoint of the line, as shown in the diagram :




If the mass of the wet jeans is 1.95 kg and the line makes an angle of 10.0° to the horizontal, what is the tension in the line?

SEE PAGE 6

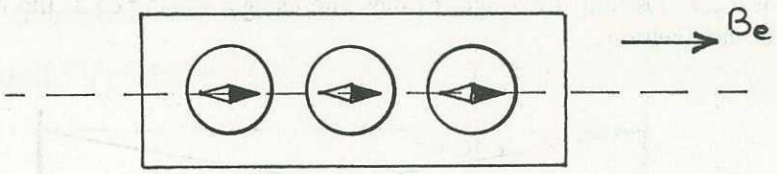
6. A small bar magnet is moved along the axis of a long solenoid from left to right, as shown in the diagram :



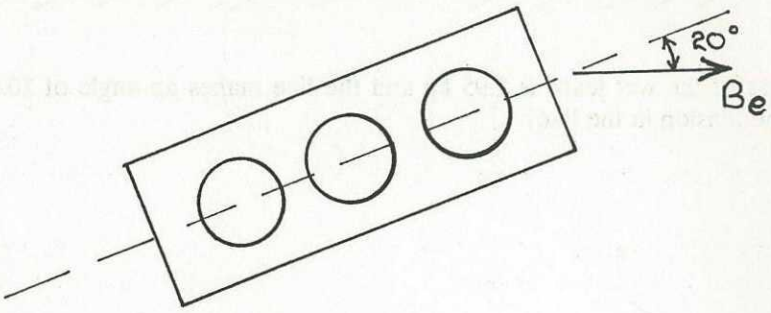

On the diagram, sketch the direction of the force exerted on the magnet, due to the presence of the coil, when it is at :

A, outside the solenoid
B, just entering the solenoid
C, in the centre of the solenoid
D, just exiting the solenoid

7. Three magnetic compasses are placed on a card and lined up close together in the Earth's magnetic field, $B_e$, as shown :




The card is rotated so that the line joining the compasses makes an angle of 20° with the Earth's magnetic field.




Clearly indicate on the diagram the directions of the three compass needles in this position.

Briefly justify your choice of directions.

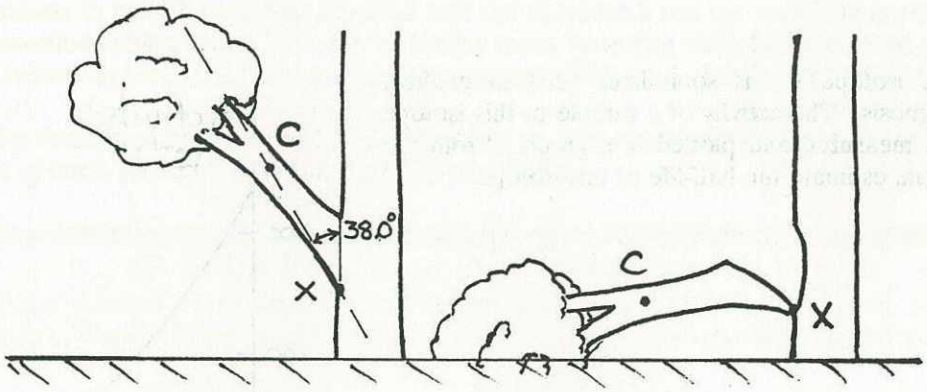
SEE PAGE 7

8. The force per unit length between two parallel current-carrying wires is given by

$$\frac{F}{l} = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{d}$$

Find the dimensions of the permeability constant $\mu_0$.

9. It was estimated that the centre of gravity (C) of a branch was 2.75 m from the base of its attachment to the trunk (X), and on a line at an angle of 38.0° to the vertical.

