



EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2022
General Certificate of Education Advanced Level
Higher 2

PHYSICS

Paper 1 Multiple Choice

9749/01**August/September 2022****1 hour**Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use paper clips, glue or correction fluid.

Write your name, civics group and registration number on the Answer Sheet in the spaces provided.

There are **thirty** questions on 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 the instructions on the Answer Sheet very carefully.**

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.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages and no blank pages.

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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
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,

$$W = p\Delta V$$

hydrostatic pressure,

$$p = \rho gh$$

gravitational potential,

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

temperature,

$$T / \text{K} = T / ^\circ\text{C} + 273.15$$

pressure of an ideal gas,

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

mean translational kinetic energy of an ideal gas molecule

$$E = \frac{3}{2} kT$$

displacement of particle in s.h.m.

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

velocity of particle in s.h.m.

$$v = v_0 \cos \omega t$$

$$= \pm \omega \sqrt{(x_0^2 - x^2)}$$

electric current,

$$I = Anvq$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

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

electric potential,

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

alternating current/voltage,

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

magnetic flux density due to a long straight wire

$$B = \frac{\mu_0 I}{2\pi d}$$

magnetic flux density due to a flat circular coil

$$B = \frac{\mu_0 NI}{2r}$$

magnetic flux density due to a long solenoid

$$B = \mu_0 nI$$

radioactive decay,

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

decay constant

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

- 1 The radius of a helium-4 atom is of the order 10^{-10} m and its nucleus has a radius that is of the order of 10^{-15} m.

If all the empty space in the helium atom is removed and the atom size is reduced to that of the nucleus, what is the approximate density of the matter that is formed?

- A 10^{14} kg m⁻³
- B 10^{18} kg m⁻³
- C 10^{22} kg m⁻³
- D 10^{26} kg m⁻³

- 2 As part of the 1945 Manhattan project, the United States Army tested the first-of-its-kind nuclear weapon in New Mexico.

The explosion resulted in a radiant, hemispherical blast wave of radius R which could be modelled using

$$R = s \left(\frac{Et^2}{\rho} \right)^{0.2}$$

where E = energy released due to explosion,
 t = time elapsed after detonation,
 ρ = density of air.

What is the SI unit of the quantity s ?

- A (dimensionless)
 - B m^{0.2}
 - C J^{0.2} m^{-0.2} s^{0.4} kg^{-0.2}
 - D J⁻¹ m² s⁻² kg
- 3 A ball is thrown upwards vertically near Earth's surface.

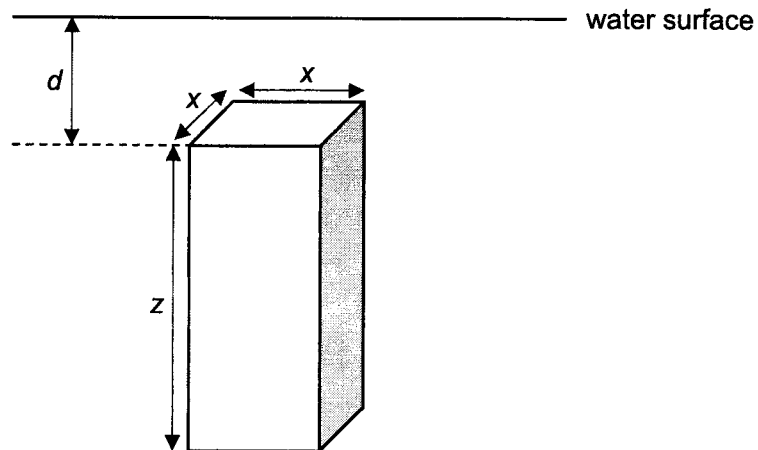
It takes a time of 3.20 s to return to the initial position.

Assume air resistance is negligible.

What is the initial speed with which the ball is thrown?

- A 3.07 m s⁻¹
- B 7.85 m s⁻¹
- C 15.7 m s⁻¹
- D 31.4 m s⁻¹

- 4 A uniform block of dimensions x^2 by z is fully submerged at depth d in a tank of water as shown.

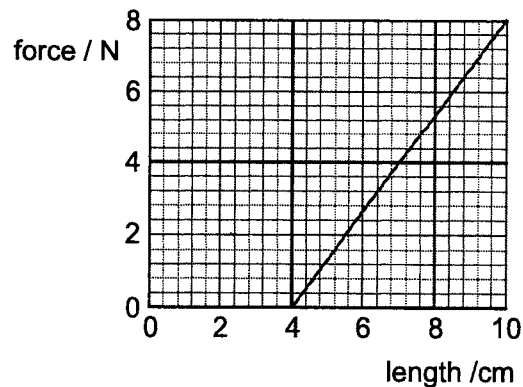
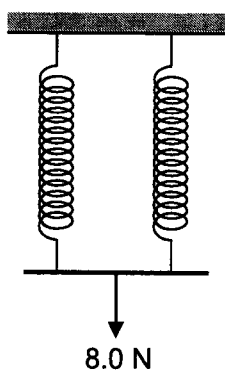


The block is held vertically in the position shown. The density of the block is the same as the density of the water.

If the block is always held at the same depth d below the surface of the water, which single change would increase the magnitude of the upthrust force on the block?

- A decrease the density of the block
 - B hold the block horizontally
 - C increase dimension z
 - D increase the density of the block
- 5 Two light identical springs are connected in parallel.

A weight of 8.0 N is exerted vertically downwards from the combination as shown.



The graph shows the variation with length of the force applied to **one** of the springs.

What is the elastic potential energy stored in **one** of the springs?

- A 0.060 J
- B 0.12 J
- C 0.14 J
- D 0.24 J

6 Which statement about energy is **not** correct?

- A Energy is never lost but it may be transferred between different forms.
- B In an inelastic collision, the total energy is constant.
- C The efficiency of a system is the ratio of the useful energy output to the total energy input.
- D When a machine does work, friction reduces the total energy.

7 In the diagram below, blocks B, C, D, E and F are all in contact with each other and are initially at rest on a smooth horizontal surface.

Block A moves towards block B with a speed of 10 m s^{-1} .

All subsequent collisions are elastic in nature.



The mass of both block A and block F is m each. Blocks B, C, D and E have mass of $4m$ each.

Which of the following options concerning blocks A, B, and E after the collisions is true?

	block A	block B	block E
A	at rest	move	move
B	move	move	at rest
C	move	at rest	move
D	move	move	move

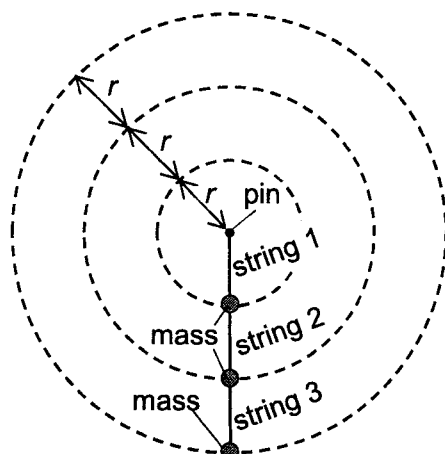
8 A uniform ladder of weight W rests against a vertical wall, tilted at an angle θ from a rough floor.

The floor exerts normal force N_F on the ladder. The wall exerts normal force N_w on the ladder.

Which of the following equations is correct?

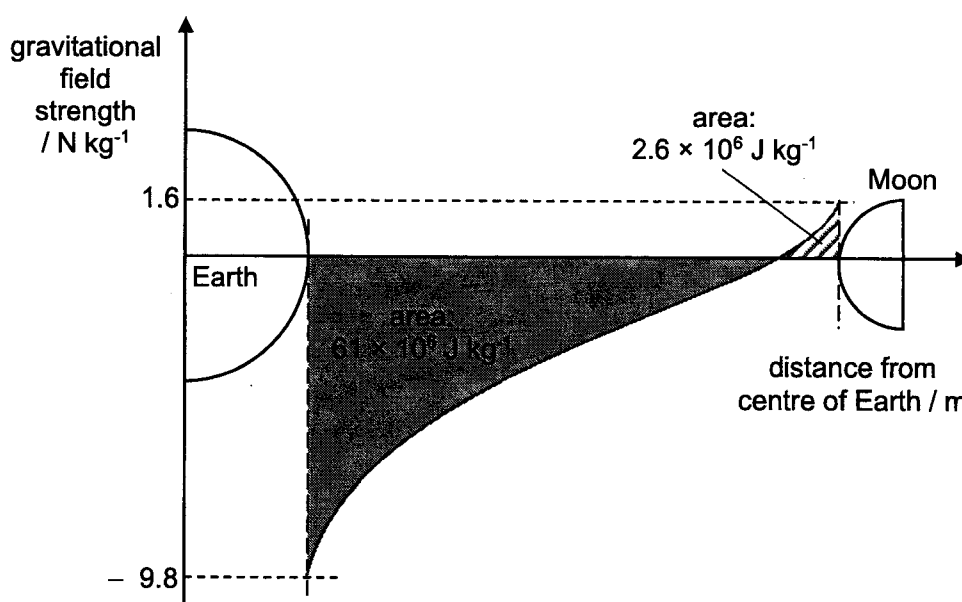
- A $N_F = N_w$
- B $N_w \tan \theta = N_F - \frac{W}{2}$
- C $N_F \tan \theta = N_w - \frac{W}{2}$
- D $N_F \tan \theta = N_w + \frac{W}{2}$

- 9 Three identical masses are tied using light, inextensible strings of equal lengths r to a pin and made to rotate around the pin by sliding over a smooth horizontal table as shown in the diagram. The strings remain along a straight line as the masses rotate.



What is the ratio of tensions in string 1 : string 2 : string 3?

- A 1 : 2 : 3
 B 3 : 2 : 1
 C 3 : 5 : 6
 D 6 : 5 : 3
- 10 The graph below shows the variation with distance from the centre of Earth, of the gravitational field strength between the surface of the Earth and the Moon. The areas under the graph segments and the value of the gravitational field strength on Earth's and on Moon's surfaces are indicated.



What is the minimum speed a mass on the surface of the Moon must have, in order to be able to reach Earth's surface?

- A 186 m s^{-1}
 B 902 m s^{-1}
 C 2280 m s^{-1}
 D $11\,000 \text{ m s}^{-1}$

- 11 A satellite orbits around the Earth in a stable orbit. It is moved to another stable orbit that is further away from the Earth.

Which one of the following quantities increases for the satellite?

- A gravitational force
- B gravitational potential energy
- C angular velocity
- D centripetal acceleration

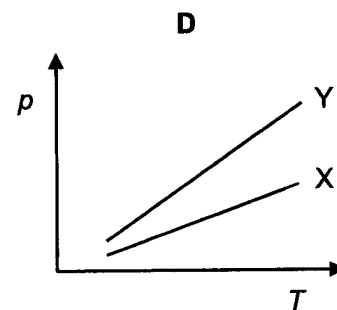
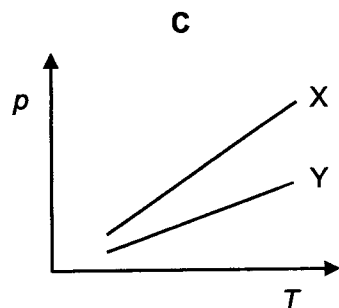
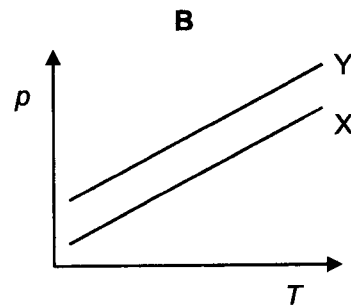
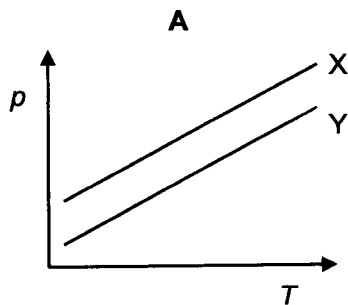
- 12 The temperature of an ideal gas is raised from 32.1 °C to 40.5 °C.

What is the percentage increase in the r.m.s. speed of its gas particles?

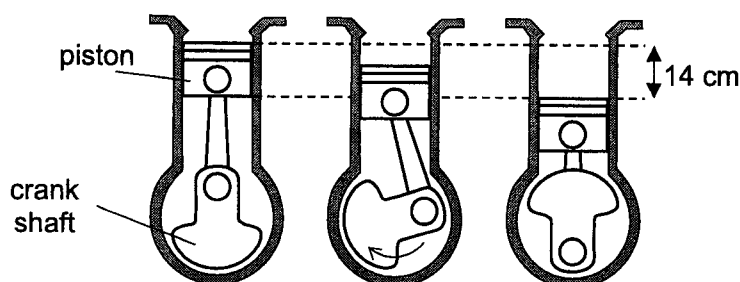
- A 1.4 %
- B 2.8 %
- C 12 %
- D 13 %

- 13 Two closed vessels X and Y contain equal masses of an ideal gas. X has a larger volume than Y.

Which of the following best represents the variation with temperature T of the pressure p of the gas in each vessel?

