A Level

Physics

Session: **2000 June**
Type: **Question paper**
Code: **9244**

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 in this paper. Answer **all** questions. For each question there are four possible answers, **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.

Any rough working should be done in this booklet.

This question paper consists of 14 printed pages and 2 blank pages.

[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion,

$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

work done on/by a gas,

$$W = p\Delta V$$

gravitational potential,

$$\phi = -\frac{Gm}{r}$$

refractive index,

$$n = \frac{1}{\sin C}$$

resistors in series,

$$R = R_1 + R_2 + \ldots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \ldots$$

electric potential,

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

capacitors in series,

$$1/C = 1/C_1 + 1/C_2 + \ldots$$

capacitors in parallel,

$$C = C_1 + C_2 + \ldots$$

energy of charged capacitor,

$$W = \tfrac{1}{2}QV$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

hydrostatic pressure,

$$p = \rho g h$$

pressure of an ideal gas,

$$p = \tfrac{1}{3}\frac{Nm}{V}<c^2>$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

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

critical density of matter in the Universe,

$$\rho_0 = \frac{3H_0^{\,2}}{8\pi G}$$

equation of continuity,

$$Av = \text{constant}$$

Bernoulli equation (simplified),

$$p_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \tfrac{1}{2}\rho v_2^2$$

Stokes' law,

$$F = Ar\eta v$$

Reynolds' number,

$$R_e = \frac{\rho v r}{\eta}$$

drag force in turbulent flow,

$$F = Br^2 \rho v^2$$

[Turn over

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

A displacement; acceleration

B force; kinetic energy

C power; speed

D work; potential energy

2 A micrometer, reading to ±0.01 mm, gives the following results when used to measure the diameter d of a uniform wire:

1.02 mm 1.02 mm 1.01 mm 1.02 mm 1.02 mm

When the wire is removed and the jaws are closed, a reading of −0.02 mm is obtained.

Which of the following gives the value of d with a precision appropriate to the micrometer?

A 1.0 mm B 1.00 mm C 1.038 mm D 1.04 mm

3 A ball is released from rest above a horizontal surface and bounces several times.

The graph shows how, for this ball, a quantity y varies with time.
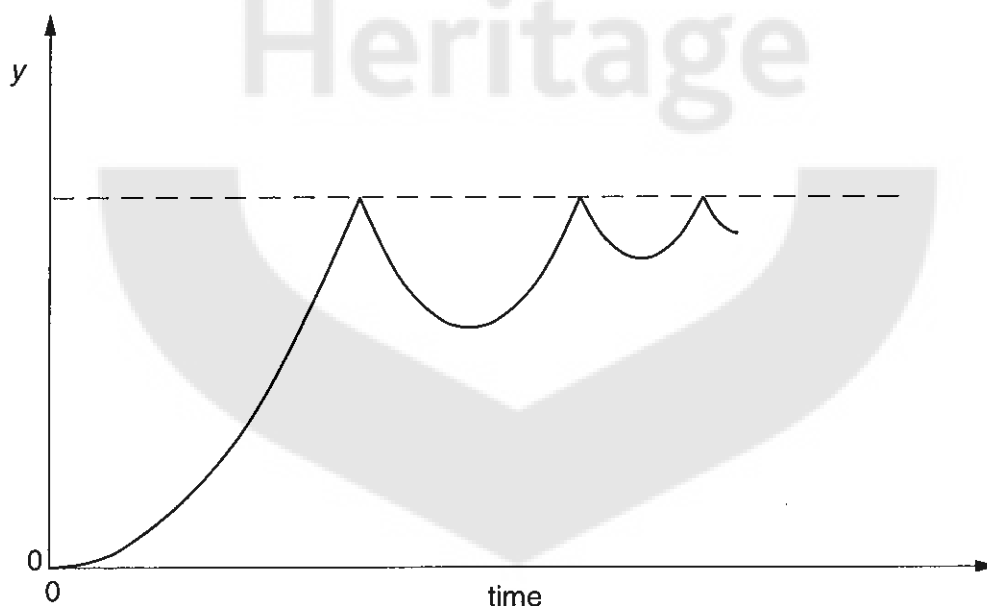

What is the quantity y?

A acceleration

B displacement

C kinetic energy

D velocity

4 Two satellites in space collide inelastically.

What happens to the kinetic energy and momentum?

	kinetic energy	momentum
A	conserved	conserved
B	conserved	reduced
C	reduced	conserved
D	reduced	reduced

5 The diagram shows the jib of a tower crane. Only three forces act on the jib: the tension T provided by a supporting cable; the weight W of the jib; and a force P (not shown) acting at point **X**.
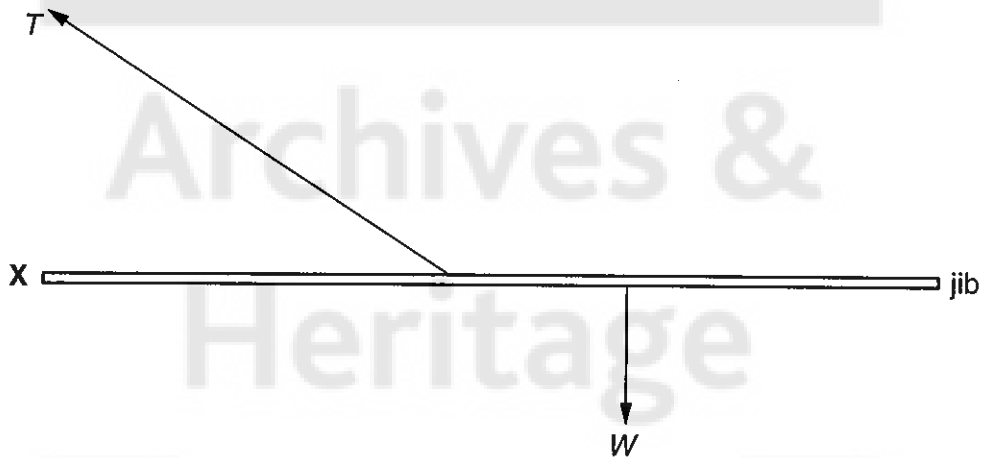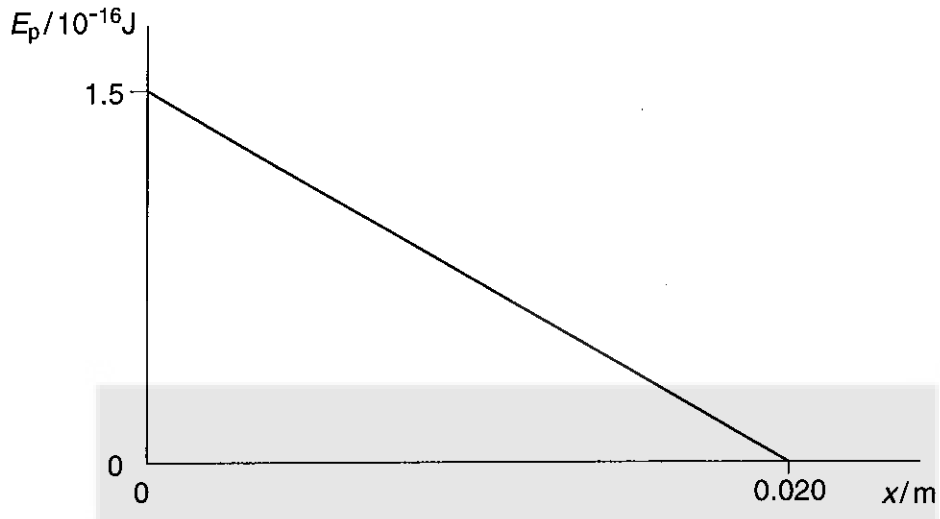

The jib is in equilibrium.

Which triangle of forces is correct?

[Turn over
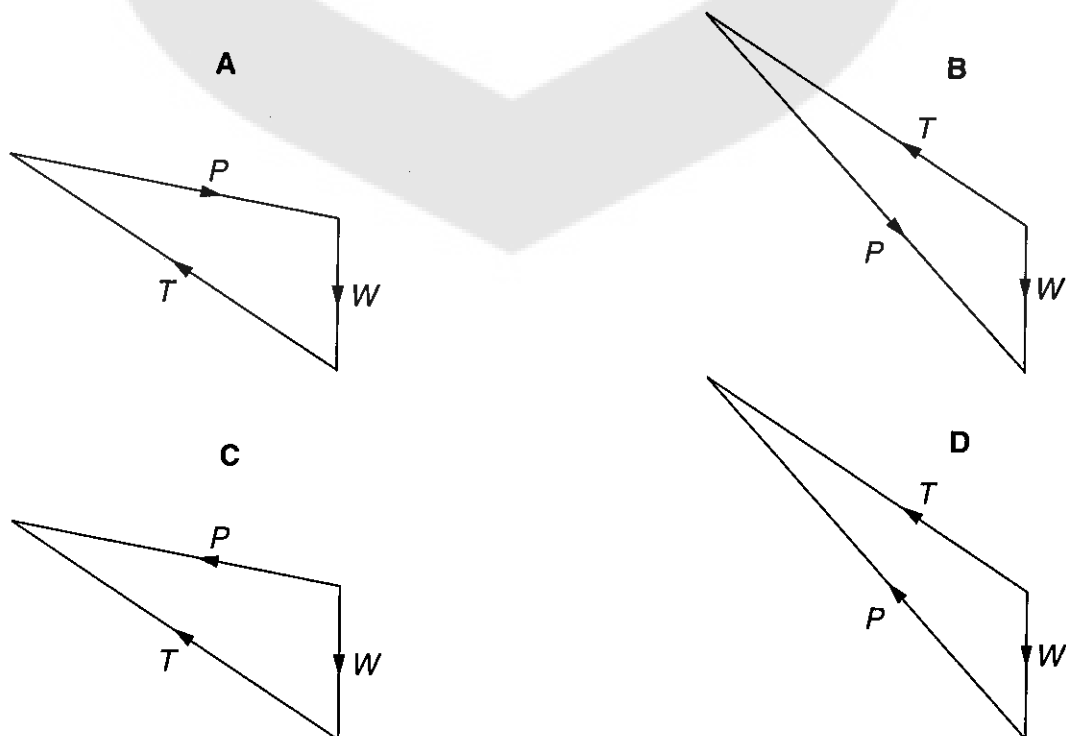
6 Two charged plates are 0.020 m apart, producing a uniform electric field. The potential energy E_p of an electron in the field varies with displacement x from one of the plates as shown.

What is the magnitude of the force on the electron?

A 3.0×10^{-18} N

B 7.5×10^{-17} N

C 3.8×10^{-15} N

D 7.5×10^{-15} N

7 Outside a uniform sphere of mass M, the gravitational field strength is the same as that of a point mass M at the centre of the sphere.

The Earth may be taken to be a uniform sphere of radius r. The gravitational field strength at its surface is g.

What is the gravitational field strength at a height h above the ground?

A $\dfrac{gr^2}{(r+h)^2}$ **B** $\dfrac{gr}{(r+h)}$ **C** $\dfrac{g(r-h)}{r}$ **D** $\dfrac{g(r-h)^2}{r^2}$

8 Which quantity is **not necessarily** the same for satellites that are in geostationary orbits around the Earth?

A   angular velocity

B   centripetal acceleration

C   kinetic energy

D   orbital period

9 A mass hanging from a spring suspended from the ceiling is pulled down and released. The mass then oscillates vertically with simple harmonic motion of period T. The graph shows how its distance from the ceiling varies with time t.
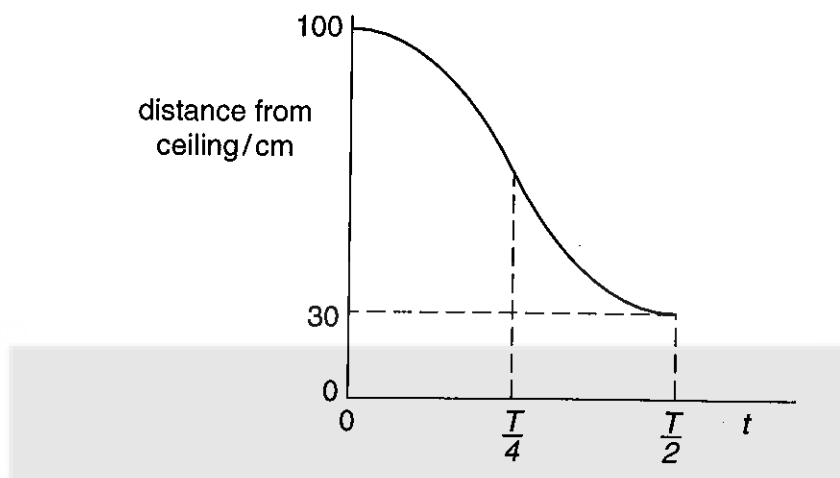
What can be deduced from this graph?

A   The amplitude of the oscillation is 70 cm.

B   The kinetic energy is a maximum at $t = \dfrac{T}{2}$.

C   The restoring force on the mass increases between $t = 0$ and $t = \dfrac{T}{4}$.

D   The speed is a maximum at $t = \dfrac{T}{4}$.

10 A ray of light travels from air to glass as shown.
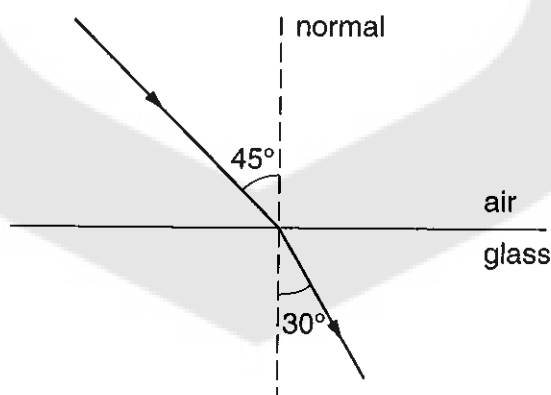
The speed of light in air is $3.00 \times 10^8\,\text{m s}^{-1}$.

What is the speed of light in the glass?

A $2.00 \times 10^8\,\text{m s}^{-1}$

B $2.12 \times 10^8\,\text{m s}^{-1}$

C $3.00 \times 10^8\,\text{m s}^{-1}$

D $4.24 \times 10^8\,\text{m s}^{-1}$

[Turn over

11 A diffraction grating has a spacing of 1.6×10^{-6} m. A beam of light is incident normally on the grating. The first order maximum makes an angle of 20° with the undeviated beam.

What is the wavelength of the incident light?

A 210 nm   **B** 270 nm   **C** 420 nm   **D** 550 nm

12 Which of the following gives three regions of the electromagnetic spectrum in order of increasing wavelength?

A gamma rays, microwaves, visible radiation

B radio waves, ultraviolet, X-rays

C ultraviolet, infra-red, microwaves

D visible radiation, gamma rays, radio waves

13 An isolated conducting sphere P has the charge distribution shown.
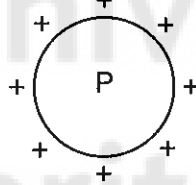
A similar sphere Q, connected to earth by a long wire, is brought close to P.

Which diagram shows the final distribution of charge on the two spheres?
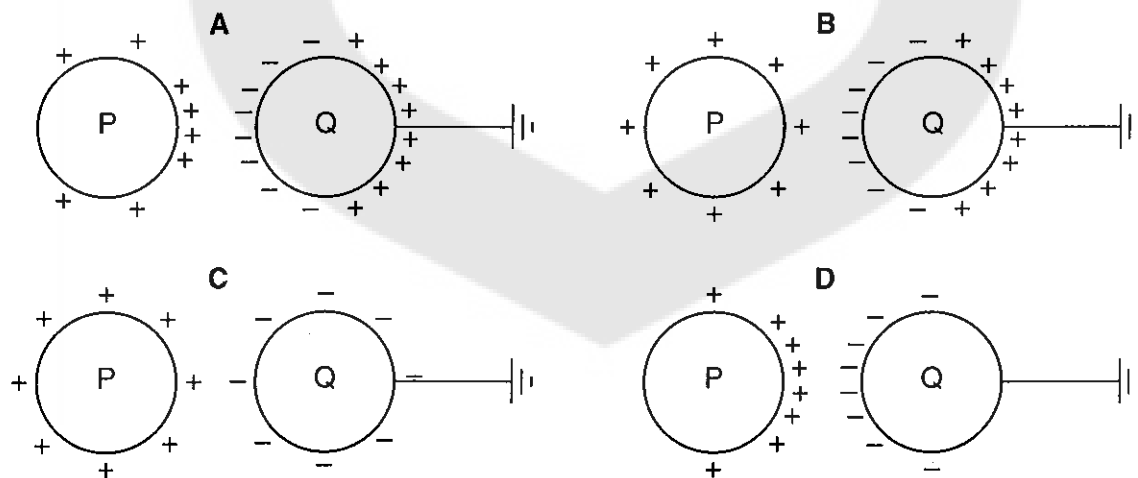
14 Two squares, X and Y are cut from the same sheet of metal of thickness t. The lengths of the sides of X and Y are l and $2l$ respectively.
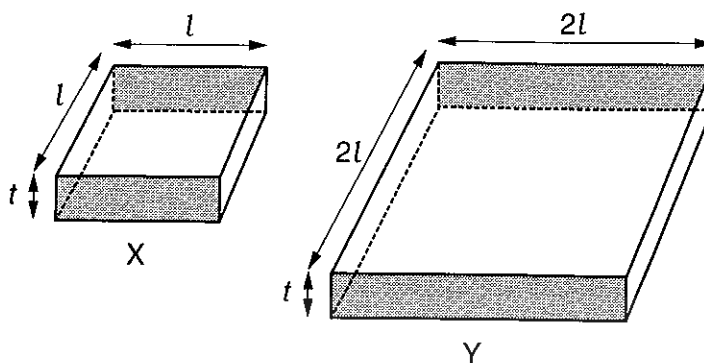
What is the ratio $\dfrac{R_X}{R_Y}$ of the resistances between the opposite shaded faces of X and of Y?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** $\dfrac{1}{1}$ **D** $\dfrac{2}{1}$

15 Four resistors are connected as shown.
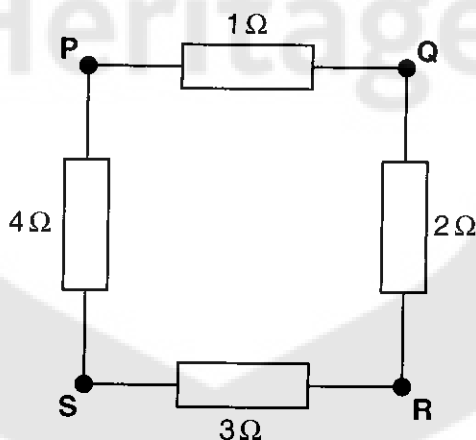
Between which two points is the resistance of the combination a **maximum**?

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

16 Which statement describes the electric potential difference between two points in a wire that carries a current?

A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

[Turn over

17 Which graph correctly relates the electric field strength or electric potential in the field of a point charge, with distance r from the charge?

