Cambridge Assessment

# A Level

## Physics

Session: 1994 June
Type: Question paper
Code: 9240

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UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

# PHYSICS 9240/1

PAPER 1

Tuesday 7 JUNE 1994 Afternoon 1 hour

Additional materials:
- Multiple Choice answer sheet
- Soft clean eraser
- Soft pencil (Type B or HB is recommended)

**TIME** 1 hour

## INSTRUCTIONS TO CANDIDATES

**Do not open this booklet until you are told to do so.**

Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has already been done for you.

There are **thirty** questions on this paper. Attempt **all** questions. For each question there are four possible answers labelled **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate answer sheet.

**Read very carefully the instructions on the answer sheet.**

## INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

**This question paper consists of 13 printed pages and 3 blank pages.**

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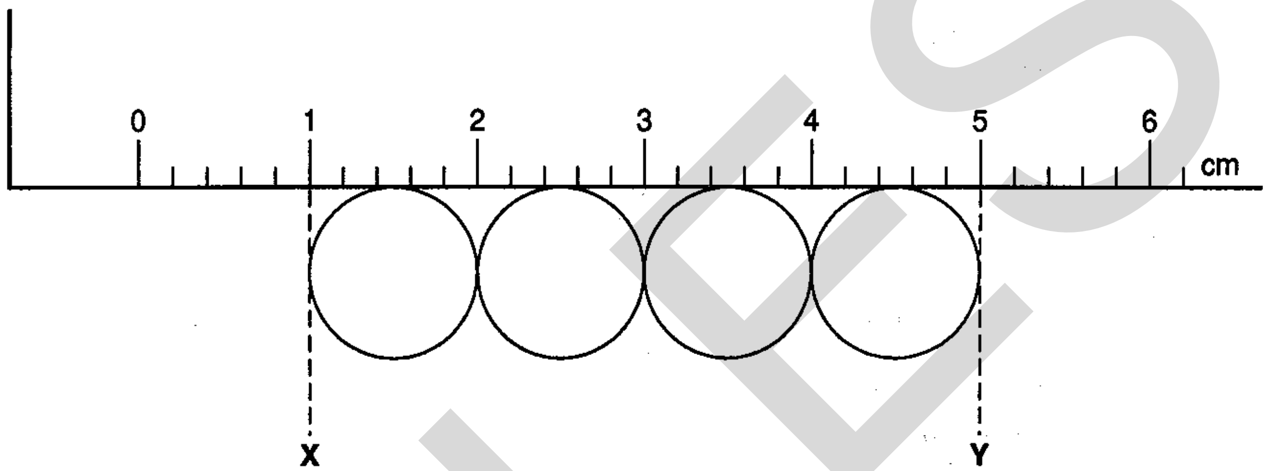
1 Which pair includes a *vector* quantity and a *scalar* quantity?

**A** displacement; acceleration
**B** power; speed
**C** work; potential energy
**D** force; kinetic energy

2 A student attempts to measure the diameter of a steel ball by using a metre rule to measure four similar balls in a row.




The positions on the scale are estimated to be

**X** (1.0 ± 0.2) cm
**Y** (5.0 ± 0.2) cm

What is the diameter of a steel ball together with its associated uncertainty?

**A** (1.0 ± 0.05) cm
**B** (1.0 ± 0.1) cm
**C** (1.0 ± 0.2) cm
**D** (1.0 ± 0.24) cm

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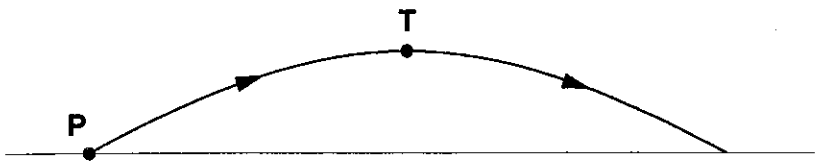
3 In the absence of air resistance, a stone is thrown from **P** and follows a parabolic path in which the highest point reached is **T**.




The vertical component of acceleration of the stone is

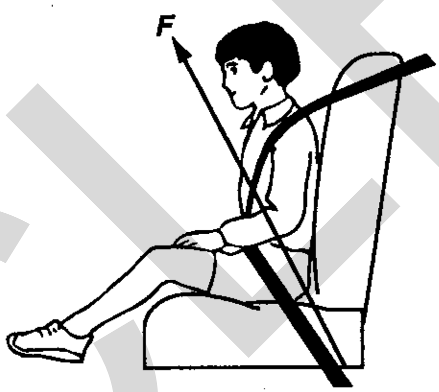
**A** zero at **T**.

**B** greatest at **T**.

**C** greatest at **P**.

**D** the same at **P** as at **T**.

4 A child (mass *m*) sits on a car seat which is accelerating horizontally at 0.50 *g* (where *g* is the acceleration of free fall).




What is the magnitude of the total force ***F*** exerted by the car seat on the child?

**A** 0.50 *mg* **B** 1.0 *mg* **C** 1.1 *mg* **D** 1.5 *mg*

5 A racing car accelerates uniformly through three gear changes with the following average speeds:

$20\,\mathrm{m\,s^{-1}}$ for 2.0 s
$40\,\mathrm{m\,s^{-1}}$ for 2.0 s
$60\,\mathrm{m\,s^{-1}}$ for 6.0 s

What is the overall average speed of the car?

**A** $12\,\mathrm{m\,s^{-1}}$ **B** $13.3\,\mathrm{m\,s^{-1}}$ **C** $40\,\mathrm{m\,s^{-1}}$ **D** $48\,\mathrm{m\,s^{-1}}$



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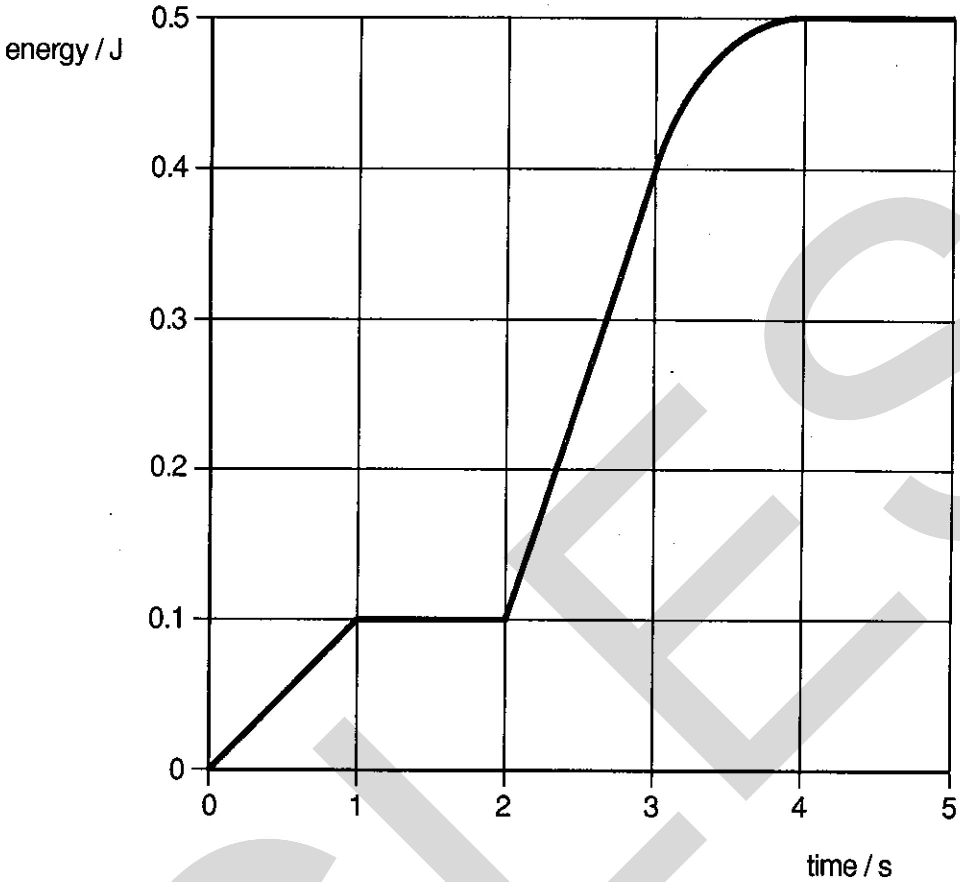
6 A bicycle dynamo is started at time zero. The total energy transformed by the dynamo during the first 5 seconds increases as shown in the graph.




What is the maximum power generated at any instant during these first 5 seconds?

**A** 0.10 W **B** 0.13 W **C** 0.30 W **D** 0.50 W

7 A satellite of mass 50 kg moves from a point where the gravitational potential due to the Earth is $-20\ \text{MJ kg}^{-1}$ to another point where the gravitational potential is $-60\ \text{MJ kg}^{-1}$.

During this change of position, it has moved

**A** closer to the Earth and lost 2000 MJ of potential energy.
**B** closer to the Earth and lost 40 MJ of potential energy.
**C** further from the Earth and gained 2000 MJ of potential energy.
**D** further from the Earth and gained 40 MJ of potential energy.

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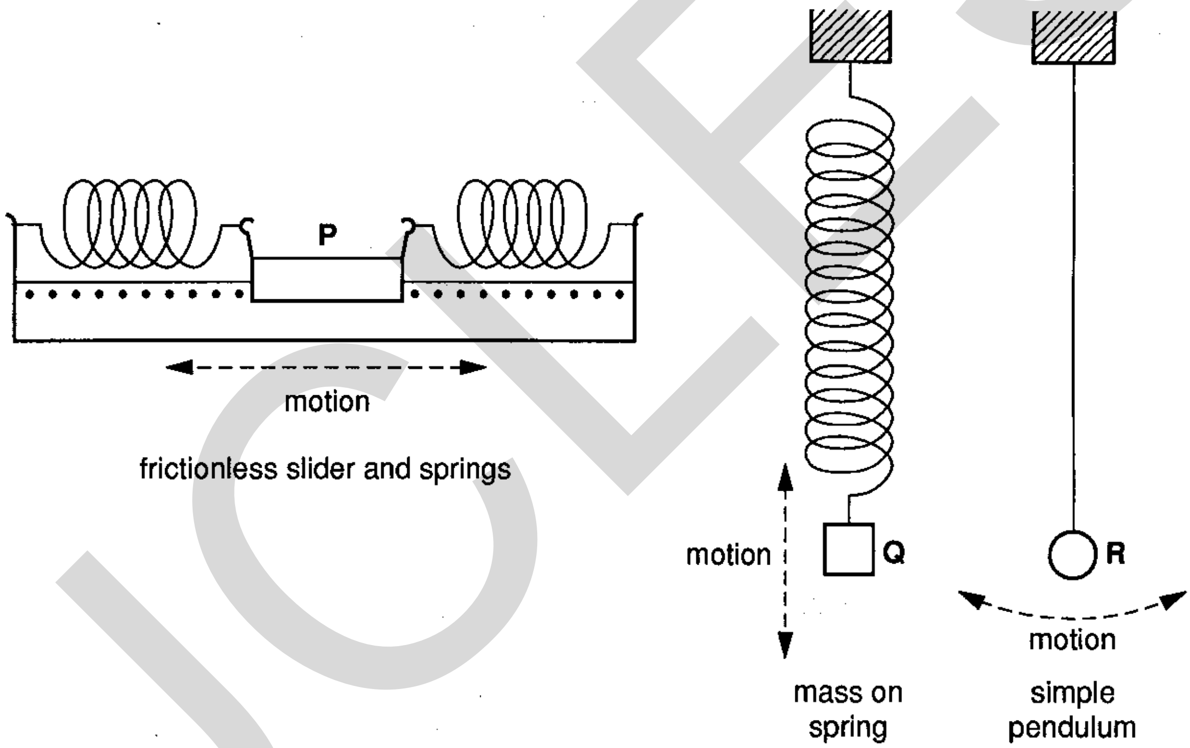
8 A body moving in a circular path of radius $r$ has tangential acceleration $a_t$, and centripetal acceleration $a_c$.

If the body is moving at constant speed $v$, what are the magnitudes of $a_t$ and $a_c$?

| | *tangential acceleration* $a_t$ | *centripetal acceleration* $a_c$ |
|---|---|---|
| **A** | $rv^2$ | 0 |
| **B** | $v^2/r$ | 0 |
| **C** | 0 | $rv^2$ |
| **D** | 0 | $v^2/r$ |

9 The three oscillating bodies, represented as **P**, **Q** and **R** in the diagrams, each show simple harmonic motion.




In which of these systems will the period increase if the mass of the body increases?

**A** **P** only **B** **Q** only **C** **P** and **Q** only **D** **Q** and **R** only

10 Which effect provides direct experimental evidence that light is a transverse, rather than a longitudinal, wave motion?

**A** Light can be diffracted.

**B** Two coherent light waves can be made to interfere.

**C** The intensity of light from a point source falls off inversely as the square of the distance from the source.

**D** Light can be polarised.





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11 A narrow beam of monochromatic light falls at normal incidence on a diffraction grating. Third-order diffracted beams are formed at angles of 45° to the original direction.

What is the highest order of diffracted beam produced by this grating?