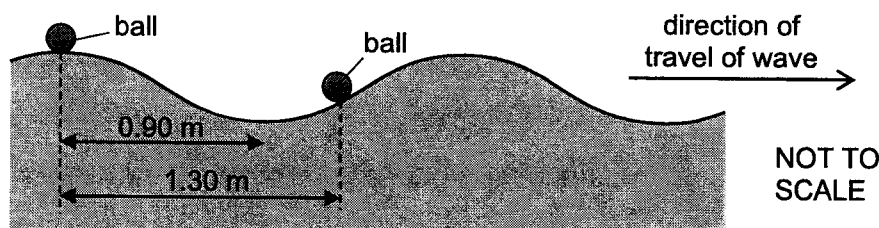


- 14 A piston undergoes simple harmonic motion vertically when cranked by a rotating crank shaft as shown in the diagram below. A coin rests on top of the initially stationary piston. The rotation of the crank shaft gradually increases in speed.



What is the frequency at which the coin loses contact with piston?

- A 1.0 Hz
 B 1.3 Hz
 C 1.9 Hz
 D 26 Hz
- 15 Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m. A wave travels on the surface of the sea such that the balls move vertically up and down. The distance between a crest and an adjacent trough of the wave is 0.90 m.



What is the phase difference between the two balls?

- A 55°
 B 110°
 C 160°
 D 260°
- 16 A diffraction grating with 5000 lines per centimetre is illuminated normally by white light.

Which of the following statements is false?

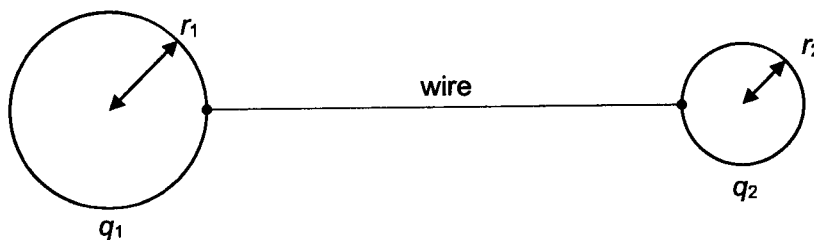
- A Within the first-order spectrum, the violet end is closer to the central maxima than the red end.
 B The yellow region of the second-order spectrum coincides with the violet end of the third-order spectrum.
 C The violet end of the third-order spectrum is visible.
 D The violet end of the fourth-order spectrum is not visible.

- 17 The screen on most modern smartphones uses tiny, regularly-spaced pixels each capable of producing red, green, or blue light to make up an image. At typical viewing distances, the human eye is unable to resolve the individual pixels that make up the image on the screen.

The wavelengths for red, green, and blue are 660 nm, 550 nm, and 470 nm respectively. The diameter of the pupil through which light enters the eye is 4.0 mm. Humans tend to place the mobile phone screens closest to the eye at about 10 cm when lying down.

What is the maximum distance between adjacent pixels?

- A 1.2×10^{-5} m
 B 1.2×10^{-6} m
 C 1.7×10^{-5} m
 D 1.7×10^{-6} m
- 18 Two spherical conductors of radii r_1 and r_2 are separated by a distance much greater than the radius of either sphere. The spheres are connected by a conducting wire as shown in the diagram below. The charges on the spheres in equilibrium are q_1 and q_2 respectively.

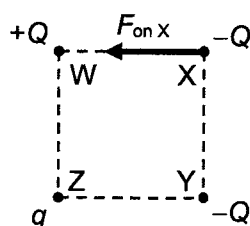


What is the ratio of the magnitudes of the electric field strengths at the surfaces of the spheres?

- A $\left(\frac{r_2}{r_1}\right)^2$
 B $\frac{r_2}{r_1}$
 C $\frac{q_2 r_2}{q_1 r_1}$
 D $\frac{q_1 r_2}{q_2 r_1}$

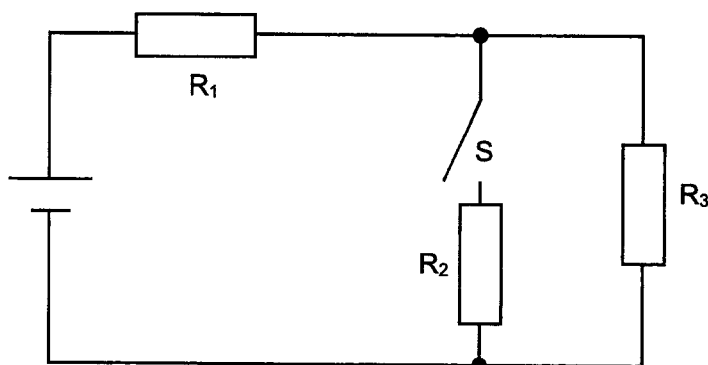
- 19 Point charges $+Q$, $-Q$, $-Q$, and q are located at the corners W, X, Y and Z of a square respectively as shown.

The charge at X experiences a net electric force towards W.



What is the magnitude of charge q in terms of Q ?

- A $+Q$
 B $+2Q$
 C $+2\sqrt{Q}$
 D $+2\sqrt{2}Q$
- 20 The diagram shows a network of resistors R_1 , R_2 , and R_3 connected to a battery of negligible internal resistance.

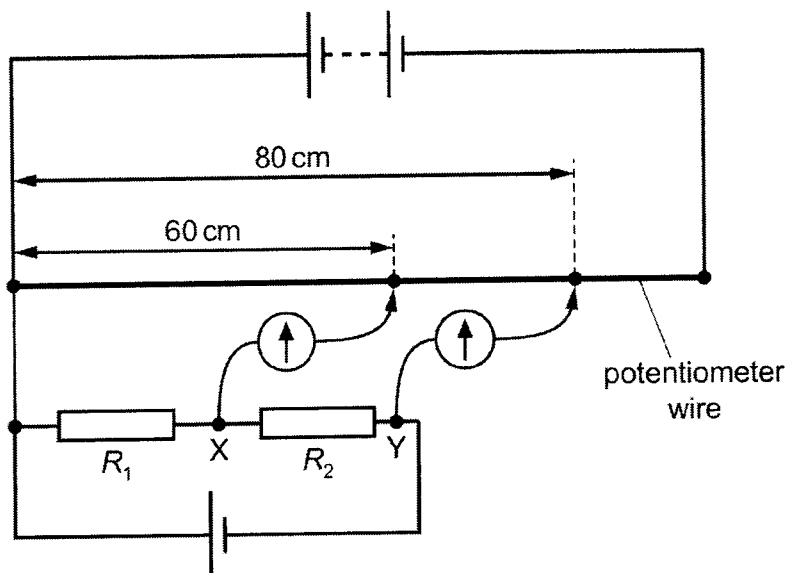


When switch S is closed, the potential difference (p.d.) across R_2 (originally zero) rapidly increases to a steady value.

What happens to the potential difference (p.d.) across each of the other two resistors, and to the power output of the battery?

	p.d. across R_1	p.d. across R_3	battery power output
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	decreases	increases
D	increases	stays the same	increases

- 21 Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

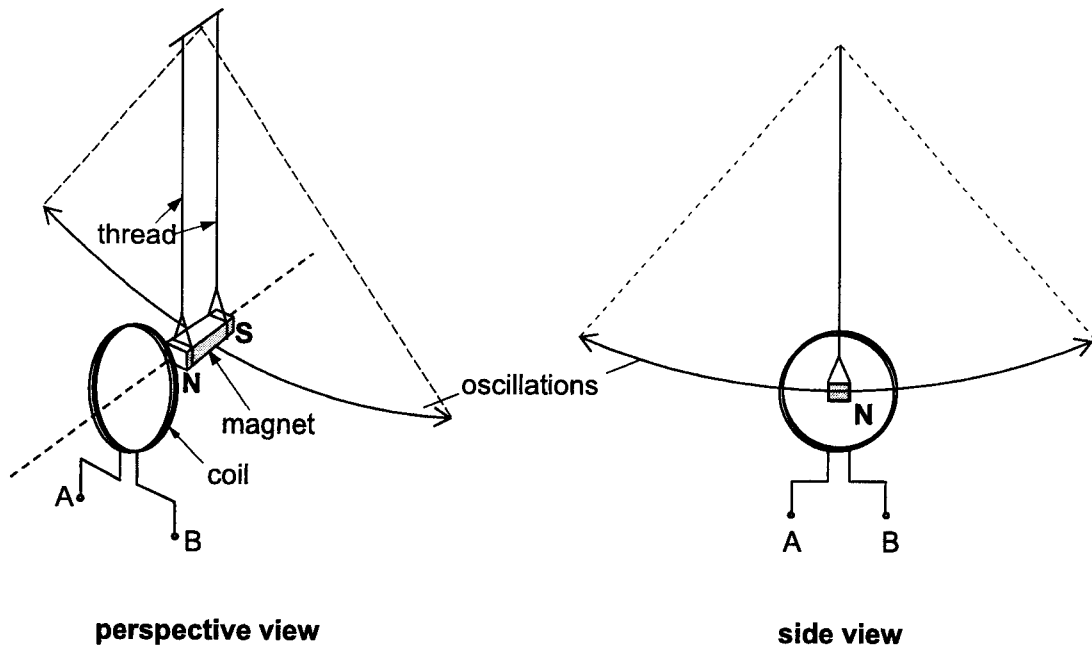
One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\frac{R_2}{R_1}$?

- A $\frac{1}{3}$
 B $\frac{3}{4}$
 C $\frac{3}{1}$
 D $\frac{4}{3}$

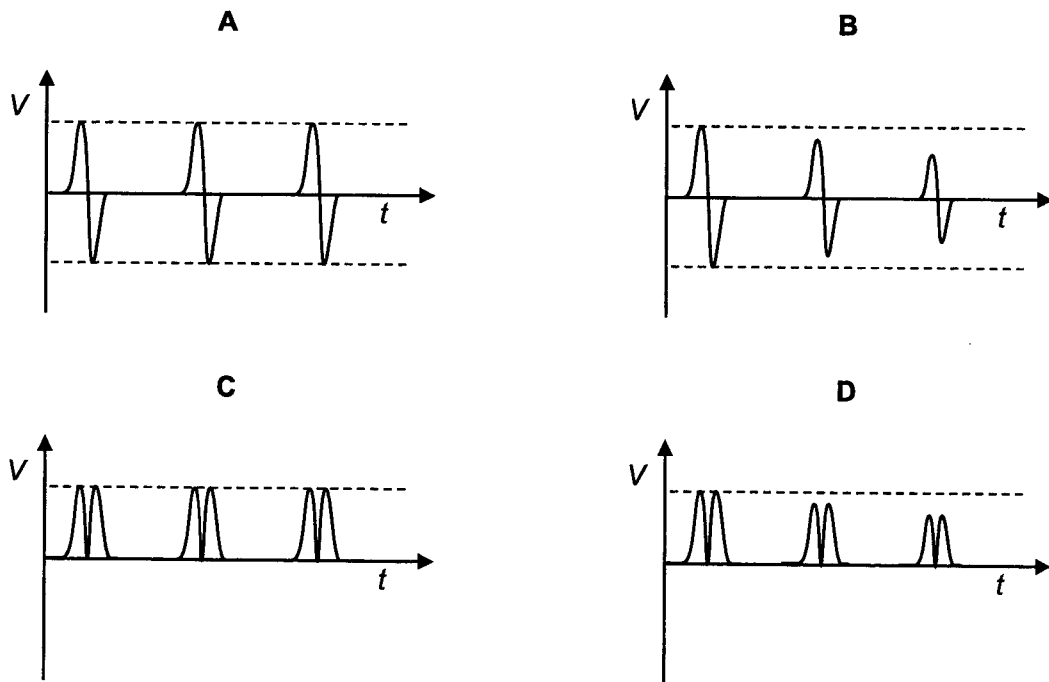
22 A magnet is suspended using threads. It swings like a pendulum as shown in the diagrams below.

The north pole of the magnet passes near a fixed coil at the bottom of its swing. The coil's plane is parallel to the plane of oscillation of the magnet.

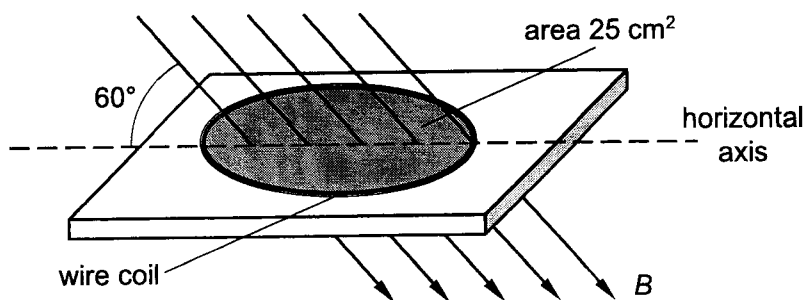


A resistor is connected in parallel across terminals A and B.

Which of the following graphs best shows the variation with time t of the potential difference V across the resistor?

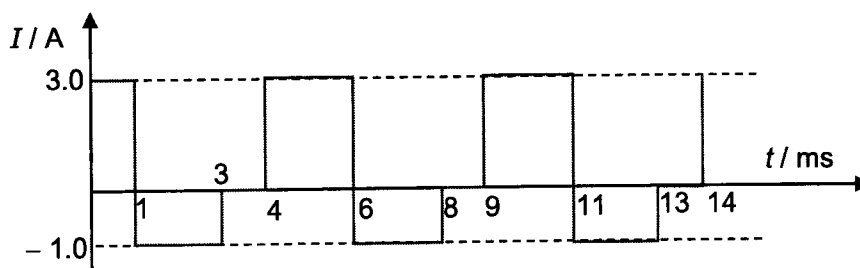


- 23 A uniform magnetic field of magnetic flux density $B = 2.0 \times 10^{-4} \text{ T}$ is directed down through a wire coil at an angle of 60° with the horizontal as shown. The coil has 500 turns, a total resistance 5.0Ω and an area of 25 cm^2 .