A

field strength

0 r^2

B

field strength

0 $\frac{1}{r}$

C

potential

0 r

D

potential

0 $\frac{1}{r}$
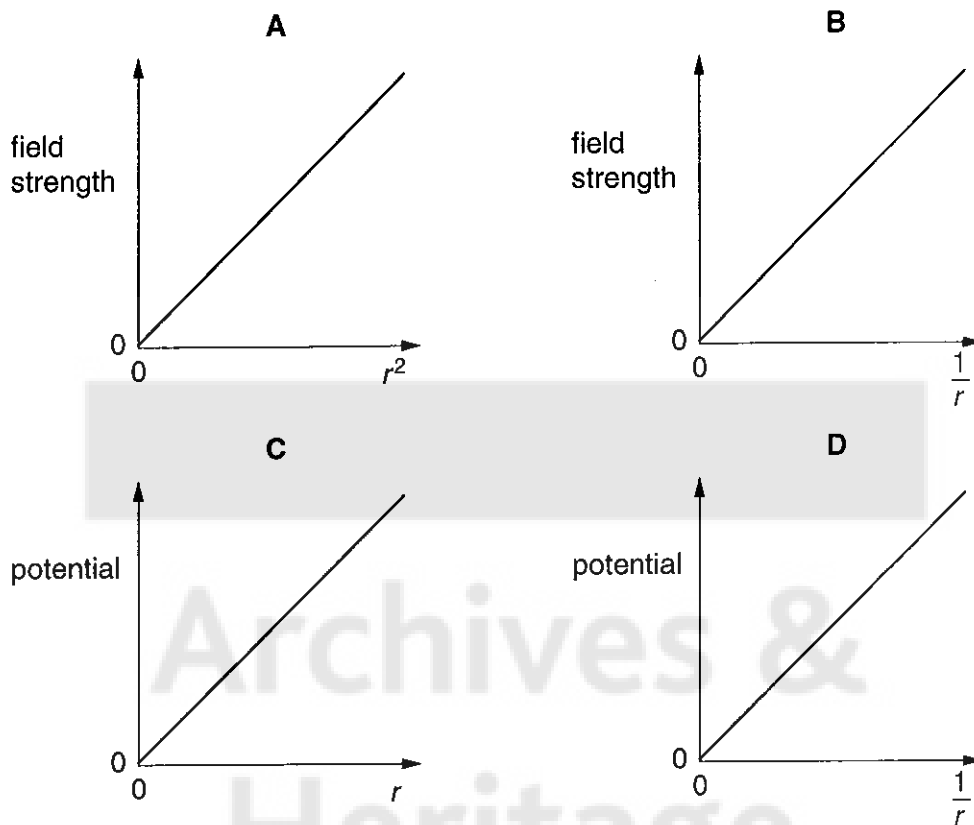
18 Four students are asked to draw graphs to show how the p.d. V across a capacitor depends on its charge Q. They are also asked to shade the area that represents the increase in energy stored in the capacitor when the charge is increased from Q_1 to Q_2.

Which graph is correct?

A

V

0 Q_1 Q_2 Q

B

V

0 Q_1 Q_2 Q

C

V

0 Q_1 Q_2 Q

D

V

0 Q_1 Q_2 Q
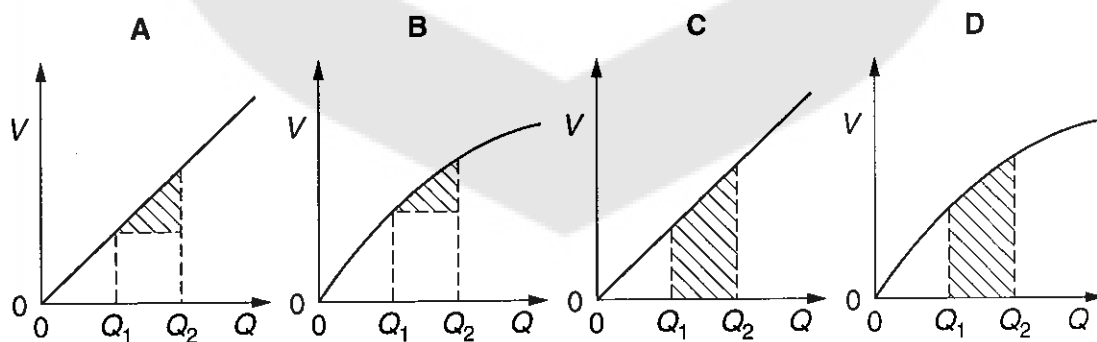
19 The diagram shows a flat surface with lines OX and OY at right angles to each other.
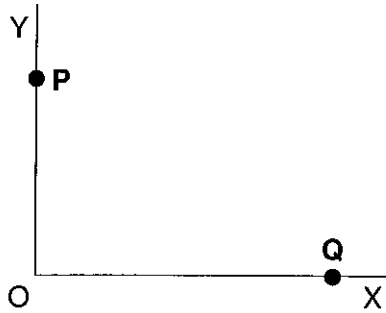
Which current in a straight conductor will produce a magnetic field at O in the direction OX?

A at **P** into the plane of the diagram

B at **P** out of the plane of the diagram

C at **Q** into the plane of the diagram

D at **Q** out of the plane of the diagram

20 A flat circular coil of 120 turns, each of area $0.070\,m^2$, is placed with its axis parallel to a uniform magnetic field. The flux density of the field is changed steadily from $80\,mT$ to $20\,mT$ over a period of $4.0\,s$.

What is the e.m.f. induced in the coil during this time?

A 0 **B** 130 mV **C** 170 mV **D** 500 mV

21 A capacitor is to be used to provide smoothing for a half-wave rectifier.

In which circuit is the capacitor correctly connected?
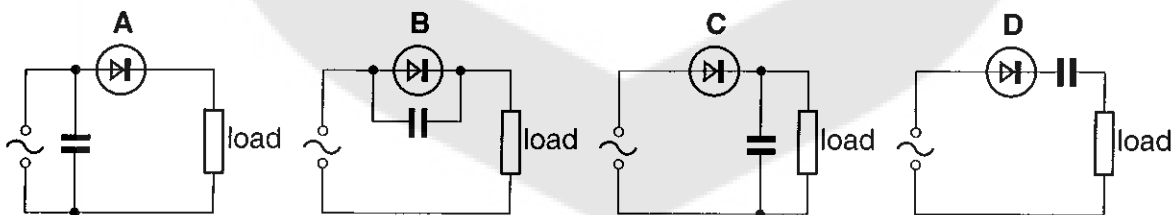
22 A student observes the Brownian motion of smoke particles in air.

Which statement explains the movement of the smoke particles?

A Smoke particles are more dense than air molecules.

B There are convection currents in the air.

C The smoke particles are bombarded by moving air molecules.

D The smoke particles collide with one another.

[Turn over

23 Which diagram shows the force-extension graph for a brittle material that is loaded to breaking point?
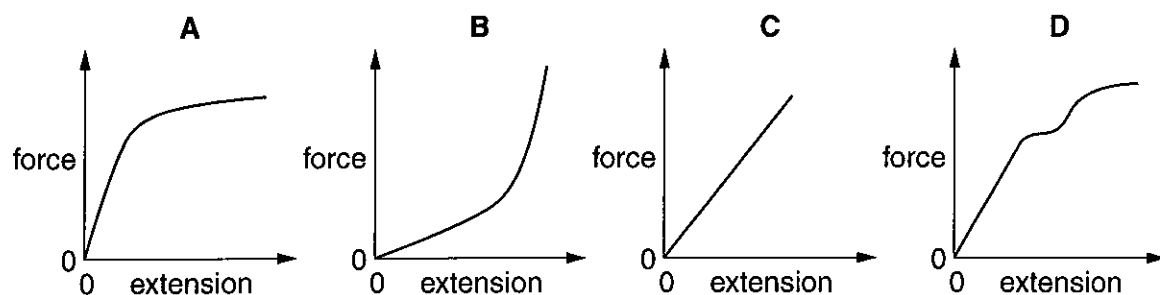
24 The table lists the approximate range and response time of different types of thermometer.

Which set of properties belongs to a liquid-in-glass thermometer?

thermometer	range / K	response time
A	3 – 1750	medium
B	30 – 1750	short
C	75 – 1550	long
D	240 – 630	medium

25 In a heating experiment, energy is supplied at a constant rate to a liquid in a beaker of negligible heat capacity. The temperature of the liquid rises at 4.0 K per minute just before it begins to boil. After 40 minutes all the liquid has boiled away.

For this liquid, what is the ratio $\dfrac{\text{specific heat capacity}}{\text{specific latent heat of vaporisation}}$?

A $\dfrac{1}{10} K^{-1}$ **B** $\dfrac{1}{40} K^{-1}$ **C** $\dfrac{1}{160} K^{-1}$ **D** $\dfrac{1}{640} K^{-1}$

26 In the diagram the volume of bulb X is twice that of bulb Y. The system is filled with an ideal gas and a steady state is established with the bulbs held at 200 K and 400 K.
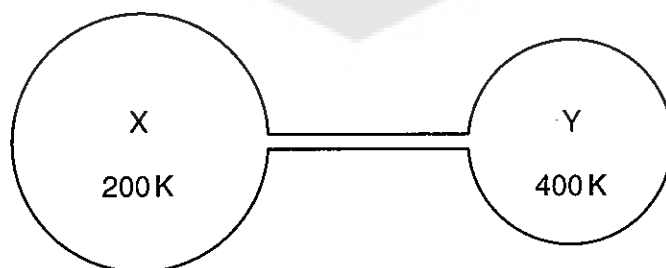
There are x moles of gas in X.

How many moles of gas are in Y?

A $\dfrac{x}{4}$ **B** $\dfrac{x}{2}$ **C** x **D** $2x$

27 A charged particle is projected horizontally at P into a uniform vertical field. The particle follows the path shown.
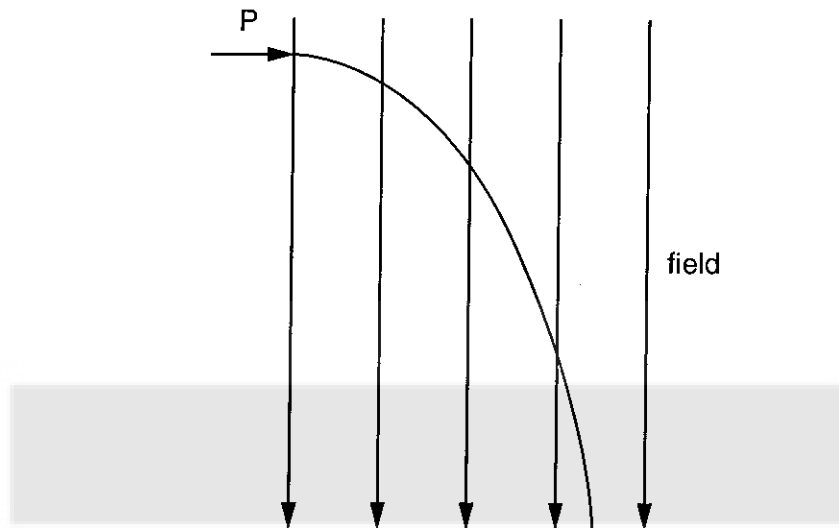
Ignoring gravitational effects, what describes a possible state of charge of the particle and the nature of the field?

	charge	field
A	negative	electric
B	negative	magnetic
C	positive	electric
D	positive	magnetic

28 An electron has mass m_e and speed $0.02\,c$, where c is the speed of light in free space.

What is the de Broglie wavelength of this electron, expressed in terms of the Planck constant h?

A $\dfrac{h}{(0.02c)}$ 　　B $\dfrac{(0.02c)}{h}$ 　　C $\dfrac{h}{(0.02c)m_e}$ 　　D $\dfrac{(0.02c)m_e}{h}$

[Turn over

29 A thin gold foil is bombarded with α-particles as shown.

incident α-particles

gold foil
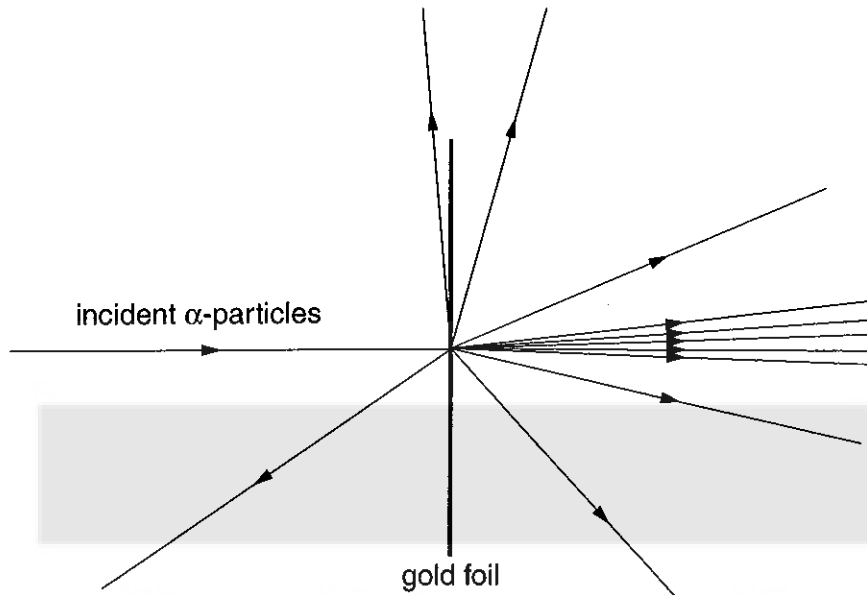
The results of this experiment provide information about the

A binding energy of a gold nucleus.

B energy levels of electrons in gold atoms.

C size of a gold nucleus.

D structure of a gold nucleus.

30 A radioactive source produces 10^6 α-particles per second. When all the ions produced in air by these α-particles are collected, the ionisation current is about $0.01\,\mu A$.

If the charge on an ion is about $10^{-19}\,C$, what is the best estimate of the average number of ions produced by each α-particle?

A 10^5 **B** 10^6 **C** 10^7 **D** 10^8
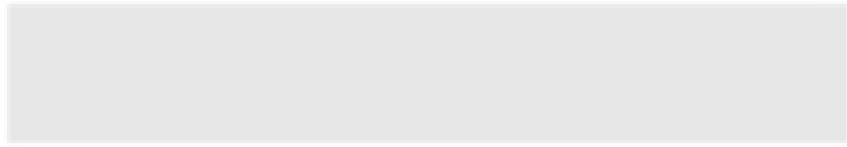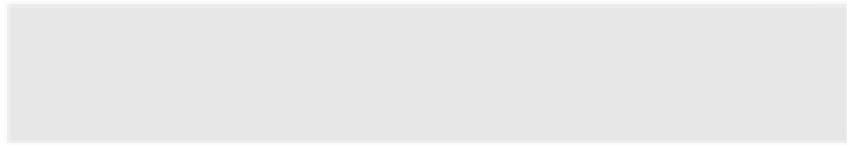
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General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS

PAPER 2

9244/2

Wednesday	**7 JUNE 2000**	Afternoon	1 hour 45 minutes

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

TIME   1 hour 45 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.

Your answers to Questions 1(c), 4(c)(iii), 5(b) and 6(a) must be in continuous prose.

INFORMATION FOR CANDIDATES

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

The quality of your language will be taken into account in the marking of your answers to Questions 1(c), 4(c)(iii), 5(b) and 6(a).

FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
6	
7	
8	
Quality of language	
TOTAL	

This question paper consists of 19 printed pages and 1 blank page.

[Turn over

Data

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Formulae

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resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \dfrac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
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radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
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Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \dfrac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

1 **(a)** Define *density* and *pressure*.

density ....

pressure .... [2]

(b) Use the definitions which you have given in **(a)** to derive the equation

$$p = \rho g h$$

for the pressure *p* at a depth *h* in a fluid of density *ρ*.

....

....

....

.... [3]

(c) Use your answer to **(b)** and Fig. 1.1 to explain why any object submerged in water is easier to lift than when not submerged.
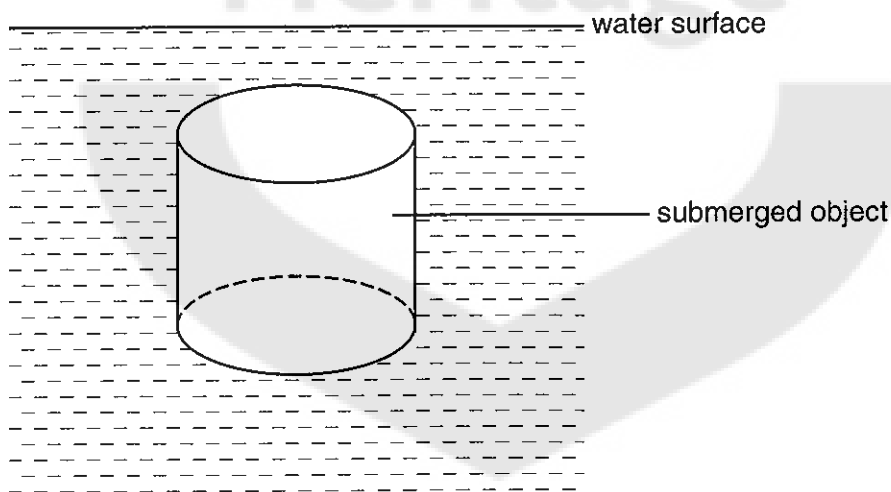
Fig. 1.1

....

....

....

.... [3]

2   Fig. 2.1 shows an electrical circuit in which the internal resistance of the battery is negligible.

Complete Fig. 2.2 by giving the electrical quantities for each of the components in the circuit. You are advised to start by completing the column for component A.
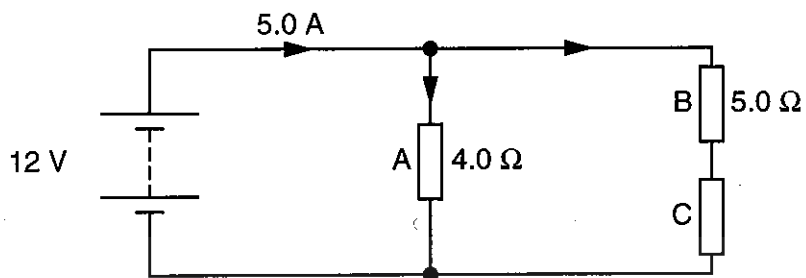
[9]

Fig. 2.1

circuit component	A	B	C	whole circuit
potential difference/V				12
current/A				5.0
power/W				
resistance/Ω	4.0	5.0		

Fig. 2.2

[Turn over

3 An aircraft flies with its wings tilted as shown in Fig. 3.1 in order to fly in a horizontal circle of radius r. The aircraft has mass 4.00×10^4 kg and has a constant speed of $250 \, m \, s^{-1}$.

$W = 3.92 \times 10^5$ N
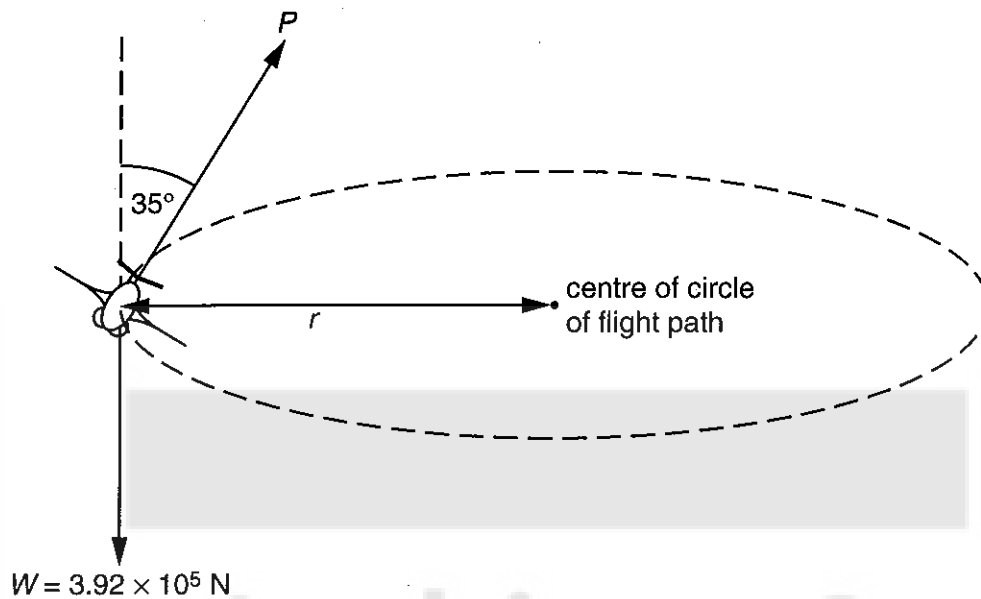
Fig. 3.1

With the aircraft flying in this way, two forces acting on the aircraft in the vertical plane are the force P acting at an angle of 35° to the vertical and the weight W.

(a) State the vertical component of P for horizontal flight.

vertical component of P =.................................... N   [1]

(b) Calculate P.

P =.................................... N   [2]

(c) Calculate the horizontal component of P.

horizontal component of P =.................................... N   [1]

(d) Use Newton's second law to determine the acceleration of the aircraft towards the centre of the circle.

acceleration = ... m s^{-2} [2]

(e) Calculate the radius r of the path of the aircraft's flight.