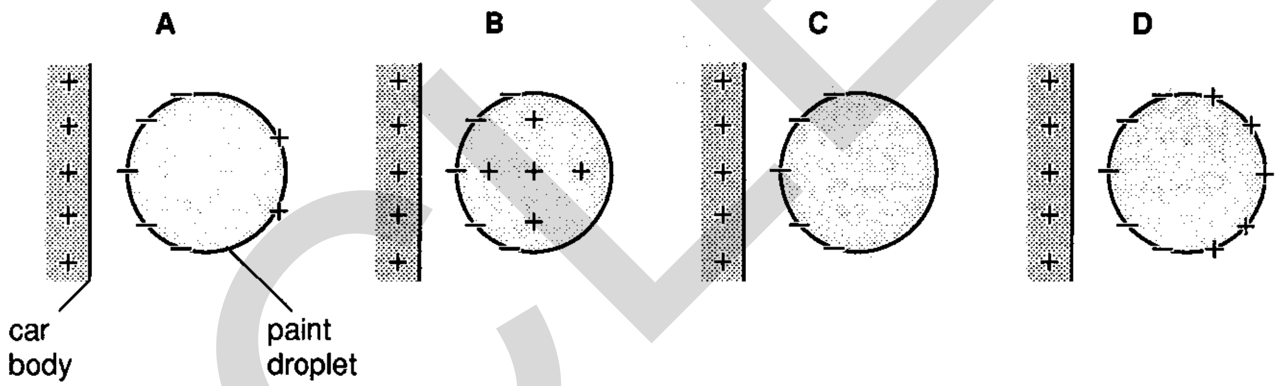
**A** 3rd **B** 4th **C** 5th **D** 6th

12 What is the approximate range of frequencies of infra-red radiation?

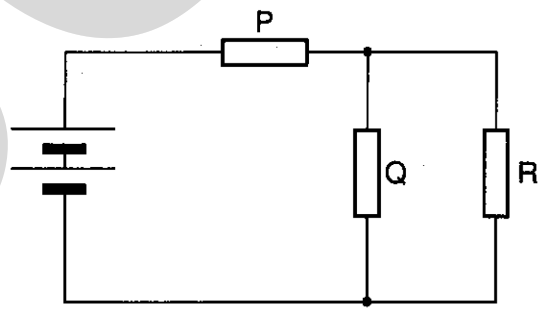
| | | | |
|---|---|---|---|
| **A** | $1 \times 10^3$ Hz | to | $1 \times 10^9$ Hz |
| **B** | $1 \times 10^9$ Hz | to | $3 \times 10^{11}$ Hz |
| **C** | $3 \times 10^{11}$ Hz | to | $4 \times 10^{14}$ Hz |
| **D** | $4 \times 10^{14}$ Hz | to | $7 \times 10^{14}$ Hz |

13 In a system used for spraying cars, a car body is positively charged. Neutral droplets of paint are then attracted to the car because the positive car body induces charge on the droplets of paint.

Which diagram best shows the charge pattern?




14 The resistors P, Q and R in the circuit have equal resistance.




The battery, of negligible internal resistance, supplies a total power of 12 W.

What is the power dissipated by heating in resistor R?

**A** 2 W **B** 3 W **C** 4 W **D** 6 W



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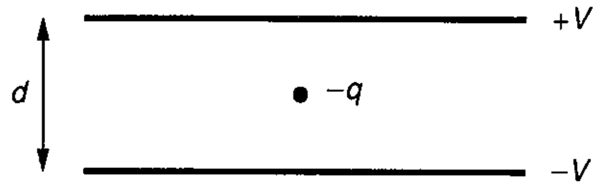
**15** An oil droplet has a charge $-q$ and is situated between two parallel horizontal metal plates as shown in the diagram.

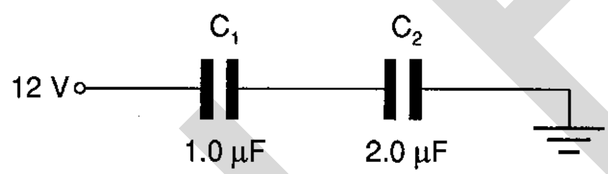



The separation of the plates is $d$. The droplet is observed to be stationary when the upper plate is at potential $+V$ and the lower at potential $-V$.

For this to occur, the weight of the droplet is equal in magnitude to

**A** $\frac{Vq}{d}$ **B** $\frac{2Vq}{d}$ **C** $\frac{Vd}{q}$ **D** $\frac{2Vd}{q}$

**16** Two capacitors are connected in series as shown in the diagram.




What is the charge carried by each of these capacitors?

| | *charge on* $C_1$/μC | *charge on* $C_2$/μC |
|---|---|---|
| **A** | 4.0 | 4.0 |
| **B** | 4.0 | 8.0 |
| **C** | 8.0 | 4.0 |
| **D** | 8.0 | 8.0 |

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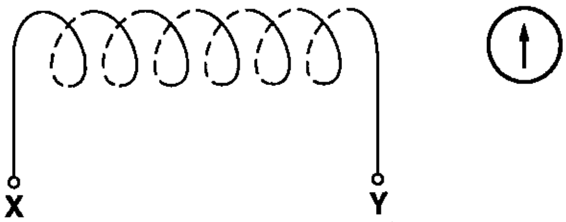
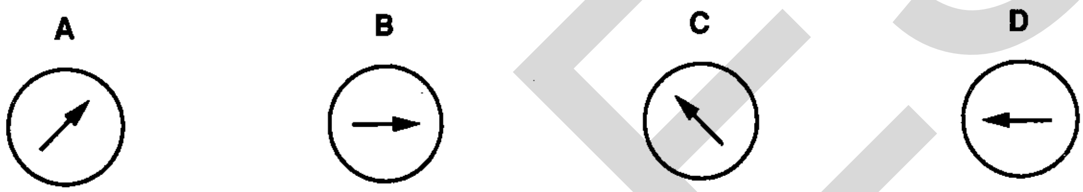
**17** A plotting compass is placed near a solenoid.

When there is no current in the solenoid, the compass needle points due north as shown.



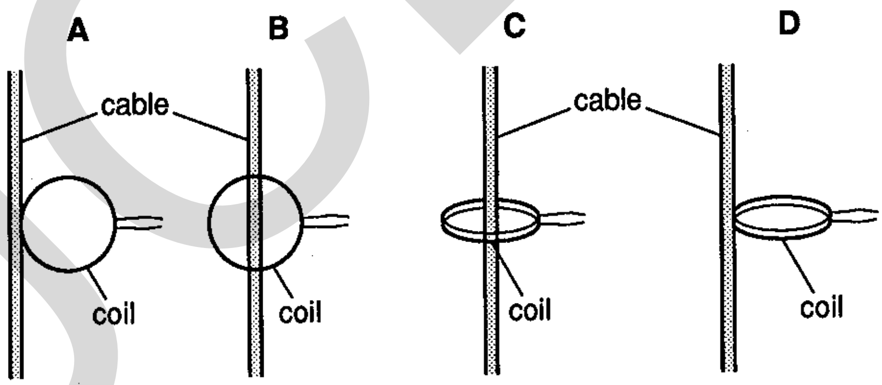

When there is a current from **X** to **Y**, the magnetic field of the solenoid at the compass is equal in magnitude to the Earth's magnetic field at that point.

In which direction does the plotting compass set?




**18** Large alternating currents in a cable can be measured by monitoring the e.m.f. induced in a small coil situated near the cable. This e.m.f. is induced by the varying magnetic field set up around the cable.

In which arrangement of coil and cable will the e.m.f. induced be a maximum?

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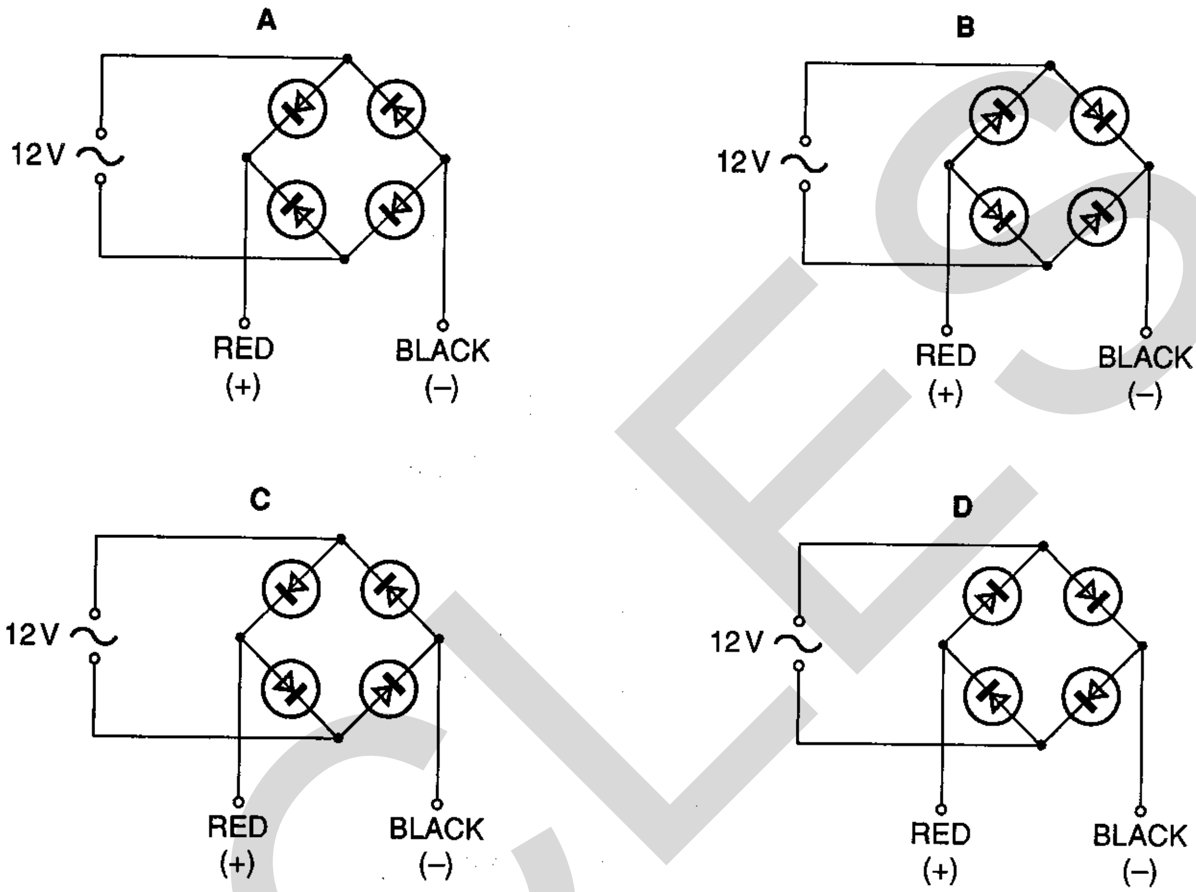
**19** Some students were given the following instructions:

'Design a circuit to give a full-wave rectified output from a low-voltage alternating supply. The positive output must be connected to a red terminal and the negative output to a black terminal.'

Which circuit satisfies these design instructions?

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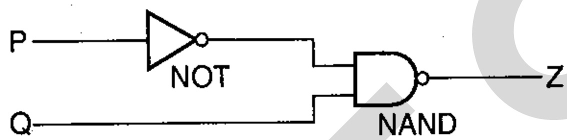
**20** A combination of logic gates has the truth table below.

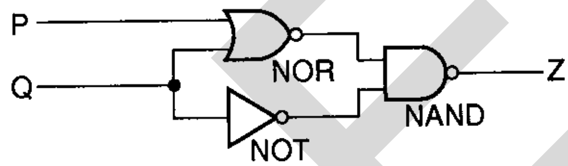
| P | Q | Z |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Which combination has this truth table?

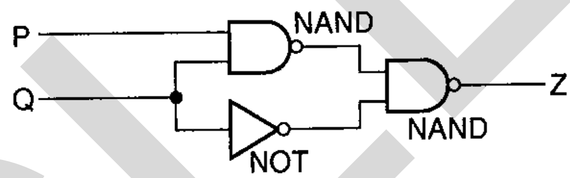
**A**



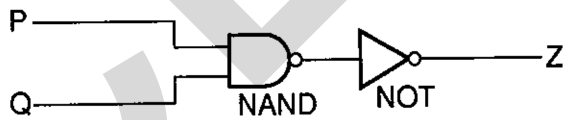

**B**




**C**




**D**




**21** Which statement concerning the evaporation and boiling of a liquid is true?

- **A** Boiling always occurs at a higher temperature than evaporation.
- **B** Evaporation and boiling are unaffected by changes in the surface area of the liquid.
- **C** Evaporation occurs at any temperature whereas the boiling point depends on the external pressure.
- **D** Evaporation results in the loss of the most energetic molecules from a liquid whereas in boiling, all molecules have the same energy.

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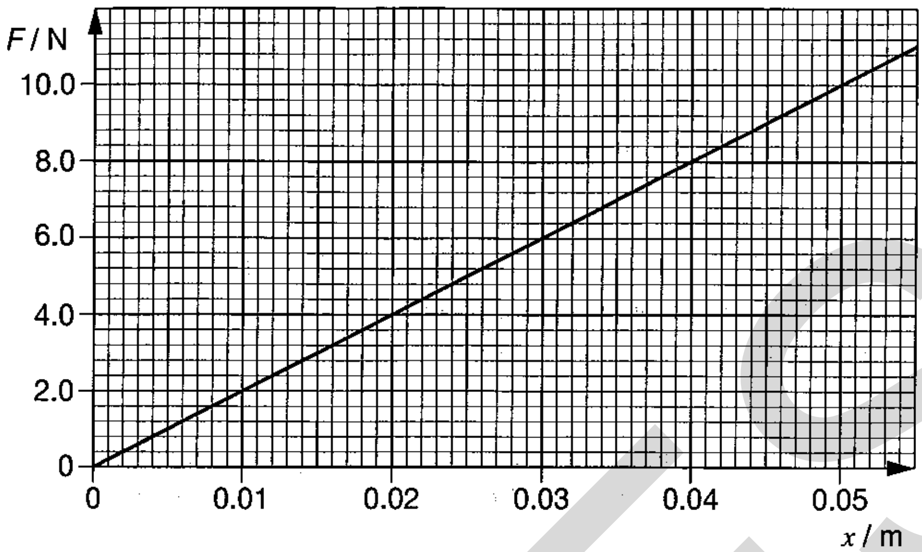
**22** The graph shows the relationship between load $F$ and extension $x$ for a certain spring.




A load of 6.0 N is placed on the spring.