What is the average charge that flows when the coil is turned π rad about the horizontal axis?

- A 0.22 C
 B 0.11 C
 C $4.3 \times 10^{-5} \text{ C}$
 D $8.7 \times 10^{-5} \text{ C}$
- 24 The diagram below shows the variation with time of an alternating current which flows through a 13Ω resistor.

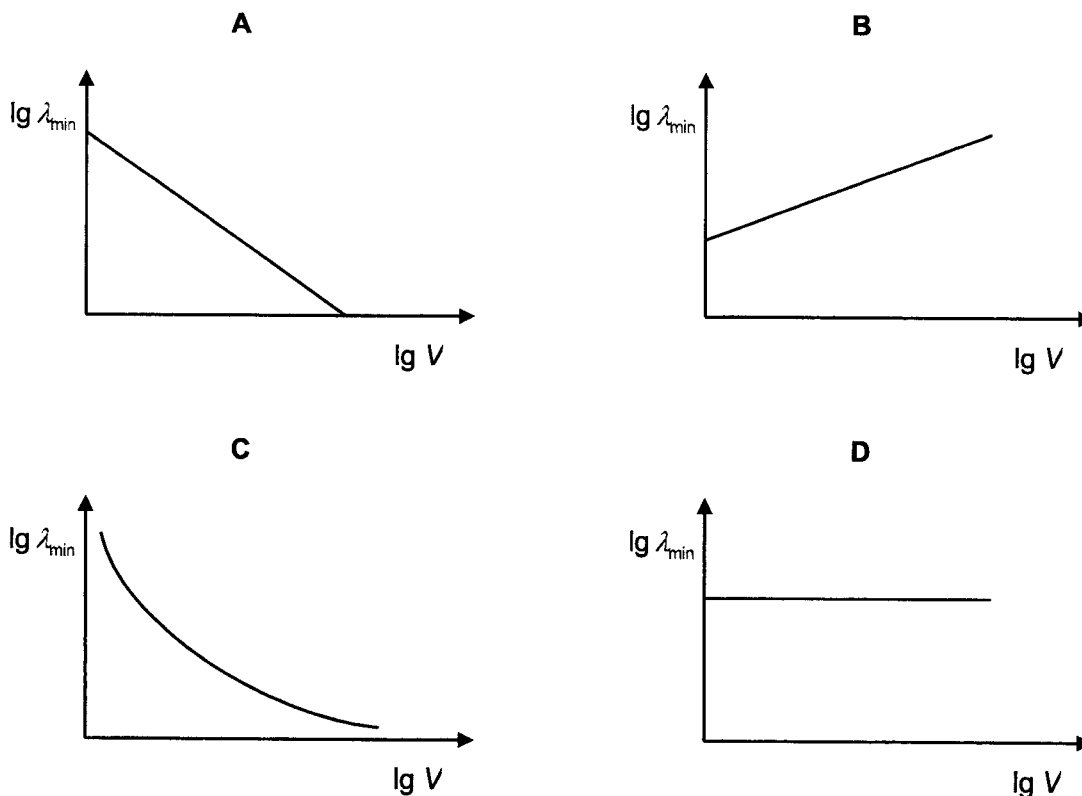


What is the average power dissipated by the resistor?

- A 52 W
 B 36 W
 C 2.8 W
 D 2.0 W
- 25 Which of the following statements about the photoelectric effect is true?
- A Photoelectrons are not emitted as long as intensity of illumination is low.
 B Doubling the frequency radiation will double the stopping potential.
 C For a particular clean metal surface, there will be a minimum wavelength below which no emission of photoelectrons will occur.
 D Increasing the intensity of incident increases the photo-current.

- 26 Electrons are accelerated from rest by a potential difference V . They bombard a metal target to produce X-rays. On the resulting X-ray spectrum, λ_{\min} is the shortest wavelength observed.

Which of the following shows the variation with $\lg V$ of $\lg \lambda_{\min}$?



- 27 An electron moves with a constant velocity of $1.5 \times 10^6 \text{ m s}^{-1}$. Its momentum is measured to a precision of 0.20%.

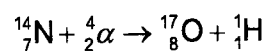
What is the uncertainty associated with its position along its direction of travel?

- A $2.4 \times 10^{-7} \text{ m}$
 - B $3.9 \times 10^{-8} \text{ m}$
 - C $1.2 \times 10^{-10} \text{ m}$
 - D $1.9 \times 10^{-10} \text{ m}$
- 28 The half-life of a radioactive substance is 752 s. The background count is found to be 8.3 s^{-1} . A Geiger Muller (GM) counter reads 77.3 s^{-1} when the GM tube is placed near a radioactive sample.

What will be the reading on the GM counter 280 s later?

- A 53.3 s^{-1}
- B 59.7 s^{-1}
- C 61.6 s^{-1}
- D 68.0 s^{-1}

- 29 A stationary nitrogen nucleus reacts with a high speed α -particle to produce a proton and a nucleus of an oxygen isotope as shown in the equation:

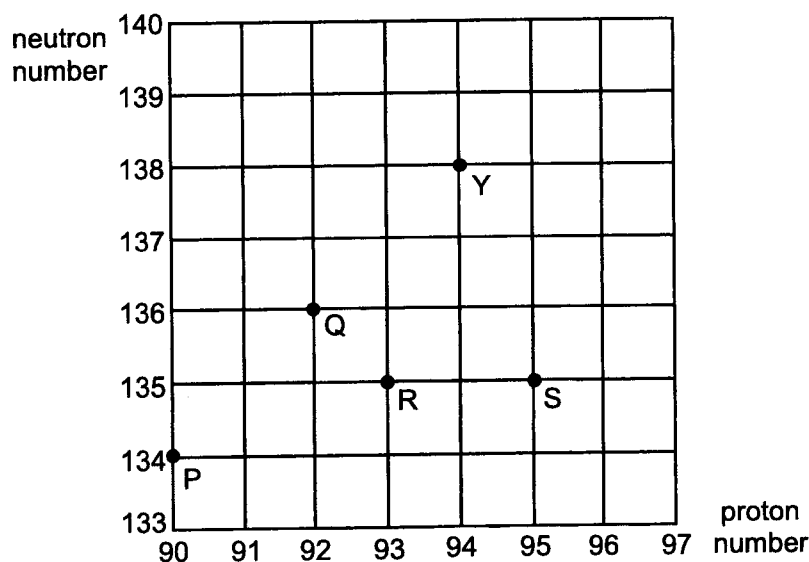


The masses of the nuclides involved are as follows

nuclide	mass / <i>u</i>
${}^4_2\alpha$	4.002604
${}^1_1\text{H}$	1.007825
${}^{14}_7\text{N}$	14.003074
${}^{17}_8\text{O}$	16.999130

Which is the minimum energy that the α -particle possess in order for the reaction to occur?

- A 1.9×10^{-13} eV
 B 4.0×10^{-13} eV
 C 1.2 eV
 D 1.2×10^6 eV
- 30 Isotope Y undergoes two successive decays to form another isotope. Each decay can be either alpha-emission or beta-emission. Four other isotopes P, Q, R and S, are shown on the diagram.



Which of the isotopes P, Q, R and S could be the final isotope after the two successive decays of isotope Y?

- A P only
 B P and R
 C Q, R and S
 D S only



EUNOIA JUNIOR COLLEGE
 JC2 PRELIMINARY EXAMINATIONS 2022
 General Certificate of Education Advanced Level
 Higher 2

CANDIDATE
 NAME

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CIVICS
 GROUP

2	1	-		
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REGISTRATION
 NUMBER

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PHYSICS

9749/02

Paper 2 Structured Questions

August/September 2022

2 hours

Candidates answer on the Question Paper.
 No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.
 Answer all questions.

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

For Examiner's Use	
1	7
2	5
3	8
4	9
5	10
6	8
7	8
8	25
s.f.	
Total	80

This document consists of **24** printed pages and **no** blank page.

2

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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
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,	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
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Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T / K = T / ^\circ\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$
electric potential,	$V = \frac{Q}{4\pi\epsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

4

- 1 A uniform metal rod AB of mass 1.2 kg and length 0.40 m is pivoted at end A. End B is suspended by a light spring as shown in Fig. 1.1. The other end of the spring is supported at X.

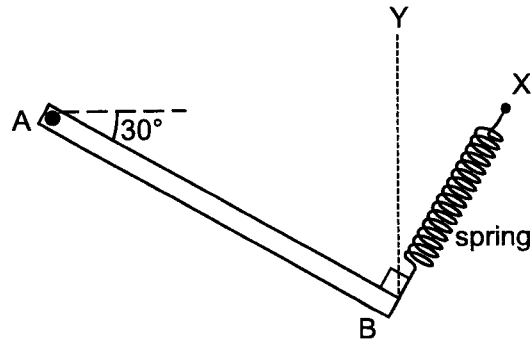


Fig. 1.1

When the rod is in equilibrium, it makes an angle of 30° below the horizontal and lies stationary with the axis of the spring perpendicular to the rod.

- (a) On Fig. 1.2, draw a labelled diagram showing the forces acting on the rod.

Label the forces clearly.

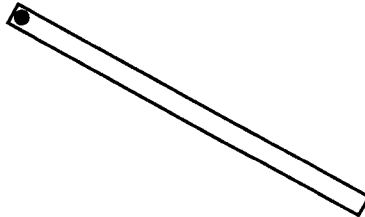


Fig. 1.2

[1]

5

(b) Calculate the tension in the spring.

tension = N [2]

(c) Determine the magnitude of the reaction force at pivot A.

force = N [3]

(d) The spring in Fig. 1.1 is now replaced with a spring of larger spring constant and of same natural length.

State the change in angle, if any, between the rod and the spring.

.....

..... [1]

[Total: 7]

- 2 A rubber ball of mass 0.30 kg is positioned directly above a basketball of mass 0.50 kg as shown in Fig. 2.1

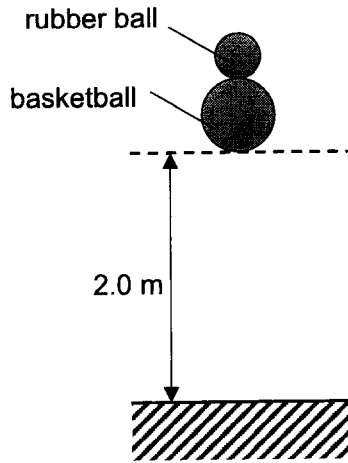


Fig. 2.1

The balls are released from a height of 2.0 m from the ground. Assume air resistance is negligible.

- (a) (i) State the *principle of conservation of momentum*.

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

- (ii) Explain why the principle of conservation of momentum is not applicable to the system of stacked balls.

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

7

(b) Determine the speed of the stacked balls just before they hit the ground.

speed = m s⁻¹ [1]

(c) The collision between the balls and ground is elastic. At the instant the basketball loses contact with the rubber ball, it moves with a speed of 3.2 m s⁻¹. The rubber ball is observed to move off at a higher speed than the basketball.

Using energy considerations, calculate the speed of the rubber ball as it loses contact with the basketball.

speed = m s⁻¹ [2]

[Total: 5]

- 3 Fig. 3.1 shows two positive point charges q_1 and q_2 affixed to positions X and Y respectively, on a circular nylon frame centred at point O. The circular frame has a radius r .

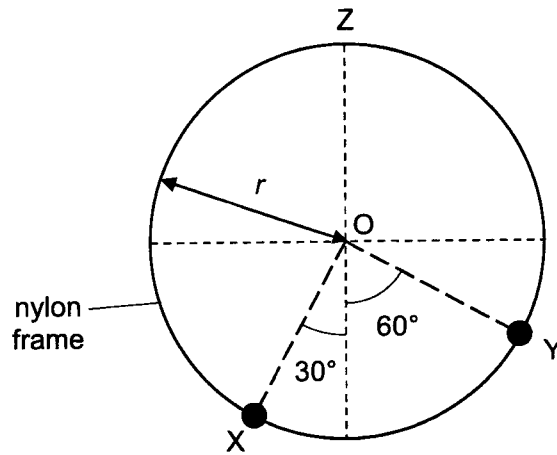


Fig. 3.1

At point O, the direction of the net electric field strength is directed upwards along OZ.

- (a) (i) Show that the ratio $\frac{q_1}{q_2}$ is 1.7.

[1]

- (ii) Hence, sketch in Fig. 3.2 the variation of electric field strength with distance along the straight line XY.