$r =$ .... m   [2]

[Turn over

4 **(a)** Two waves of different frequency pass through the same point. Figs. 4.1 and 4.2 show the displacement-time graphs for the waves. On Fig. 4.3, sketch the resultant displacement showing the superposition of these two waves. [2]

displacement

Fig. 4.1

time

displacement

Fig. 4.2

time

displacement

Fig. 4.3

time
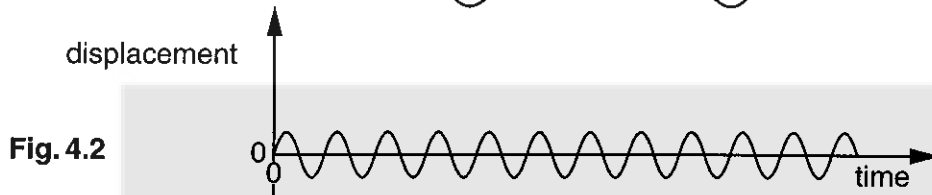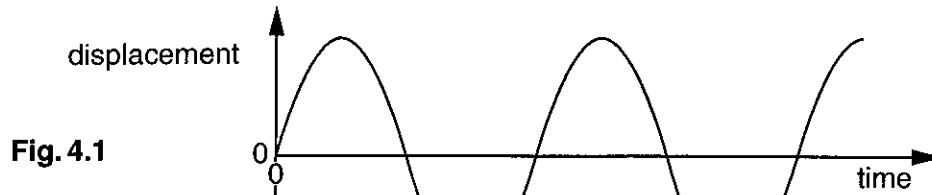
(b) Sketch on Figs. 4.4(i) and 4.4(ii) the diffraction of waves through gaps which are

(i) large compared with the wavelength,

(ii) small compared with the wavelength.

[3]
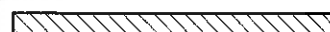
Fig. 4.4(i)　　　　　　　　　　　　**Fig. 4.4(ii)**

(c) Two microwave sources A and B are in phase with one another. They emit waves of equal amplitude and of wavelength 30.0 mm. They are placed 140 mm apart and at a distance of 810 mm from a line OP along which a detector is moved, as shown in Fig. 4.5.
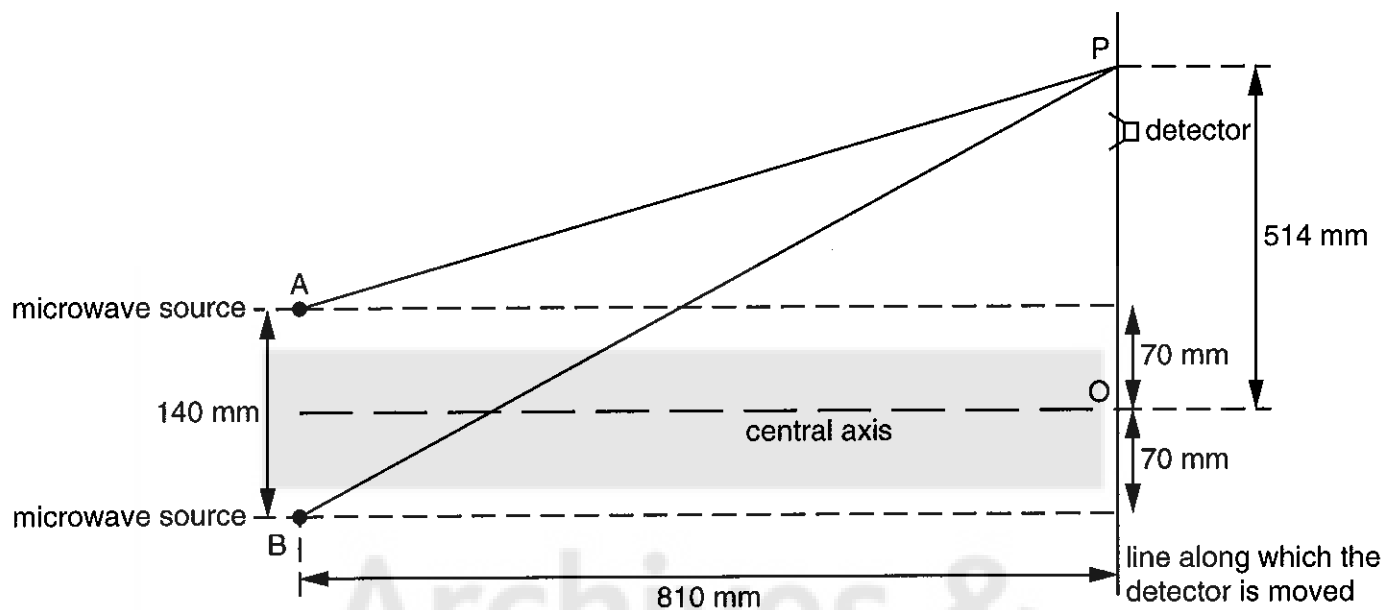
Fig. 4.5 (not to scale)

(i) Using Pythagoras' theorem, it can be shown that the distance AP is 923.7 mm. Calculate the number of wavelengths between source A and point P.

number of wavelengths between A and P = ... [1]

(ii) Show that there are 33.3 wavelengths between source B and point P.

[2]

(iii) 1. State what intensity of microwaves will be received by the detector when it is at P.

....

2. Describe how the intensity of reception varies as the detector is moved from P to the point O on the central axis.

....

....

....

....

[3]

[Turn over

5 The primary coil of a transformer has 1000 turns and is connected to a 230 V r.m.s. supply. The secondary coil has 40 turns and may be connected, through a switch and a diode, to a 9.0 V rechargeable battery, as illustrated in Fig. 5.1.

230 V r.m.s.   1000 turns   40 turns   9.0 V
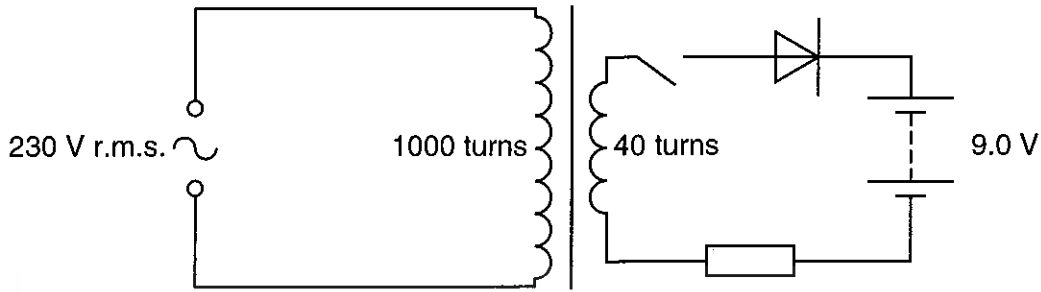
Fig. 5.1

(a) Initially the switch is open. Considering both the transformer and the diode to be ideal, calculate

(i) the r.m.s. potential difference across the secondary,

r.m.s. potential difference =.................................... V

(ii) the peak potential difference across the secondary.

peak potential difference =.................................... V

[4]

(b) The switch is now closed so that the battery is being recharged.

(i) Suggest why the diode is necessary in the secondary circuit.

....

....

....

(ii) Suggest why the resistor is necessary in the circuit.

....

....

....

[4]

6 **(a)** Describe the phenomenon of photoelectric emission.

....

....

....

....

....

.... [3]

(b) Give the meaning of the following terms, as used in describing the photoelectric effect.

   (i) photon ....

....

   (ii) work function energy ....

....

   (iii) threshold frequency ....

....

                                                       [4]

(c) Calculate the energy of a photon of light of wavelength 5.89×10^{-7} m.

energy = ... J   [3]

[Turn over

7 A specimen fibre of glass has the same dimensions as a specimen of copper wire.

The length of each specimen is 1.60 m and the radius of each is 0.18 mm. Force-extension graphs for both specimens are shown in Fig. 7.1.
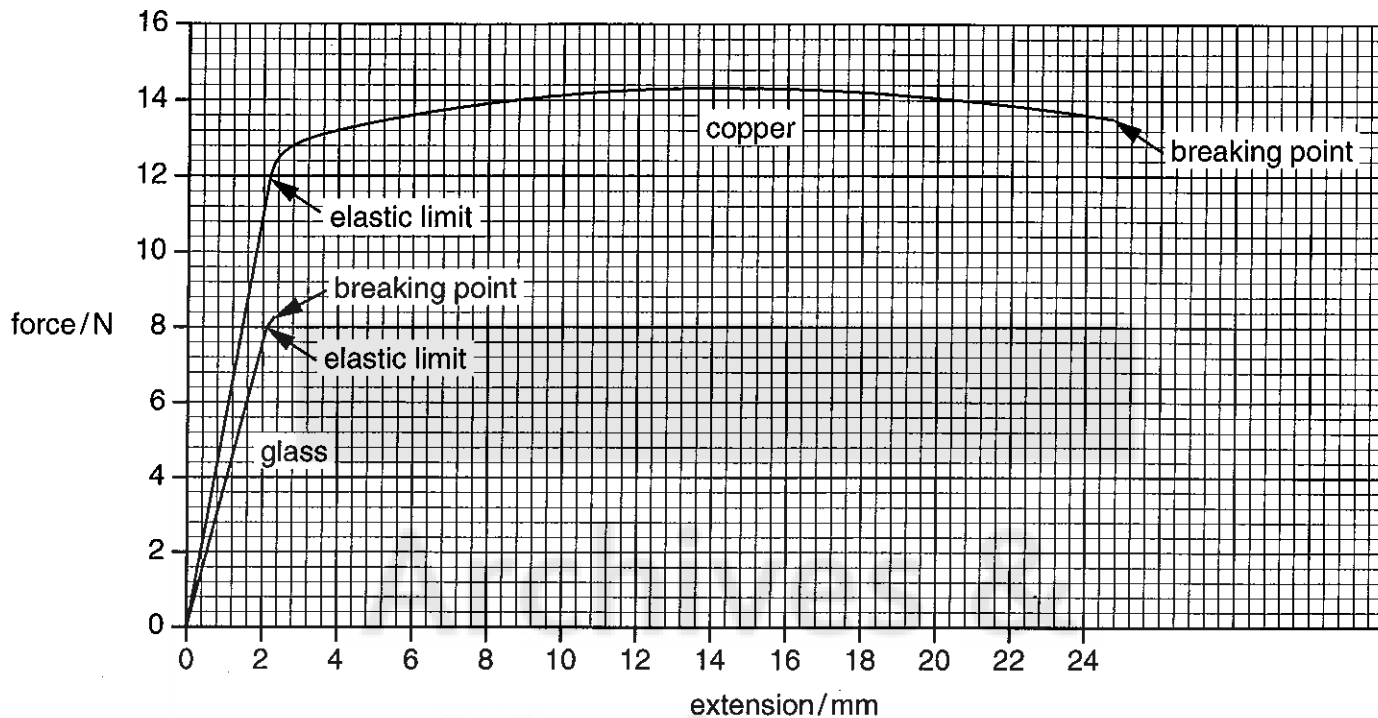

Fig. 7.1

(a) (i) State which of the two materials is brittle...

(ii) Explain which feature of Fig. 7.1 leads you to your answer in **(i)**.

....

....

[2]

(b) Using the graphs and the data given, determine

(i) the area of cross-section of each specimen,

area of cross-section = ... m² [1]

(ii) the Young modulus of the glass,

Young modulus = ... Pa   [4]

(iii) the ultimate tensile stress for copper,

ultimate tensile stress = ... [2]

(iv) an approximate value for the work done to stretch the copper wire to its breaking point.

work done = ... J   [3]

[Turn over

8 **Read the passage below and then answer the questions that follow.**

When a structural engineer is designing a building there will be occasions when a beam has to be used to bridge a gap. The width of the gap is called the span. The engineer makes calculations to ensure that the beam is strong enough to withstand any forces applied to it, and to ensure that there is not too much sag in the beam. This question concerns how the choice of beam is made.

Sometimes, when the loading is small, a plain wooden beam is sufficient, as shown in Fig. 8.1. A beam such as this, loaded at its centre, will undergo a maximum depression x given by

$$x = \frac{WL^3}{kab^3}$$

where W is the load at the centre, a is the width and b is the depth of the beam and k is a constant.
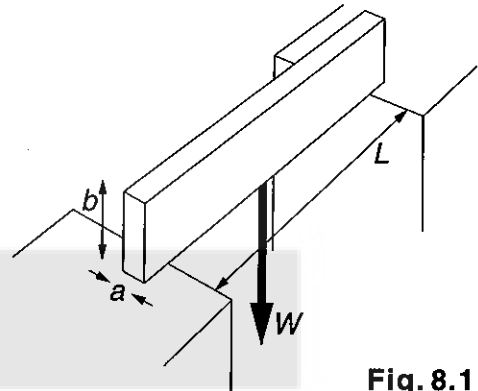

Fig. 8.1

When greater loads or greater spans are required, a steel beam may be used. In order to minimise the amount of steel required the shape of the beam used is as shown in Fig. 8.2.
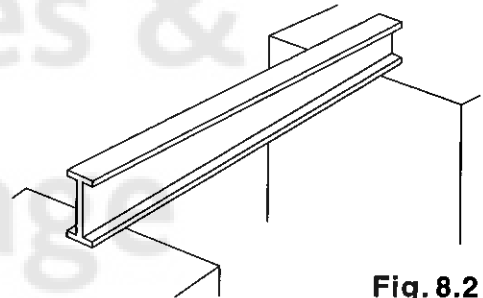

Fig. 8.2

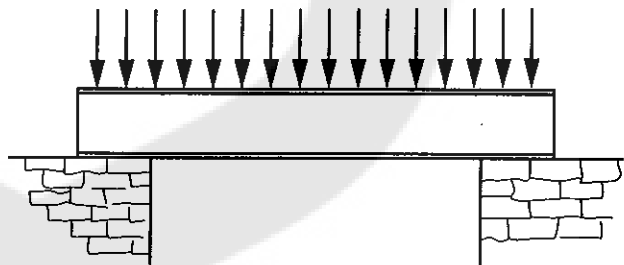Sometimes, the loading of the beam is uniform along its length, as shown in Fig. 8.3.

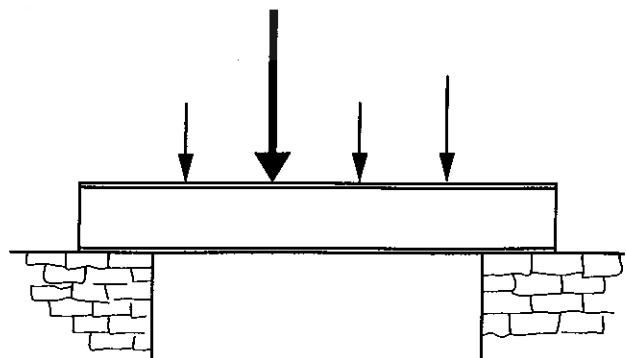Sometimes, with complex loading (Fig. 8.4), the moments of the forces have to be calculated.

Fig. 8.3

Fig. 8.4

(a) (i) State **two** reasons why the structural engineer has to make calculations when using a beam to bridge a gap.

1..

2..

(ii) Write down the reason given in the passage for making the steel beam the shape shown in Fig. 8.2.

....

....

(iii) The cross-sectional area of the beams shown in Fig. 8.5 are the same.

Fig. 8.5

Suggest why, for beams of the same length, one would sag more than the other.

....

....

....

....

[5]

(b) A wooden beam has width 0.050 m, depth 0.10 m and spans 3.0 m. Calculate the maximum load which it can support at its centre for a maximum depression of 0.010 m. Take k to be 3.6×10^{10} Pa for this wood.

maximum load = ... N   [3]

[Turn over

(c) A steel beam, loaded uniformly as in Fig. 8.3, is allowed to sag by a maximum of 1/360 of the gap it is spanning. A particular beam is used to carry a load of 33 000 N and to span a gap of 4.20 m. A quantity B, known as the bending moment for this loading pattern is given by

$$B = \frac{WL}{8} \text{ and the depression } x \text{ at the centre is given by}$$

$$x = \frac{BL^3}{c} \text{ where } c \text{ has the value } 3.35 \times 10^8 \, \text{N m}^3.$$

Calculate

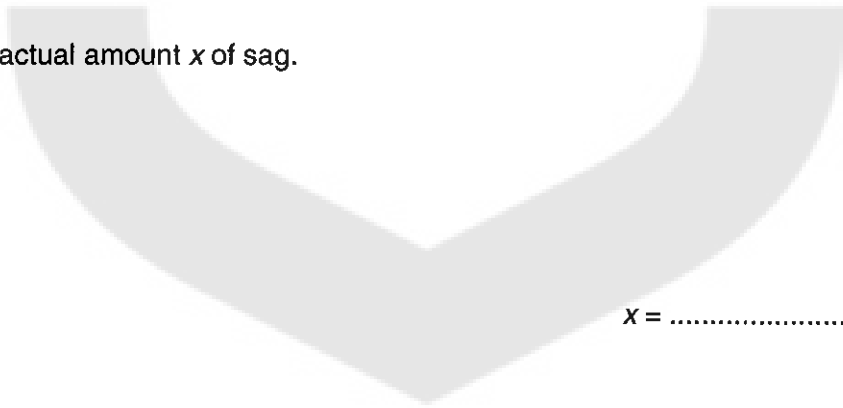**(i)** the amount x_{max} by which the beam is allowed to sag,

$$x_{max} = \text{.................................... m}$$

(ii) the bending moment B,

$$B = \text{....................................}$$

(iii) the actual amount x of sag.

$$x = \text{.................................... m}$$

[5]

(d) A beam across a gap is shown in Fig. 8.6, together with values of the forces acting and their distances from X.
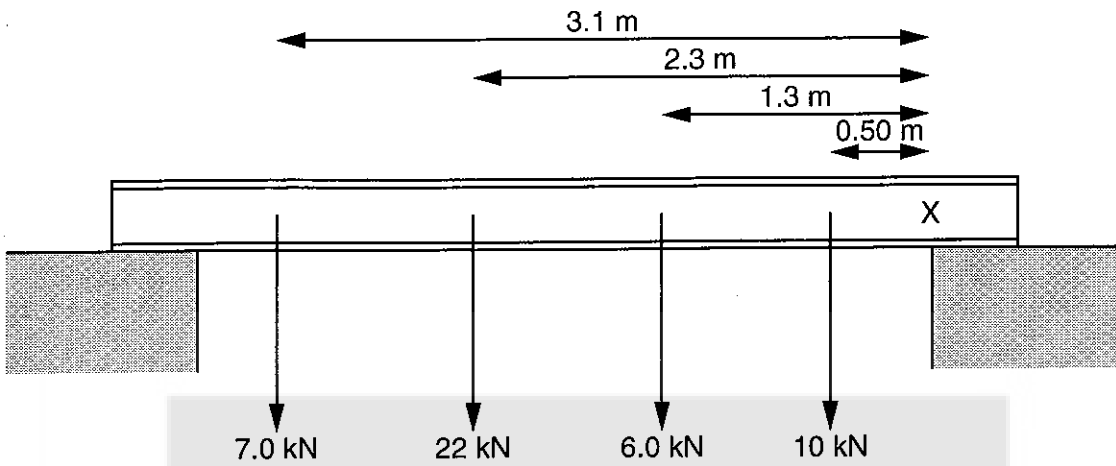

Fig. 8.6

Calculate the total moment of the forces shown about point X.

total moment = ... [4]

[Turn over

(e) The final check on the suitability of any beam is to ensure that it is strong enough. This is done, using a table of values, to find the allowable bending stress.

(i) For the beam in **(c)**, two constants P and Q, without units, are found from the dimensions of the beam and the gap it is spanning. For this beam $P = 21$ and $Q = 170$. Use Fig. 8.7 to find the allowable bending stress.

allowable bending stress/MPa				
	P			
Q	15	20	25	30
160	111	96	88	82
170	106	93	83	77
180	102	89	80	73

Fig. 8.7

allowable bending stress = ... MPa
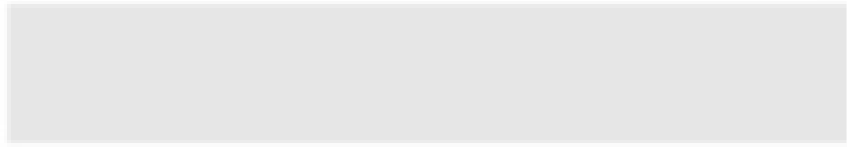
(ii) The beam is safe to use if

$$\frac{\text{bending moment}}{\text{allowable bending stress}} < 2.0 \times 10^{-4}\,\text{m}^3$$

Use this relationship to determine whether the beam is safe under these conditions.

$$\frac{\text{bending moment}}{\text{allowable bending stress}} =$$

Is the beam safe?..................................... [3]

Quality of language [4]

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General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS   **9244/3**

PAPER 3

Monday   **19 JUNE 2000**   Morning   2 hours 30 minutes

Additional materials:
   Answer paper
   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 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 number of marks is given in brackets [ ] at the end of each question or part question.