What additional strain energy will be stored in the spring if it is then extended a further 0.01 m?

**A** 0.010 J **B** 0.060 J **C** 0.070 J **D** 0.160 J

**23** The table lists the approximate range, accuracy and response time of different types of thermometer.

| *thermometer* | *range/K* | *accuracy* | *response time* |
|---|---|---|---|
| **A** | 3 - 1750 | very good | long |
| **B** | 30 - 1750 | average | short |
| **C** | 75 - 1550 | good | long |
| **D** | 230 - 630 | poor | medium |

Which set of properties belongs to a thermocouple?

**24** An airgun pellet, mass $m$ and specific heat capacity $c$, hits a steel plate at speed $v$. During the impact, 50% of the pellet's kinetic energy is converted to thermal energy in the pellet.

What is the rise in temperature of the pellet?

**A** $\frac{v^2}{2c}$ **B** $\frac{v^2}{4c}$ **C** $\frac{mv^2}{2c}$ **D** $\frac{mv^2}{4c}$

25 The simple kinetic theory of gases may be used to derive the expression relating the pressure $p$ to the density $\rho$ of a gas.

$$p = \frac{1}{3}\rho <c^2>$$

In this expression, what does $<c^2>$ represent?

**A** the average of the squares of the speeds of the gas molecules

**B** the most probable value of the squares of the speeds of the gas molecules

**C** the root-mean-square speed of the gas molecules

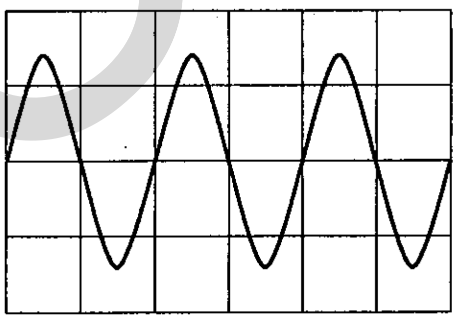
**D** the square of the average speed of the gas molecules

26 In designing a method for measuring the thermal conductivity of polystyrene, care must be taken to choose a specimen of appropriate dimensions as well as to decide whether or not the specimen requires lagging.

Which of the following would be the correct choice?

| | *cross-sectional area of specimen* | *thickness of specimen* | *lagging required* |
|---|---|---|---|
| **A** | small | thin | no |
| **B** | small | thick | yes |
| **C** | large | thin | no |
| **D** | large | thick | yes |

27 An alternating p.d. is applied across the Y-plates of a cathode-ray oscilloscope (c.r.o.) and produces the trace shown below.



If the peak voltage of the alternating p.d. is 2.8 V and its frequency is 50 Hz, what are the time-base and Y-gain settings of the c.r.o.?

| | *time-base setting* | Y-*gain* |
|---|---|---|
| **A** | 10 μs cm$^{-1}$ | 2.0 V cm$^{-1}$ |
| **B** | 20 μs cm$^{-1}$ | 1.0 V cm$^{-1}$ |
| **C** | 10 ms cm$^{-1}$ | 2.0 V cm$^{-1}$ |
| **D** | 20 ms cm$^{-1}$ | 1.0 V cm$^{-1}$ |



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**28** White light from a tungsten filament lamp is passed through sodium vapour and viewed through a diffraction grating.

Which of the following best describes the spectrum which would be seen?

**A** coloured lines on a black background

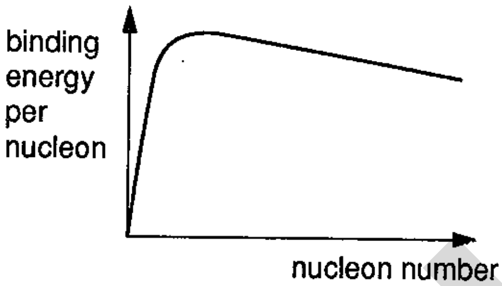
**B** coloured lines on a white background

**C** dark lines on a coloured background

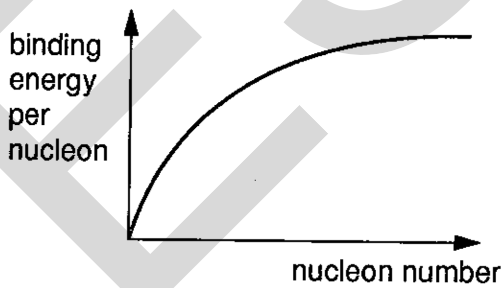
**D** dark lines on a white background

**29** Which sketch graph best represents the variation of binding energy per nucleon with nucleon number?

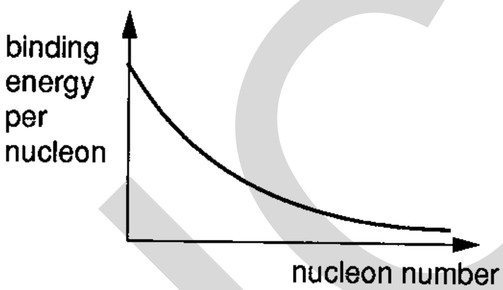
**A**



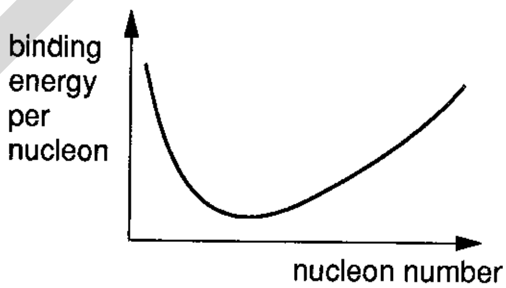

**B**




**C**




**D**




**30** A radioactive source contains the nuclide ${}^{187}_{74}W$ which has a half-life of 24 hours.

In the absence of this source, a constant average count-rate of $10\,s^{-1}$ is recorded.

Immediately after the source is placed in a fixed position near the counter, the average count-rate rises to $90\,s^{-1}$.

What average count-rate is expected with the source still in place 24 hours later?

**A** $30\,s^{-1}$ **B** $40\,s^{-1}$ **C** $45\,s^{-1}$ **D** $50\,s^{-1}$

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| Centre Number | Candidate Number |
|---|---|
| | |

Candidate Name ______________________________

**UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE**
**General Certificate of Education Advanced Level**

**PHYSICS** **9240/2**

PAPER 2

Tuesday **7 JUNE 1994** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data booklet
Electronic calculator and/or Mathematical tables
30 cm ruler

**TIME** 1 hour 30 minutes

## INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

## INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

| FOR EXAMINER'S USE | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| TOTAL | |

**This question paper consists of 16 printed pages and 4 blank pages.**

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[Turn over

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1 (a) (i) Define *linear momentum.*

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(ii) State whether linear momentum is a vector or a scalar quantity.

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(b) State the principle of conservation of momentum.

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(c) The principle can be applied in different types of interaction. These are illustrated by the following examples.

(i) Inelastic collision: a piece of plasticine of mass 0.20 kg falls to the ground and hits the ground with a velocity of $8.0\,\text{m}\,\text{s}^{-1}$ vertically downward. It does not bounce but sticks to the ground. Calculate the momentum of the plasticine just before it hits the ground.

State the transfers of momentum and of kinetic energy of the plasticine which occur as a result of the collision.

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..........................................................................................................................................................[3]

(ii) Elastic collision: a neutron of mass 1.00 u travelling with velocity $6.50 \times 10^5\,\text{m}\,\text{s}^{-1}$ collides head on with a stationary carbon atom of mass 12.00 u. The carbon atom moves off in the same direction with velocity $1.00 \times 10^5\,\text{m}\,\text{s}^{-1}$. Calculate the velocity of the neutron after the collision. State what happens to the total kinetic energy as a result of this collision.

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**(iii)** There is a third type of interaction: this happens when two strong magnets are held stationary with the north pole of one pushed against the north pole of the other. On letting go, the magnets spring apart. It is apparent that the kinetic energy of the magnets has increased. Explain how the law of conservation of momentum applies in this case.

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......................................................................................................................................[2]

**2 (a)** Define the term *gravitational field strength*.

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......................................................................................................................................[1]

**(b)** State the numerical value and the unit of the gravitational field strength of the Earth at its surface.

......................................................................................................................................[2]

**(c)** Why is it incorrect to call $g$ (= 9.8 m s$^{-2}$) 'gravity'?

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......................................................................................................................................[2]

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**(d)** This part of the question is about the rotation of the Moon in a circular orbit around the Earth. You will need to use the following astronomical data.

Radius of the Moon's orbit $= 3.84 \times 10^8$ m
Mass of the Moon $= 7.35 \times 10^{22}$ kg
Time for Moon to complete one orbit around the Earth $= 2.36 \times 10^6$ s

Calculate

**(i)** the speed of the Moon in its orbit around the Earth,

**(ii)** the acceleration of the Moon,

**(iii)** the force the Earth exerts on the Moon,

**(iv)** the gravitational field strength of the Earth at the Moon. [6]

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**Question 3**
**starts on page 6**



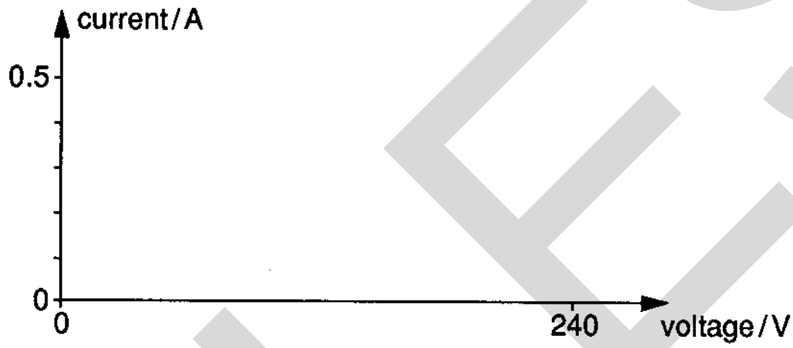
[Turn over

3 (a) A filament lamp is marked 240 V 60 W. Calculate

(i) the current through the lamp when it is working normally, [1]

(ii) the resistance of the lamp when it is working normally. [1]

(iii) The resistance of the lamp is found to be less when it is not lit than when it is working normally. Sketch the current-voltage characteristic of the filament lamp on the axes in Fig. 3.1.




[3]

**Fig. 3.1**

(b) A lighting circuit includes four lamps connected as shown in Fig. 3.2. The resistance of each lamp *should* be 120 Ω when it is not lit.

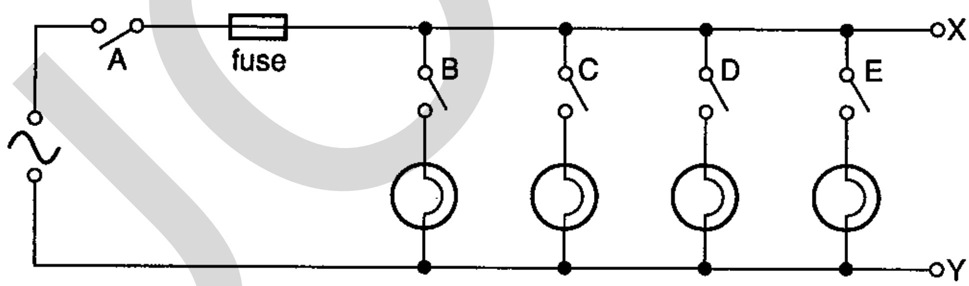



**Fig. 3.2**



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A fault is discovered in the circuit, so switch A is turned off and the fuse is removed for safety. A resistance meter is connected between the points X and Y and the following readings are obtained for different switch positions.

| Switches A | B | C | D | E | Resistance meter reading/Ω |
|---|---|---|---|---|---|
| off | off | off | off | off | 14 600 000 |
| off | off | off | off | on | 120 |
| off | off | off | on | on | 60 |
| off | off | on | on | on | 40 |
| off | on | on | on | on | 0.2 |

**(i)** If there were no fault in the circuit, what would the resistance meter read when switches B, C, D and E are on and A is off?

**(ii)** Why does the resistance meter not read infinity when all the switches are off?

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**(iii)** Suggest what the fault in the circuit may be.

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4 The three graphs in Fig. 4.1 are load-extension graphs for strands of three different materials **X, Y** and **Z.** Each strand is of cross-sectional area 1.0 mm$^2$.

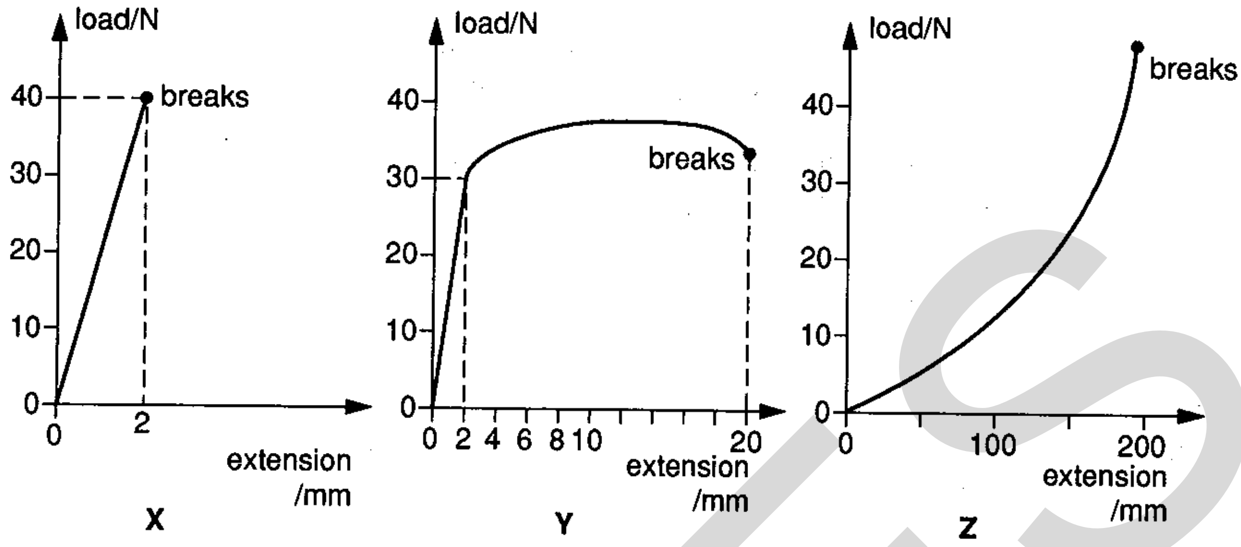


**Fig. 4.1**

**(a)** Which material is

**(i)** ductile,

......................................................................................................................................