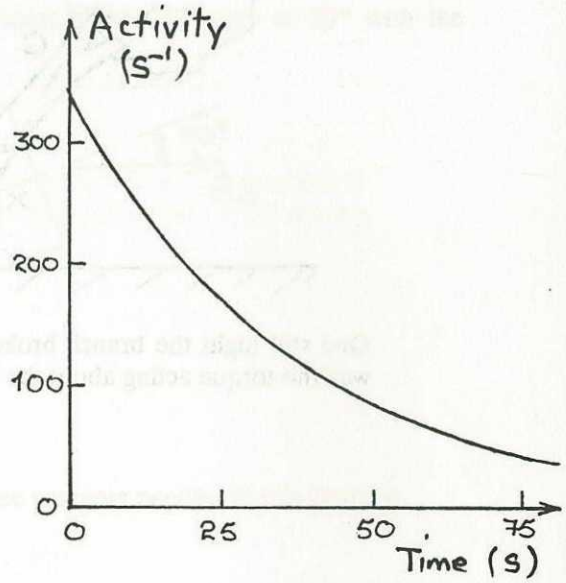



One still night the branch broke off. If the mass of the branch was found to be 125 kg, what was the torque acting about the point X, where the branch joins the trunk, causing it to break?

SEE PAGE 8

10. What is the radius of curvature of the path of an electron with kinetic energy of $1.60 \times 10^{-17}$ J moving perpendicular to a magnetic field of $5.00 \times 10^{-5}$ T ?

11. The isotope $^{128}I$ is sometimes used in medical diagnosis. The activity of a sample of this isotope was measured and plotted in a graph. From the graph, estimate the half-life of this isotope.




SEE PAGE 9

12. A speck of dust of mass 50.0 mg is blowing with a horizontal velocity of 1.5 m $s^{-1}$ when it lodges in the eye of a cyclist riding in the opposite direction at 4.50 m $s^{-1}$. What is the change in momentum of the speck of dust?

13. A witness to a traffic accident reported that she observed a red car travelling north towards an intersection collide with a blue car, of similar mass, travelling west. She estimated the speed of the red car to be 40.0 km $h^{-1}$ and the blue car to be 80.0 km $h^{-1}$ before the collision.

Police found that both cars had locked together on impact and came to rest at a position 35.0° west of north (N 35.0° W) from the point of collision.

Is the evidence of the witness consistent with the police findings? Justify your answer.

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14. Explain why a passenger in a fast moving car feels that he loses weight as the car travels over the crest of a hill.

15. A Grand Prix racing car travels round a bend of radius 30.0 m at a speed of 120 km $h^{-1}$.

(a) What supplies the centripetal force to the car?

(b) What is the magnitude of the centripetal force which is supplied to the driver's head by his neck, if the mass of his head and helmet combined is 8.00 kg?

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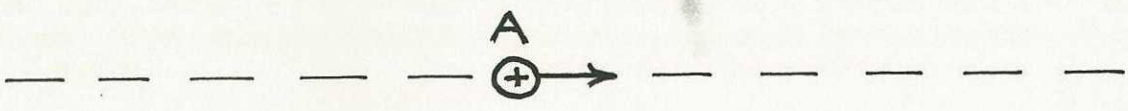
16. The planet Saturn has a mass 95.2 times greater than that of Earth, and an equatorial radius 9.50 times greater. When an astronaut stood on a set of bathroom scales at the equator on Earth, they read 65.0 kg. What would the same scales indicate for the same astronaut at the equator on the surface of Saturn?

17. A single positive charge is travelling in a straight line from left to right, as shown in the diagram. Sketch the magnetic field produced by this moving charge when it is at position A.

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18. A satellite is put into a stable, circular orbit over the equator so that it orbits in the same direction as the rotation of the earth and with the same period. This is called a geostationary orbit.

Explain why all satellites in a geostationary orbit must be at the same altitude.

19. Both the Sun and an electric light globe emit a continuous spectrum of visible light. However, there are dark lines in the Sun's spectrum (called Fraunhofer lines) which are not seen in the spectrum from a light globe. Explain the reason for this difference.