You are advised to spend about 40 minutes on Section B.

You are reminded of the need for good English and clear presentation in your answers.

This question paper consists of 19 printed pages and 1 blank page.

[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^8 \, \text{m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \, \text{H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \, \text{F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \, \text{C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \, \text{J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \, \text{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \, \text{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \, \text{kg}$
molar gas constant,	$R = 8.31 \, \text{J K}^{-1} \, \text{mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \, \text{mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23} \, \text{J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \, \text{N m}^2 \, \text{kg}^{-2}$
acceleration of free fall,	$g = 9.81 \, \text{m s}^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\dfrac{Gm}{r}$
refractive index,	$n = \dfrac{1}{\sin C}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \dfrac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \dfrac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

SECTION A

Answer any **four** questions from this Section.

1   In a dynamics experiment, a trolley is accelerated from rest along a horizontal runway as shown in Fig. 1.1.
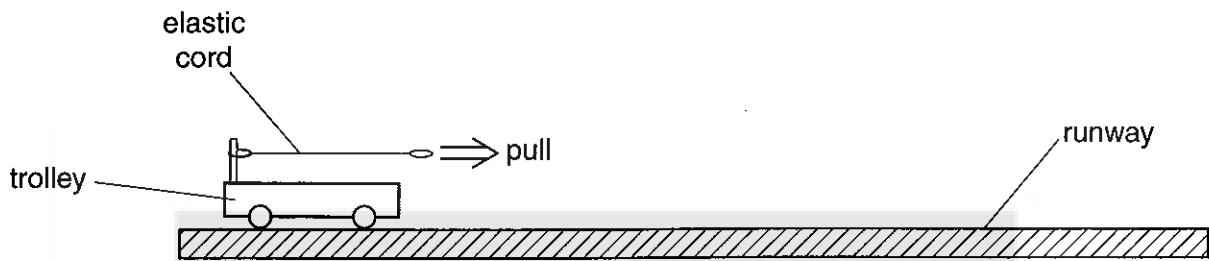

Fig. 1.1

The accelerating force is provided by an elastic cord. One end of the cord is attached to the trolley and the other end is pulled so that the extension of the cord remains constant as the trolley moves along the runway.

The acceleration a of the trolley varies with the extension x of the elastic cord as shown in Fig. 1.2.
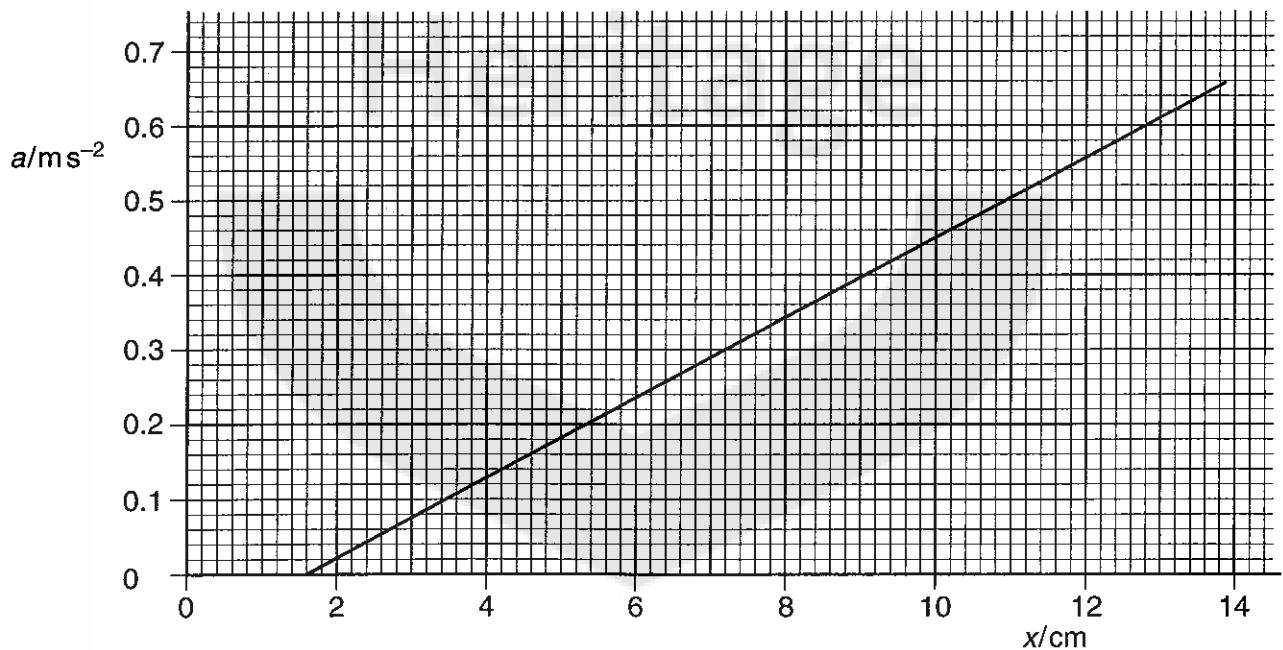

Fig. 1.2

The trolley experiences a constant frictional force when in motion.

(a) Use Fig. 1.2 to

  (i) determine the extension of the cord required to maintain constant speed of the trolley, giving a brief explanation for your answer,

  (ii) show that the increase in extension, beyond that found in **(i)**, to produce an acceleration of $0.60\,m\,s^{-2}$ is $11.2\,cm$.

[4]

(b) **(i)** Calculate the force required, in the absence of friction, to cause the trolley of mass $800\,g$ to have an acceleration of $0.60\,m\,s^{-2}$.

  (ii) Using your answers to **(b)(i)** and **(a)(ii)**, determine the spring constant of the elastic cord. Assume that the cord obeys Hooke's law.

  (iii) Calculate the frictional force on the trolley.

[5]

(c) In one particular experiment, the extension of the cord is kept constant at $3.5\,cm$. Calculate

  (i) the speed of the trolley after it has travelled $1.2\,m$ from rest along the runway,

  (ii) the time taken to travel a further $30\,cm$ along the runway.

[6]

(d) By reference to Fig. 1.2, state and explain

  (i) whether the acceleration of the trolley is proportional to the extension of the cord,

  (ii) how it may be concluded that the Hooke's law limit of the cord has not been exceeded.

[5]

[Turn over

2 **(a)** Define

    (i) work,

    (ii) power.

                 [3]

(b) By reference to equations of motion, derive an expression for the kinetic energy E_k of an object of mass m moving at speed v.   [4]

(c) A car is travelling along a horizontal road with speed v, measured in metres per second. The power P, measured in watts, required to overcome external forces opposing the motion is given by the expression

$$P = cv + kv^3,$$

where c and k are constants.

    (i) Use base units to obtain an SI unit for the constant k.

    (ii) For one particular car, the numerical values, in SI units, of c and of k are 240 and 0.98 respectively. Calculate the power required to enable the car to travel along a horizontal road at $31 \, \mathrm{m\,s^{-1}}$.

                 [6]

(d) The car in **(c)** has mass 720 kg. Using your answer to **(c)(ii)** where appropriate, calculate, for the car travelling at $31 \, \mathrm{m\,s^{-1}}$,

    (i) its kinetic energy,

    (ii) the magnitude of the external force opposing the motion of the car,

    (iii) the work done in overcoming the force in **(ii)** during a time of 5.0 minutes.

                 [5]

(e) By reference to your answers to **(d)**, suggest, with a reason, whether it would be worthwhile to develop a system whereby, when the car slows down, its kinetic energy would be stored for re-use when the car speeds up again.   [2]

3 (a) Distinguish between a progressive wave and a stationary wave by making reference to

(i) energy transfer,

(ii) amplitude of vibration of neighbouring particles,

(iii) phase angle between particles.

[7]

(b) A horizontal steel wire is fixed at one end and is kept under tension by means of weights suspended over a pulley, as shown in Fig. 3.1.
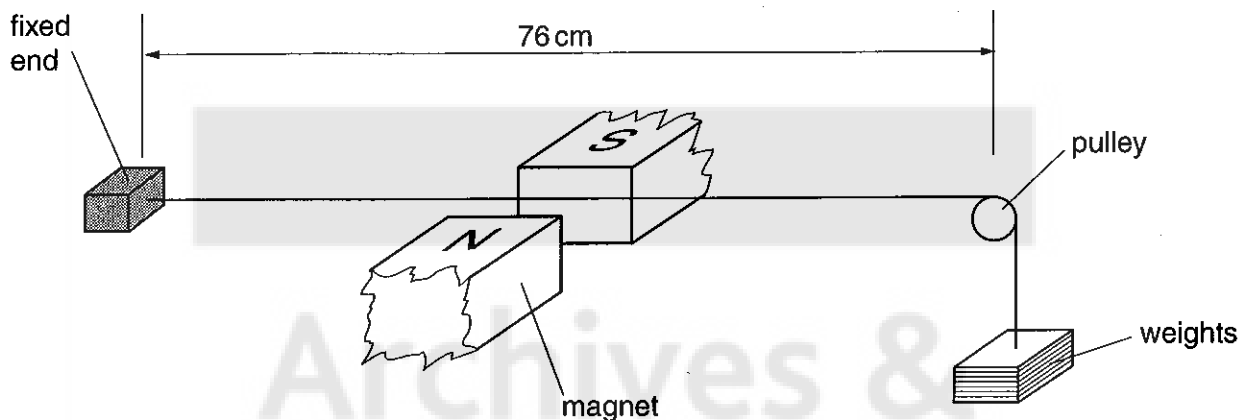

Fig. 3.1

A low-voltage alternating supply of frequency 50 Hz is connected to the wire between the fixed end and the pulley. Magnets are placed near to the centre of the horizontal section of the wire in order to produce a magnetic field at right angles to the wire.

The tension in the wire is gradually increased from a small value, thereby changing the speed with which waves may travel along the wire. Suddenly, the amplitude of vibration of the wire increases to a maximum and then becomes small once more.

(i) Explain why

1. the wire vibrates,

2. the amplitude of vibration is a maximum at one value of the tension. [6]

(ii) The distance between the fixed point and the pulley is 76 cm. For the wire vibrating with maximum amplitude,

1. sketch the shape of the stationary wave on the wire,

2. calculate the wavelength of this stationary wave. [2]

(c) The low-voltage power supply in (b) is removed and the ends of the wire are connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.). The wire is plucked at its centre and a sinusoidal trace is observed on the screen of the c.r.o.

By reference to laws of electromagnetic induction, explain why

(i) an e.m.f. is induced between the ends of the wire,

(ii) the e.m.f. is alternating.

[5]

[Turn over

4 **(a)** **(i)** Sketch a graph to show the variation with potential of the charge on an isolated conductor.

(ii) By reference to your graph in **(i)**,

1. define what is meant by *capacitance*,

2. derive an expression for the energy *E* stored in a capacitor of capacitance *C* charged to a potential *V*.

[6]

(b) Four capacitors, each of capacitance 50 μF, are connected as shown in Fig. 4.1 to a high-voltage supply, a resistor and a switch S.
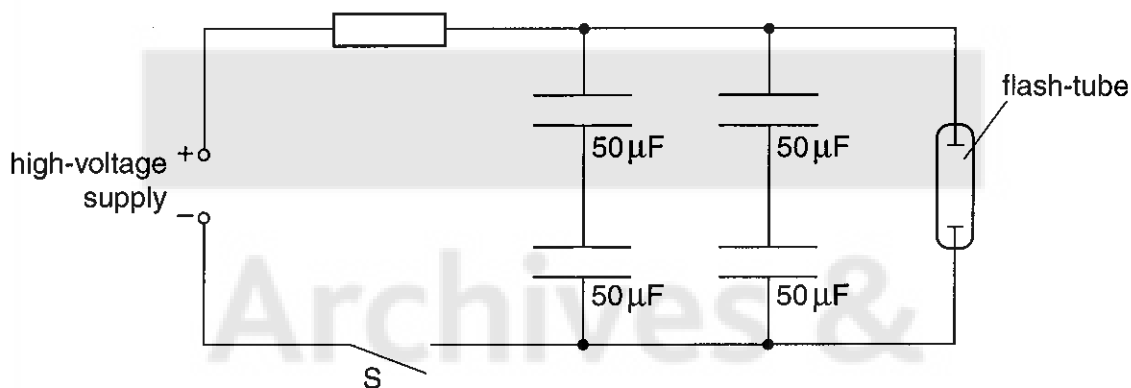

Fig. 4.1

A flash-tube is connected across the combination of capacitors. When S is closed, the capacitors charge up gradually and, when the potential difference across the flash-tube reaches 540 V, the capacitors discharge rapidly through the flash-tube. A flash of light is emitted as the capacitors discharge 63% of their energy.

(i) **1.** Determine the total capacitance of the arrangement of capacitors.

2. Suggest one advantage of this arrangement compared with a single capacitor of the same total capacitance.

[3]

(ii) The potential difference across the flash-tube creates an electric field in the tube. State two differences between the force due to the electric field on the nucleus and the force due to the electric field on an electron of an atom of xenon gas in the tube. [2]

(iii) Suggest why there is a current in the tube when the potential difference across it is sufficiently large. [2]

(iv) Calculate

1. the energy dissipated in one flash of light,

2. the potential difference across each capacitor immediately after the flash of light has occurred.

[4]

(c) The circuit of Fig. 4.2 was designed by a student.
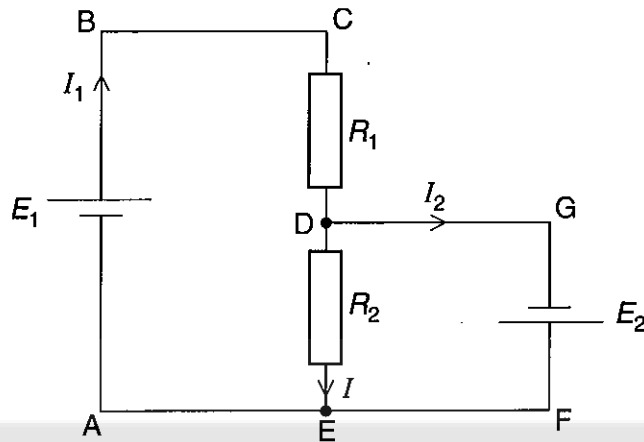
Fig. 4.2

The cells have e.m.f.'s E_1 and E_2 and the currents in the cells are I_1 and I_2 respectively. The resistors have resistances R_1 and R_2 and the current in the resistor of resistance R_2 is I.

Use Kirchhoff's laws to write down expressions in terms of E_1, E_2, R_1, R_2, I, I_1 and I_2 (where appropriate) for

(i) the currents at junction D,

(ii) the circuit loop ABCDEA,

(iii) the circuit loop GFEDG.

[3]

[Turn over

5 **(a)** **(i)** Distinguish between the processes of evaporation and of boiling.

(ii) Use the first law of thermodynamics to explain why, when a liquid evaporates or boils, thermal energy must be supplied to the liquid in order to maintain constant temperature.

[6]

(b) The pressure p of an ideal gas of density ρ is related to the mean-square speed $<c^2>$ of its molecules by the expression

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

(i) State three basic assumptions of the kinetic theory of gases, which lead to a model of an *ideal* gas. [3]

(ii) Write down the equation of state for an ideal gas. [1]

(iii) Show that the average kinetic energy of a molecule of an ideal gas is proportional to the thermodynamic temperature T. [4]

(c) Free neutrons in the core of a fission reactor are sometimes referred to as a 'neutron gas'. These free (thermal) neutrons may be assumed to behave as molecules of an ideal gas at a temperature of 35 °C.

(i) Calculate, for a free neutron of mass 1.67×10^{-27} kg,

1. its mean kinetic energy,

2. its root-mean-square (r.m.s.) speed.

(ii) Determine the temperature of helium gas, assumed to be an ideal gas, at which helium molecules (each of mass $4\,u$) would have the same r.m.s. speed as the free neutrons.

[6]

6 **(a)** Distinguish between a *nucleon*, a *nucleus* and a *nuclide*. [5]

(b) Radon-220 ($^{220}_{86}$Rn) decays spontaneously with a half-life of 56 s to form polonium (Po). During this decay, an α-particle and a γ-ray photon are emitted with energies of 6.29 MeV and 0.55 MeV respectively.

   (i) Write down a nuclear equation to represent the decay of a Radon-220 nucleus. [2]

   (ii) Define what is meant by *half-life*. [2]

   (iii) Calculate, for this decay,

      1. the mass equivalence of the energy released during the decay,

      2. the wavelength of the emitted γ-ray photon.

      [5]

(c) The radon in **(b)** may be found in the air in buildings. For health reasons, the safe limit of activity due to the decay of radon is set at 200 Bq per cubic metre of air. Calculate, for this safe limit,

   (i) the number of radon atoms present per cubic metre of air,

   (ii) the ratio

$$\frac{\text{number of radon atoms per cubic metre}}{\text{number of air molecules per cubic metre}},$$

given that 1.0 mol of air in the building is contained in 0.024 m^3.

      [4]

(d) Suggest why the presence of radon gas in buildings is of environmental importance. [2]

[Turn over

Section B

Answer **two** questions in this Section.

One question is set on each of the seven optional topics, namely

Option A, Astrophysics and Cosmology,
Option C, The Physics of Materials,
Option E, Electronics,
Option F, The Physics of Fluids,
Option M, Medical Physics,
Option P, Environmental Physics,
Option T, Telecommunications.

You may choose any **two** of the questions.

Option A

Astrophysics and Cosmology

7 **(a)** A galaxy has been discovered which is 1.2×10^{10} light-years away from Earth.

Briefly describe what is meant by

(i) a galaxy,

(ii) a light-year.

[4]

(b) The galaxy in **(a)** was discovered using an instrument in Earth orbit. Suggest why this galaxy could not be detected at the surface of the Earth. [3]

(c) A value accepted by some astronomers for the Hubble constant H_0 is $2.6 \times 10^{-18}\,s^{-1}$.

(i) Suggest why there is doubt as to the value of the Hubble constant.

(ii) Using the value of H_0 given above, calculate the critical density of matter in the Universe.

(iii) For the critical density calculated in **(ii)**, estimate the average number density of nucleons in the Universe.

(iv) Suggest the fate of the Universe if the actual mean density exceeds the critical value.

[8]

Option C

The Physics of Materials

8 **(a)** Explain, with the aid of diagrams where appropriate,

  (i) what is meant by a *dislocation* in a lattice structure,

  (ii) why a dislocation in an otherwise perfect lattice moves easily,

  (iii) why a large number of dislocations in a material may increase its strength and hardness.

[7]

  (b) Some modern cars are constructed with a strong metal cage surrounding the passenger compartment as illustrated in Fig. 8.1.

metal cage
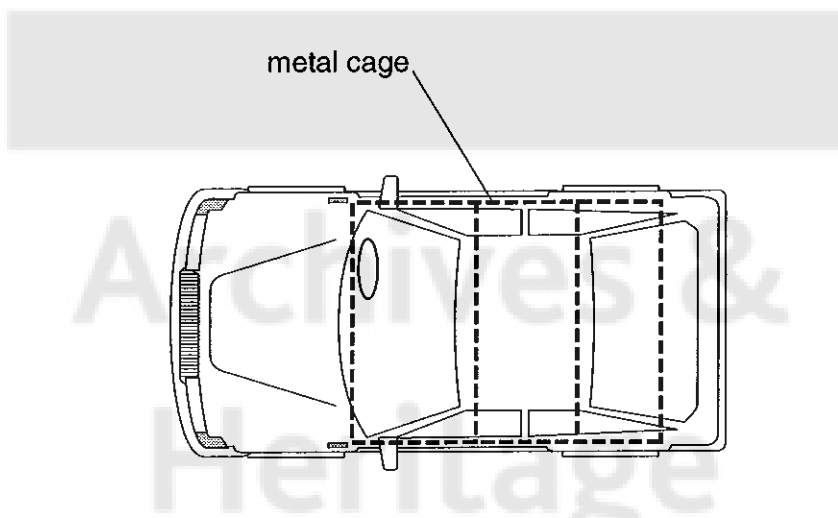
Fig. 8.1

The front and rear sections of the car are designed to be tough but not stiff.