**(ii)** brittle,

......................................................................................................................................

**(iii)** polymeric?

......................................................................................................................................[2]

**(b)** Name a possible substance for each of the three materials.

| X | Y | Z | [3] |
|---|---|---|---|
| .............................. | .............................. | .............................. | |

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(c) (i) Deduce the strain energy stored in the strand of material **Y** for an extension of 2.0 mm. [2]

(ii) Estimate how much additional work would have to be done on this strand in order to break it. [2]

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5 A fixed mass of gas in a heat pump undergoes a cycle of changes of pressure, volume and temperature as illustrated in the graph, Fig. 5.1. The gas is assumed to be ideal.

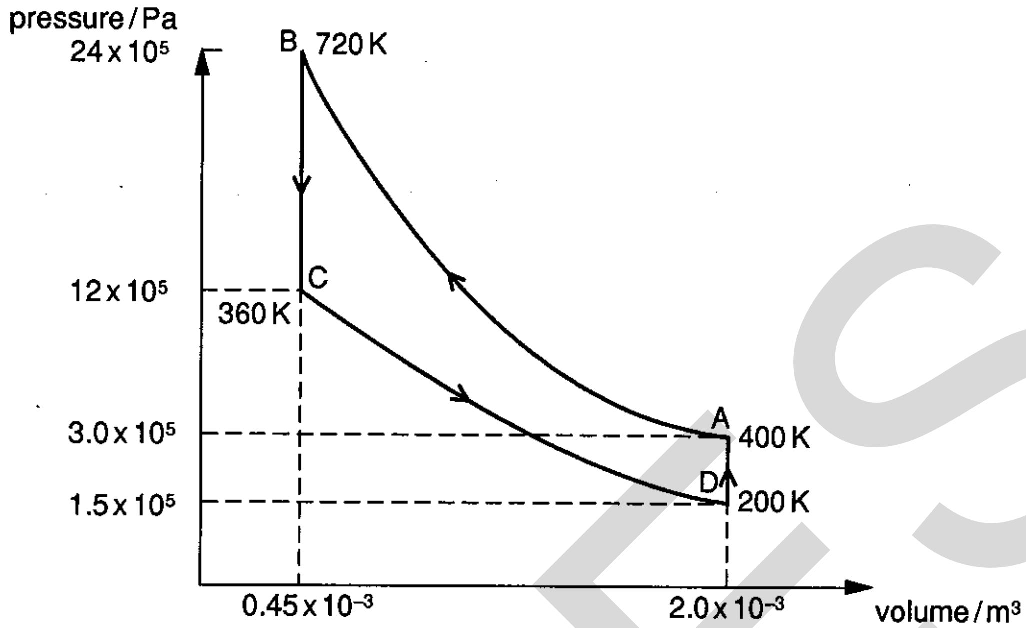


**Fig. 5.1**

The table below shows the increase in internal energy which takes place during each of the changes A to B, B to C and C to D. It also shows that in both of sections A to B and C to D, no heat is supplied to the gas.

| | *Increase in internal energy /J* | *Heat supplied to gas /J* | *Work done on gas /J* |
|---|---|---|---|
| A to B | 1200 | 0 | |
| B to C | −1350 | | |
| C to D | −600 | 0 | |
| D to A | | | |

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**(a)** Using the first law of thermodynamics and necessary data from the graph, complete the table. You will find it helpful to proceed in the following order.

**(i)** work done on gas for A to B and C to D

**(ii)** work done on gas for B to C and D to A

**(iii)** heat supplied to gas for B to C

**(iv)** increase in internal energy for D to A

**(v)** heat supplied to gas for D to A [6]

UCLES

**(b)** Calculate *P*, the coefficient of performance of the heat pump, given that

$$P = \frac{\text{Heat delivered by gas (during change B to C)}}{\text{Net work done on gas}} .$$

[1]



[Turn over

For Examiner's Use

6 Fig. 6.1 shows a typical arrangement for a domestic hot-water tank. The water can be heated by an immersion heater and the tank has lagging around the walls and over the top.

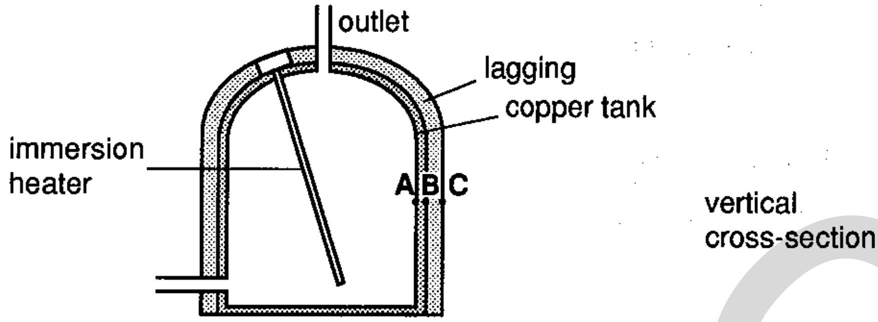



**Fig. 6.1**

**(a)** Why is convection important in heating the water?

.......................................................................................................................................

.......................................................................................................................................[1]

**(b)** Why is the bottom of the tank not lagged?

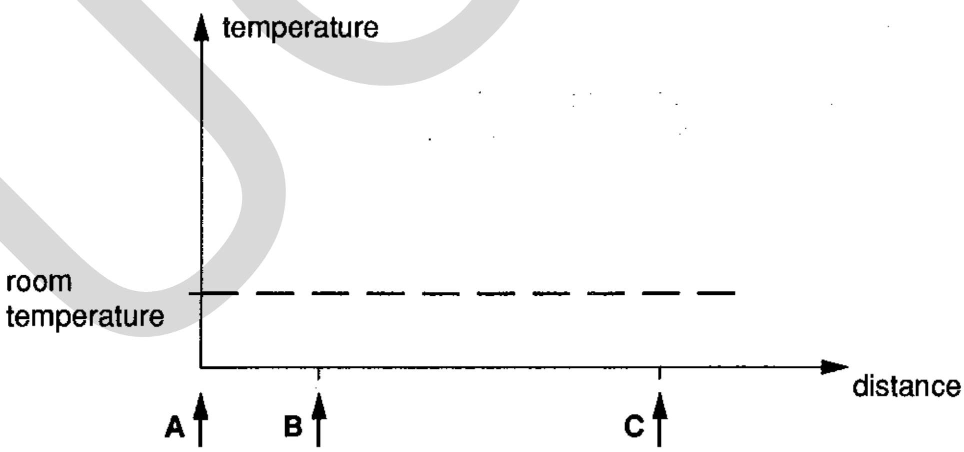
.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................[2]

**(c)** Sketch a graph on the axes below to show how the temperature is likely to vary along the line of points **ABC** shown in Fig. 6.1. Assume the tank surface is flat in this region. [3]

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7 **(a)** What is meant by

**(i)** the *decay constant* $\lambda$ of a radioactive material,

..........................................................................................................................................

..........................................................................................................................................

**(ii)** the *half-life* $t_{\frac{1}{2}}$?

..........................................................................................................................................

.......................................................................................................................................... [2]

**(b)** The decay constant and the half-life are related by the equation

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}.$$

The half-life of $^{60}_{27}Co$ is 5.26 years.

**(i)** What do the numbers 27 and 60 represent?

27 ..........................................................................................................................

60 .......................................................................................................................... [2]

**(ii)** Calculate the decay constant of $^{60}_{27}Co$. [1]

**(iii)** Calculate the activity of 1.00 gram of $^{60}_{27}Co$. [3]

(60 grams of $^{60}_{27}Co$ contain $6.02 \times 10^{23}$ atoms.)

UCLES

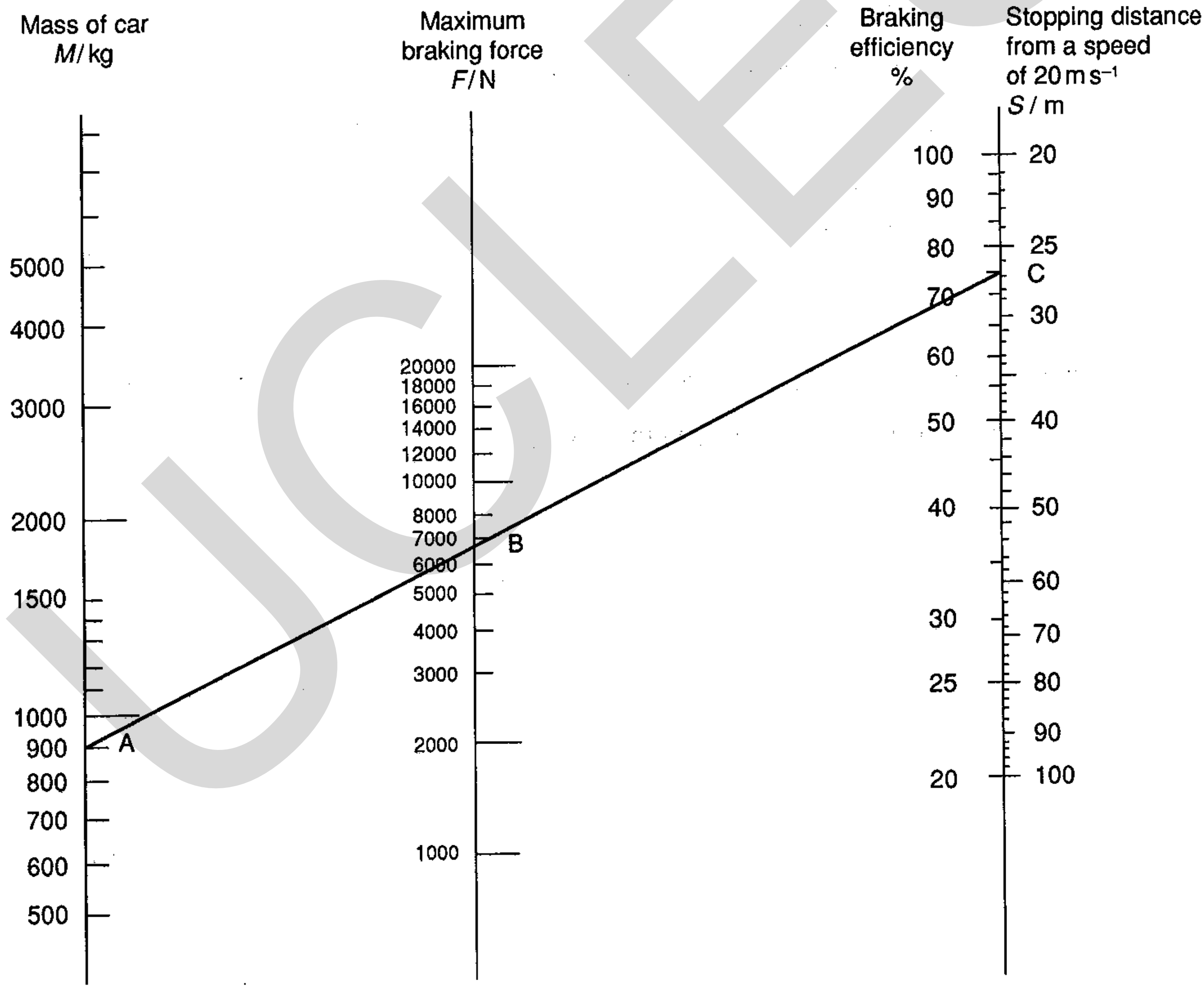
**8** When a car has a brake test, two sets of measurements are made:

1. the maximum braking force on the wheels produced by operating the foot brake,
2. the maximum braking force produced by operating the hand brake.

Typical data for a car of mass 900 kg are as follows.

| | *Maximum braking force* /N |
|---|---|
| 1. Foot brake | 6700 |
| 2. Hand brake | 2000 |

In order to determine whether or not the brakes are satisfactory, the data are applied to a chart (called a nomogram) like the one shown in Fig. 8.1. This chart has three vertical lines, marked with scales.




Brake efficiency and stopping distance from $20\,m\,s^{-1}$

**Fig. 8.1**

UCLES

The central vertical line is for the maximum braking force.
The left line is for the mass of the car.
The right hand line is for the braking efficiency and also for the stopping distance from an initial speed of $20\,m\,s^{-1}$. The braking efficiency $E$ is defined by the equation

$$E = \frac{\text{deceleration of car}}{\text{acceleration of free fall}} \times 100.$$

As an example of the use of this chart for the car of mass 900 kg, the figures in the table show a maximum braking force for the foot brake of 6700 N. The point A corresponding to the mass and the point B corresponding to the braking force are joined to give a straight, sloping line. This line is extended to cut the braking efficiency scale at the point C, and shows that in this particular case the stopping distance $S$ from a speed of $20\,m\,s^{-1}$ is about 27 m.