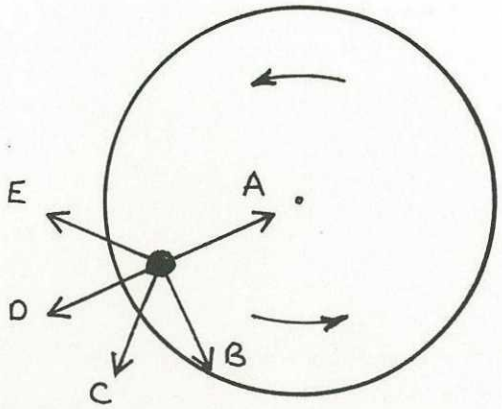
SEE PAGE 13

20. A frisbee (a round plastic disc) with a diameter of 145 mm is floating on the surface of an indoor swimming pool immediately above a small light at the bottom of the pool. What is the diameter of the frisbee's shadow on the ceiling above the pool if the pool is 2.2 m deep, the ceiling is 3.5 m above the surface of the pool, and the refractive index of water is 1.33 ?

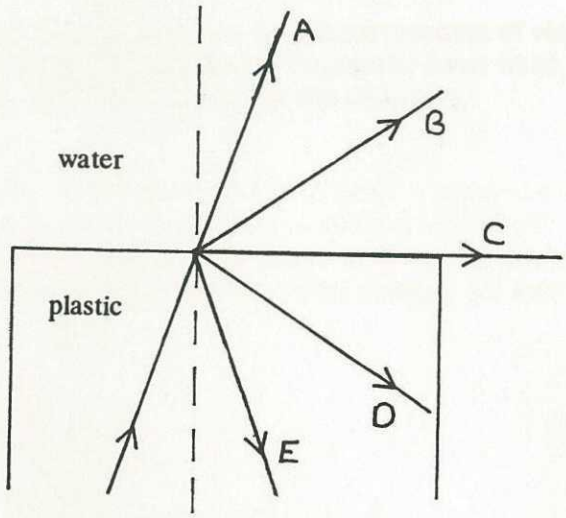
SEE PAGE 14

For the next ten (10) questions, choose the alternative which **best** answers each question and indicate your choice by writing the appropriate letter in the box provided.

21. A potter's wheel rotates in a horizontal circle at a constant speed. At the instant shown on the diagram, what is the direction of the centripetal force acting on a piece of clay stuck to the wheel?




22. The diagram shows a ray of light travelling in a block of clear plastic immersed in water. The water has a smaller refractive index than the plastic. Which of the following paths – A, B, C, D, or E – would not be possible for the ray after it reaches the interface?




23. A small magnet is freely suspended about its centre to act as a compass. Small samples of different materials are brought near to the magnet and then removed. Which of the following statements would best describe the results?

A. Neither glass nor paper cause the magnet to move.

B. Neither iron nor mercury cause the magnet to move.

C. Both aluminium and water cause the magnet to move.

D. Both copper and alcohol cause the magnet to move.

E. Both iron and silver cause the magnet to move.

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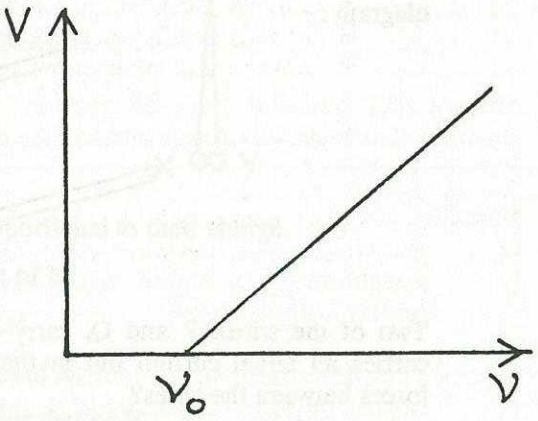
24. A graph of stopping potential V versus light frequency $\upsilon$ is shown in the graph. From the relationship