  (i) Explain what is meant by a *strong* material and suggest a suitable metal for the construction of the cage.

  (ii) Suggest why

   1. the front and rear sections are *tough* but not *stiff*,

   2. there is little protection for passengers when the car is hit side-on.

[8]

[Turn over

Option E

Electronics

9 (a) Fig. 9.1 shows an inverting amplifier circuit incorporating an ideal operational amplifier (op-amp).
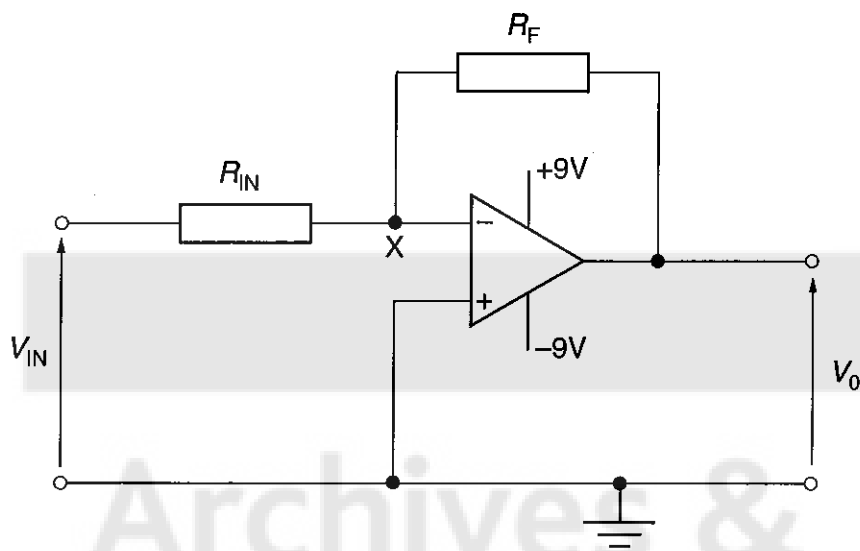
Fig. 9.1

(i) 1. Explain why the potential at point X is approximately 0 V unless the op-amp is saturated.

2. Derive an expression for the gain of the amplifier circuit in terms of the input resistance R_{IN} and the feedback resistance R_F.

(ii) In one particular application of the circuit, the gain of the amplifier is −10. State the value of the output voltage V_0 when the input voltage V_{IN} is

1. +0.1 V,

2. −1.0 V.

[8]

(b) A student designed the circuit of Fig. 9.2 in order to compare two logic states represented by X and Y.
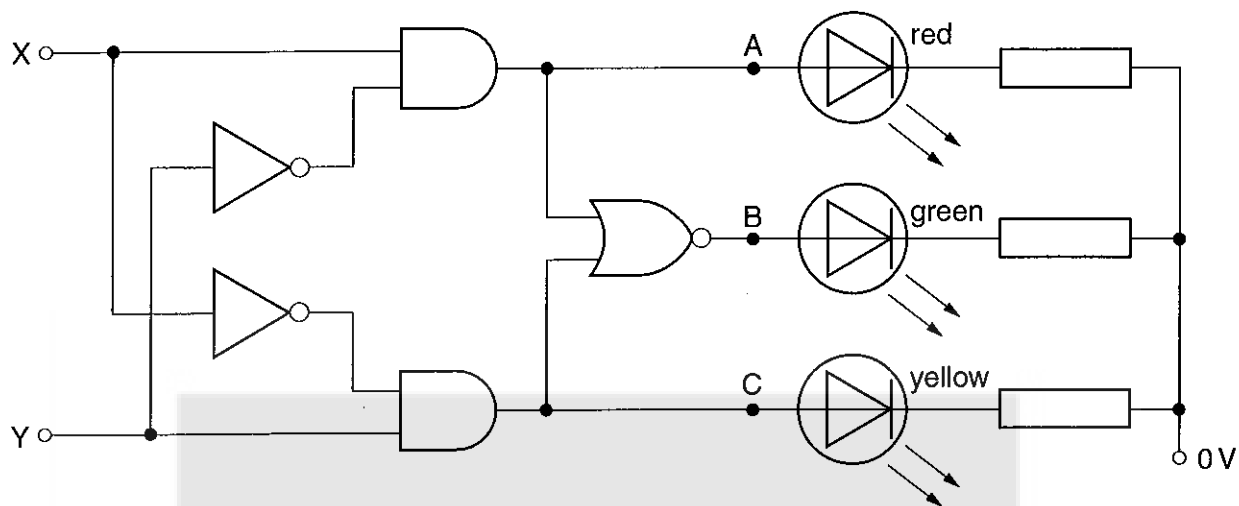
Fig. 9.2

(i) Copy Fig. 9.3 and complete the truth table for the logic outputs A, B and C.

X	Y		A	B	C
0	0				
0	1				
1	0				
1	1				

Fig. 9.3

(ii) Hence state which LED, red, green or yellow, will conduct when

1. $X < Y$,

2. $X = Y$,

3. $X > Y$.

(iii) Draw the symbol of the single logic gate which would produce the same output as that detected at B.

[7]

[Turn over

Option F

The Physics of Fluids

10 (a) Outline the necessary conditions for a ship to

   (i) float,

   (ii) remain stable.

[3]

(b) An incompressible fluid of density ρ moves with streamline flow through a horizontal pipe as indicated in Fig. 10.1.
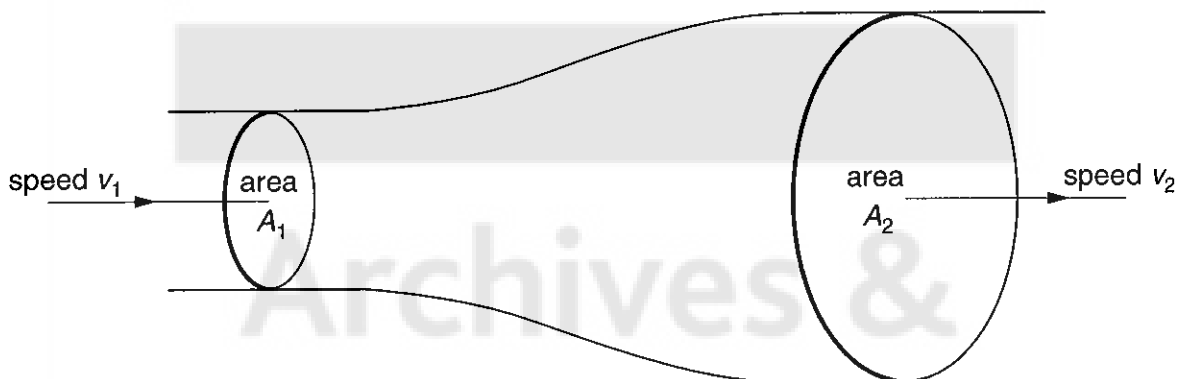
Fig. 10.1

The fluid enters the pipe of area of cross-section A_1 with speed v_1 and leaves through a cross-sectional area A_2 at speed v_2. The pressure of the fluid on entering the section of pipe is p_1 and on leaving is p_2.

   (i) Show that, for a section of pipe with uniform cross-sectional area A, where the streamline flow of the fluid has speed v,

   1. the mass of fluid flowing per unit time is $\rho A v$,

   2. the energy transfer per unit time in the fluid is pAv, where p is the fluid pressure.

   (ii) **1.** Using the expressions in **(i)**, derive the simplified Bernoulli equation

   $$p_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \tfrac{1}{2}\rho v_2^2.$$

   2. State one assumption made in deriving the expression in **(ii)1**.

[8]

(c) The drag force F_D on a car moving at speed v through air of density ρ is given by the expression

$$F_D = \tfrac{1}{2}C_D\rho A v^2,$$

where A is the effective cross-sectional area of the car and C_D is the drag coefficient.

   (i) A certain car requires a power of 50 kW to travel along a horizontal road through still air at 100 km h^{-1}. Give a quantitative explanation as to why the power required is considerably greater when travelling into a head-wind of 10 km h^{-1}.

   (ii) Suggest two reasons why car manufacturers strive to design cars with a low value for C_D.

[4]

Option F

Medical Physics

11 (a) Briefly outline one use of each of the following in medical diagnosis.

    (i) X-rays

    (ii) lasers

[6]

(b) (i) Explain how the eye forms focused images of objects which are at different distances from the eye.

    (ii) Estimate the change in optical power of the eye when the eye focuses firstly on a point 30 cm from the eye and then on a distant star.

[5]

(c) (i) Define *intensity level* for a sound of intensity I.

    (ii) A student states that intensity level is a measure of the loudness of a sound. Comment briefly on whether this statement is correct.

[4]

[Turn over

12 (a) (i) Outline the principles of the fission process.

(ii) Suggest two forms of energy into which the nuclear energy of the fission of a single nucleus is converted.

(iii) Briefly describe the purpose of the moderator in a nuclear reactor.

[7]

(b) Fig. 12.1 shows an idealised indicator diagram for a petrol engine.
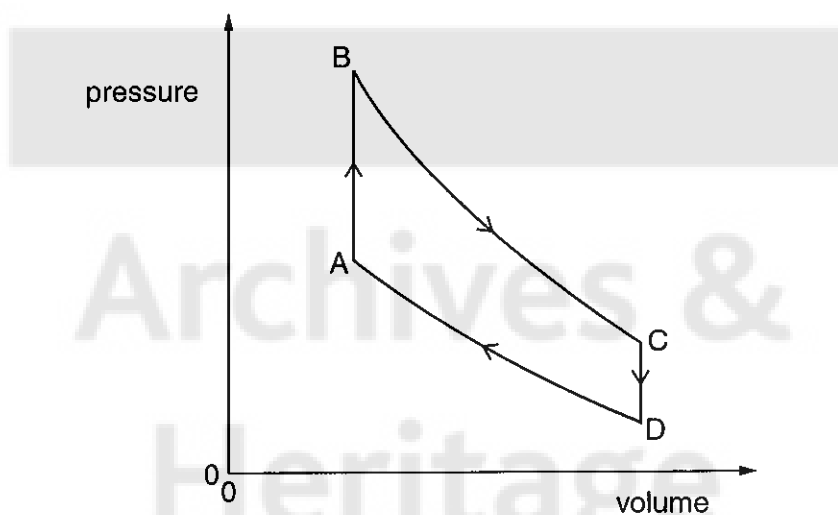
Fig. 12.1

In one particular cycle, 380 J of energy is supplied when the fuel is burned and 180 J is lost in the exhaust gases.

By reference to Fig. 12.1,

(i) identify that part of the cycle which represents the burning of the fuel,

(ii) calculate

1. the energy represented by the area of the loop ABCD,

2. the efficiency of the engine.

[4]

(c) Briefly outline two forms of pollution associated with the use of cars, other than exhaust gases and noise. [4]

Option T

Telecommunications

13 (a) An analogue signal is sampled at a frequency of 18 kHz so that it may be transmitted in digital form. Each sample is converted into a 5-bit number, each bit lasting 0.5 μs.

(i) State what is meant by a *digital* signal.

(ii) Calculate the time interval between the end of one 5-bit number and the start of the next.

(iii) Suggest one use to which the time intervals calculated in **(ii)** could be put.

(iv) The maximum signal frequency which can be transmitted and de-coded successfully is 9 kHz for a sampling rate of 18 kHz. Suggest the effect on the transmitted signal after decoding if the signal to be sampled contains frequencies greater than 9 kHz.

[7]

(b) A transmitter sends out a signal of power 60 mW. The signal is transmitted along a cable of length 140 km having an attenuation per unit length of 2.3 dB km^{-1}. The receiver operates for a minimum signal power at its input of 6.0 μW.

(i) Calculate the loss in signal power along the cable.

(ii) The ratio of two powers P_1 and P_2 is expressed as a number of decibels (dB) according to

$$\text{number of dB} = 10 \lg \left(\frac{P_1}{P_2} \right).$$

Calculate the ratio, in dB of

$$\frac{\text{minimum input power to receiver}}{\text{transmitted power}}.$$
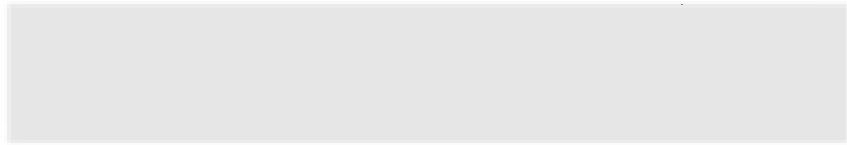
(iii) Hence determine the minimum number of repeater amplifiers, each of gain 75 dB, which must be situated along the cable so that the received signal power is sufficient.

[5]

(c) 'Satellite TV' uses geostationary satellites for regional transmissions. Explain briefly what is meant by a *geostationary* satellite. [3]

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RECOGNISING ACHIEVEMENT

General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS   **9244/4**

Paper 4 Practical Test (Alternative A)

Wednesday	**24 MAY 2000**	· Morning	3 hours

Candidates answer on the question paper.
Additional materials:
    As listed in Instructions to Supervisors
    Answer paper
    Electronic calculator
    Graph paper

TIME   3 hours

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 **all** questions.

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

In Questions 1 and 2, 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, for their suitability and accuracy, and for the use made of them.

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

INFORMATION FOR CANDIDATES

Questions 1 and 2 carry the same number of marks.

You will be allowed one hour only with the apparatus for each of Questions 1 and 2.

Questions 3 and 4 together carry about the same number of marks as either Question 1 or Question 2.

Squared paper and Mathematical tables are available.

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

You are advised to spend approximately one hour on each of Questions 1 and 2 and 30 minutes on each of Questions 3 and 4.

You are reminded of the need for good English and clear presentation in your answers.

FOR EXAMINER'S USE	
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2	
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TOTAL	

This question paper consists of 11 printed pages, 1 blank page and 4 lined pages.

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It is recommended that you spend about 60 minutes on this question.

1   In this experiment, you will investigate how the period of oscillation of a V-shaped pendulum changes as the distance between the supports is changed.

    (a)   **(i)**   Thread a pendulum bob on to a piece of string and tie the ends of the string together so that a loop is formed. The length of string in the loop should be approximately 180 cm.

       (ii)   Measure and record the length L of string in the loop.

      (iii)   Suspend the loop on horizontal rods so that the pendulum bob hangs vertically below the mid-point between the rods as shown in Fig. 1.1. The rods should be parallel and the section of the loop of length d should be horizontal.
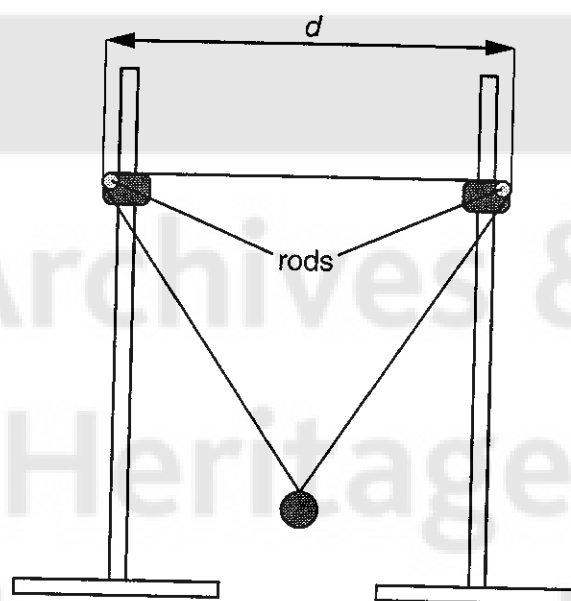
Fig. 1.1

    (b)   **(i)**   Measure and record the distance d.

       (ii)   Gently displace the bob from its equilibrium position and release it so that it performs small oscillations. Make and record measurements to determine the period T of these oscillations.

      (iii)   Change the value of d by moving the stands and repeat **(i)** and **(ii)** until you have six sets of values for d and T where d is in the range 30 cm $< d <$ 80 cm. Include values of T^4 in your table of results.

    (c)   The equation which relates T and d for this oscillator is

$$T^4 = \frac{4\pi^4 L}{g^2}(k - 2d)$$

where g is the acceleration of free fall and k is a constant.

    (i)   Plot a graph of T^4 (y-axis) against d (x-axis).

    (ii)   Determine the gradient and the y-intercept of the graph.

    (iii)   Use your answers from **(ii)** to find values for g and k. Include appropriate units in each case.

(d) An amusement ride in a fairground consists of a harness suspended at the end of a large V-shaped steel cable. The harness (with the riders securely strapped in) is raised by a winch and then released. The harness then performs large amplitude oscillations. The arrangement is shown in Fig. 1.2.

Fig. 1.2

Give one reason why the equation in **(c)** may not be suitable for describing the behaviour of this fairground ride.

Measurements and calculations

For
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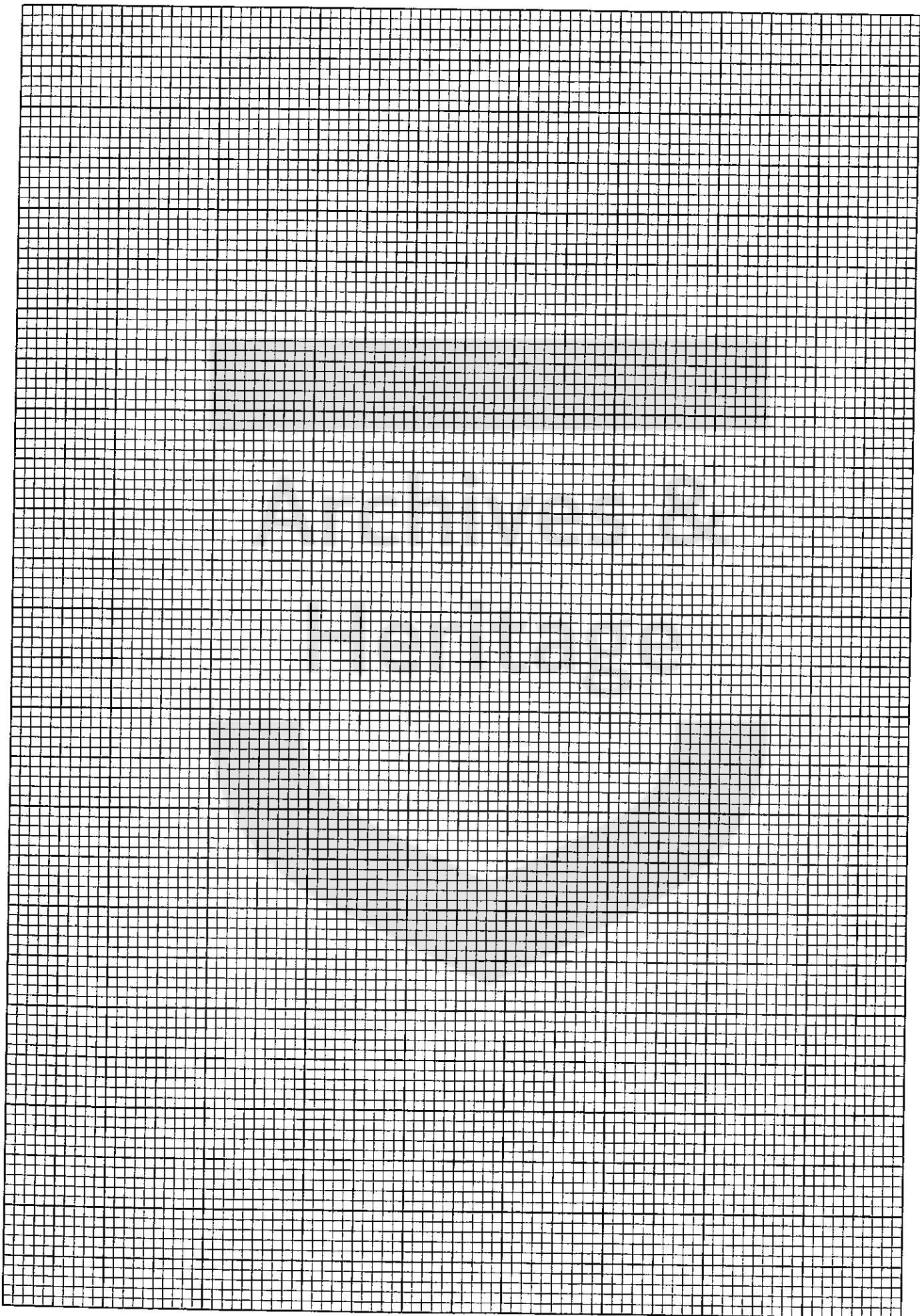
It is recommended that you spend about 60 minutes on this question.