**(a)** Read from the chart the braking efficiency corresponding to point C.

..................................................................................................................................[1]

**(b)** Using the definition of braking efficiency given above, find the deceleration corresponding to this value of braking efficiency. Give your answer in $m\,s^{-2}$. [2]

**(c)** Show, by calculation from the equations of motion, that the deceleration you obtained in **(b)** gives a stopping distance of 27 m to 2 sig. fig. from an initial speed of $20\,m\,s^{-1}$.[3]

**(d)** **(i)** Draw a line on the chart to represent the results of the hand brake test on the car of mass 900 kg. [1]

**(ii)** Using the hand brake alone,

1. what would be the stopping distance from a speed of $20\,m\,s^{-1}$, [1]

2. what is the braking efficiency? [1]

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**(e)** Now consider a car of mass 1300 kg. Read from the chart in Fig. 8.1 corresponding pairs of values of the maximum braking force and stopping distance from 20 m s$^{-1}$, and tabulate them below.

| *Maximum braking force*/N | *Stopping distances from 20 m s$^{-1}$*/m |
|---|---|
| ................................ | ................................................ |
| ................................ | ................................................ |
| ................................ | ................................................ |
| ................................ | ................................................ |
| ................................ | ................................................ |
| ................................ | ................................................ |
| ................................ | ................................................ |

[3]

Plot a graph of these values on the grid on page 17. [3]

**(f)** Use the chart to estimate the braking efficiency for the car of mass 1300 kg if the maximum braking force were 14 000 N. Comment on your answer.

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..........................................................................................................................................

..........................................................................................................................................[3]

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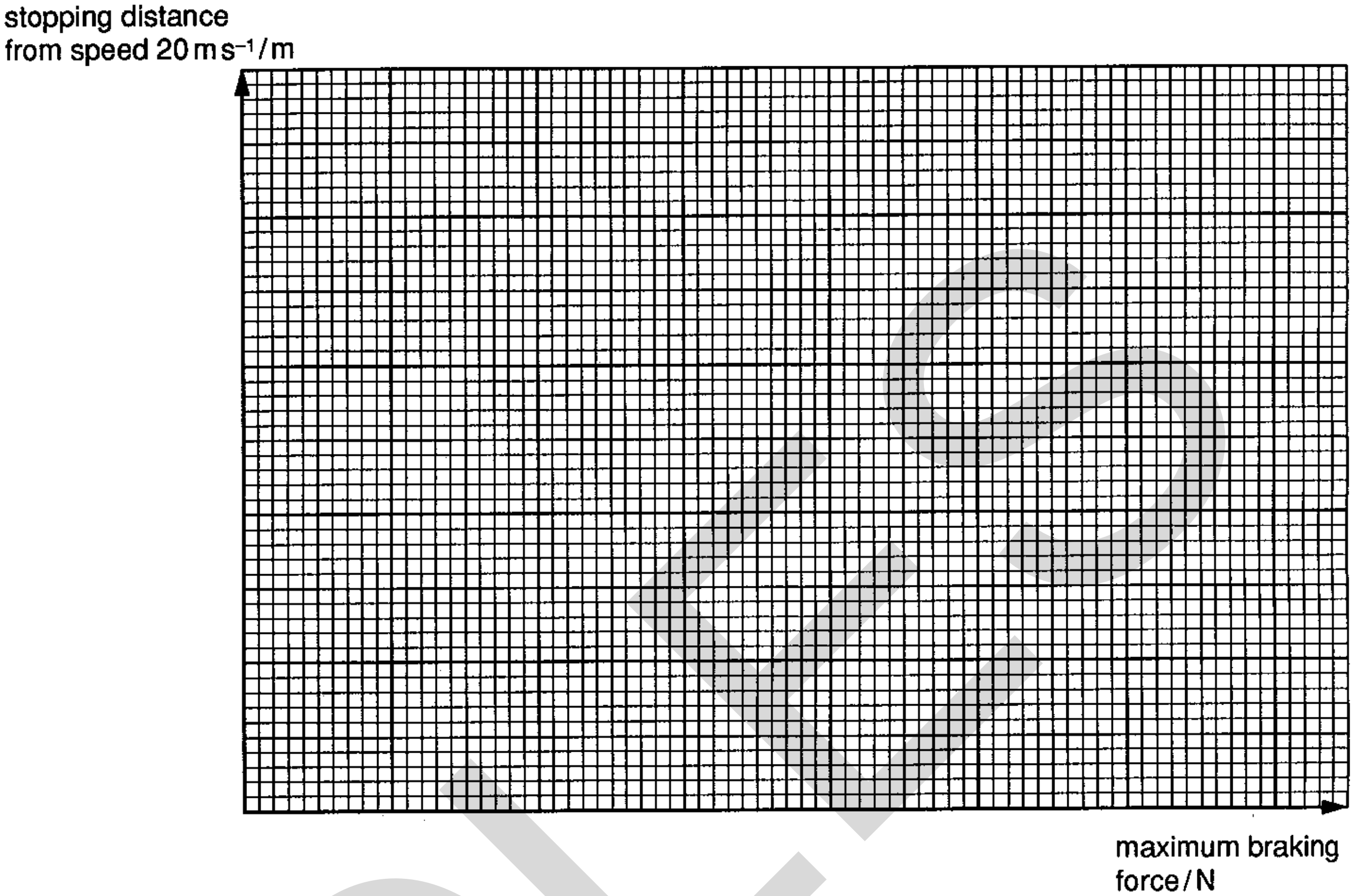


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**UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE**
**General Certificate of Education Advanced Level**

# PHYSICS **9240/3**

PAPER 3

Monday **13 JUNE 1994** Morning 2 hours 15 minutes

Additional materials:
- Answer paper
- Data booklet
- Electronic calculator and/or Mathematical tables
- Graph paper
- Ruler (mm)

**TIME** 2 hours 15 minutes

## INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **six** questions.

Answer **four** questions from Section A and **two** questions from Section B.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

All working for numerical answers must be shown.

## INFORMATION FOR CANDIDATES

The intended number of marks is given in brackets [ ] at the end of each question or part question.

You are advised to spend about 35 minutes on Section B.

**This question paper consists of 16 printed pages.**

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**[Turn over**

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## Section A

Answer **four** questions from this section.

1 **(a)** State what is meant by *angular velocity*. [2]

**(b)** A stone is tied to one end of a cord and then made to rotate in a horizontal circle about a point C with the cord horizontal, as shown in Fig. 1.1.

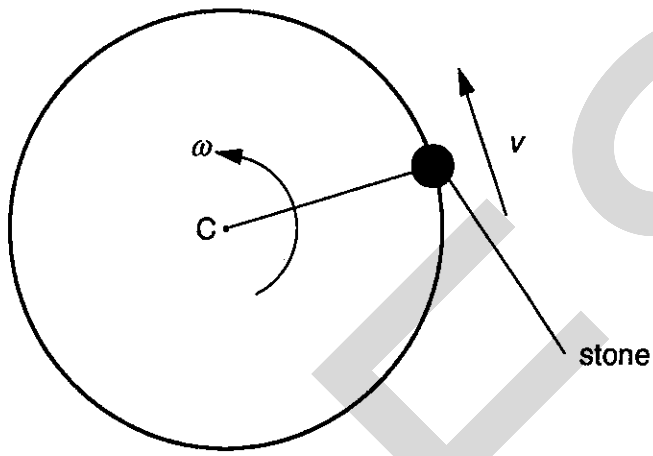


**Fig. 1.1**

The stone has speed $v$ and angular velocity $\omega$ about C.

**(i)** Write down a relation between the speed $v$, the length $r$ of the cord and the angular velocity $\omega$.

**(ii)** Explain how $v$ can be made to vary when $\omega$ is constant.

**(iii)** Explain why there needs to be a tension in the cord to maintain the circular motion.

**(iv)** Write down an expression for the acceleration of the stone in terms of $v$ and $r$. Hence, if the stone has mass $m$, show that the tension $T$ in the cord is given by

$$T = mv\omega.$$ [8]

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**(c)** On one particular ride in an amusement park, passengers 'loop-the-loop' in a vertical circle, as illustrated in Fig. 1.2.

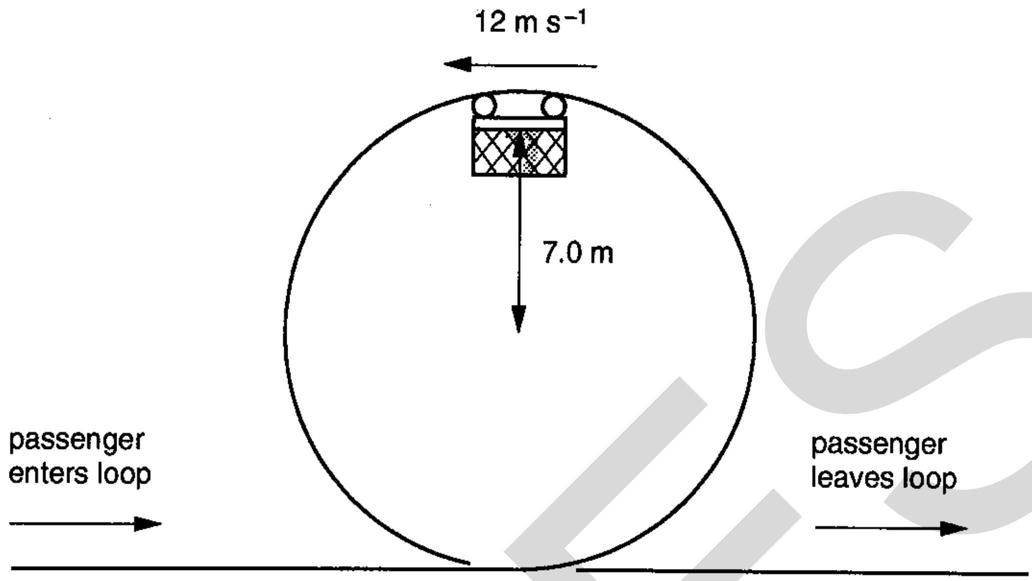


**Fig. 1.2**

The loop has a radius of 7.0 m and a passenger, mass 60 kg, is travelling at 12 m s$^{-1}$ when at the highest point of the loop. Assume that frictional forces may be neglected.

**(i)** Calculate, for the passenger when at the highest point,

(1) the centripetal acceleration,

(2) the force the seat exerts on the passenger.

**(ii)** The passenger now moves round and descends to the bottom of the loop. Calculate

(1) the change in potential energy of the passenger in moving from the top of the loop to the bottom,

(2) the speed of the passenger on leaving the loop.

**(iii)** Operators of this ride must ensure that the speed at which the passengers enter the loop is above a certain minimum value. Suggest a reason for this. [10]

UCLES

2 **(a)** Define *capacitance* and the *farad*. [2]

**(b)** In the circuit of Fig. 2.1, the capacitor has capacitance $C$ and the resistor has resistance 20 kΩ. The milliammeter has negligible resistance.

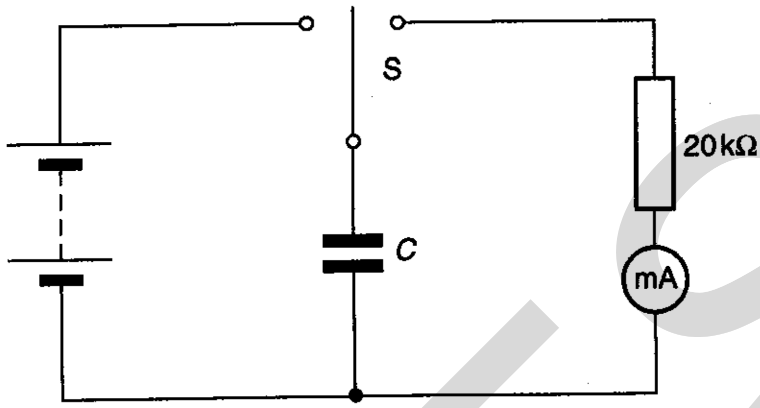


**Fig. 2.1**

The switch S enables the capacitor to be charged by the battery and then discharged through the resistor. The variation of the current $i$ in the resistor with time $t$ during discharge is shown in Fig. 2.2.

**(i)** Read from the graph the current $i$ in the resistor at the following times:

(1) $t = 10.0$ s,

(2) $t = 30.0$ s.

**(ii)** Hence calculate the potential difference across the capacitor at each of the times listed in **(b)(i)**.

**(iii)** Using your readings in **(b)(i)**, or otherwise, estimate the charge which has flowed from the capacitor between the times $t = 10.0$ s and $t = 30.0$ s.

**(iv)** Hence, estimate the capacitance of the capacitor. [10]

**(c)** Describe how you would use the graph of Fig. 2.2 to show that the current in the resistor during the discharge of the capacitor follows an equation of the form

$$x = x_0 \exp(-t/CR).$$ [3]

**(d)** **(i)** Use the values of the resistance and the capacitance to calculate the time constant $\tau$ for the discharge of the capacitor.