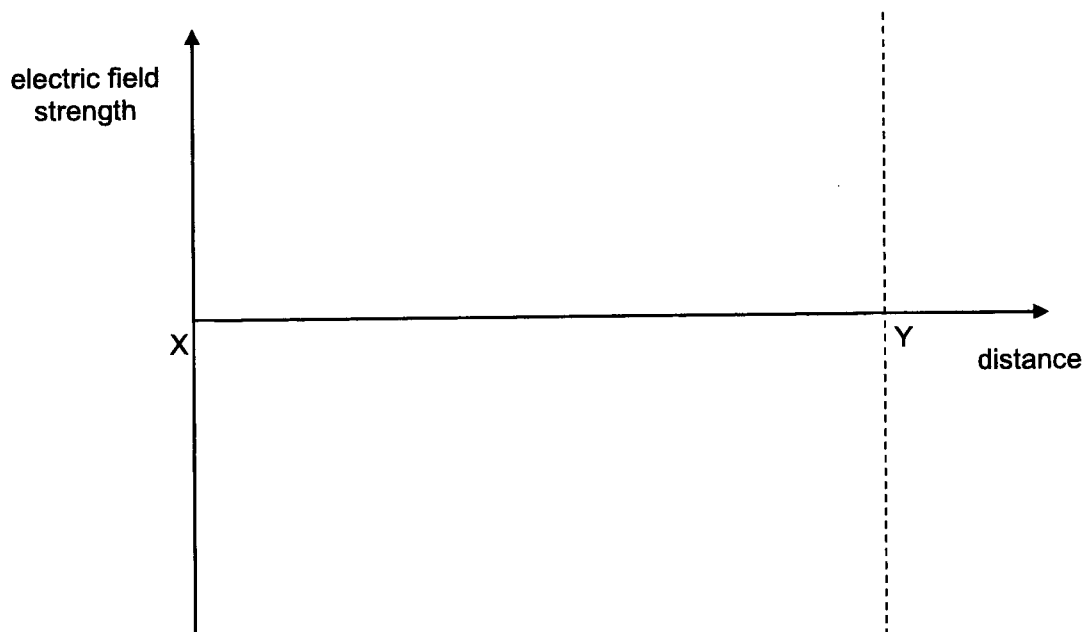


Fig. 3.2

[2]

9

(b) Given that $r = 0.50$ m and $q_2 = 200$ nC, determine the

(i) magnitude of electric field strength at O,

electric field strength = V m⁻¹ [2]

(ii) total electric potential at O,

electric potential = V [1]

(iii) the work done in moving an additional third charge $q_3 = -2q_2$ from infinity to point O.

work done =eV [2]

[Total: 8]

4 (a) Define *magnetic flux density*.

.....

 [1]

(b) A charged particle is initially located at point P on the plane of the page and is moving to the right with speed v .

The charged particle moves within the vicinity of a non-uniform magnetic field that is generated by a long, straight wire carrying current I to the right. The wire is located on the same plane of page as the initial position of the charged particle.

As a result, the particle travels along a curved path of non-uniform radius.

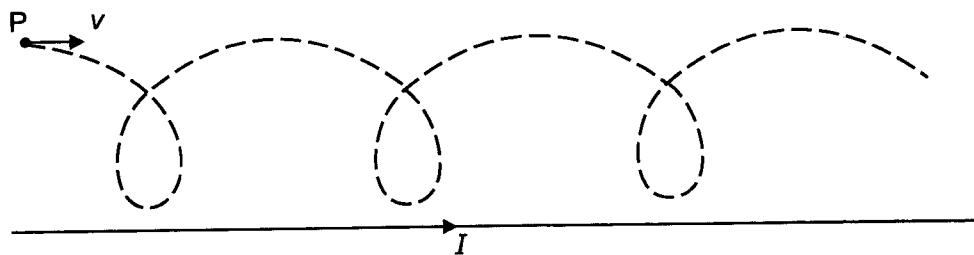


Fig. 4.1

(i) 1. On Fig. 4.1, sketch a representation of the magnetic field lines on the plane of paper generated by the long straight wire. [2]

2. State the sign of the charged particle.
 [1]

(ii) Explain, using energy considerations, why the speed of the charged particle remains constant throughout the motion.

 [2]

(iii) State an assumption made for the speed of the charged particle to remain constant.

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

(c) Two long parallel wires X and Y are separated by a distance of 5.0 cm and carry currents 7.0 A and 8.0 A respectively. Both the currents are directed out of the plane of paper.

Point Z is located 3.0 cm from wire X and 4.0 cm from wire Y as shown in Fig. 4.2.

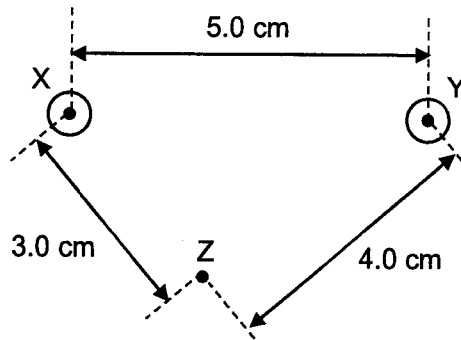


Fig. 4.2 (not to scale)

Determine the magnitude of magnetic flux density at point Z due to wires X and Y.

magnitude of magnetic flux density = T [2]

[Total: 9]

- 5 Two resistors of resistance $1.2\text{ k}\Omega$ and $1.6\text{ k}\Omega$, and a thermistor are connected to an ideal cell of electromotive force of 9.0 V .

An ideal voltmeter is placed between points A and B of the circuit, as shown in Fig. 5.1.

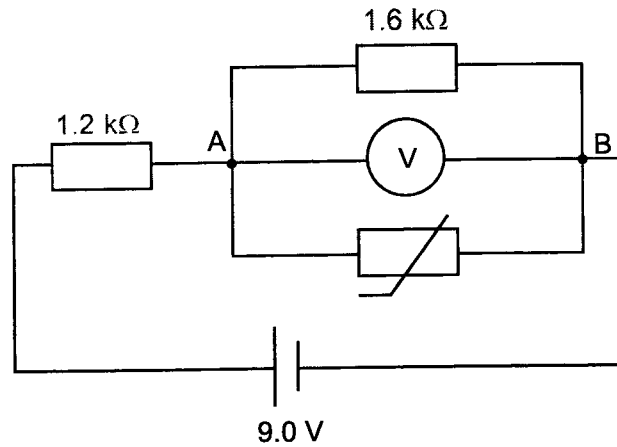


Fig. 5.1

The variation with temperature of the resistance R_T of the thermistor is shown in Fig. 5.2.

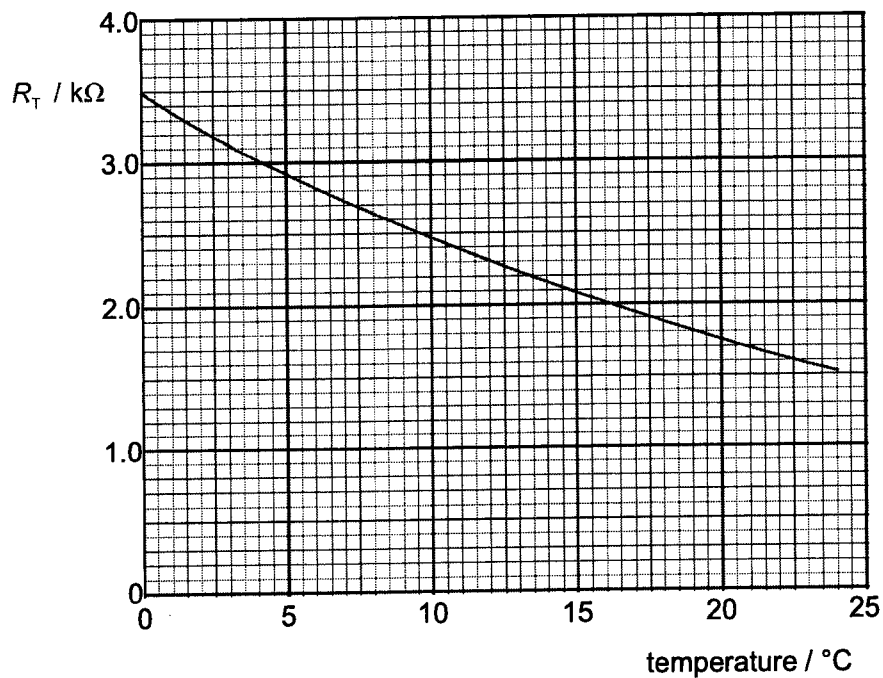


Fig. 5.2

13

(a) The thermistor has a current temperature of 22.5 °C. Determine the

(i) total resistance between points A and B,

resistance = Ω [2]

(ii) reading on the voltmeter,

voltmeter reading = V [2]

(b) The temperature of the thermistor is now changed. The new voltmeter reading is now 4.0 V.

Find the

(i) total resistance between points A and B,

resistance = Ω [2]

(ii) temperature of the thermistor.

temperature = °C [2]

(c) A student suggests that the voltmeter, reading up to 10 V, could be calibrated to measure temperature.

Suggest two disadvantages of using the circuit of Fig. 5.1 with this voltmeter for the measurement of temperature in the range 0 °C to 25 °C.

1.

.....

2.

..... [2]

6 (a) (i) Explain what is meant by a *progressive transverse* wave.

progressive

.....

transverse

.....

..... [2]

(ii) Explain whether a longitudinal wave can be polarised.

.....

.....

.....

.....

.....

..... [2]

(b) A microwave emitter produces polarised microwaves that passes through a microwave polariser before reaching a microwave detector. The emitter, receiver and polariser are initially aligned along the horizontal axis as shown in Fig. 6.1.

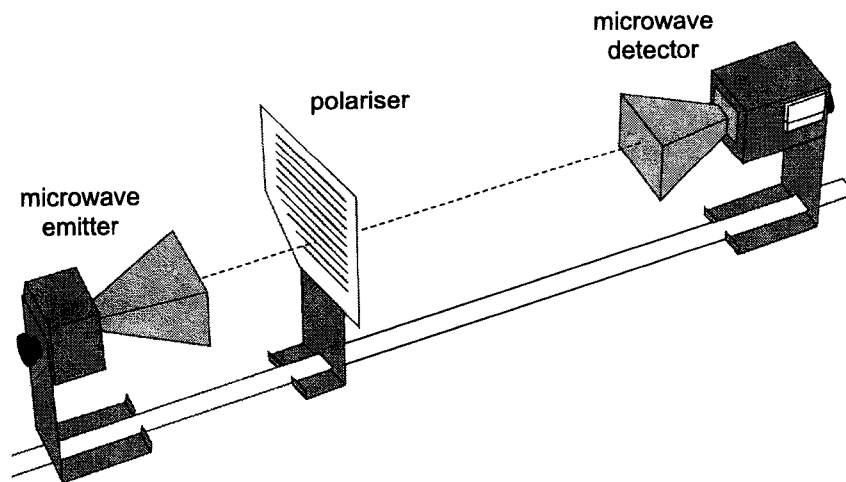


Fig. 6.1

Fig. 6.2 shows the variation with time of the electric field strength of the detected signal.

Graph A shows the variation obtained with the initial set up as per Fig. 6.1, which results in the maximum possible field strength that can be received via the set up.

Graph B shows the variation of the field strength after the polariser has been rotated about the horizontal axis by an angle θ .

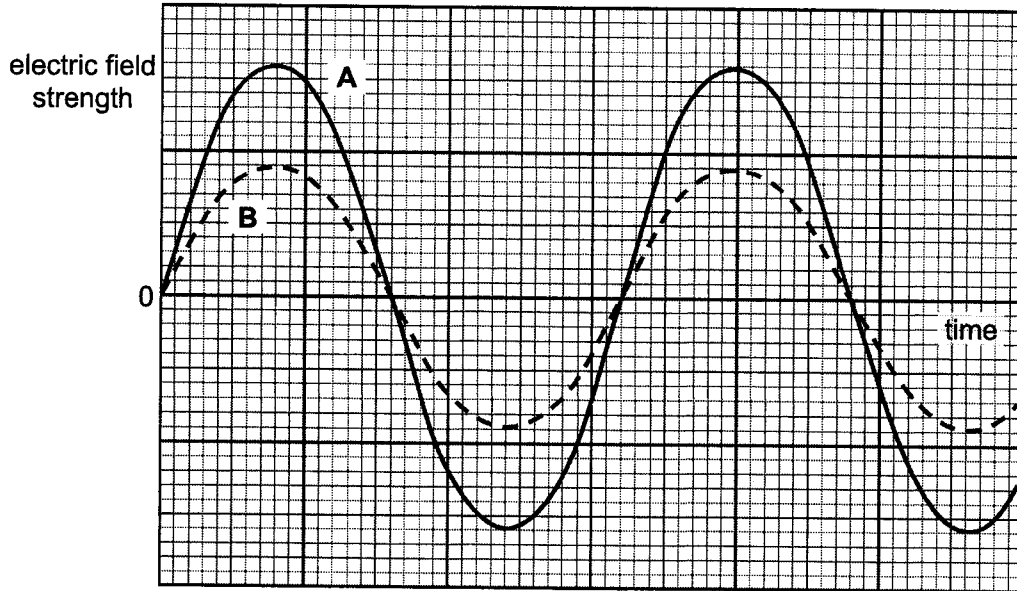


Fig. 6.2

(i) Use Fig. 6.2 to determine θ .

$\theta = \dots\dots\dots^\circ$ [2]

(ii) Determine the ratio

$$\frac{\text{intensity of signal after rotation by } \theta}{\text{intensity of signal at maximum field strength}}$$

ratio = $\dots\dots\dots$ [2]

[Total: 8]

7 Electrons are often used in diffraction experiments to study the regularly repeating atomic structure in crystals. In such experiments, an electron gun is used to direct a beam of electrons towards a thin slice of crystal. The scattered electrons form scintillations when they impinge on a phosphor-coated screen.