2 In this experiment, you will investigate how the current through a milliammeter varies as the resistance of a resistor is changed.

(a) Connect the circuit shown in Fig. 2.1. You should not attempt to adjust the output voltage from the power supply unit.
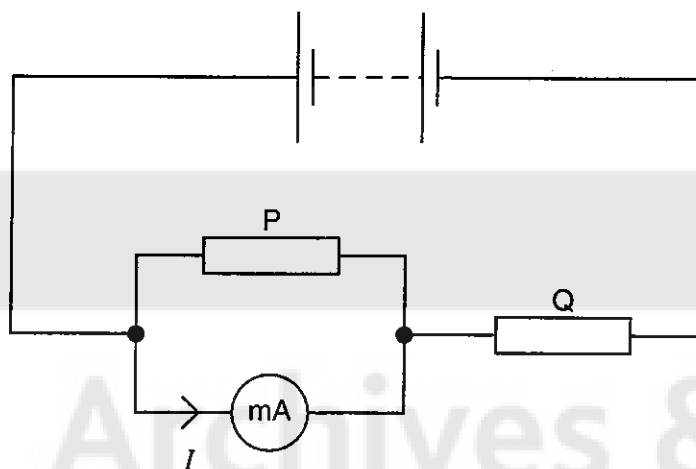
Fig. 2.1

Resistor Q is labelled. The resistor P may be selected from any of the other six resistors supplied.

(b) (i) Record the current I through the milliammeter and the resistance R of P.

(ii) Change the resistor P and repeat (i) until you have six sets of readings for I and R. Include values of $1/I$ and $1/R$ in your table of results.

(iii) Justify the number of significant figures which you have given for $1/I$.

(c) I and R are related by the equation

$$\frac{1}{I} = \frac{rs}{ER} + c$$

where r is the resistance of the resistor Q (written on a card), s is the effective resistance of the milliammeter, E is the e.m.f. of the power supply and c is a constant.

(i) Plot a graph of $1/I$ (y-axis) against $1/R$ (x-axis).

(ii) Determine the gradient and the y-intercept of the graph.

(iii) Use one of your answers from (ii) to find c.
You should include an appropriate unit with your value.

(d) (i) Construct the circuit shown in Fig. 2.2.
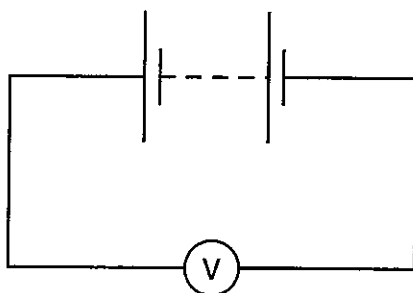
Fig. 2.2

(ii) Measure and record a value for the e.m.f. *E* of the power supply.

(iii) Use this value, together with the gradient of your graph, to determine a value for the effective resistance of the milliammeter.

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Measurements and calculations

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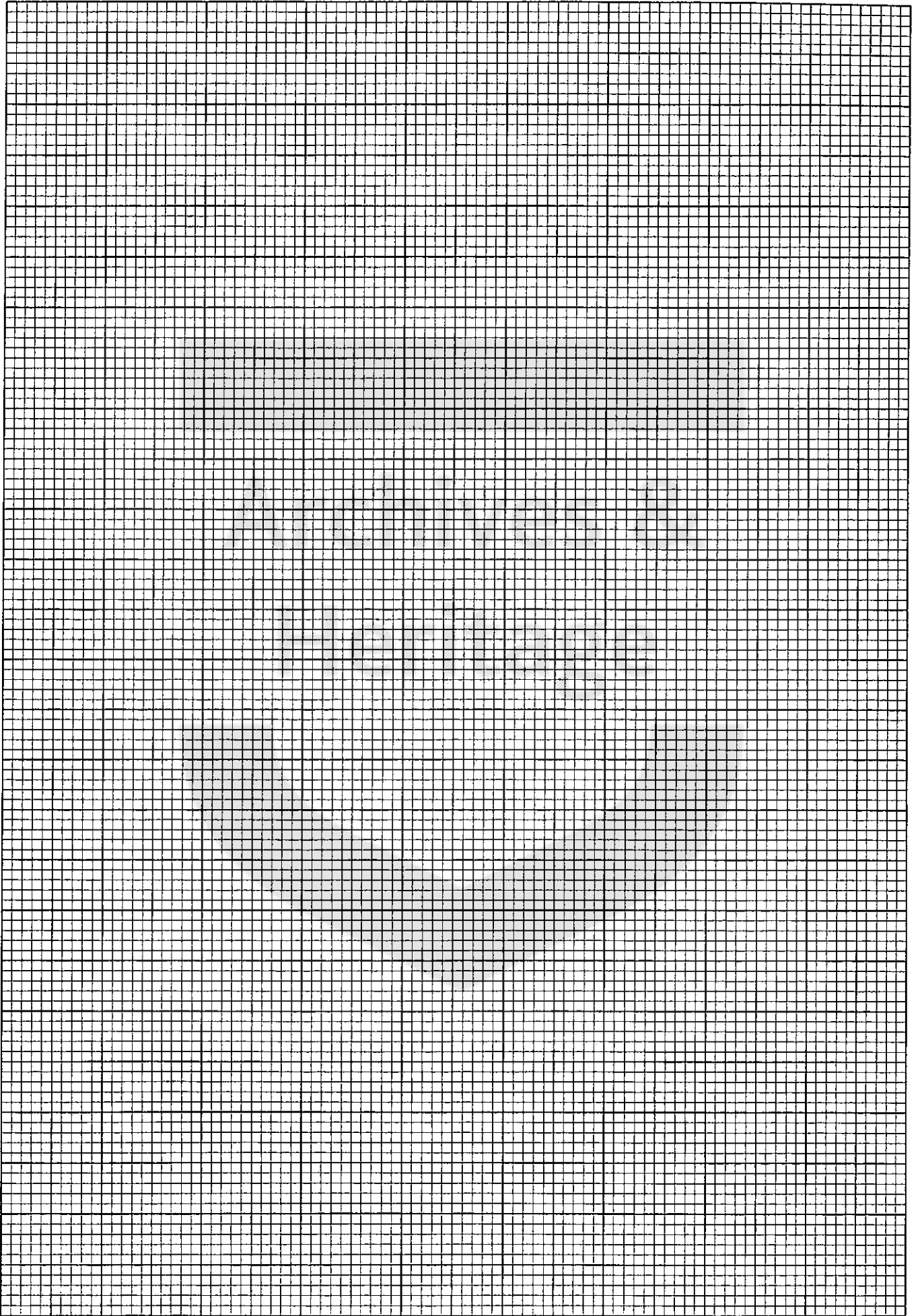
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It is recommended that you spend about 30 minutes on this question.

3   It is predicted that the average temperature of the Earth will increase by a few degrees over the next few hundred years. One consequence of this is that sea levels will rise due to

   (i)   melting of the Antarctic ice cap,

   (ii)   expansion of water in the oceans.

In order for scientists to make any kind of estimate of how much the levels will rise, it is necessary to know how much expansion will occur for a given rise in temperature.

Design a laboratory experiment to investigate how the volume of a given amount of water changes with temperature. It is known that the increase in volume per degree temperature rise is very small.

You should make use of the flask and capillary tubing shown in Fig. 3.1.

glass capillary tubing

glass flask
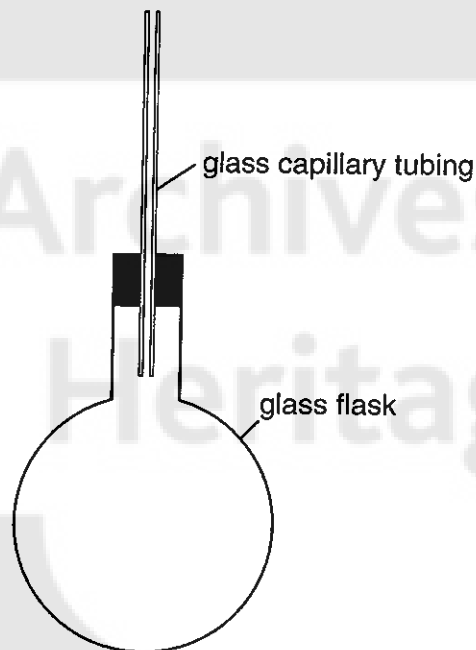
Fig. 3.1

You may assume that the following equipment is available in addition to the standard equipment which may be found in a school or college science laboratory.

Top-pan balance	Oscilloscope
Micrometer screw gauge	Low voltage power supply
Vernier calipers	Signal generator
Metre rule	Water bath
Microscope with scale	Ammeter
Thermocouple thermometer	Mercury-in-glass thermometer
Measuring cylinder	Stopwatch

In your account, you should pay particular attention to

(a)   how the initial volume of water would be accurately measured (you may assume that the density of water at the starting temperature is known),

(b)   the method of accurately measuring the increase in volume of the water for a given temperature rise,

(c)   the precautions which should be taken to ensure that the water is at a uniform temperature when measurements are made.
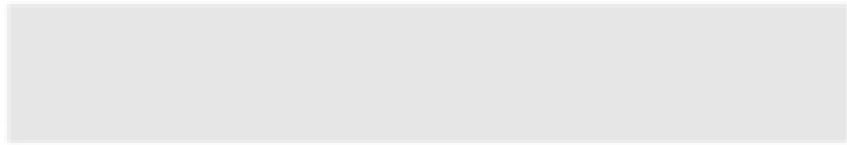
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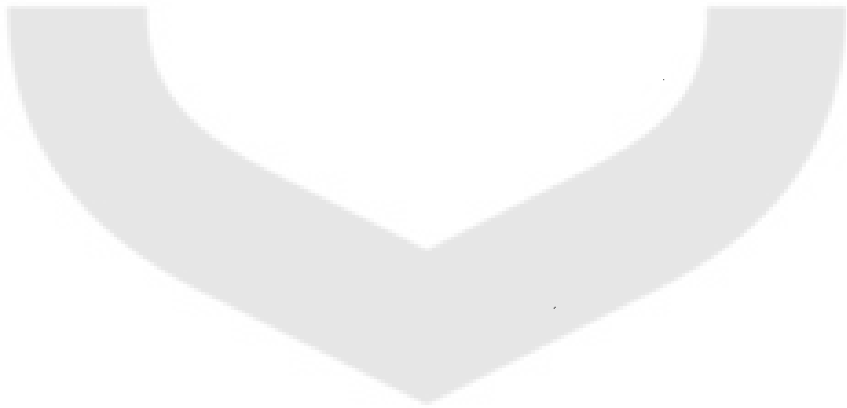
It is recommended that you spend about 30 minutes on this question.

4   When a sound is produced in a large hall, multiple reflections occur at the walls. It can take an appreciable time for the reflections to die away. This effect is known as reverberation, and sometimes leads to poor quality acoustics if care is not taken in the design of the hall.
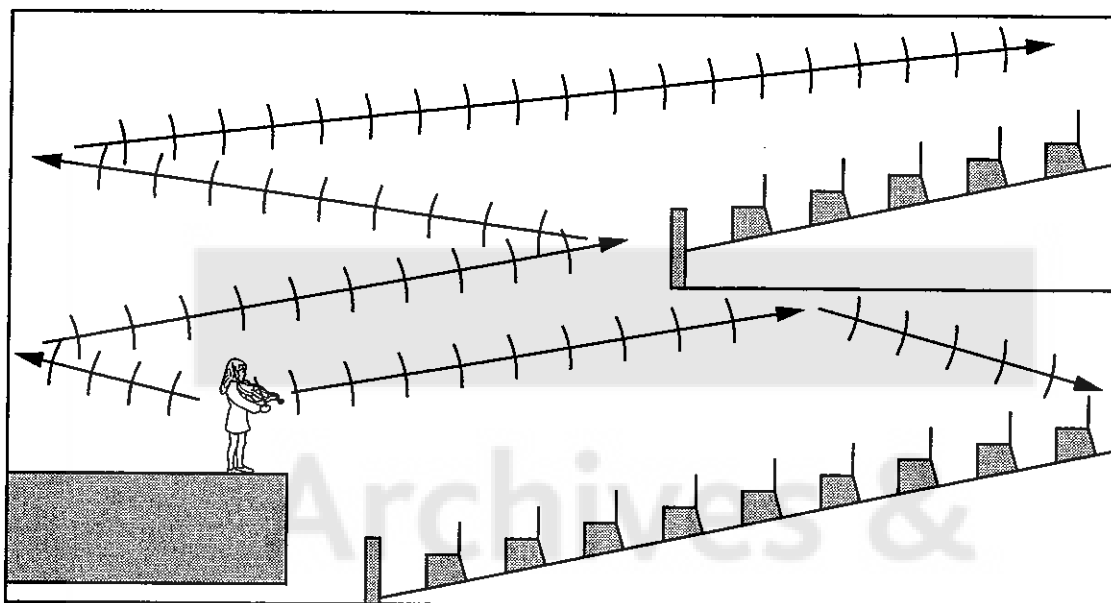
Fig. 4.1

One way of reducing reverberation is to use sound-absorbing materials for the seating and walls of the hall. It is known that the absorption of sound is frequency-dependent.

Design an experiment to investigate how the amplitude of the reflected sound from a particular surface depends upon the frequency of the incident sound. You should draw a diagram showing the arrangement of apparatus you would use. In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the method of measuring the frequency of the incident sound,

(c) the method of measuring the amplitude of the reflected waves.
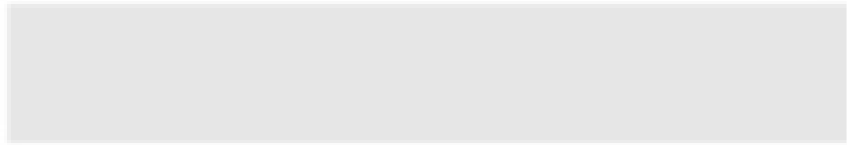
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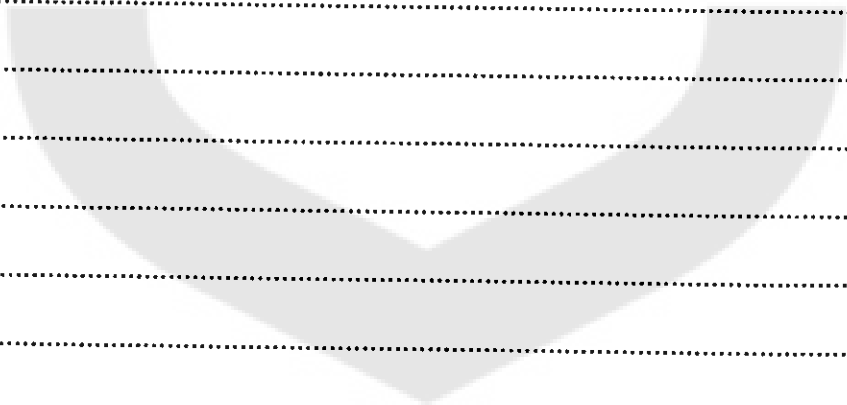
General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS

9244/4

PAPER 4 Practical Test (Alternative A)

INSTRUCTIONS

| Wednesday | **24 MAY 2000** | Morning | 3 hours |

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

These instructions consist of 8 printed pages.

[Turn over

Instructions for preparing apparatus

These instructions detail the apparatus required for each experiment in this paper. A summary of the questions that will be presented to the candidates is included, to allow the Physics teacher to test the apparatus appropriately. No access is permitted to the question paper in advance of the examination session.

The following suppliers have been notified of the special items of apparatus required. These items are indicated by the presence of catalogue numbers on the following pages.

RS Components
PO Box 99
Corby
Northants
NN17 9RS
United Kingdom

Number of sets of apparatus

In addition to a few spare sets, the minimum number of sets of apparatus to be provided should be sufficient for half the candidates to carry out each experiment simultaneously.

A possible scheme for organising the exercise is this. Half the candidates start on Question 1, for one hour, and the other half on Question 2. The candidates then move to the other experiment for one hour. The order in which candidates answer these questions will be determined by the Supervisor. The final hour would be spent on the design questions.

Candidates should be advised in advance that they will have access to the apparatus for each experiment for one hour only.

Extra graph paper and Mathematical Tables should be available. It is assumed that candidates will supply their own geometrical instruments, such as a set square, 0° to 180° protractor, pair of compasses and 30 cm rule. Candidates should be advised, in advance, that they may, if they wish, use quartz wristwatches with stopwatch facilities, providing that such wristwatches afford the required precision.

Instructions for the supervision of the examination

The Supervisor, who may be a Physics teacher, is responsible for the administration of the examination according to the procedures detailed in the Handbook for Centres. In all instances, a Physics teacher should be present. Preferably, this teacher should have been responsible for the preparation of the apparatus. Two invigilators must be present at all times: it is not acceptable for a teacher who has been responsible for preparing the candidates for this paper to be the sole Supervisor or Invigilator.

Supervisors may make the following announcement at the start of the examination.

'The Examiners do not want you to waste time when you are unable to do any experiment. Any candidate who is unable to get results with an experiment may ask for help. The extent of this help will be reported to the Examiners, who may make a deduction of marks.'

Supervisors should note that a candidate may only be given enough assistance to allow some raw readings or observations to be made. On no account should any assistance be given with the treatment or analysis of these readings and observations.

Supervisors may draw to the attention of the candidates any significant deviation between the apparatus provided and that detailed in the question paper, particularly where diagrams are given in the paper.

Candidates should be reminded that all their work should be written on the printed Question Paper. Rough paper must not be used.

The Supervisor must complete the Report on the back page of these instructions. Details should be given of any significant deviation between the apparatus used and that specified in these Instructions. A sample set of results can often help Examiners. A copy of this Report must be included in *each* packet of scripts.

Question 1

Candidates will be required to perform an experiment to investigate how the period of oscillation of a V-shaped pendulum changes as the distance between the supports is changed.

Apparatus requirements (per set of apparatus unless otherwise specified).

Pendulum bob

Length of string (approximately 2 m)

Scissors

Metre rule

Two stands & bosses

Two short lengths (approximately 15 cm) of dowelling

Stopwatch reading to 0.1 s or better

The pieces of dowelling should be mounted horizontally about 20 cm above the bench using the stands and bosses. It may be necessary to place weights on the bases of the stands in order to prevent unwanted movement during the experiment. Candidates should be advised of the purpose of these weights.

The remainder of the apparatus should be laid on the bench. If the apparatus is to be used by a second candidate then it should be disassembled and restored to its original state. A new length of string must be supplied.

Procedure to be followed by candidates

Candidates will be required to assemble the apparatus as shown in Fig. 1.1. The section of the loop of length *d* should be horizontal and the pendulum bob should hang vertically below the mid-point between the rods. The total length of string in the loop should be about 1.8 m.
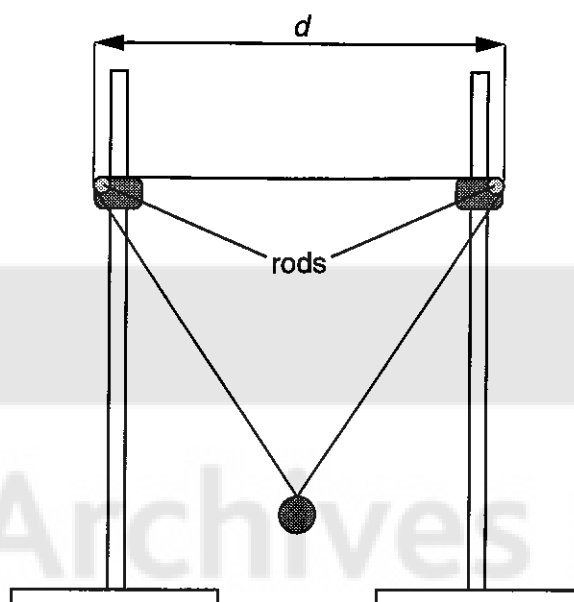
Fig. 1.1

The pendulum should be displaced slightly from its rest position so that it performs small oscillations when released. Candidates will be required to determine the period *T* of these oscillations for values of *d* in the range 30 cm < *d* < 80 cm. A graph of T^4 vs *d* should give a straight line which does not pass through the origin.