$$h\upsilon = \phi + qV$$

we can write

$$V = h\upsilon/q - \phi/q$$




The slope of the graph is then

A. $h/q$

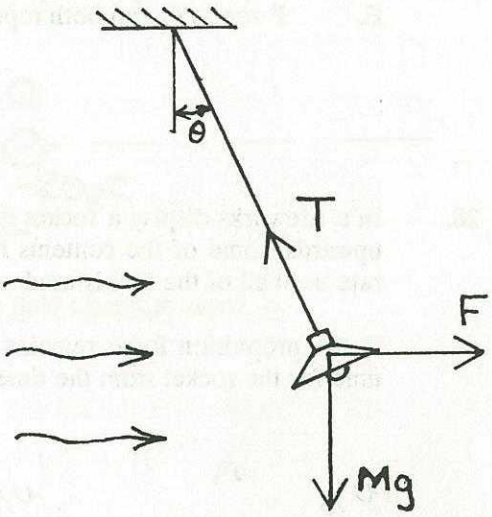
B. $-\phi/q$

C. $h$

D. $\upsilon_0$

E. $-\phi$

25. A small lamp of mass M is suspended by a light wire. A fan blows a steady stream of air onto the lamp, imparting a constant horizontal force F. The lamp takes up a position such that the wire is at an angle $\theta$ to the vertical, as shown. The tension in the wire is T.




The force F can be expressed in terms of T and $\theta$ as follows :

A. $F = T \cos \theta$

B. $F = T \sin \theta$

C. $F = T \tan \theta$

D. $F = \cos \theta / T$

E. $F = T / \tan \theta$

26. A ray of light travelling in water bends towards the normal when it enters a layer of oil. This shows that :

A. The velocity of light in water is greater than the velocity of light in oil.

B. The wavelength of light in water is less than the wavelength of light in oil.

C. The frequency of light in water is greater than the frequency of light in oil.

D. The frequency of light in water is less than the frequency of light in oil.

E. The light consists of a range of wavelengths.

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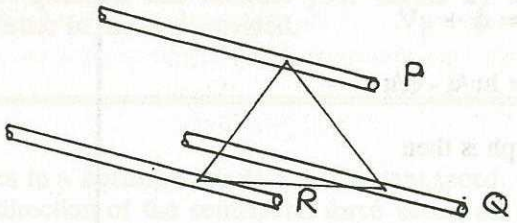
27. Three parallel wires are positioned at equal distances from one another, as shown in the diagram :




Two of the wires, P and Q, carry equal currents in the same direction, while the third, R, carries an equal current but in the opposite direction. Which statement best describes the forces between the wires?

A. P attracts Q and both attract R

B. P repels Q and attracts R

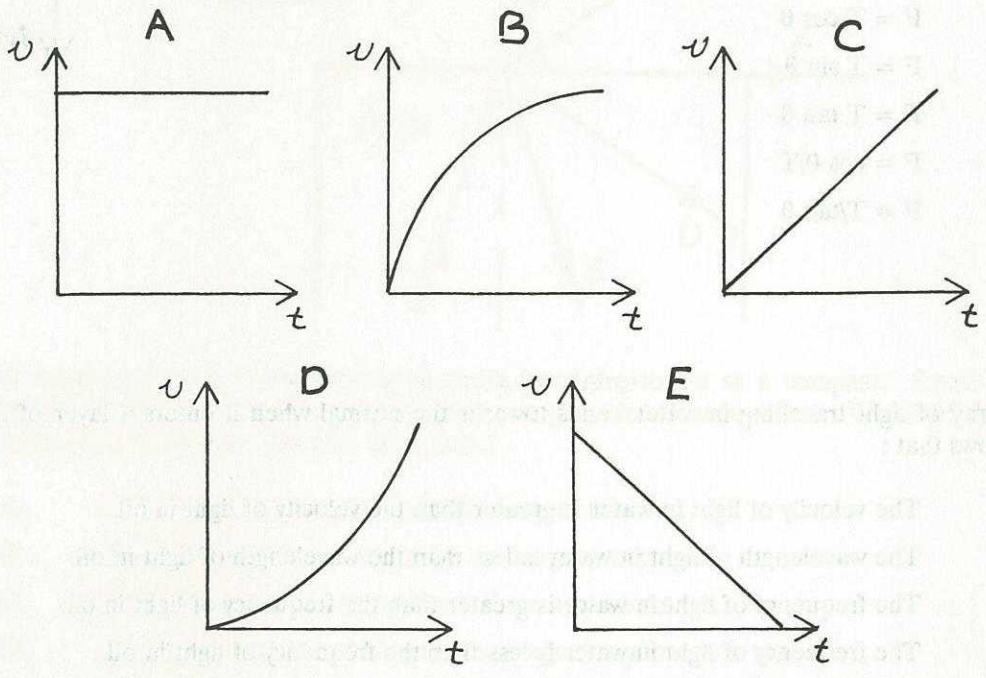
C. P attracts Q and both repel R

D. P repels Q and R

E. P repels Q and both repel R

28. In a fireworks display a rocket is used to propel a firecracker into the air. As it goes vertically upwards, some of the contents burn causing the mass of the rocket to decrease at a constant rate until all of the fuel is used. At this point the firecracker explodes.