(a) In one experiment, electrons are accelerated from rest through a potential difference of 45 V.

(i) Show that the electrons reach a speed of $4.0 \times 10^6 \text{ m s}^{-1}$.

[1]

(ii) Determine the wavelength associated with the moving electron.

wavelength = m [2]

(b) Fig. 7.1 below shows a hypothetical one-dimensional crystal consisting of a single row of atoms with regular spacing of $d = 2.0 \times 10^{-10}$ m.

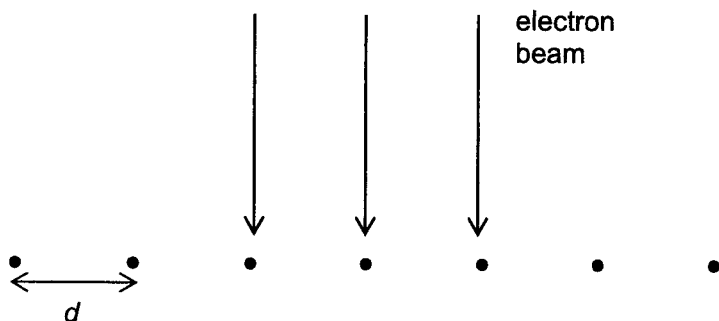


Fig. 7.1

(i) Explain why the electrons scattered by the crystal form a line of bright spots on the screen.

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

(ii) Explain how the spacing between the bright spots will vary as the accelerating potential of the electron gun increases.

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

[Total: 8]

- 8 SpinLaunch is a California-based company established in 2014 with the goal of building an alternative method of launching spacecraft into Low Earth Orbit (LEO). Instead of burning through massive amounts of rocket fuel at lift-off to gain altitude, the company is developing a launch system which uses kinetic energy as its primary method. The advantages include reducing the costs of launching satellites and having an environmental impact that is smaller than traditional rockets, as it avoids fossil fuels as well as the exhaust gases emitted as a result of fuel combustion. In addition, since the projectile doesn't have to carry much fuel, more of the mass can be dedicated to the transport of payloads such as satellites.

Scaled Down Prototype

The most recent accelerator prototype from the company is located in New Mexico, United States of America and is a one-third scale of the eventual accelerator. Designated as the A-33, the prototype accelerator cost USD \$38 million and has a height of 50.4 m, as shown in Fig. 8.1.

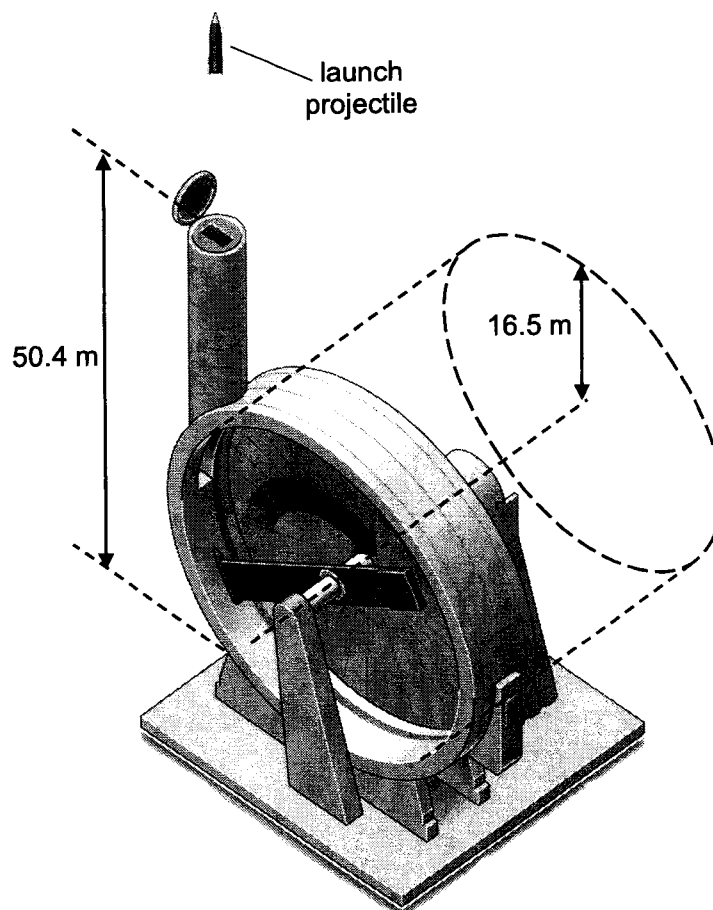


Fig. 8.1

For the latest test launch held in April 2022, the accelerator launched a 50.4 kg projectile at a maximum speed of 536 m s^{-1} , and reached a maximum height of 9300 m. The prototype accelerator required an hour to evacuate air out of the vertically-oriented centrifuge chamber, and then took an additional hour to gradually increase the rotational speed of the arm before releasing the launch projectile at an angle of 86.7° from the horizontal.

(a) Assuming that air resistance on the launch projectile is negligible,

(i) show that the magnitude of the vertical component of the initial velocity is 535 m s^{-1} ,

[1]

(ii) determine the time taken for the launch projectile to reach the ground,

time taken = s [2]

(iii) find the maximum height attainable by the launch projectile with respect to the ground.

maximum height = m [2]

(b) (i) Find the ratio of $\frac{\text{maximum gravitational potential energy attained in real life}}{\text{maximum gravitational potential energy in absence of air resistance}}$.

ratio = [1]

(ii) Suggest if the ratio in (b)(i) is larger or smaller for a traditional fuel-combustion rocket.

.....

 [2]

Full Scale Design

SpinLaunch's design for the eventual full-scale accelerator will involve a Kevlar-carbon-fiber rotating arm within the circular vacuum chamber, as shown in Fig. 8.2. The launch projectile is expected to have a mass of 200 kg and will be flung above the stratosphere. Thereafter, a rocket will fire to provide the final velocity boost necessary for positioning into LEO. At those altitudes, there is hardly any atmosphere and therefore there is minimal drag on the launch projectile. Hence, a couple of minutes of fuel combustion will be sufficient to boost the launch projectile's speed to sufficiently high orbital speeds.

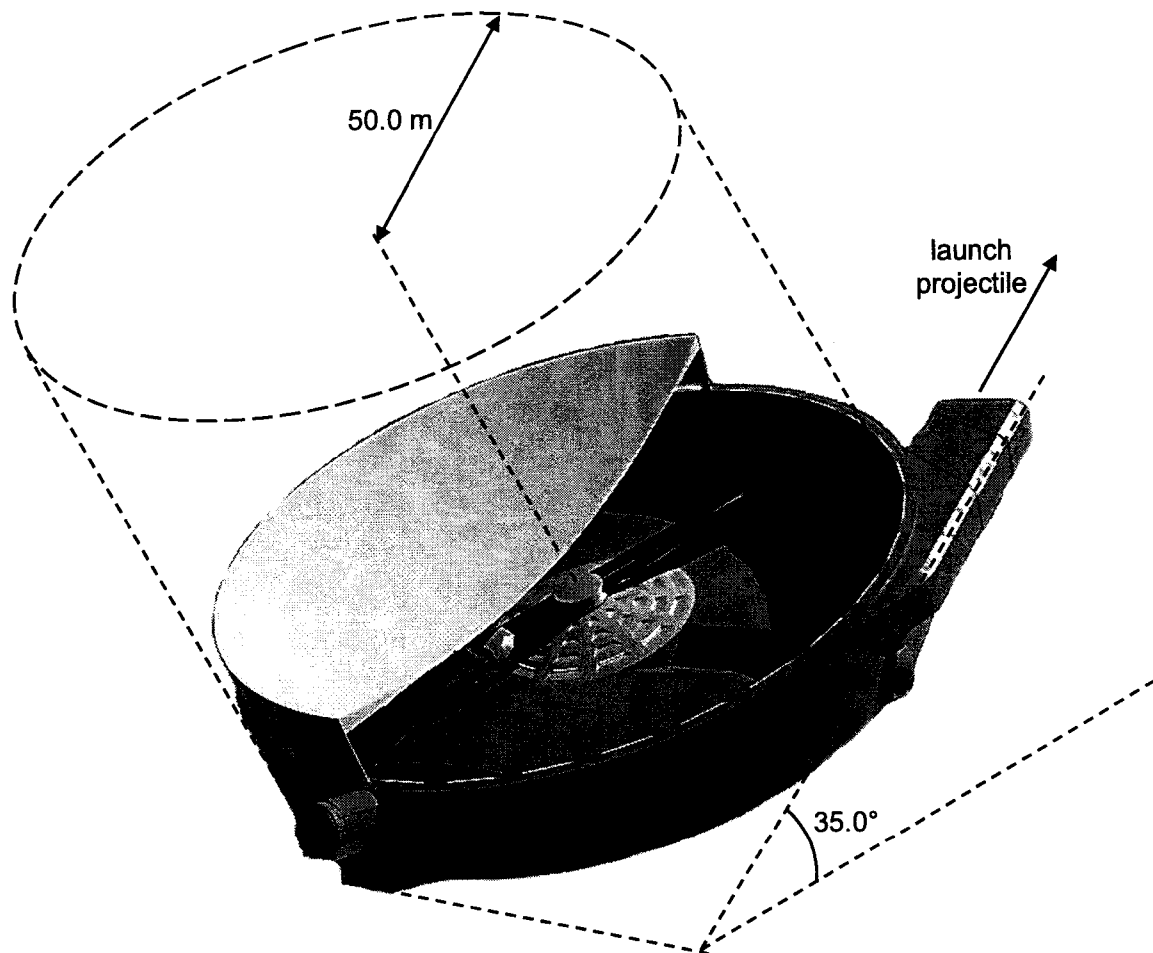


Fig. 8.2

The full-scale accelerator will feature a vacuum chamber that spins the launch projectile around a radius of 50.0 m. It will gradually ramp up the rotational speed to 450 revolutions per minute before launching the projectile at speed of 8000 km per hour, directed 35.0° above the horizontal.

Once the launch projectile reaches an altitude of 61 000 m, a traditional fuel-combustion rocket ignites in order to accelerate to the desired speed of 28 200 km per hour.

(c) (i) Determine the angular speed of Earth's rotation about its own axis.

angular speed = rad s⁻¹ [1]

(ii) To allow for a more efficient launch, the accelerator should be sited somewhere along the equator of the Earth.

State and explain the direction that the launch projectile be directed towards, in order to achieve further energy efficiency.

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

(d) (i) Show that the linear speed of the launch projectile in the full-scale design just before launch is 2360 m s⁻¹.

[1]

(ii) Find the ratio of $\frac{\text{kinetic energy of launch projectile at launch}}{\text{kinetic energy of launch projectile just before launch}}$.

ratio = [1]

(iii) Using energy considerations, explain why the interior of the accelerator has to be in vacuum.

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

- (e) (i) The effective power supplied in spinning up the launch projectile is 100 kW.

Determine the amount of time (in minutes) required to spin the launch projectile up to launch speed from rest.

time = min [2]

- (ii) Humans can briefly survive being subject to accelerations of up to 9 g's.

Suggest if this method of launch is suitable for sending humans up to satellite bodies such as the International Space Station.

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

Low Earth Orbit (LEO)

Low Earth Orbit (LEO) is an orbit around Earth with a period of 128 minutes or less. This is a region of Earth's atmosphere that is below an altitude of 2,000 km, about one-third of Earth's radius. Fig. 8.3 shows the variation of gravitational potential ϕ with distance from Earth's surface. The Earth has a radius of 6400 km.