Information required by Examiners

Sample set of results, including the graph.

Question 2

Candidates will be required to construct a circuit which will be used to determine the effective resistance of a milliammeter.

Apparatus requirements (per set of apparatus unless otherwise specified).

Selection of 0.66 W carbon film resistors as detailed below:

Number required	Resistance/Ω	RS stock number
1	10	132–012
1	15	132–056
1	22	132–090
3	47	132–179
1	100	132–258
1	220	132–337

One of the 47 Ω resistors must be clearly labelled Q. Another 47 Ω resistor should be attached to a milliammeter (as detailed below). All the other resistors, used separately as resistor P in Fig. 2.1, must carry labels giving the resistance of each resistor. Candidates are not expected to know the colour coding for resistors.

Analogue milliammeter, range 0–100 mA. The resistance of this meter should be less than 5 Ω. One terminal of the milliammeter must be covered so that candidates cannot make connections to it directly. A 47 Ω resistor must be connected to this terminal. The markings on this resistor should be hidden from the candidates by the use of masking tape. The other end of this resistor should be attached to a crocodile clip (or a suitable alternative) so that candidates may make a connection to the resistor without difficulty.

Card on which is written 'The resistance of resistor Q is 47 Ω.'

Low voltage d.c. power supply. The output of this supply should be fixed at 9.0 V. Candidates must not be able to adjust the output voltage.

Analogue or digital voltmeter. Range 0–10 V or 0–12 V.

Two component holders to mount carbon film resistors. If component holders are not available then some other method may be used provided candidates are able to make connections to the resistors without difficulty.

Sufficient connecting wires to enable candidates to assemble the circuit shown in Fig. 2.1.
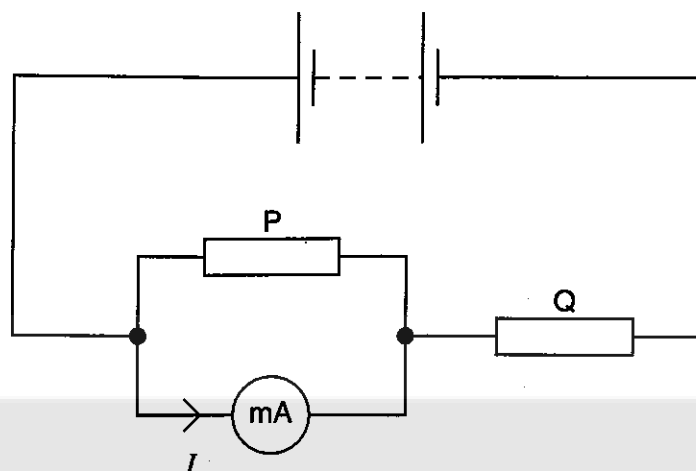
Fig. 2.1

The circuit must not be assembled. If candidates require assistance in constructing the circuit then details of the help which has been given must be recorded on this Report in the usual way and sent with the scripts.

If the apparatus is to be used by a second candidate then the circuit must be dismantled and the equipment laid out on the bench ready for the next candidate to use.

Procedure to be followed by candidates

Candidates will be required to construct the circuit shown in Fig. 2.1 and use it to obtain a series of readings of current I through the milliammeter as the resistance R of resistor P is changed (using each resistor singly). A graph of $1/I$ vs $1/R$ should give a straight line which does not pass through the origin.

Candidates will also be required to use the voltmeter to measure the e.m.f. of the power supply.

Information required by the Examiners

Sample set of results, including the graph.

NOTE: Questions 3 and 4 are design exercises and do not require apparatus.

This form should be completed and sent to the Examiner with the scripts.

REPORT ON PRACTICAL PHYSICS

General Certificate of Education Advanced Level

JUNE 2000

General

If the scripts are to be despatched in more than one envelope it is essential that a copy of this form is enclosed in each envelope with the details requested.

The Supervisor is invited to give details, on the reverse of this form, of any difficulties experienced by particular candidates, giving names and index numbers. These should include reference to:

(a) accidents to apparatus or materials;

(b) any other information that is likely to assist the examiner, especially if this cannot be discovered in the scripts;

(c) any help given to a candidate.

Other cases of individual hardship, e.g. illness, disability, should be reported direct to OCR on the normal 'Special Consideration' form.

In cases of faulty apparatus (not arising from a candidate's mishandling) which prevent the required readings being taken, the following action is permissible.

The Invigilator – in consultation with the Physics teacher responsible for preparing the examination – may allow extra time to give the candidate a fair opportunity of performing the experiment as if the fault had not been present. The candidate should use a spare copy of the Question Paper when the fault has been rectified or when working with a second set of apparatus. The Invigilator is asked to provide OCR with details of such cases of time compensation (a copy being enclosed with the scripts), including, in particular

(i) the candidate's name and index number,

(ii) the extra time allowed,

(iii) notes on the nature of the fault, the action taken to rectify the difficulty and any other comments which would be helpful to the Examiner in making a fair assessment of the candidate's work during the practical examination.

A list, by name and index number, of candidates requiring help, with details of help provided

Declaration (to be signed by the Principal)

The preparation of this practical examination has been carried out so as to maintain fully the security of the examination.

Signed ....

Centre No. ....

Name of Centre ....

OCR ✫

RECOGNISING ACHIEVEMENT

General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS   **9244/5**

Paper 5 Practical Test (Alternative B)

Wednesday	**28 JUNE 2000**	Morning	3 hours

Candidates answer on the question paper.
Additional materials:
  As listed in Instructions to Supervisors
  Answer paper
  Electronic calculator
  Graph paper

TIME   3 hours

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 **all** questions.

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

In Questions 1 and 2, 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, for their suitability and accuracy, and for the use made of them.

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

INFORMATION FOR CANDIDATES

Questions 1 and 2 carry the same number of marks.

You will be allowed one hour only with the apparatus for each of Questions 1 and 2.

Questions 3 and 4 together carry about the same number of marks as either Question 1 or Question 2.

Squared paper and Mathematical tables are available.

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

You are advised to spend approximately one hour on each of Questions 1 and 2 and 30 minutes on each of Questions 3 and 4.

You are reminded of the need for good English and clear presentation in your answers.

FOR EXAMINER'S USE	
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This question paper consists of 12 printed pages, 4 blank pages and 4 lined pages.

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It is recommended that you spend about 60 minutes on this question.

1   In this experiment, you will investigate how the period of oscillation of a metre rule, suspended by an inverted V-shaped piece of string, depends upon the perpendicular distance between the rule and the support.

   (a) (i)   Thread a length of string through the small hole near one end of a metre rule and tie the string firmly to the end of the rule. Do the same at the other end of the rule.

   (ii) Suspend the rule from the rod using the string so that the rule is horizontal as shown in Fig. 1.1.
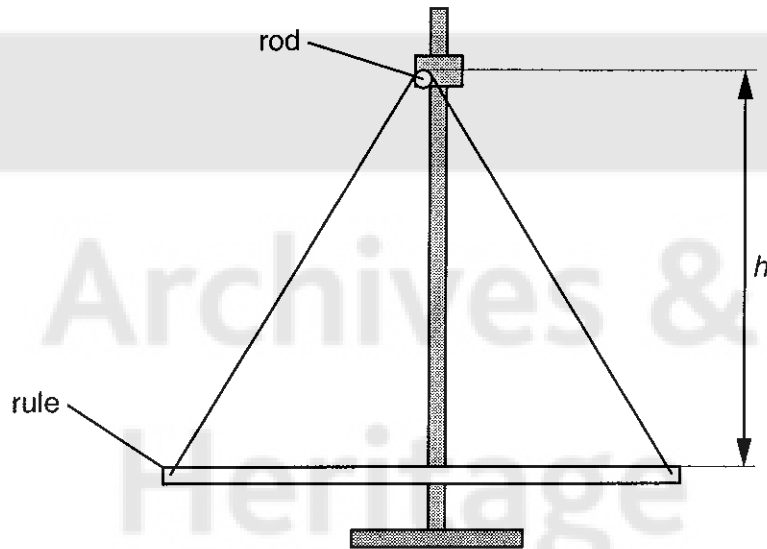
Fig. 1.1

(b) **(i)** Measure and record the perpendicular distance h from the top of the rule to the top of the rod as shown in Fig. 1.1.

(ii) Gently displace the rule from its equilibrium position and release it so that it performs small oscillations in a vertical plane as shown in Fig. 1.2. Make and record measurements to determine the period T of these oscillations.
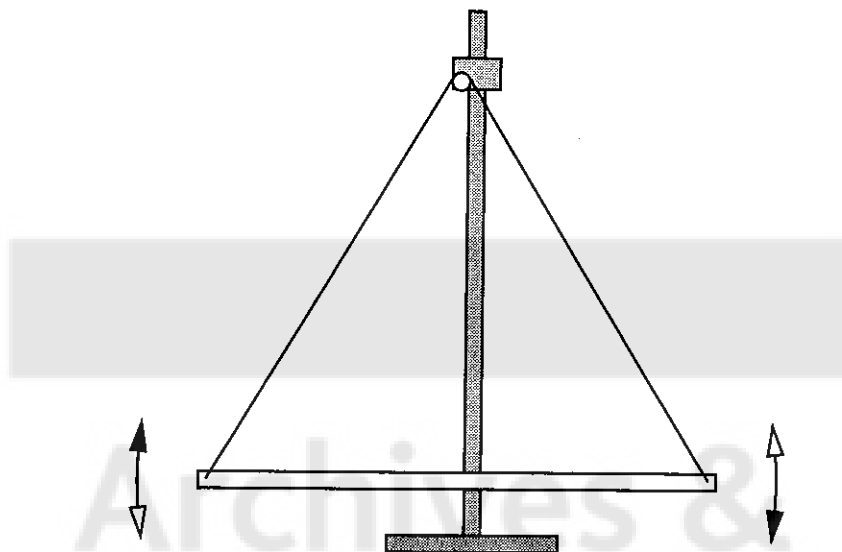
Fig. 1.2

(iii) Cut the string near one of the knots. Change the value of h by reducing the length of string and repeat **(i)** and **(ii)** until you have six sets of readings for h and T where h is in the range $25\,\text{cm} < h < 70\,\text{cm}$. Include values of T^2h and h^2 in your table of results.

(c) The equation which relates T and h for this oscillator is

$$T^2h = \frac{4\pi^2}{g}\,(h^2 + k^2)$$

where k is a constant and g is the acceleration of free fall.

(i) Plot a graph of T^2h (y-axis) against h^2 (x-axis).

(ii) Determine the gradient and the y-intercept of the graph.

(iii) Use your answers from **(ii)** to find the values for k and g. Include appropriate units in each case.

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(d) An amusement ride in a fairground consists of a mock ship suspended by metal rods. The ship and occupants perform large amplitude oscillations as shown in Fig. 1.3.
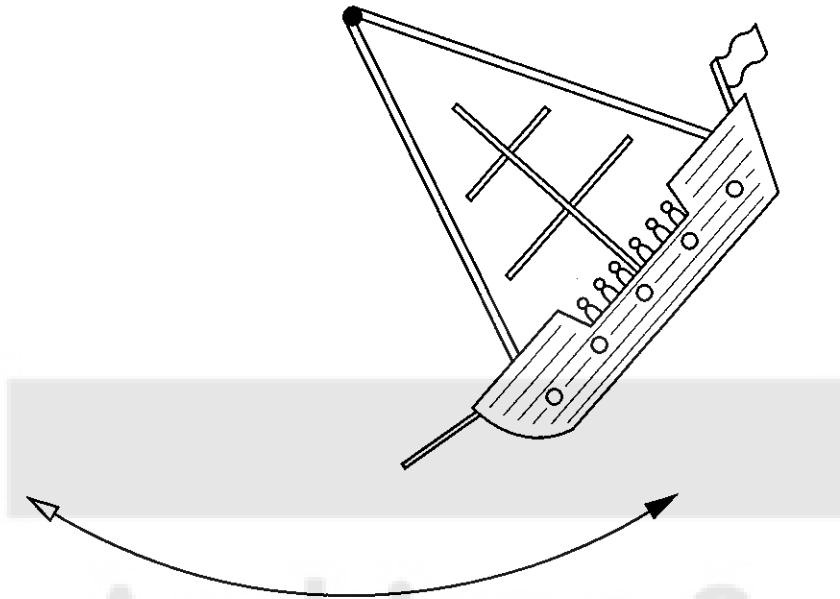
Fig. 1.3

Give one reason why the equation in **(c)** may not be suitable for describing the behaviour of this fairground ride.

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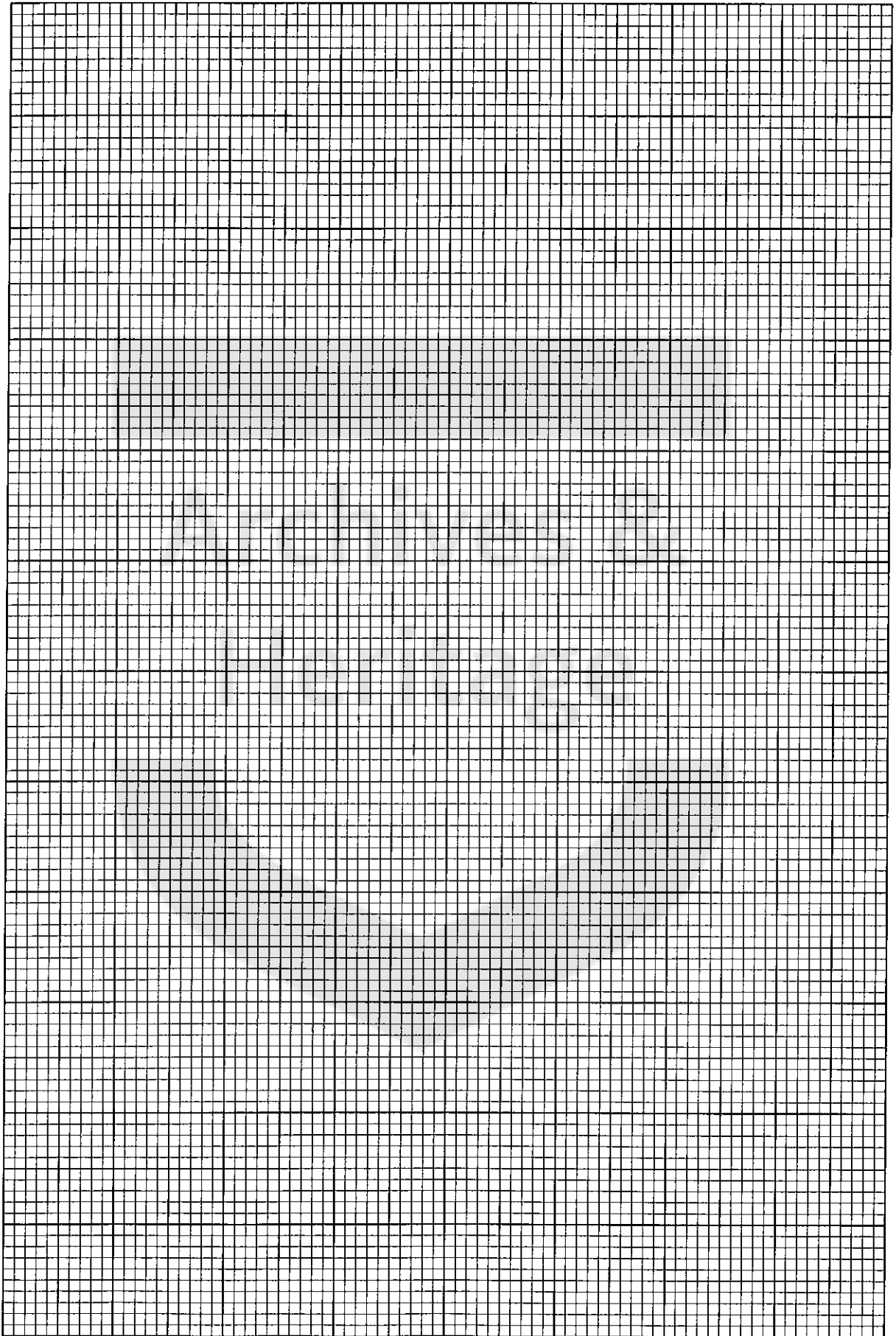
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Measurements and calculations

M

R

A

G

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It is recommended that you spend about 60 minutes on this question.

2   In this experiment you will investigate how the potential difference across a resistor (labelled P in Fig. 2.1) varies as its resistance is changed.

(a)   Connect the circuit shown in Fig. 2.1.
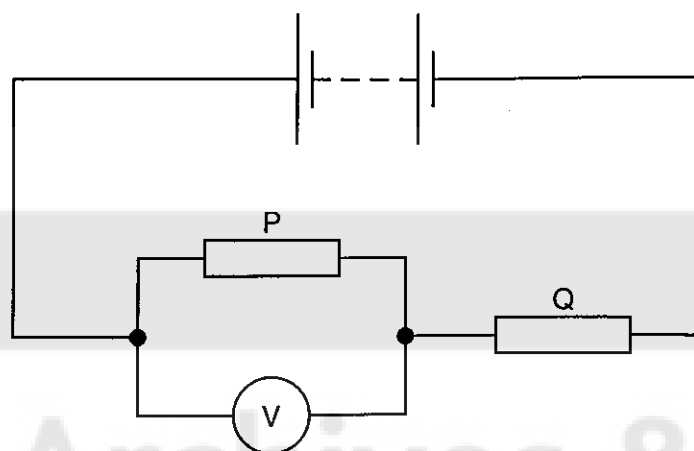
Fig. 2.1

Resistor Q is labelled. The resistor P may be selected from any of the other six resistors supplied.

(b)   (i)   Record the potential difference V across P and the resistance R of P.

(ii)   Change the resistor P and repeat **(i)** until you have six sets of readings for V and R. Include values of $1/V$ and $1/R$ in your table of results.

(iii)   Justify the number of significant figures which you have given for $1/V$.

DO NOT WRITE IN THIS SPACE

(c) V and R are related by the equation

$$\frac{1}{V} = \frac{r}{ER} + c$$

where r is the resistance of the resistor Q (written on a card), E is the e.m.f. of the power supply and c is a constant.

(i) Plot a graph of $1/V$ (y-axis) against $1/R$ (x-axis).

(ii) Determine the gradient and the y-intercept of the graph.

(iii) Use your answers from **(ii)** to find values for E and c.
You should include appropriate units in each case.

(d) Remove the resistor P from the circuit. Measure and record the reading from the voltmeter. Use the new value of V to determine a further value for c.