**(ii)** Hence calculate the current in the resistor at time $t = 2\tau$. [2]

**(e)** **(i)** Read from Fig. 2.2 the time at which the current $i$ is 0.74 mA.

**(ii)** Comment on your answers to **(d)(i)** and **(e)(i)**. [3]

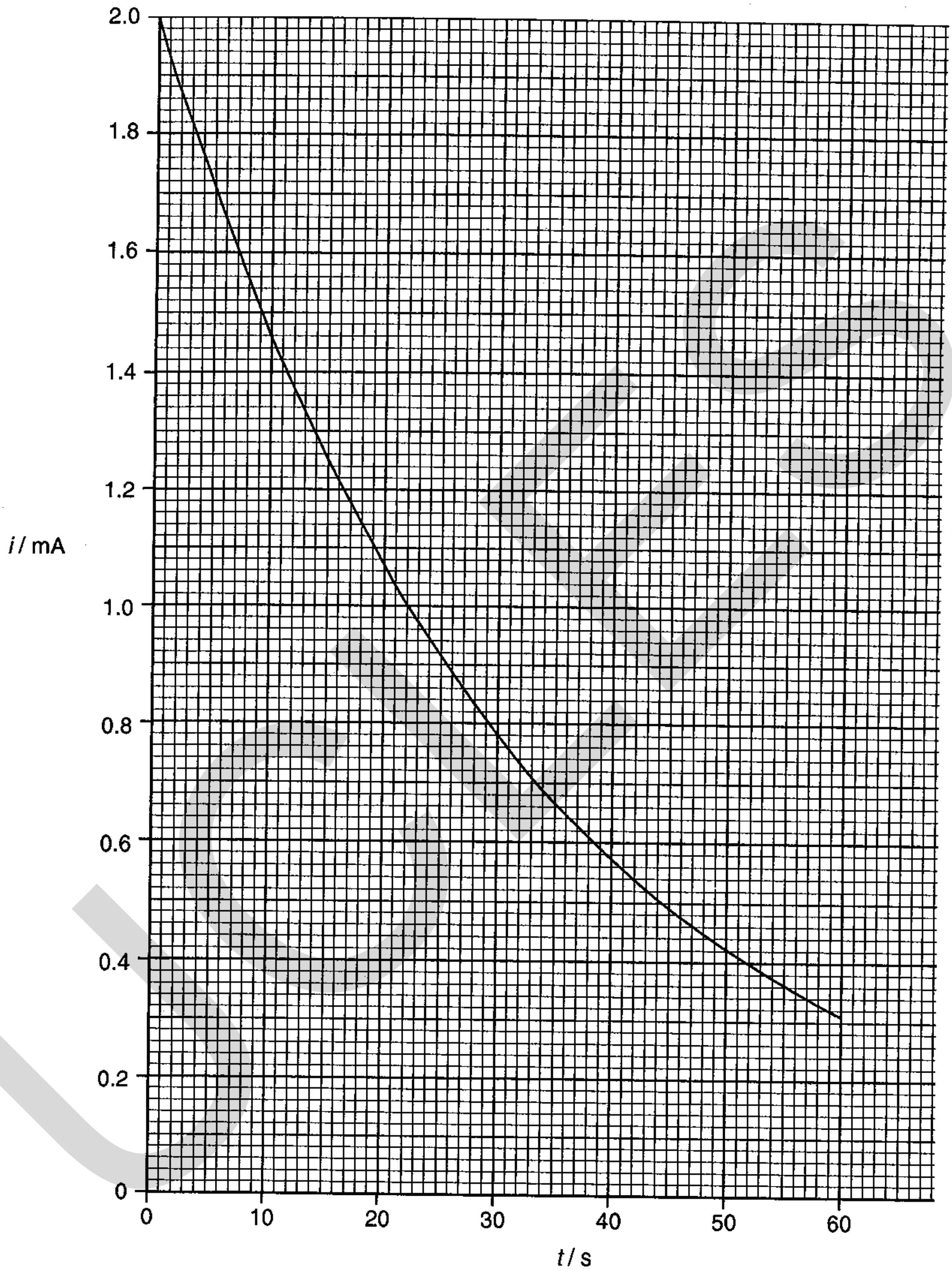


**Fig. 2.2**

3 **(a)** A long bar magnet hangs from one end of a spring, as shown in Fig. 3.1.

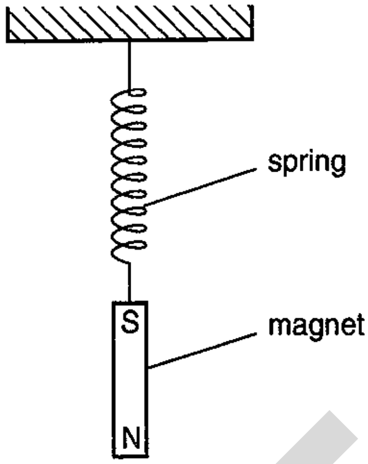


**Fig. 3.1**

The magnet is displaced vertically downwards and then released. The subsequent vertical displacement $x$ is found to vary with time $t$ as shown in Fig. 3.2.

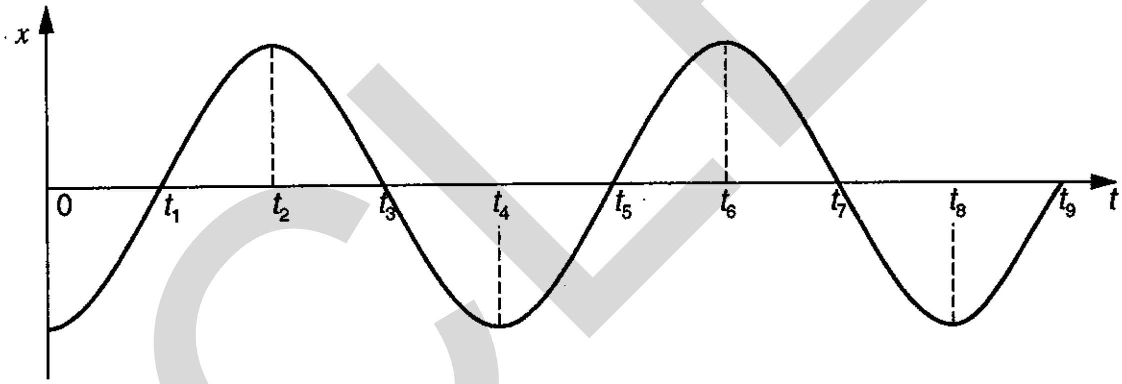


**Fig. 3.2**

(i) State **two** times, apart from $t = 0$, at which the magnet is stationary.

(ii) State **two** times at which the magnet is moving vertically upwards with maximum speed.

(iii) State **two** times at which the magnet is moving vertically downwards with maximum speed. [3]



UCLES

**(b)** The north pole of the magnet is now placed inside a coil of wire, as shown in Fig. 3.3.

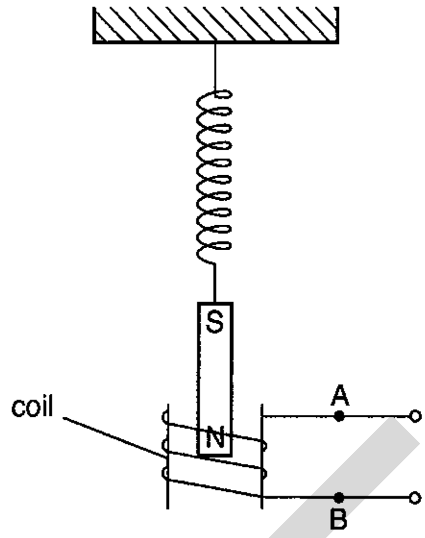


**Fig. 3.3**

The terminals of the coil are connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) which may be assumed to have infinite input resistance.

**(i)** Sketch a graph to show how the induced e.m.f. in the coil will vary with time $t$ when the magnet oscillates in the coil. Mark relevant times (for example, $t_1$, $t_2$, $t_3$) on the $t$-axis of your graph.

**(ii)** Use the laws of electromagnetic induction to explain the shape of your graph. [7]

**(c)** A high resistance resistor is now connected in parallel with the c.r.o. between the points A and B (see Fig. 3.3).

**(i)** Draw a second graph to show how the e.m.f. will vary with time $t$.

**(ii)** Explain, in terms of the principle of conservation of energy, why this graph is different from your first graph.

**(iii)** Describe, with the aid of a sketch graph, the changes which would occur in the shape of the graph drawn in **(c)(i)** if the resistance of the resistor has been reduced to a very low value. [10]

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4 **(a)** Describe, with the aid of a labelled diagram, the basic structure of a cathode-ray tube in a cathode-ray oscilloscope (c.r.o.). [4]

**(b)** In one type of c.r.o., the electrostatic deflection system consists of two parallel metal plates, each of length 2.0 cm, with a separation of 0.50 cm, as shown in Fig. 4.1.

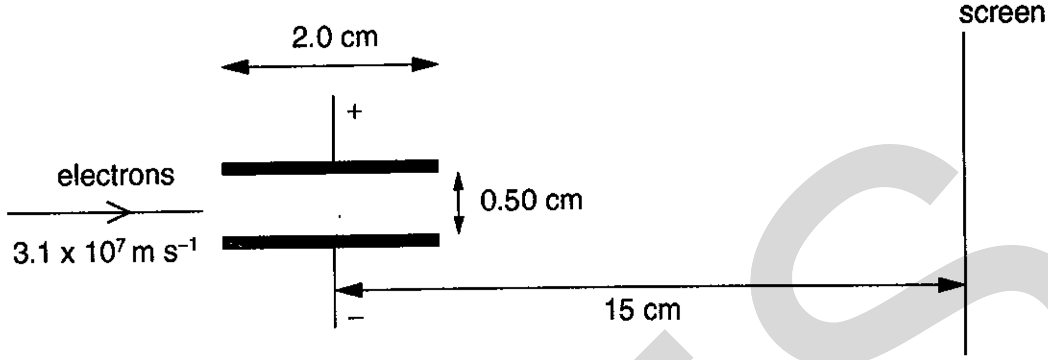


**Fig. 4.1**

The centre of the plates is situated 15 cm from a screen. A potential difference of 80 V between the plates provides a uniform electric field in the region between the plates. Electrons of speed $3.1 \times 10^7\,\mathrm{m\,s^{-1}}$ enter this region at right angles to the field. Calculate

**(i)** the time taken for an electron to pass between the plates,

**(ii)** the electric field strength between the plates,

**(iii)** the force on an electron due to the electric field,

**(iv)** the acceleration of the electron along the direction of the electric field,

**(v)** the speed of the electron at right angles to its original direction of motion as it leaves the region between the plates. [9]

**(c)** Hence, by considering your answer to **(b)(v)** and the original speed of the electron, estimate the deflection of the electron beam on the screen. [2]

**(d)** **(i)** Figure 4.2 represents the front of the screen of the c.r.o.

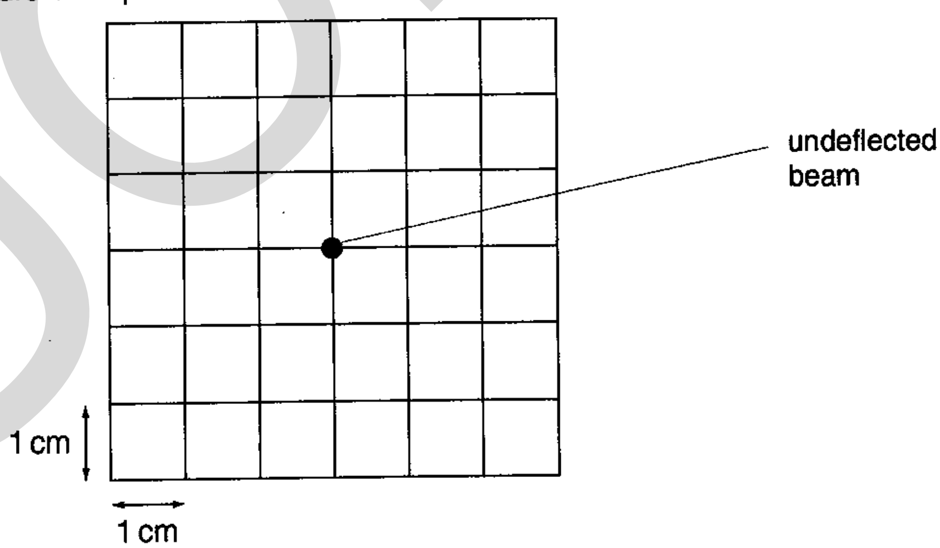


**Fig. 4.2**

Copy Fig. 4.2 on to your paper and mark on your diagram the position of the deflected beam of electrons.

**(ii)** Draw similar sketch diagrams to show the trace on the screen if the p.d. across the plates is

(1) varying sinusoidally with r.m.s. value 80 V,

(2) a half-wave rectified sinusoidal voltage of r.m.s. value 80 V. [5]

5 **(a)** The wavelength of the monochromatic light from a lamp is to be determined by means of a double-slit interference experiment.

**(i)** Outline the experiment. State what measurements are taken and explain how these measurements are used to calculate the wavelength.

**(ii)** Give approximate values for the separation of the two slits and the width of one of these slits.

**(iii)** Explain briefly the parts played by diffraction and by interference in the production of the observed fringes. [10]

**(b)** **(i)** State what is meant by the *photoelectric effect.*

**(ii)** Give **three** of the experimental observations associated with this effect. [5]

**(c)** **(i)** A lamp is placed above a metal surface which contains atoms of radius $2.0 \times 10^{-10}$ m. Each electron in the metal requires a minimum energy of $3.2 \times 10^{-19}$ J before it can be emitted from the metal surface, and it may be assumed that the electron can collect energy from a circular area which has a radius equal to that of the atom. The lamp provides energy at a rate of $0.40\ \mathrm{W\,m^{-2}}$ at the metal surface.

Estimate, on the basis of wave theory, the time required for an electron to collect sufficient energy for it to be emitted from the metal.

**(ii)** Comment on your answer to **(c)(i)**. [5]

6 **(a)** Explain how a physical property of a substance which varies with temperature may be used for the measurement of temperature. [2]

**(b)** **(i)** Describe the principal features of **one** type of liquid-in-glass thermometer.

**(ii)** Discuss the relative advantages and disadvantages of a liquid-in-glass thermometer and a resistance thermometer which may be used in the same temperature range. [7]

**(c)** A resistance thermometer is placed in a bath of liquid at 0 °C and its resistance is found to be 3740 Ω. At 100 °C, its resistance is 210 Ω. The bath is now cooled until the resistance of the thermometer is 940 Ω.

**(i)** What is the temperature of the bath, as measured using the resistance thermometer?

**(ii)** The reading taken at the same time on a mercury-in-glass thermometer placed in the bath is 40 °C. Suggest a reason for the difference between this reading and the value calculated in **(c)(i)**. [3]

**(d)** **(i)** What do you understand by the absolute (thermodynamic) scale of temperature?

**(ii)** The pressure $p$ of an ideal gas of density $\rho$ is related to the mean square speed $<c^2>$ of its molecules by the expression

$$p = \tfrac{1}{3}\rho <c^2>.$$

Deduce an expression for the thermodynamic temperature $T$ of the gas in terms of the mean kinetic energy $<E_k>$ of a molecule at that temperature. [5]

**(e)** Explain, in terms of the energies of atoms, conditions under which it is possible to increase the total energy of the atoms of a substance without any change of temperature of that substance. [3]





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## Section B

Answer **two** questions from this section.