If the propulsion force remains constant, the graph which best describes the velocity against time for the rocket from the time it is launched to the time it explodes is :

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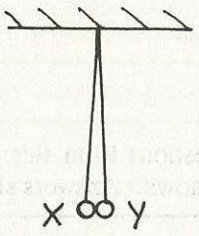
29. Two light balls of equal mass are suspended on equal lengths of light thread from a single point, as shown:




The balls are both given positive charges such that X has four times the charge on Y. Which statement best describes their new rest position?

A. X and Y make angles with the vertical proportional to their charge.

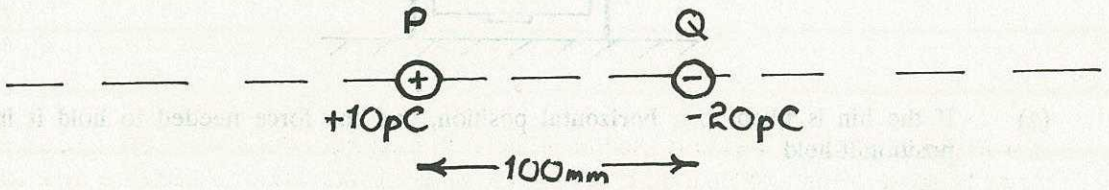
B. X makes an angle to the vertical twice that of Y.

C. X and Y make equal angles with the vertical.

D. X makes an angle with the vertical half that of Y.

E. X makes an angle to the vertical one quarter that of Y.

30. Two charges, P and Q, of +10 pC and -20 pC respectively are separated by 100 mm, as shown on the diagram :




Where, on the line through both charges, is the electric field closest to zero?

A. 240 mm to the left of P

B. At P

C. 40 mm to the right of P

D. 40 mm to the left of Q

E. 200 mm to the right of Q

**END OF SECTION A**

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## SECTION B

**MARKS ALLOTTED : 52**

Attempt ALL questions from this section. Credit will be obtained for method and reasoning only if these are clearly shown. Answers should be evaluated numerically.

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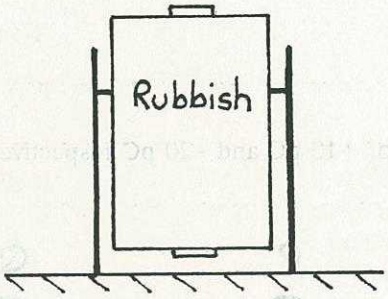
[7 marks]

1. A rubbish bin is hinged exactly two-thirds of the way up from the base and is emptied by turning it upside down.

   The bin is filled with rubbish of uniform density, making the total mass of the bin, lid and rubbish 36.5 kg. The height of the bin is 1.20 m.




(a) If the bin is tilted to a **horizontal** position, find the force needed to hold it in this position if held

(i) by the handle on the base,
(ii) by the handle on the lid.

[2 marks]

(b) Explain why the bin has been hinged two-thirds of the way up rather than at the top or in the middle.

[2 marks]

(c) What is the minimum force required to hold the bin at an angle of 45° to the horizontal if the bin is held by the handle on the base?

[3 marks]

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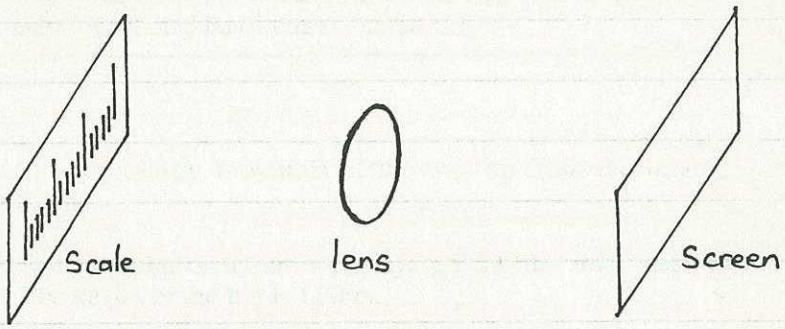
[6 marks]

2. You have been asked to select a lens which will produce a magnified image of an illuminated scale on a screen placed 250 mm from the scale.