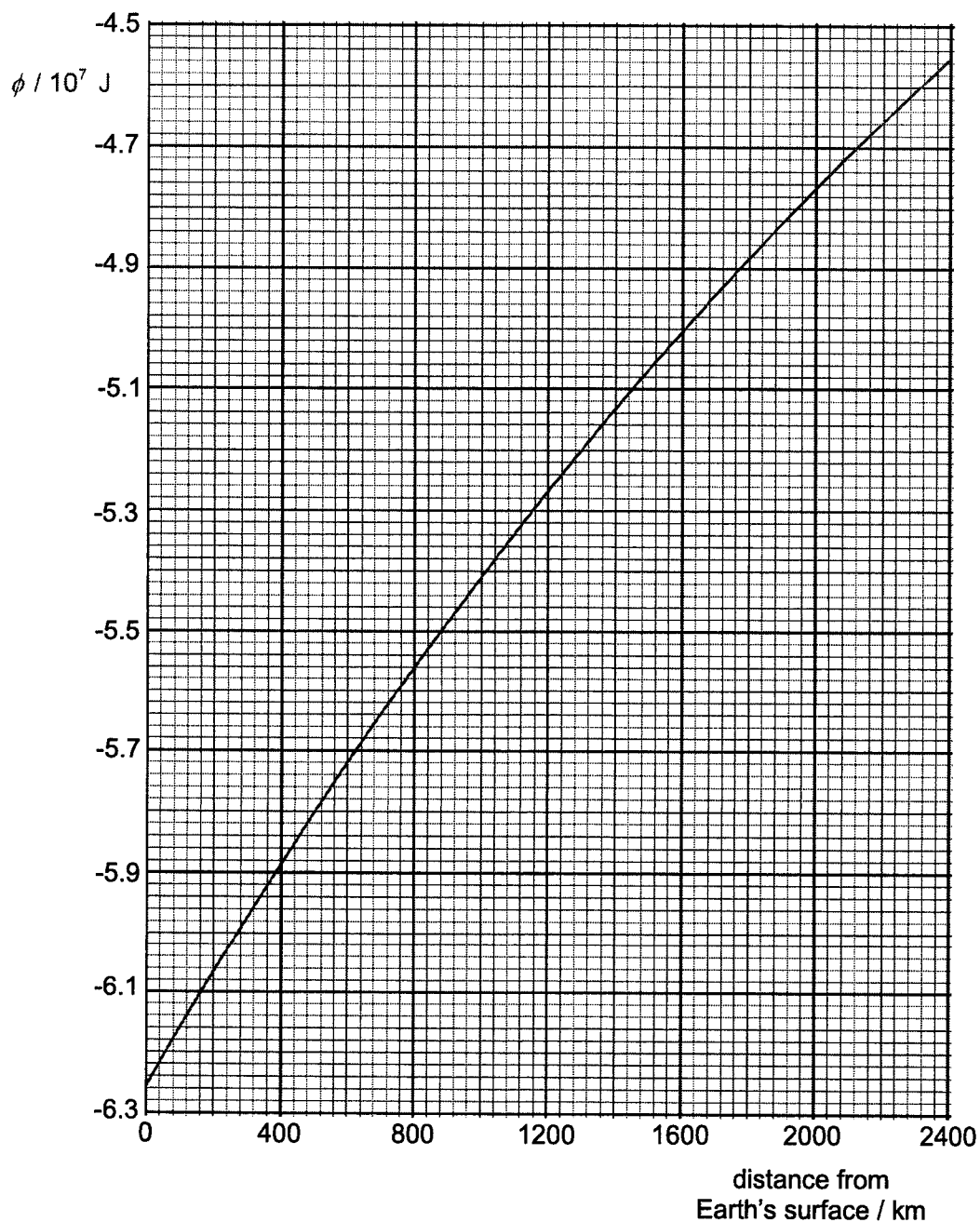


Fig. 8.3

(f) (i) State what is meant by *gravitational potential*.

.....

.....

..... [1]

(ii) Use Fig. 8.3 to determine the gravitational field strength g at an altitude of 2000 km.

Show your working clearly.

$g = \dots\dots\dots \text{ N kg}^{-1}$ [2]

(iii) Your answer to part (f)(ii) is clearly non-zero.

Explain why astronauts onboard the International Space Station which orbit the Earth in a LEO, experience weightlessness despite being subject to Earth's gravitational field.

.....

.....

..... [2]

(iv) A launch projectile of mass 200 kg is launched via SpinLaunch and successfully docks with the International Space Station, which orbits the Earth at an altitude of 400 km.

Use Fig. 8.3 to find the work done against gravity in doing so.

work done = J [2]

[Total: 25]



EUNOIA JUNIOR COLLEGE
 JC2 PRELIMINARY EXAMINATIONS 2022
 General Certificate of Education Advanced Level
 Higher 2

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PHYSICS

9749/03

Paper 3 Longer Structured Questions

August/September 2022

2 hours

Candidates answer on the Question Paper.
 No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.

Section A

Answer all questions.

Section B

Answer one question only.

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

For Examiner's Use		
1		10
2		5
3		13
4		8
5		4
6		10
7		10
Section B		
8	9	20
s.f.		
Total		80

This document consists of 27 printed pages and 1 blank page.

2

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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
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,

$$W = p\Delta V$$

hydrostatic pressure,

$$p = \rho gh$$

gravitational potential,

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

temperature,

$$T / \text{K} = T / ^\circ\text{C} + 273.15$$

pressure of an ideal gas,

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

mean translational kinetic energy of an ideal gas molecule

$$E = \frac{3}{2} kT$$

displacement of particle in s.h.m.

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

velocity of particle in s.h.m.

$$v = v_0 \cos \omega t$$

$$= \pm \omega \sqrt{(x_0^2 - x^2)}$$

electric current,

$$I = Anvq$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

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

electric potential,

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

alternating current/voltage,

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

magnetic flux density due to a long straight wire

$$B = \frac{\mu_0 I}{2\pi d}$$

magnetic flux density due to a flat circular coil

$$B = \frac{\mu_0 NI}{2r}$$

magnetic flux density due to a long solenoid

$$B = \mu_0 nI$$

radioactive decay,

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

decay constant

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

Section A

Answer all the questions in this Section in the spaces provided.

- 1 (a) (i) State what is meant by *gravitational field strength*.

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

- (ii) State Newton's law of gravitation and hence, show that the gravitational field strength g at a distance R from a point mass M is given by

$$g = \frac{GM}{R^2}$$

[3]

5

(b) A star is spherical in shape, has mass 6.2×10^{30} kg and radius 2.7×10^4 m.

(i) Calculate the average density of the star.

average density = kg m⁻³ [2]

(ii) It is found that the density inside a star is non-uniform.

State and explain how the density is likely to vary with distance from the centre of the star.

.....

 [2]

(iii) Find the minimum speed needed for a mass of 250 kg at the surface of the star to escape the effects of the gravitational field due to the star.

Show your working clearly.

speed = m s⁻¹ [2]

[Total: 10]

2 (a) State what is meant by *simple harmonic motion*.

.....

 [1]

(b) In a particular video game, players control the movement of characters through obstacle courses. One particular obstacle features a rectangular wall which moves vertically up and down with simple harmonic motion, as shown in Fig. 2.1. The wall is tall such that the character cannot progress with the game by jumping over the wall. The bottom face of the wall touches the ground every 4.0 s, and rises to a maximum height of 1.4 m.

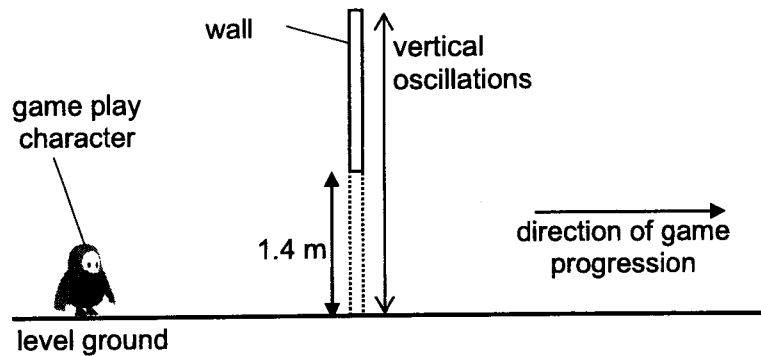


Fig. 2.1 (not to scale)

(i) Find the speed of the wall when the bottom face of the wall is 0.50 m above the ground.

speed = m s⁻¹ [2]

(ii) The bottom face of the wall needs to be at least 0.55 m above the ground for the character to pass under successfully.

Find the duration of time that the character can pass under, in each cycle of simple harmonic motion.

time = s [2]

[Total: 5]

- 3 (a) Fig. 3.1 shows a set up that measures the specific latent heat of vaporization of pure water.

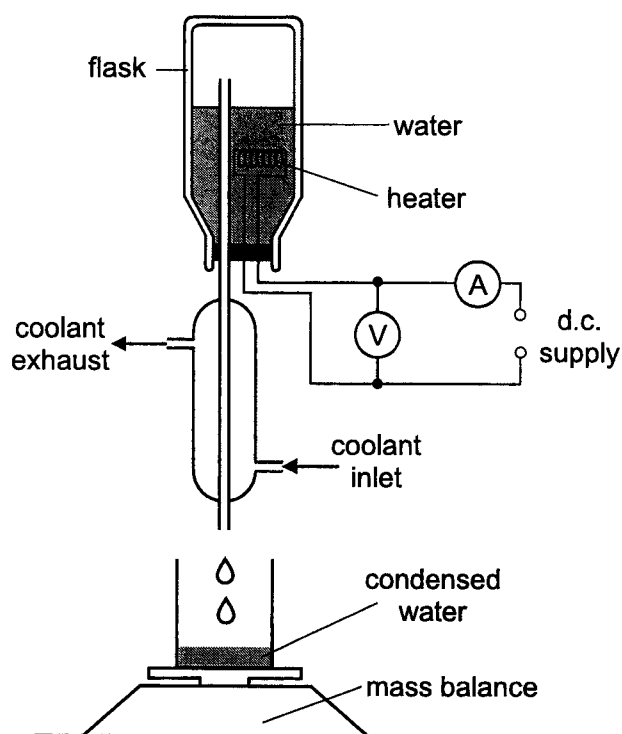


Fig. 3.1

The measurements in Fig 3.2 were made across 2 separate experiments each lasting for 1.5 minutes.

voltmeter reading / V	ammeter reading / A	mass of condensed water / g
78	5.0	16
60	4.0	10

Fig. 3.2

- (i) Show that the specific latent heat of vaporization of water is $2.25 \times 10^6 \text{ J kg}^{-1}$.

8

- (ii) The assumption when using the values provided in Fig 3.2 to determine the specific latent heat of vaporization of water is that the rate of heat loss from the system is constant.

Explain why the assumption is valid.

.....

 [1]

- (b) At a temperature of 100 °C and a pressure of 1.00×10^5 Pa, steam of mass 1.00 kg occupies a volume of 1.67 m³. In comparison, liquid water of the same mass, at the same temperature and subject to the same external pressure, occupies a volume of 1.04×10^{-3} m³.

1.00 kg of water undergoes phase change from liquid to gas at 100 °C and 1.00×10^5 Pa. Using (a)(i), determine the

- (i) heat supplied to the water,

heat supplied = J [2]

- (ii) work done by the water,

work done = J [2]

- (iii) increase in internal energy of the water.

increase in internal energy = J [1]

- (iv) The total potential energy and total kinetic energy of all the molecules in 1.0 kg of liquid water at a temperature of 100 °C is 3.41×10^5 J and 2.58×10^5 J respectively.

Find the potential energy of all the molecules in 1.0 kg of gaseous water at the same temperature and at the same external pressure.

potential energy = J [2]

- (v) Explain why energy has to be continuously supplied during the vaporization process.

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

[Total: 13]

11

(ii) show that the e.m.f. described in (a)(i) is given by

$$E = BAf$$

where B is the magnetic flux density inside the long solenoid,
 A is the circular area of the copper disc, and
 f is the frequency of revolution of the copper disc.

[2]

- (b) (i) Using (a)(ii), show with clear explanation that the resistance R when the galvanometer registers null deflection is given by

$$R = \mu_0 n A f$$

where n is the number of turns per unit length of the solenoid.

[1]

- (ii) Hence, suggest the advantage in using this method for finding resistance.

.....
 [1]

- (c) The copper disc has a radius of 0.20 m and is rotated at 5.0 revolutions each second. When the galvanometer meter registers null deflection, the current flowing through the resistor R of 10Ω is found accurately to be 1.0 mA.

Determine B .

$B = \dots\dots\dots$ T [1]
 [Total: 8]

- 5 (a) In Fig. 5.1, sketch the variation with frequency f of the stopping potential V_s when electromagnetic radiation is incident on a metal surface of work function energy 2.4 eV.

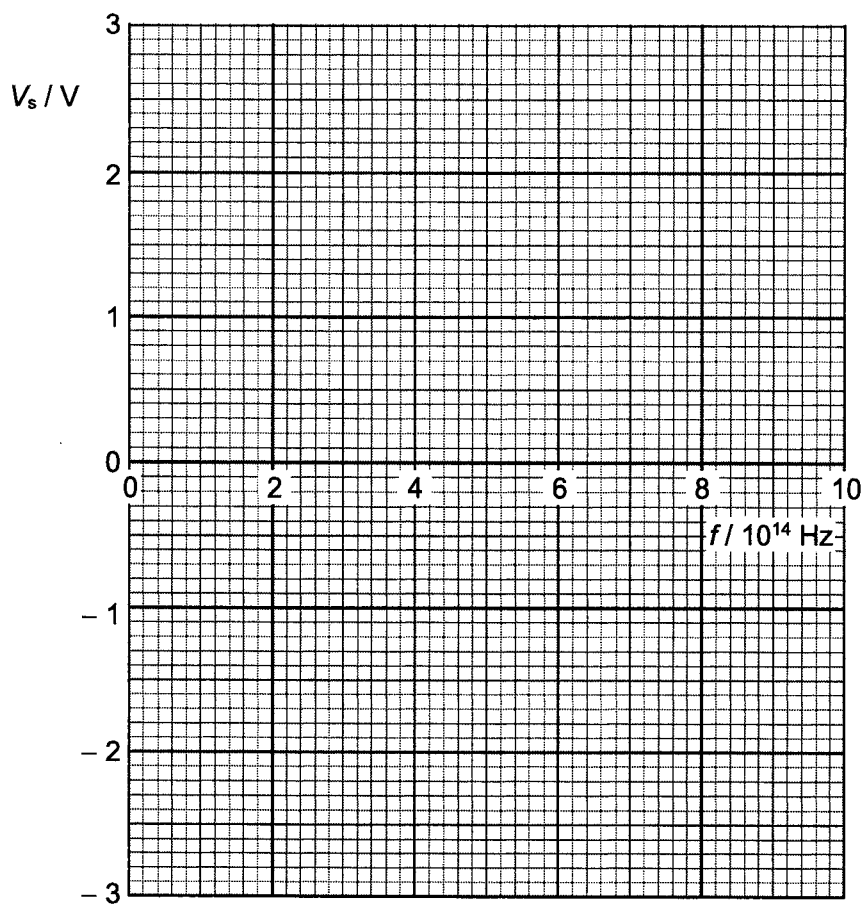
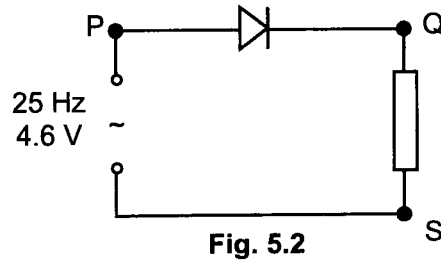


Fig. 5.1

[2]

- (b) Fig. 5.2 shows an alternating supply, of frequency 25 Hz and rated at an output p.d. of 4.6 V, connected in series with an ideal diode and a resistor.