Questions 7, 8 and 9 are based on Option S, Sound and Music; Questions 10, 11 and 12 are based on Option C, Communications; Questions 13, 14 and 15 are based on Option M, Medical Physics; Questions 16, 17 and 18 are based on Option T, Physics of Transport.

You may choose any of the questions.

### OPTION S

### *SOUND AND MUSIC*

**7** **(a)** **(i)** Distinguish between the *intensity* and the *loudness* of a sound.

**(ii)** Hence compare the loudness of two sound waves, each of intensity 0.01 $W\,m^{-2}$, having frequencies 3 kHz and 20 kHz. [6]

**(b)** A musical instrument may be tuned with the aid of a tuning fork. Explain, with the use of a diagram, how tuning of a named instrument is possible, even though the note produced by the tuned instrument does not have the same tone as the vibrating fork. [4]

**(c)** Briefly discuss the physical principles by which the following instruments may be tuned to a note from another instrument:

**(i)** a wood-wind instrument, such as a recorder,

**(ii)** a stringed instrument, such as a guitar. [5]

**8** **(a)** What is meant by a *stationary* wave? [2]

**(b)** A drum consists of a circular membrane (skin) which is kept under tension.

**(i)** Describe the vibration of the membrane when it is vibrating at its fundamental frequency.

**(ii)** Draw a diagram to illustrate one mode of vibration other than the fundamental mode. [4]

**(c)** Distinguish between the sounds produced by a drum when its circular skin is struck

**(i)** gently at its centre,

**(ii)** forcefully at its edge. [4]

**(d)** **(i)** Briefly describe a steel drum as used in a steel band.

**(ii)** In what way does the length of the drum affect the sounds produced? [5]



UCLES

9 **(a)** **(i)** What do you understand by the *acoustic properties* of a room?

**(ii)** Discuss the importance of reflecting and of absorbing materials in determining acoustic properties. [6]

**(b)** Explain why, on the basis of acoustic design,

**(i)** the seating in a theatre is usually cloth-covered rather than plain wood,

**(ii)** a ceiling covered with decorative wood panelling, as shown in Fig. 9.1, affects reverberation time.

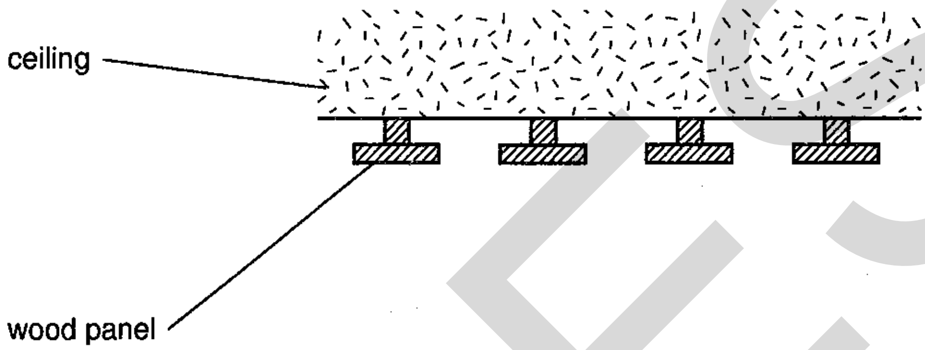


**Fig. 9.1**

**(iii)** the double-glazed panel shown in Fig. 9.2 is a better sound insulator than that shown in Fig. 9.3.

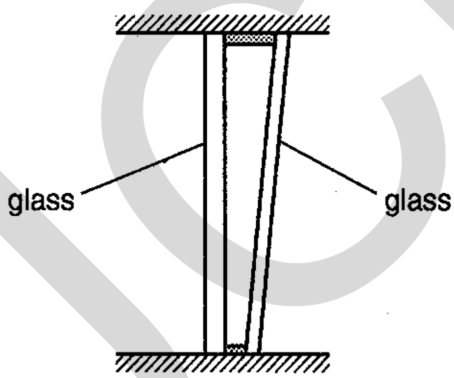


**Fig. 9.2**

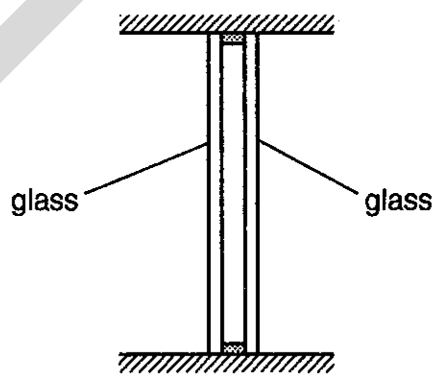


**Fig. 9.3**

[9]



UCLES

## OPTION C

### *COMMUNICATIONS*

**10** **(a)** Write brief notes comparing a resistor and an inductor as circuit components. [3]

**(b)** An inductor of inductance 5.0 mH is connected in series with a capacitor of capacitance 20 μF and a variable frequency sinusoidal supply, as shown in Fig. 10.1.

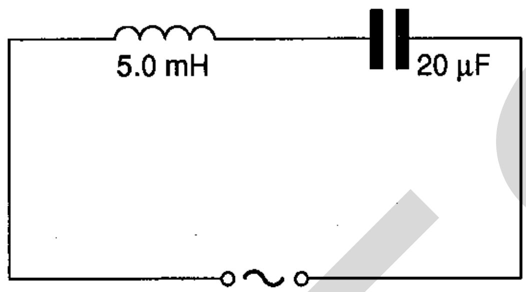


**Fig. 10.1**

**(i)** When the frequency of the supply is 250 Hz, the r.m.s. current in the circuit is 230 mA. Calculate

(1) the reactance of the inductor,

(2) the r.m.s. p.d. across the inductor,

(3) the r.m.s. p.d. across the capacitor. [5]

**(ii)** By reference to the current in the inductor and in the capacitor, state the phase of the p.d. across

(1) the inductor,

(2) the capacitor.

Hence, using the values of p.d. calculated in **(i)**, calculate the r.m.s. p.d. across the supply. [4]

**(iii)** The frequency of the supply is now increased until the current in the circuit is a maximum. The supply voltage remains constant.

(1) At what frequency will this maximum current occur?

(2) What, in practice, will limit the size of this maximum current? [3]

UCLES

11 A sinusoidal signal of frequency 1.0 kHz and amplitude 0.50 V is to be transmitted by means of a carrier wave of frequency 100 MHz and amplitude 50 V. The carrier wave is to be either amplitude modulated (AM) or frequency modulated (FM).

(a) What do you understand by a *carrier wave*? [2]

(b) Describe, giving numerical values where possible, the form of the carrier wave when it is

(i) amplitude modulated,

(ii) frequency modulated, the variation of the carrier wave frequency being at a rate of 8.0 kHz per volt of the modulating wave. [8]

(c) (i) By reference to an amplitude modulated wave, explain what is meant by *bandwidth*.

(ii) Explain the implications of bandwidth for radio reception. [5]

12 (a) What is meant by a *digital* signal? [2]

(b) The variation in light output from an optical fibre is sampled every millisecond and this output is converted into a 4-bit number, the most significant bit coming first. A series of consecutive 4-bit numbers is given below:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0001 | 0010 | 0100 | 0110 | 1010 | 1100 | 1010 | 0110 | 0010 |
| 0001 | 0001 | 0010 | 0110 | | | | | |

(i) Plot a graph showing the variation with time of the output.

(ii) Estimate the frequency at which the pulses of light are being transmitted along the fibre. [8]

(c) An optical fibre transmission system consists of a transmitter, an optical fibre of length 30 km and a receiver. The minimum detectable power leaving the fibre and entering the receiver is $1.0 \times 10^{-8}$ W.

(i) Calculate the minimum power entering the fibre from the transmitter, given that the power $P$ is related to the distance $x$ along the fibre by the expression

$$P = P_0 e^{-ax},$$

where $P_0$ and $a$ are constants and the value of $a$ is 0.15 km$^{-1}$.

(ii) List **two** possible sources of power loss associated with an optical fibre. [5]

UCLES

## OPTION M

## *MEDICAL PHYSICS*

**13** **(a)** Describe the mechanisms by which radiation causes damage to the cells of living matter. Hence explain the probable effects on a cell of such damage. [7]

**(b)** On the basis of your account in **(a)**, explain why the extent of radiation damage depends on

**(i)** the type of radiation to which the cells are exposed,

**(ii)** the total dose of radiation,

**(iii)** the dose rate of the radiation. [8]

**14** A student complains that he is not able to see clearly any object unless it is more than 75 cm from his eyes. The normal near point is taken as being 25 cm from the eye.

**(a)** **(i)** Name the student's eye defect.

**(ii)** State what is meant by the *near point* of the eye. [2]

**(b)** **(i)** Copy Fig. 14.1 on to your answer sheet.

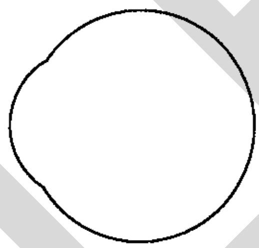

**Fig. 14.1**

On this, draw a ray diagram to illustrate the paths of two rays of light from a point object at the normal near point, showing how they would reach the retina of the student's eye.

**(ii)** Draw a second ray diagram to show how a lens may be used to correct the defect for an object set at 25 cm from the eye.

**(iii)** Calculate the power of this correcting lens. [9]

**(c)** Some animals are able to change the curvature of the cornea so that they are able to see clearly both in air and in water. Explain why a change in curvature is necessary. [4]

**15** **(a)** **(i)** What do you understand by *basal metabolic rate* (BMR)?

**(ii)** Why is the BMR of a child greater than that of an adult? [3]

**(b)** A flight of stairs consists of 60 steps, each of height 20 cm. A man of mass 80 kg claims to be able to run up the steps in 5.5 s. Make suitable calculations so that you can decide whether the claim is justified. [5]

**(c)** When climbing the steps in **(b)**, the body muscles are able to work with an efficiency of 17%.

**(i)** Calculate the amount of energy wasted.

**(ii)** Given that the specific latent heat of vaporisation of sweat is 2400 kJ kg$^{-1}$, what mass of sweat must evaporate in order to dissipate this waste energy? [4]

**(d)** Discuss why, in practice, the mass of sweat excreted is likely to differ from that calculated in **(c)(ii)**. [3]



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OPTION T

*PHYSICS OF TRANSPORT*

**16** **(a)** Explain how a motive force is provided by a propeller. [4]

**(b)** The propellers on an aircraft engine are of length $r$. Show that $P$, the kinetic energy delivered per unit time to the air behind the propeller, is given approximately by the expression

$$P = \tfrac{1}{2}\pi r^2 v^3 \rho,$$

where $v$ is the speed of the air leaving the propeller and $\rho$ is the density of air. For this part of the question, assume that the aircraft is stationary and that the air in front of the propeller is also stationary. [4]

**(c)** On take-off, the instruments in the aircraft indicate that the engine, rotating at 45 revolutions per second, is providing a torque of $2.0 \times 10^3$ N m to the propeller. The blades of the propeller are 0.90 m long.

**(i)** Show that the power supplied to the propeller is 0.57 MW.

**(ii)** Calculate the speed of the air behind the propeller, assuming that all the power is supplied to the air and that the density of air is 1.3 kg m$^{-3}$. You may assume the formula given in **(b)**.

**(iii)** Hence calculate the thrust provided by the propeller. [7]

**17** **(a)** An aircraft is flying horizontally with constant velocity. The forces A, B, C and D acting on the aircraft are illustrated in Fig. 17.1.

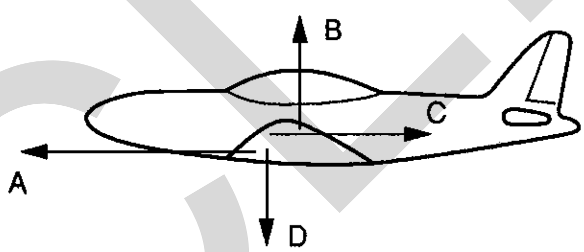


**Fig. 17.1**

**(i)** Identify each of the forces. [4]

**(ii)** Discuss the equilibrium of the aircraft under the action of these forces. [3]

**(iii)** Briefly discuss the purpose of the tailplane. [2]

**(iv)** Describe the effect on the path of the aircraft of a loss of engine power. [3]

**(b)** A second design of aircraft has forces as illustrated in Fig. 17.2.

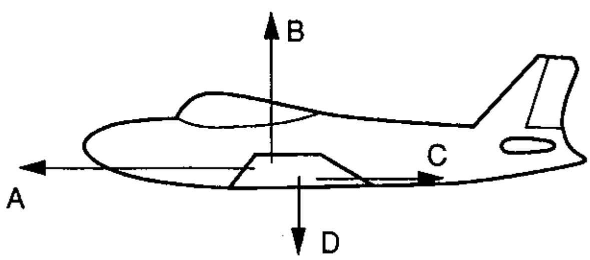


**Fig. 17.2**

Explain why this design is potentially more dangerous than that illustrated in Fig. 17.1. [3]



**[Turn over**

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**18** **(a)** When an object is placed in water, it experiences an upthrust.

**(i)** What is meant by an *upthrust*?

**(ii)** Explain how an object made of material which is more dense than water may be designed so that it will float in water. [4]

**(b)** A boat may capsize if it is not stable.

**(i)** What is meant by *stability*?

**(ii)** Explain, with the aid of a diagram, how the stability of a partially submerged submarine is achieved. [6]

**(c)** Discuss the problems involved in maintaining the stability of a submarine whether it is partially or totally submerged. [5]

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| | Centre Number | Candidate Number |
|---|---|---|
| Candidate Name ______________________ | | |

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

**General Certificate of Education Advanced Level**

# PHYSICS 9240/4

PAPER 4 Practical Test

Thursday **16 JUNE 1994** Morning 2 hours 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator and/or Mathematical tables

**TIME** 2 hours 30 minutes

## INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page and on any separate answer paper used.

Answer **both** questions.