(a) What type of lens would you use? (State your reason). [2 marks]

(b) Sketch a diagram showing how the image is formed by the lens. Make sure that you show the orientation of the image.
[2 marks]

(c) Find the focal length of the lens if the image is required to have a magnification of 4.5.
[ 2 marks]

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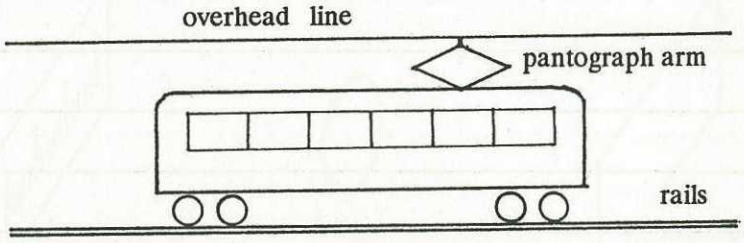
[6 marks]

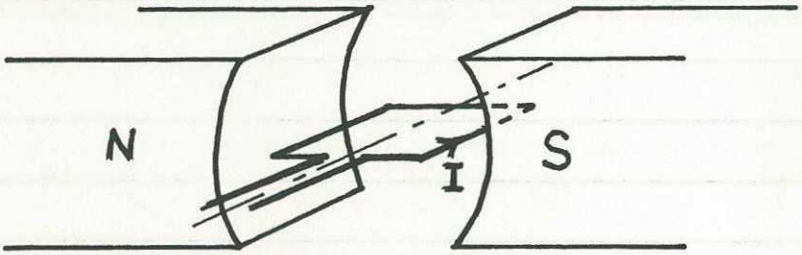
3. (a) A high-speed electric train picks up power from the overhead line through a pantograph arm; the other connection is made to earth through the rails. The height of the overhead line above the rails is 5.0 m.




The train is travelling east-west at 80 m $s^{-1}$ and the horizontal component of the Earth's magnetic field is 20.0 μT. If no other power is being supplied to the train, what would be the voltage induced between the overhead line and the rails?

[2 marks]

(b) A simple electric motor consists of a single square loop of wire with sides 141 mm, rotating in a magnetic field B = 1.00 mT, between the poles of a permanent magnet, as shown in the diagram :




(i) If the current supplied is 5.00 A, in the direction shown, find the torque on the loop. [3 marks]

(ii) In which direction will the loop rotate? [1 mark]

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[7 marks]