- (i) Calculate the maximum potential difference (p.d.) that is applied across the diode.

maximum p.d. = V [1]

- (ii) The waveform seen on the screen of the c.r.o. when the Y-plates are connected across points QS is shown on Fig. 5.3.

On the same figure Fig. 5.3, sketch the waveform that is seen on the screen of the c.r.o. when the Y-plates are connected across PQ instead.

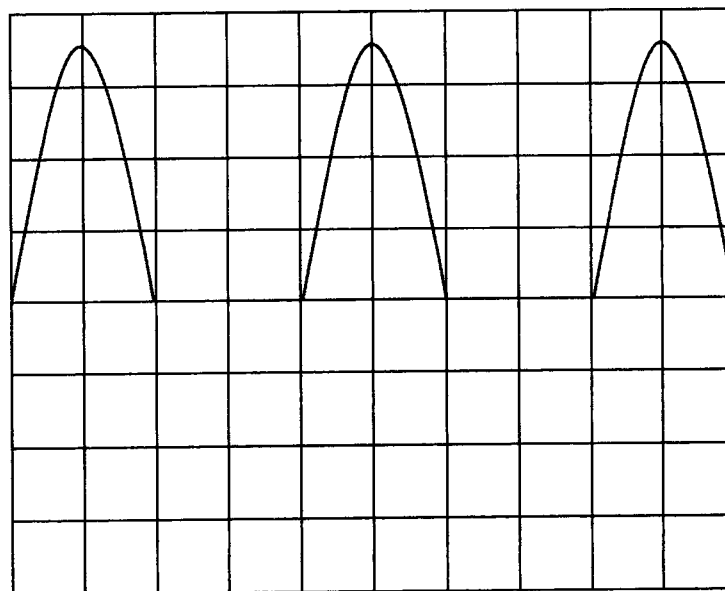


Fig. 5.3

[1]

[Total: 4]

- 6 Fig. 6.1 shows two parallel metal plates each of length 10 cm, at a distance of 4.0 cm apart, in a vacuum environment. A proton with speed $6.5 \times 10^5 \text{ m s}^{-1}$ is emitted from a proton source.

The proton travels along a straight path exactly down the middle of the region between the parallel plates when there is no electric potential difference between the metal plates. It then strikes a screen where it shows up as a scintillation.

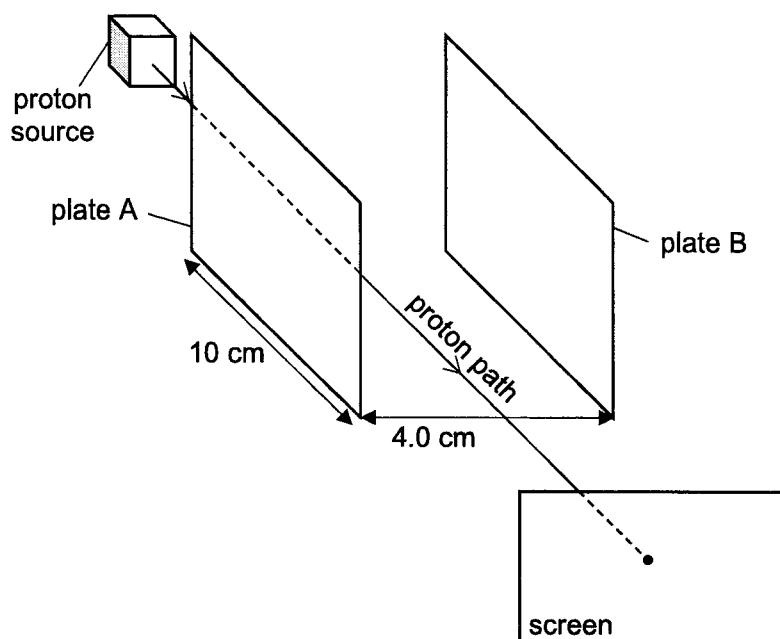


Fig. 6.1 (not to scale)

- (a) When a potential of +250 V and – 250 V is applied to plates A and B respectively, a region of uniform electric field is set up between the metal plates.
- (i) Determine the speed at which the proton emerges from the region of uniform electric field.

speed = m s⁻¹ [4]

- (ii) Calculate the electric potential at the point where the proton emerges from the region of uniform electric field.

potential = V [2]

- (b) In Fig. 6.1, indicate with a cross (x) where the deflected proton is likely to hit the screen. [1]

- (c) Suggest how the set up in Fig. 6.1 can be modified to be used as a velocity selector.

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

[Total: 10]

- 7 (a) Explain what is meant by a *photon*.

.....

 [1]

- (b) (i) Determine the maximum and minimum energy of photons spanning the visible spectrum.

maximum photon energy = eV

minimum photon energy = eV [1]

- (ii) White light is passed through hydrogen gas. The emerging beam is passed through a diffraction grating.

Explain why there are dark lines observed in the resulting absorption spectrum despite all of the wavelengths that are absorbed are subsequently re-emitted.

.....
 [1]

- (iii) Fig. 7.1 shows some of the energy levels present in the hydrogen atom.

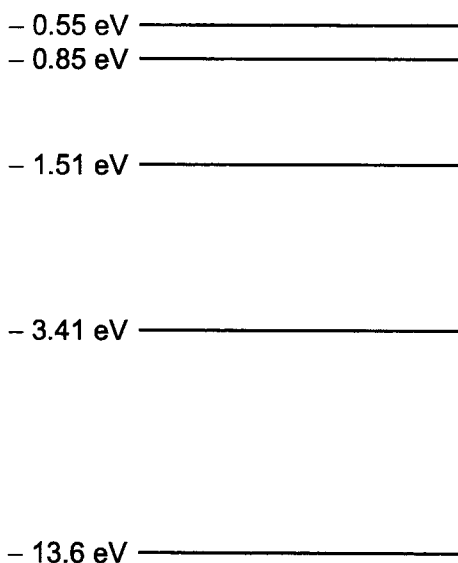


Fig. 7.1 (not to scale)

In Fig. 7.1, draw arrows to represent the electron promotion between energy levels that give rise to the dark lines observed in an absorption spectrum. [2]

(c) The hydrogen gas is now cooled to ground state.

(i) State and explain the changes, if any, to the resulting absorption spectrum.

.....

 [2]

(ii) The white light source is switched off. An electron beam is accelerated from rest through potential difference V and made to pass through the cooled hydrogen gas. There are now three bright lines visible in the resulting emission spectrum.

1. Determine the minimum V for the above emission spectrum to occur.

minimum $V = \dots\dots\dots V$ [2]

2. Find the shortest wavelength of visible light emitted as part of the emission spectrum.

shortest wavelength = $\dots\dots\dots m$ [1]

[Total: 10]

Section B

Answer any **one** question in this Section in the spaces provided.

- 8 (a) A helicopter hovers at a height of 200 m above the sea. It then releases an emitter which emits radio waves in all directions, from rest. As the emitter drops towards the sea, a receiver on the helicopter detects a series of distinct minima and maxima. The variation of the intensity detected by the receiver with distance d between emitter and receiver is shown in Fig. 8.1.

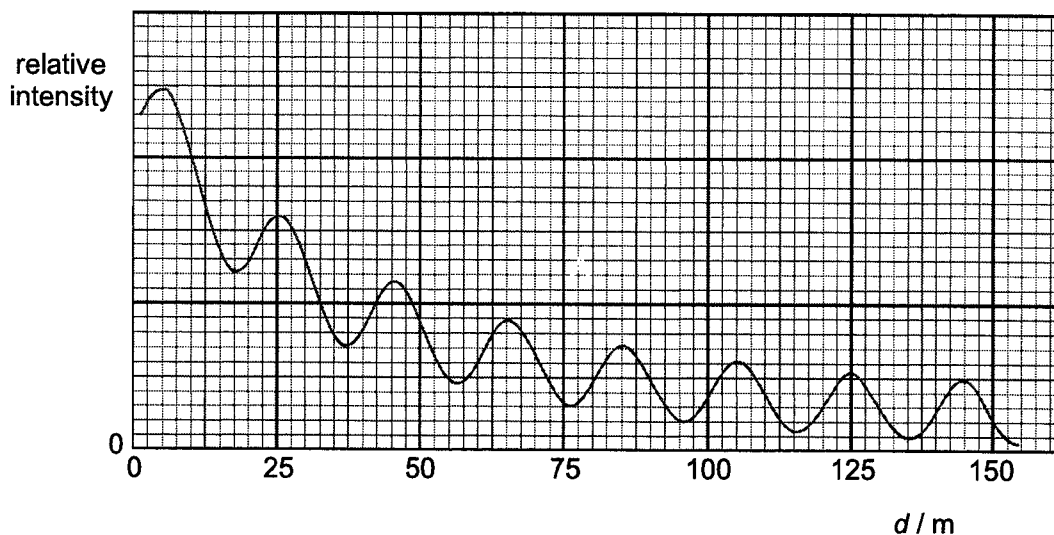


Fig. 8.1

- (i) State the *principle of superposition*.

.....

 [1]

- (ii) Explain the following features of the graph in Fig. 8.1:
 1. the formation of alternating minima and maxima,

.....

 [3]

2. the intensity of the minima decreases with increasing d ,

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

(iii) Determine the wavelength of the radio wave.

wavelength = m [3]

(b) (i) Explain what is meant by *nuclear fission*.

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

(ii) State what is *radioactive decay*.

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

(iii) Describe the process of *nuclear fusion*.

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

- (c) When a uranium-235 nucleus ${}_{92}^{235}\text{U}$ is exposed to neutrons, it may absorb a neutron and then undergo fission. The percentage mass yield of the fission products varies with nucleon number as shown in Fig. 8.2.

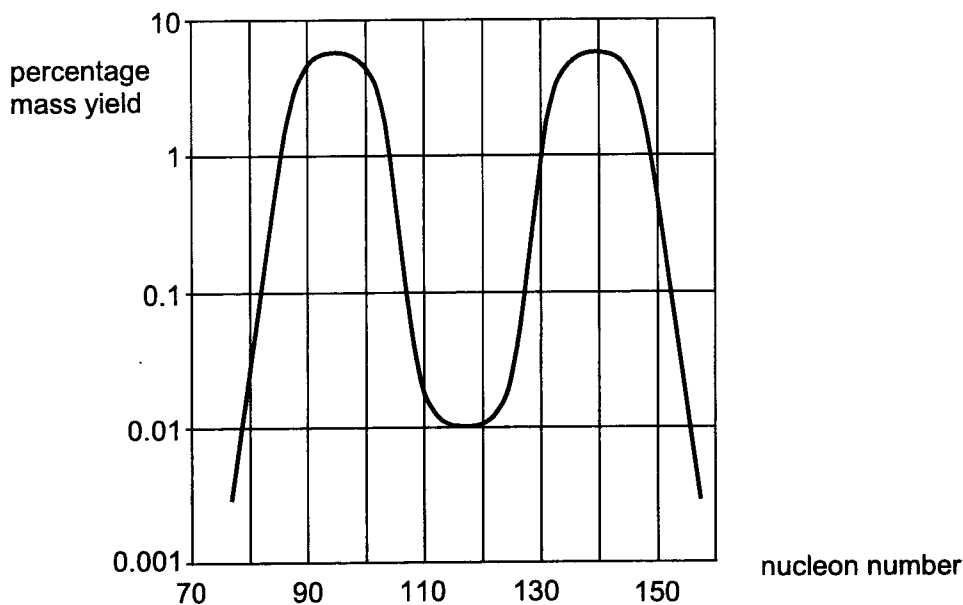


Fig. 8.2

- (i) Suggest why the percentage mass yield is shown on a logarithm scale.

.....
 [1]

- (ii) The nuclear process referenced in Fig. 8.2 results in two neutrons amongst the products.

Explain why the graph is symmetrical about the nucleon number 117.

.....

 [3]

- (d) In a particular fission reaction, one of the products is iodine-140 ${}^{140}_{53}\text{I}$. A student suggests that the iodine-140 nucleus could decay by emitting either a neutron or a β^- particle.