Write your answers in the spaces provided on the question paper.

You are expected to record all your observations as soon as these observations are made, and to plan the presentation of the records so that it is not necessary to make a fair copy of them. The working of the answers is to be handed in. Marks are mainly given for a clear record of the observations actually made, their suitability and accuracy, and for the use made of them.

**Routine** precautions and theory are **not** wanted. You should, however, record any **special** precautions you have taken so as to aid accuracy.

At the end of the examination, fasten any separate answer paper used securely to the question paper.

## INFORMATION FOR CANDIDATES

Both questions on this paper carry equal marks.

Squared paper and mathematical tables are available.

Additional answer paper and graphs should be submitted **only** if it becomes **necessary** to do so.

| FOR EXAMINER'S USE | |
|---|---|
| 1 | |
| 2 | |
| TOTAL | |

**This question paper consists of 9 printed pages and 3 blank pages.**

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1 In this experiment you will be required to investigate the characteristics of a thermistor.

**(a)** Set up the circuit shown in Fig. 1.1. Immerse the thermistor in a beaker of water and arrange the apparatus so that the water can be heated.

Ensure that the wires leading to the thermistor are kept well away from the source of heating. The stand and clamp have been provided for this purpose.

**(b)** **(i)** Measure and record the values of the current $I$ through the thermistor, potential difference $V$ across the thermistor, and temperature $\theta$ of the water before heating.

**(ii)** Calculate the resistance of the thermistor $R$ at this temperature.

**(iii)** Justify the number of significant figures you have given in your value of $R$.

**(c)** **(i)** Measure and record **four further** sets of values of current $I$, potential difference $V$ and temperature $\theta$, for $\theta$ in the range 20 °C to 80 °C. Calculate and record corresponding values of $R$. Include in your table of results values for the thermodynamic temperature $T$ (i.e. $\theta + 273$) of the thermistor.

**(ii)** State the precautions taken to ensure that the temperature of the thermistor was the same as that indicated by the thermometer.

**(d)** It is suggested that the resistance $R$ of the thermistor is related to its thermodynamic temperature $T$ by the expression

$$\frac{1}{R} = \mathrm{A}e^{-\mathrm{B}/T},$$

where A and B are constants.

**(e)** **(i)** Tabulate values of $\ln(1/R)$ and $1/T$.

**(ii)** Plot these values on the graph grid on page 5.

**(iii)** Draw the best straight line through your points.

**(f)** **(i)** By taking appropriate measurements from your graph, determine the values of the constants A and B.

**(ii)** State the unit of A and the unit of B.



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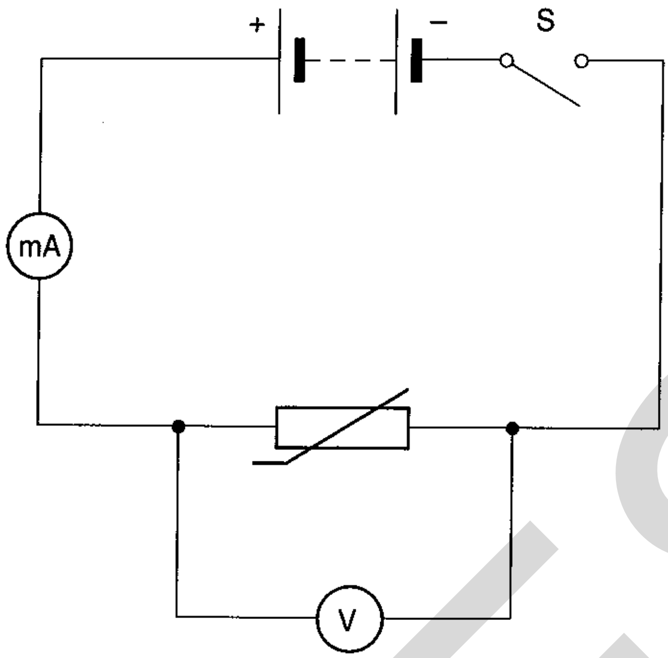


Fig. 1.1

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*Observations and calculations*

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2 When a ball falls through a fluid, it soon reaches a steady speed called the terminal velocity. It is suggested that this terminal velocity is proportional to the square of the radius of the ball.

The diameters of the four smallest balls are given on a card.

**(a)** Design and carry out an investigation to test the validity of the suggestion made above using the materials provided. You should avoid excessive contact between the oil and your skin.

**(b)** On page 7 write a brief account of your experimental procedure, including any use made of the sticky tapes A and B, the set square C, the plumb-line (thread with a small mass attached) and the magnet.

On page 8 record your observations, together with any conclusions that you have reached concerning the validity of the suggestion.

Page 9 is to be used to plot a suitable graph of your results.

**(c)** Suggest, with a reason, one possible improvement that you would make to the design or execution of your experiment if you had to repeat it, either using existing apparatus, or additional standard laboratory equipment.

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UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

# INSTRUCTIONS FOR PRACTICAL PHYSICS

**9240/4**

**JUNE 1994**

**Great care should be taken that any confidential information given does not reach the candidates either directly or indirectly.**

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These instructions consist of 7 printed pages and 1 blank page.

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[Turn over

## Instructions for preparing apparatus

In order to assist the laboratory staff in making preparations, the Physics teacher should study the Question Paper 3 days before the paper is taken in order to be satisfied that the apparatus provided is in accordance with these instructions and is fully suitable for the performance of the experiments. To this end, the teacher concerned is invited to perform the experiments and then to submit with the candidates' answers a sample set of results in the same form as that expected of the candidates.

The Question Paper is to be re-sealed and locked up with the other copies of the Question Paper as soon as possible.

The apparatus required for each question is set out below.

It is assumed that the ordinary apparatus of a Physics laboratory will be available.

## Instructions for the Practical Physics Supervisor

Candidates should be informed that, if they find themselves in real difficulty, they may ask the Supervisor for practical assistance but that the extent of this assistance will be reported to the Examiner, who may make a deduction of marks.

The Supervisor should complete the questionnaire form attached herewith and enclose it in the envelope containing the answers of the candidates. A note of any help given to, or any particular difficulties experienced by, a candidate should also be enclosed, especially if the Examiner would be unable to discover these from the written answers.

The following firms have been notified of the apparatus required:

RS Components,
P.O. Box 99,
Corby,
Northampton,
NN17 9RS

Griffin & George Ltd.,
285 Ealing Road,
Alperton,
Wembley
Middx, HA0 1HJ

Philip Harris Ltd.,
Lynn Lane,
Shenstone,
Staffordshire,
WS14 0EE

BDH,
MERCK Ltd,
Merck House,
Poole,
Dorset BH15 1TD

It is assumed that candidates will provide themselves with such standard items as a 30 cm ruler, a pair of compasses, a 0° to 180° protractor and set squares.

Squared paper and Mathematical tables including reciprocals should be available.

Whenever a stopwatch or stopclock is specified, candidates should be advised, in advance, that they may, if they wish, use quartz wristwatches with stopwatch facilities.

It is assumed that the number of sets of apparatus for any one experiment will be not less than half the number of candidates. Where necessary, Supervisors should direct candidates as to which experiment they are to perform first. The experiments carry the same mark value.

See also pages 7 and 8.

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**Question 1**

Candidates will be required to investigate the characteristics of a thermistor.

**Apparatus requirements:**

Rod thermistor. Type TH-3 available from RS components. It is important that this type of thermistor is used, as it is robust and is unlikely to cause difficulties when used by a second candidate. The thermistor should be firmly soldered to two leads of approximate length 70 cm. The thermistor and soldered connections should then be painted with polyurethane or similar substance.

Low voltage power supply unit. Three 1.5 V, dry cells in series will suffice. If a laboratory power pack is used, the output must be fixed at around 5 V. Candidates must not be able to change the supply voltage. When trying out the experiment, the Supervisor must ensure that the voltage chosen does not cause the milliammeter to go 'off-scale' when the thermistor is at a temperature of around 95°C.

Analogue voltmeter with full-scale deflection 5 or 6 V, or digital voltmeter. **The voltmeter must have a resistance much greater than the thermistor specified.** A value of 5 kΩ or larger would be satisfactory.

Analogue milliammeter of full-scale deflection 100 mA, or digital milliammeter

Switch

Connecting wires

Glass rod for stirring

Thermometer, calibrated in degrees, or half degrees. A range from around 0 °C to 100 °C would be suitable.

Two beakers (250 ml)

Tripod; heatproof mat; gauze; Bunsen burner; or alternative means of heating the water in the beaker to a temperature of around 80 °C

Retort stand, boss and clamp

The apparatus is to be assembled by the candidate, and should **not** be assembled prior to the start of the experiment. The apparatus must be dismantled at the end of the experiment if the equipment is to be used by a second candidate. Supervisors must ensure that the leads connected to the thermistor have not been damaged.

Both beakers should be approximately three-quarters full of water at room temperature. Candidates must have reasonable access to a sink and cold water tap.

**Supervisors will need to be particularly vigilant at the start of the experiment to ensure that candidates have connected the circuit correctly.**

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**Question 2**

Candidates will be required to perform an investigation of a ball falling in a viscous fluid.

**Apparatus requirements:**

Rigid transparent tube, length about 1.50 m, diameter 30 mm, e.g. glass tube available from BDH (cat. no. TWL-600-250F). The length and diameter of the tube are not critical, but must be reasonably close to the specified values.

Rubber bung to fit the tube

Supply of clean motor oil (SAE 20W/50 or thicker), sufficient to fill the tube

Selection of 5 small steel balls, diameters in the range from about 1 mm to about 5 mm. The values are not critical, but the largest ball must not be larger than 6 mm. The balls must be clean and grease free. In some cases these balls can be obtained from a local bicycle repair shop.

**All candidates must be provided with identical sets of steel balls. The diameter of each of the steel balls must be measured by the Supervisor, and this information must be given on page 8 and sent with the scripts.**

Small bar magnet/horseshoe magnet. The magnet must be strong enough to raise the balls from the bottom of the tube through the oil to the top of the tube.

Metre rule

Half-metre rule

Micrometer screw gauge

One stand with two bosses and two clamps

Stop-watch or timer (reading to 0.1 s or better)

Plumb-line

Large 'card' set square labelled 'C', as shown opposite. The corner of the set square should be removed as shown so that it may be placed against the tube without the rubber bung coming into contact with the set square. The set square can conveniently be cut from the card sheet found at the back of packs of A4 paper. See Fig. 1.1.

250 ml beaker or other small container for oily steel balls

Card, on which is written 'The diameters of the four smallest balls are .......................... mm'

Two short lengths of self adhesive label marked A and B

Soft cloth/absorbent paper (e.g. kitchen roll) for cleaning small spillages of oil

G-clamp for securing the base of the stand to the table. If a G-clamp is not used, there must be some suitable arrangement for securing the tube safely.

Length of white card or paper



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Using the stand and clamps, mount the tube so that it is **slightly inclined to the vertical**. The tube should be filled with oil to within 2 or 3 cm of the top, ready for the candidate to use. The stand should be firmly clamped to the bench to keep the apparatus stable. The outside of the tube must be clean and dry so that the labels stick to it easily. White card or paper must be arranged so that the passage of the ball down the tube can be easily seen against the white background. A distance of 10 cm between the tube and card is satisfactory.

**It is important that the oil has been allowed to reach room temperature prior to the start of the experiment. It is therefore suggested that the oil be left overnight in the examination room.**

**Supervisors will be required to give the room temperature and time of fall over 1 metre for one ball of stated diameter, before and after the examination session.**

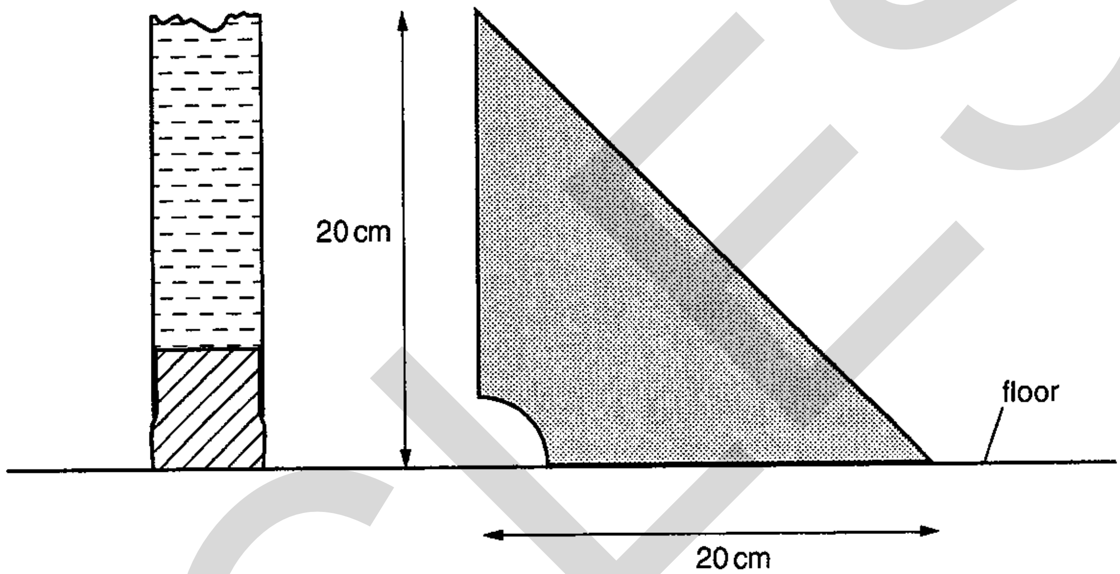


**Fig. 1.1**

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