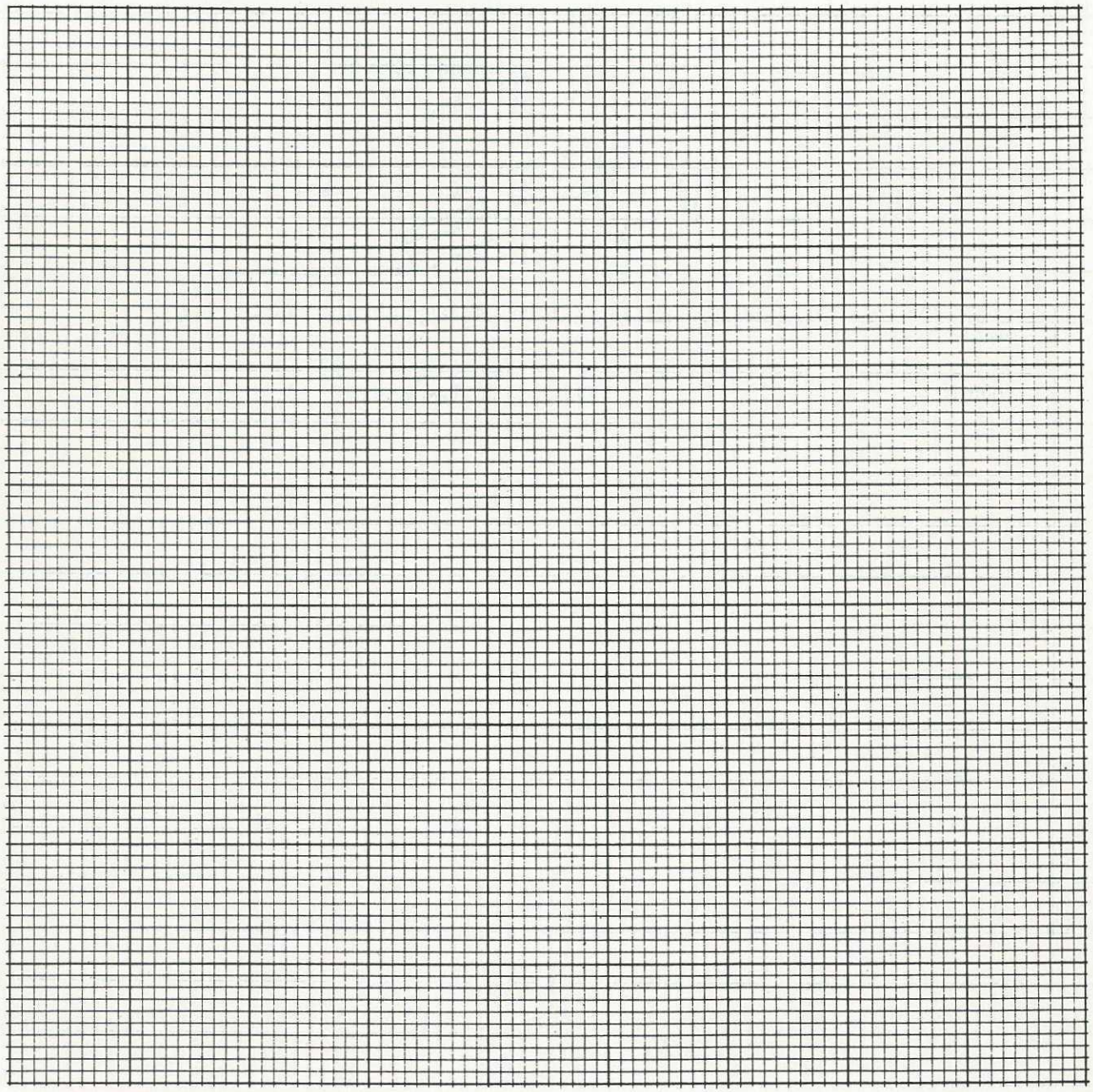
4. In an experiment to measure the focal length of a lens, an object was placed at different distances from the lens, and the distances of the images from the lens were measured. The results obtained were :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Object distance | 240 | 280 | 320 | 360 | 400 | 440 | 500 | mm |
| Image distance | 650 | 470 | 380 | 340 | 330 | 290 | 270 | mm |

(a) Use the above set of results to draw a straight line graph.
[Note: It may be necessary to process the above set of results to enable the appropriate form of graph to be obtained]. [3 marks]

(b) **From this graph,** determine the focal length of the lens. [2 marks]

(c) Explain clearly the method you used to calculate the focal length. [2 marks]



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[6 marks]

5. A power station has four generators, each producing 250 MW at an output voltage of 16 kV.

(a) What is the total current produced by the power station? [2 marks]

(b) If the price paid by the consumers is 17.9 cents per kWh, what is the value of five minutes output from this power station. [3 marks]

(c) Why is the output voltage stepped up to 330 kV for long distance transmission? [1 mark]

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[7 marks]

6. An isotope of samarium decays to neodymium according to

$$^{146}_{62}Sm \rightarrow ^{142}_{60}Nd + X$$

where $^{142}_{60}Nd$ = 141.9077 u and $^{146}_{62}Sm$ = 145.9130 u.