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Measurements and calculations

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R

A

G

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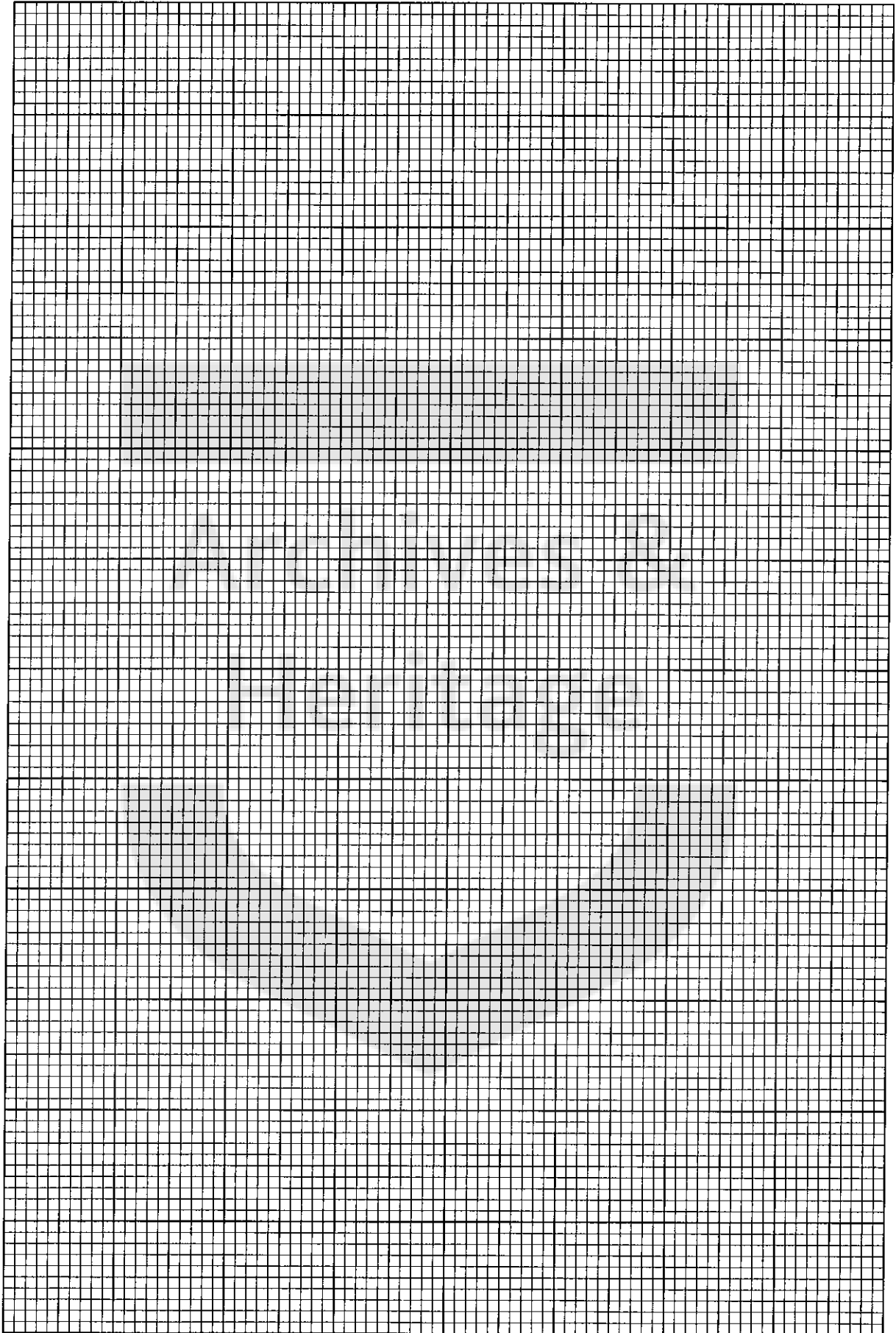
It is recommended that you spend about 30 minutes on this question.

3   A sauna is a room which is maintained at a high temperature and humidity. The humidity can be measured using an instrument known as a hygrometer. The humidity can be increased by pouring a small amount of water on to some hot coals. The water vaporises, the water content of the air increases and hence the humidity increases.
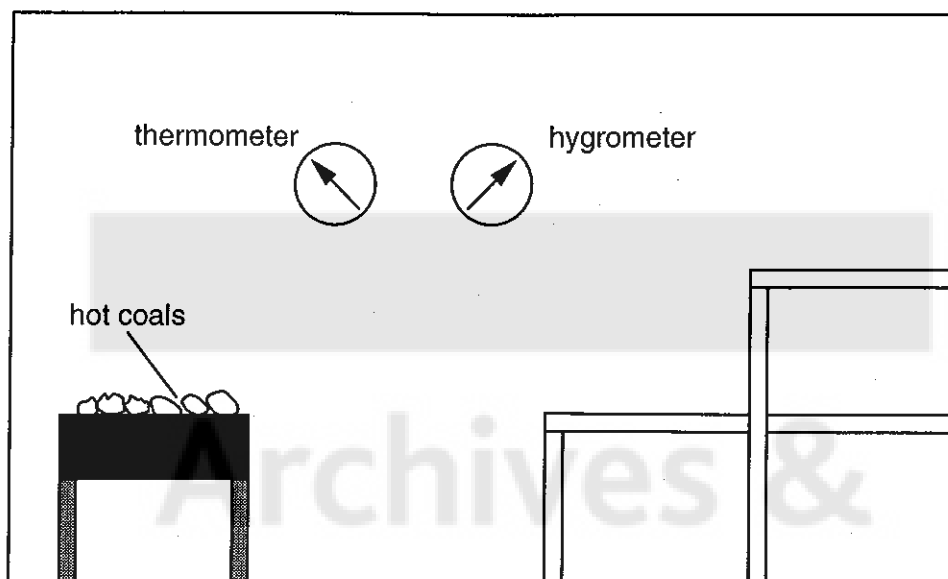
Fig. 3.1

It is necessary to provide a lighting system for the sauna. Two engineers are having a discussion as to how this should be done. The first engineer maintains that since the air in the sauna contains so much water vapour it will be dangerous to use a 240 V mains circuit and therefore a low-voltage system (12 V) should be used. The second engineer thinks that the ability of air to conduct electricity is so low that it will not matter what voltage is used.

Design a laboratory experiment to investigate how the current which passes between two electrodes in air of high humidity varies with the potential difference between the electrodes.

You may assume that the following apparatus is available, together with any other standard equipment which may be found in a school or college science laboratory.

Hygrometer   Connecting wires
Bucket of water   Large glass tank with lid
Vacuum pump   Signal generator
0–500 V power supply unit   Voltmeter
Multimeters   Electrodes
Mercury-in-glass thermometer   Double-beam oscilloscope
Boiler   Various lengths of rubber tubing

You should draw a diagram showing how the apparatus would be arranged. In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the control of variables,

(c) any relevant safety precautions which may need to be taken.

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It is recommended that you spend about 30 minutes on this question.

4   An architect is drawing plans for a block of flats. She is considering what material to use for the floor of each flat. If the material is very dense then there is little transmission of sound from one flat to another, but the building costs are greater because the structure has to support a greater weight.
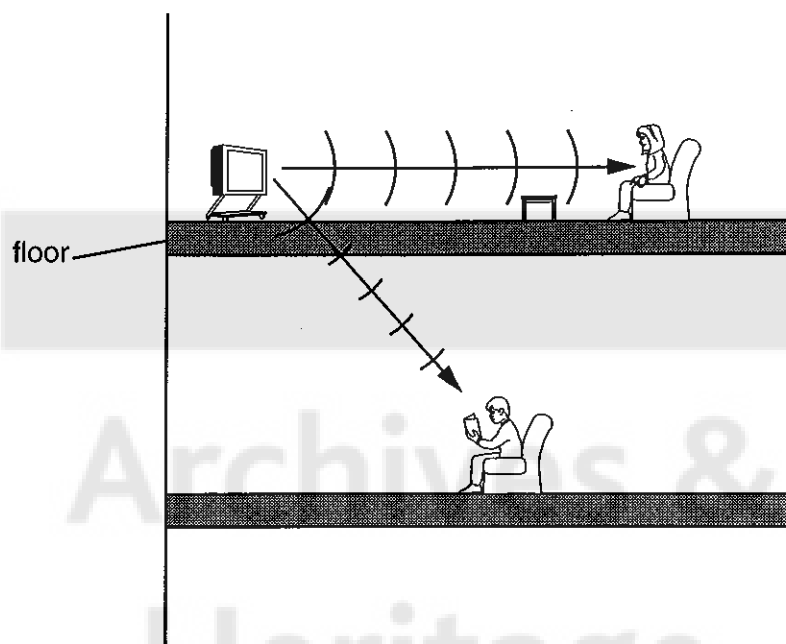
Fig. 4.1

Design an experiment to investigate how the amplitude of transmitted sound through a material depends upon the density of the material.

You should draw a diagram of the experimental arrangement. In your account, you should pay particular attention to

(a) the arrangement of the apparatus,

(b) the procedure to be followed,

(c) the method of measuring the amplitude of the transmitted sound and the density of the material through which it passes,

(d) the control of variables.
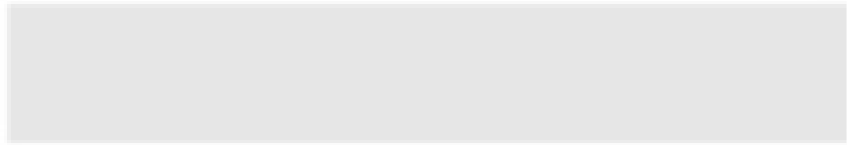
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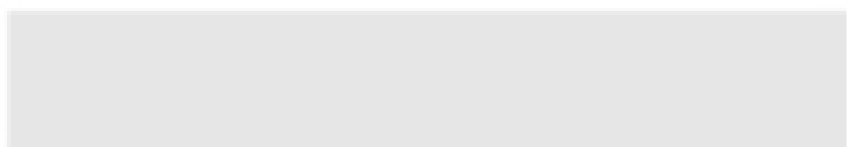
General Certificate of Education Advanced Level

former Cambridge linear syllabus

PHYSICS   **9244/5**

PAPER 5 Practical Test (Alternative B)

INSTRUCTIONS

Wednesday   **28 JUNE 2000**   Morning   3 hours

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

These instructions consist of 8 printed pages.

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Instructions for preparing apparatus

These instructions detail the apparatus required for each experiment in this paper. A summary of the questions that will be presented to the candidates is included, to allow the Physics teacher to test the apparatus appropriately. No access is permitted to the question paper in advance of the examination session.

Number of sets of apparatus

In addition to a few spare sets, the minimum number of sets of apparatus to be provided should be sufficient for half the candidates to carry out each experiment simultaneously. A possible scheme for organising the exercise is this. Half the candidates start on Question 1, for one hour, and the other half on Question 2. The candidates then move to the other experiment for one hour. The order in which candidates answer these questions will be determined by the Supervisor. The final hour would be spent on the design questions.
Candidates should be advised in advance that they will have access to the apparatus for each experiment for one hour only.

Extra graph paper and Mathematical Tables should be available. It is assumed that candidates will supply their own geometrical instruments, such as set square, 0° to 180° protractor, pair of compasses and 30 cm rule. Candidates should be advised, in advance, that they may, if they wish, use quartz wristwatches with stopwatch facilities, providing that such wristwatches afford the required precision.

Instructions for the supervision of the examination

The Supervisor, who may be a Physics teacher, is responsible for the administration of the examination according to the procedures detailed in the Handbook for Centres. In all instances, a Physics teacher should be present. Preferably, this teacher should have been responsible for the preparation of the apparatus. Two invigilators must be present at all times: it is not acceptable for a teacher who has been responsible for preparing the candidates for this paper to be the sole Supervisor or Invigilator.

Supervisors may make the following announcement at the start of the examination. 'The Examiners do not want you to waste time when you are unable to do any experiment. Any candidate who is unable to get results with an experiment may ask for help. The extent of this help will be reported to the Examiners, who may make a deduction of marks.'

Supervisors should note that a candidate may only be given enough assistance to allow some raw readings or observations to be made. On no account should any assistance be given with the treatment or analysis of these readings and observations.

Supervisors may draw to the attention of the candidates any significant deviation between the apparatus provided and that detailed in the question paper, particularly where diagrams are given in the paper.

Candidates should be reminded that all their work should be written on the printed Question Paper. Rough paper must not be used.

The Supervisor must complete the Report on the back page of these instructions. Details should be given of any significant deviation between the apparatus used and that specified in these Instructions. A sample set of results can often help Examiners. A copy of this Report must be included in *each* packet of scripts.

Question 1

Candidates will be required to perform an experiment in which they will measure the period of oscillation of a metre rule suspended by an inverted V-shaped string.

Apparatus requirements (per set of apparatus unless otherwise specified):

Two metre rules. One of the rules should have small holes drilled about 5 mm from each end. The holes should be large enough so that a length of string may be passed through without difficulty.

Length of string (approximately 2 m). Spare lengths of string must be available.

Scissors

Stand and boss. The height of the stand must not be less than 75 cm.

Length of dowelling (approximately 15 cm)

Stopwatch reading to 0.1 s or better

The piece of dowelling should be mounted horizontally about 20 cm above the bench using the stand and boss.

The remainder of the apparatus should be laid on the bench. If the apparatus is to be used by a second candidate then it should be disassembled and restored to its original state. A new length of string must be supplied.

Procedure to be followed by candidates

Candidates will be required to suspend the rule using a V-shaped length of string as shown in Fig. 1.1.

Fig. 1.1

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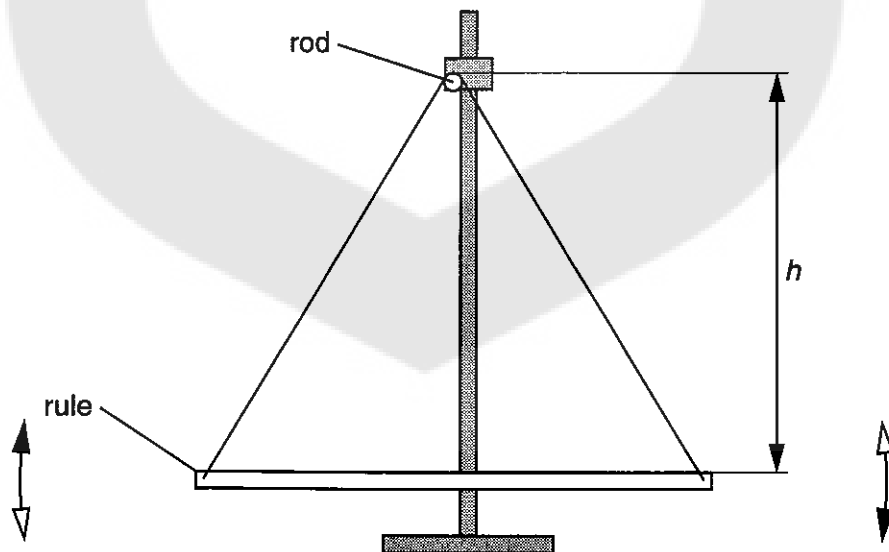
The rule should be displaced from its equilibrium position so that it performs small oscillations in a vertical plane. Candidates will be required to make a series of measurements of the perpendicular distance h and the corresponding period T. The values of h should be in the range $25\,\text{cm} < h < 70\,\text{cm}$. A graph of $T^2 h$ vs h^2 should give a straight line which does not pass through the origin. The gradient, when equated with $4\pi^2/g$, should yield a numerical value for g of between 9.6 and 10.1.

Information required by Examiners

Sample set of results, including the graph.

Question 2

Candidates will be required to measure the e.m.f. of a cell using a voltmeter and a selection of carbon resistors.

Apparatus requirements (per set of apparatus unless otherwise specified):

The precise specification of some of these items should be chosen to match the apparatus available in the Centre. An example is given at the end of this section.

Analogue voltmeter of resistance R_V

Low voltage power supply unit. Dry cells in series may be suitable. The e.m.f. of the arrangement should be approximately twice the full scale deflection of the voltmeter. Candidates must not be able to adjust this voltage.

Seven 0.25 W (or greater) carbon resistors. The resistance of one of these resistors must be similar to that of the voltmeter. The resistor is to be labelled Q. The other six resistors, used separately as resistor P in Fig. 2.1, should range in value from about $R_V/5$ to about $5R_V$ (e.g. $R_V/5$, $R_V/3$, $R_V/2$, R_V, $2R_V$ and $5R_V$). The values are not critical, but should be chosen so that the graph which is to be drawn by the candidates (see below) produces points which are well-spaced. The resistance of each of these resistors must be clearly labelled in ohms.

Card, on which is written '$r =$ ....', where r is the resistance of the resistor Q.

Two component holders. If some other means of mounting the resistors is employed then the arrangement must be such that candidates are able to make connections to the resistors without difficulty.

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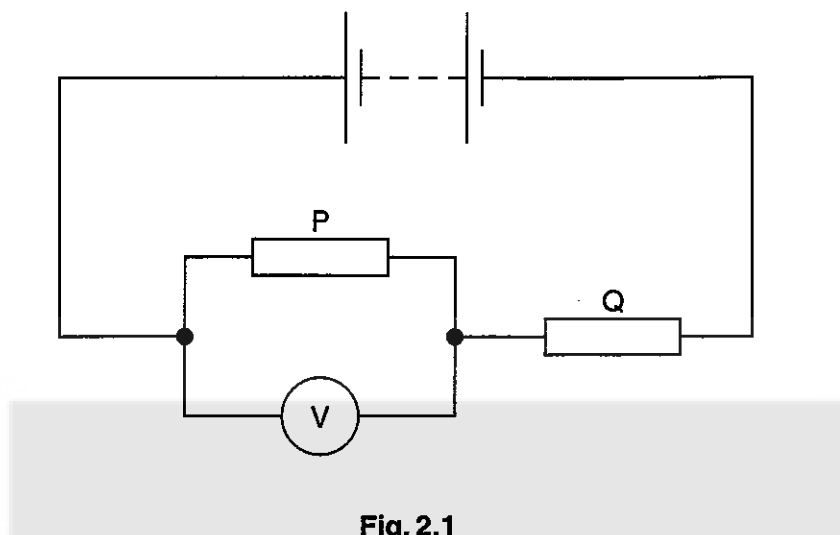Sufficient connecting wires to enable candidates to set up the circuit shown in Fig. 2.1.

Fig. 2.1

The circuit must not be assembled. If candidates require assistance in constructing the circuit then details of the help which has been given must be recorded on the Report in the usual way and sent with the scripts.

If the apparatus is to be used by a second candidate then the circuit must be dismantled and the equipment laid out on the bench ready for the next candidate to use.

Possible values:

Voltmeter:	0–5 V, 50 kΩ
Power supply:	10 V d.c.
Resistance r of resistor Q:	47 kΩ (i.e. nearest preferred value to 50 kΩ)
Values of resistance of resistor P:	10 kΩ, 15 kΩ, 22 kΩ, 47 kΩ, 100 kΩ, 220 kΩ

Procedure to be followed by candidates

Candidates will be required to construct the circuit shown in Fig. 2.1. Values of the potential difference V across the resistor P are to be recorded as the resistance R of the resistor P is changed (using each resistor singly). A graph of $1/V$ vs $1/R$ should give a straight line which does not pass through the origin.

Information required by Examiners

Sample sets of results, including the graph.

NOTE: Questions 3 and 4 are design exercises and do not require apparatus.

This form should be completed and sent to the Examiner with the scripts.

REPORT ON PRACTICAL PHYSICS

General Certificate of Education Advanced Level

JUNE 2000

General

If the scripts are to be despatched in more than one envelope it is essential that a copy of this form is enclosed in each envelope with the details requested.

The Supervisor is invited to give details, on the reverse of this form, of any difficulties experienced by particular candidates, giving names and index numbers. These should include reference to:

(a) accidents to apparatus or materials;

(b) any other information that is likely to assist the examiner, especially if this cannot be discovered in the scripts;

(c) any help given to a candidate.

Other cases of individual hardship, e.g. illness, disability, should be reported direct to OCR on the normal 'Special Consideration' form.

In cases of faulty apparatus (not arising from a candidate's mishandling) which prevent the required readings being taken, the following action is permissible.

The Invigilator – in consultation with the Physics teacher responsible for preparing the examination – may allow extra time to give the candidate a fair opportunity of performing the experiment as if the fault had not been present. The candidate should use a spare copy of the Question Paper when the fault has been rectified or when working with a second set of apparatus. The Invigilator is asked to provide OCR with details of such cases of time compensation (a copy being enclosed with the scripts), including, in particular

(i) the candidate's name and index number,

(ii) the extra time allowed,

(iii) notes on the nature of the fault, the action taken to rectify the difficulty and any other comments which would be helpful to the Examiner in making a fair assessment of the candidate's work during the practical examination.

A list, by name and index number, of candidates requiring help, with details of help provided

Declaration (to be signed by the Principal)

The preparation of this practical examination has been carried out so as to maintain fully the security of the examination.

Signed ....

Centre No. ....

Name of Centre ....