(a) Identify the unknown particle X. [1 mark]

(b) Given the energy of the particle X is 2.55 MeV, calculate the velocity of the neodymium atom immediately after the decay. In which direction is it travelling? [3 marks]

(c) If a nucleus of about the same mass as the samarium emitted a particle of smaller mass and about the same energy as particle X, what effect would this have on your answer to (b)? (No calculation is required). [1 mark]

(d) State three means whereby the particle in (a) may be detected. [2 marks]

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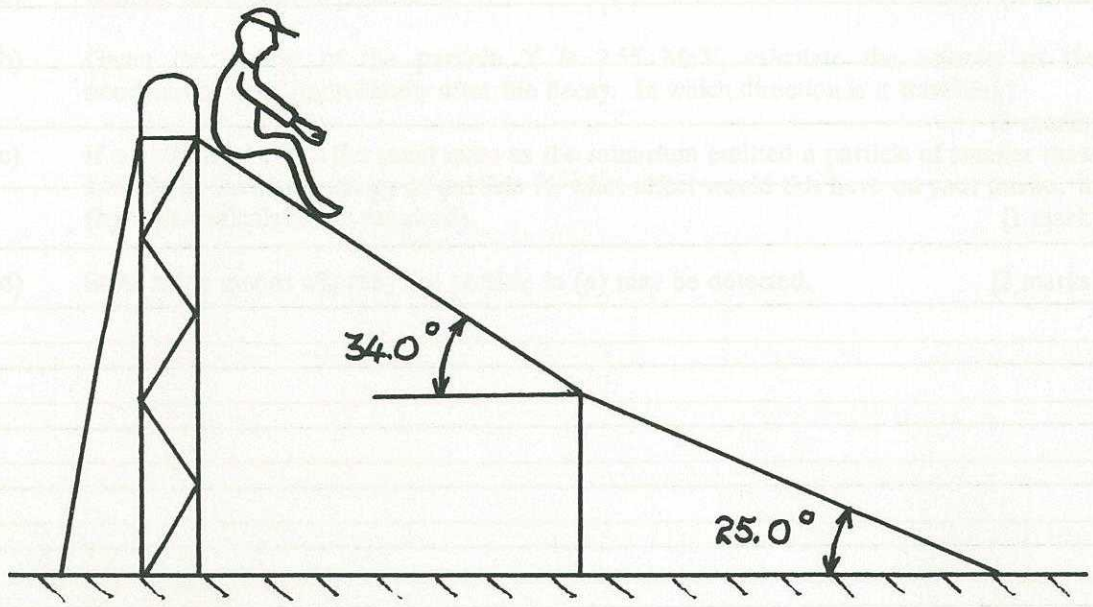
[7 marks]

7. A young child of mass 30.0 kg is at the top of the slide shown in the diagram below.

The child then accelerates uniformly down the first section of the slide. At the point where the slope changes, the child is travelling with a speed of 2.68 m $s^{-1}$ down the slope. On the second section of the slide, the child moves at this **constant speed** to the ground.

Assume that frictional force remains constant throughout the slide.




(a) Determine the force due to friction during the slide. [2 marks]

(b) Find the rate of change of kinetic energy (in joules per second) of the child, down the first section of the slide. [3 marks]

(c) Explain how energy is conserved as the child moves down each section of the slide. [2 marks]

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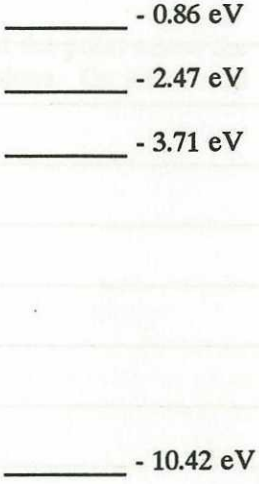
[6 marks]

8. Some energy levels of the mercury atom are shown in the diagram.




(a) What is the maximum number of lines which could appear in the line emission spectrum of mercury from the energy levels shown? [2 marks]

(b) What is the longest wavelength which could be found in the line emission spectrum? [1 mark]

(c) Briefly describe how an atom may be induced to emit its line emission spectrum, pointing out what changes occur in the atom. [2 marks]

(d) What is a major limitation of the Bohr model of the atom? [1 mark]

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**END OF QUESTIONS**

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