Fig. 8.3 shows some relevant data:

		mass / u
electron	${}^0_{-1}\text{e}$	0.0006
neutron	${}^1_0\text{n}$	1.0087
iodine-139	${}^{139}_{53}\text{I}$	138.8969
xenon-140	${}^{140}_{54}\text{Xe}$	139.8919
iodine-140	${}^{140}_{53}\text{I}$	139.9019

Fig. 8.3

For the iodine-140 nucleus, write an equation representing the radioactive decay involving

- (i) neutron emission

[1]

- (ii) beta emission

[1]

- (iii) Use Fig. 8.3 to show if the radioactive decay involving neutron emission is feasible.

.....
 [1]

- (iv) Use Fig. 8.3 to show if the radioactive decay involving beta emission is feasible.

.....
 [1]

[Total: 20]

- 9 (a) Fig. 9.1 shows a metal wire held taut between a knife edge X and a smooth pulley P. The wire passes between opposing poles of permanent bar magnets.

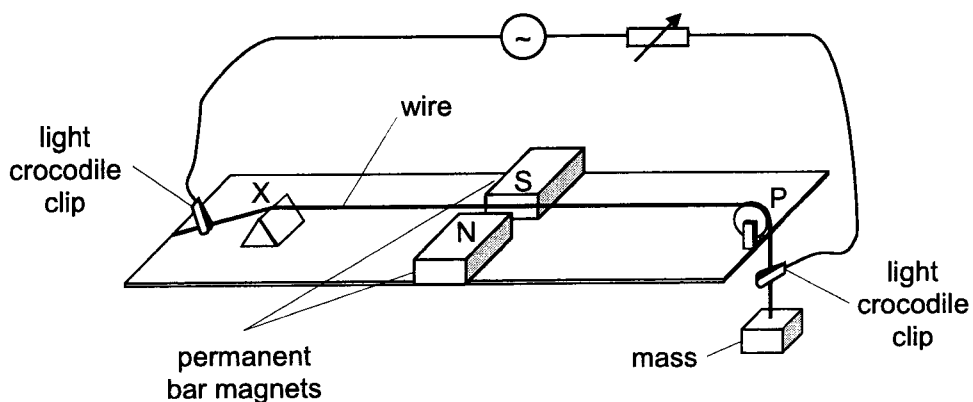


Fig. 9.1

- (i) The wire vibrates when a sinusoidal alternating source is connected across the wire.

Explain how these vibrations are created.

.....

.....

.....

.....

.....

.....

.....

..... [2]

(ii) When the frequency of the alternating source is 50 Hz and the distance XP is 40 cm, a fundamental stationary wave is observed between XP.

1. Calculate the speed of the wave in the wire.

speed = m s⁻¹ [1]

2. Explain, with reference to the formation of a stationary wave, what is meant by the speed calculated in (a)(ii)1.

.....
.....
.....
.....
.....
.....
.....
.....
..... [4]

3. State and explain how the amplitude of the vibration would change if X is shifted closer to P.

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

4. Determine the next 2 higher frequencies that will produce stationary waves when XP remains 40 cm apart.

frequencies = Hz, Hz, [1]

- (b) The decay of a radioactive nuclei is random and spontaneous. In a radioactive decay, the activity of the atoms at time t is given by

$$A = A_0 \exp(-\lambda t)$$

where A_0 is the activity at the start of the decay and λ is the decay constant.

As part of monitoring of a particular disposal site where nuclear waste in the form of a particular radioactive isotope is disposed, the activity on-site is recorded on a yearly basis from 1990 through to 2003. A significant reduction in activity was recorded in 1998, as shown in Fig. 9.2.

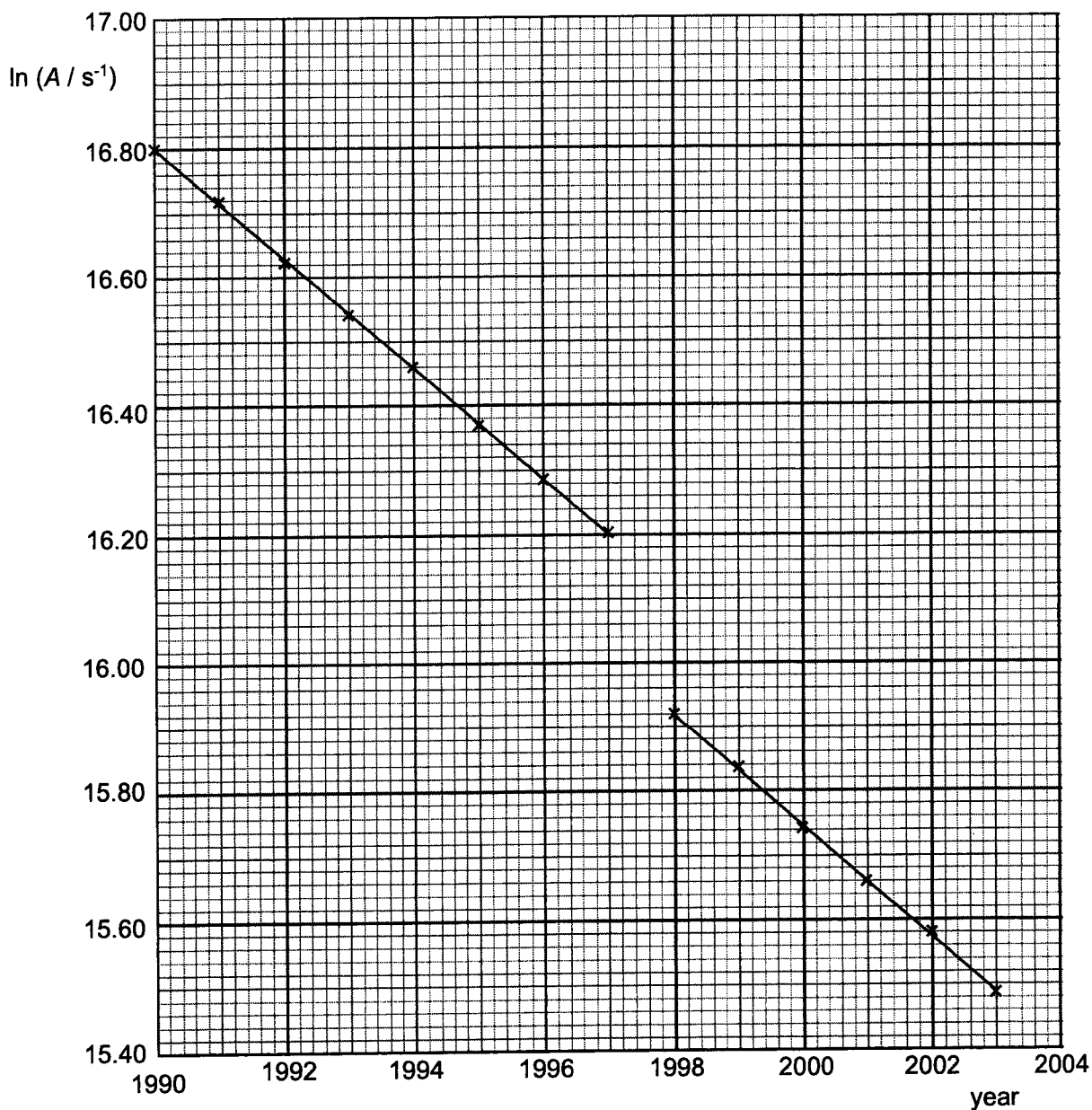


Fig. 9.2

- (i) Use Fig. 9.2 to determine the decay constant λ of the radioactive isotope.

$$\lambda = \dots\dots\dots \text{ s}^{-1} \text{ [2]}$$

- (ii) Hence or otherwise, find the half-life of the radioactive isotope.

$$\text{half-life} = \dots\dots\dots \text{ years [2]}$$

- (iii) Use Fig. 9.2 to show that the number of undecayed nuclei present in the year 1997 is 4.00×10^{15} .

- (iv) It is alleged that some of the radioactive waste material was stolen between 1997 to 1998.

Estimate the number of radioactive nuclei that was stolen.

$$\text{number} = \dots\dots\dots \text{ [2]}$$

- (v) Explain why the two sections of the graph before and after the alleged theft, are parallel.

.....

[2]
 [Total: 20]



EUNOIA JUNIOR COLLEGE
 JC2 PRELIMINARY EXAMINATIONS 2022
 General Certificate of Education Advanced Level
 Higher 2

CANDIDATE
 NAME

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CIVICS
 GROUP

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REGISTRATION
 NUMBER

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PHYSICS

Paper 4 Practical

9749/04

August 2022

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.

You may use an HB pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

Answer all questions.

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

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together.

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

Shift
Laboratory

For Examiner's Use	
1	13
2	12
3	19
4	11
Total	55

This document consists of **18** printed pages and 2 blank pages.

2

1 In this experiment, you will investigate the oscillations of a pendulum.

(a) Set up the apparatus as shown in Fig. 1.1.

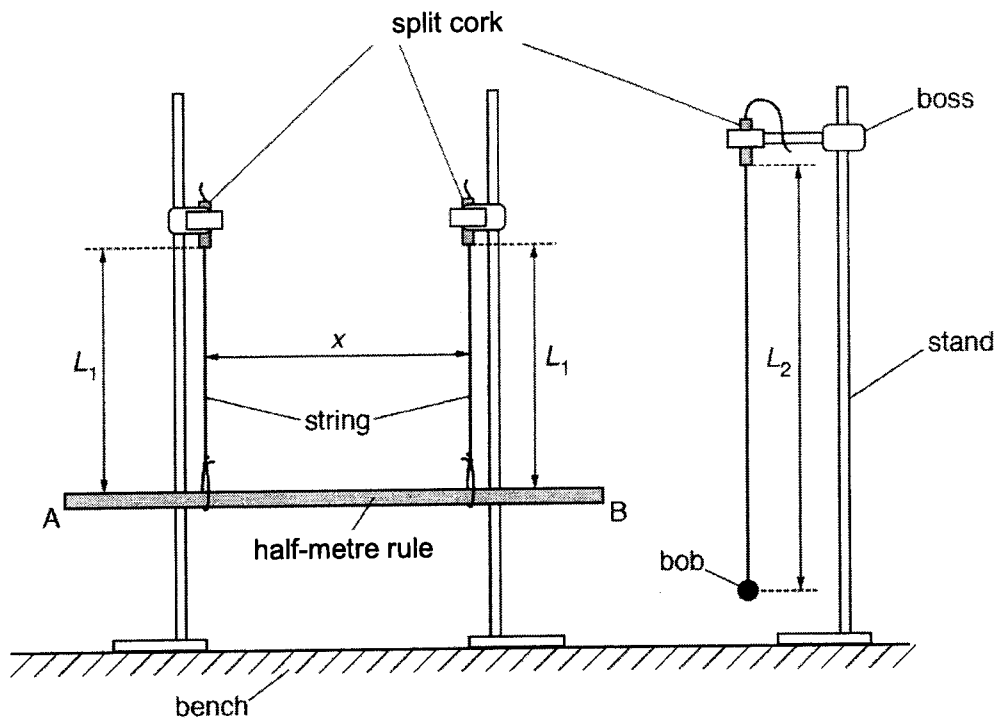


Fig. 1.1

The distance between the strings supporting the half-metre rule is x . The marked face of the rule should be facing upwards towards the ceiling.

The distances between the top of the half-metre rule and the bottom of the split cork should be equal. These distances are both L_1 .

The distance between the centre of the bob and the bottom of the split cork is L_2 .

Adjust the position of the strings so that $x \approx 25$ cm, $L_1 \approx 25$ cm, and $L_2 \approx 45$ cm.

The strings should be vertical, and the half-metre rule should be parallel to the bench.

(i) Measure and record x and L_1 .

$x =$

$L_1 =$

[1]

3

- (ii) Estimate the percentage uncertainty in your value of
- L_1
- .

percentage uncertainty in $L_1 = \dots\dots\dots$
[1]

- (b) (i) Pull the bob and end B of the half-metre rule towards you through a short distance. End A of the half-metre rule will be away from you.

Release the bob and the half-metre rule simultaneously so that they oscillate. The half-metre rule will oscillate about a vertical axis.

Adjust L_2 until the periods of the oscillations of the bob and of the half-metre rule are the same.

Measure and record L_2 .

$L_2 = \dots\dots\dots$
[1]

- (ii) Estimate the percentage uncertainty in your value of
- L_2
- .

percentage uncertainty in $L_2 = \dots\dots\dots$
[1]

- (iii) Calculate
- $\frac{L_1}{L_2}$
- .

$\frac{L_1}{L_2} = \dots\dots\dots$
[1]

- (c) (i) Change
- x
- to approximately 30 cm and
- L_1
- to approximately 20 cm.

Measure and record x and L_1 .

$x = \dots\dots\dots$

$L_1 = \dots\dots\dots$

4

(ii) Repeat (b)(i) and (b)(iii).

$L_2 = \dots\dots\dots$

$\frac{L_1}{L_2} = \dots\dots\dots$

[3]

(d) It is suggested that the relationship between L_1 , L_2 and x is

$$\frac{L_1}{x^2 L_2} = \frac{3}{l^2}$$

where l is the effective length of the half-metre rule.

(i) Determine l by referring to your values in (a), (b) and (c).

$l = \dots\dots\dots$

[1]

(ii) If you were to repeat this experiment by varying x and L_1 for several more times, describe the graph you would plot to determine l .

.....

[2]

(e) (i) Suggest one significant source of uncertainty in this experiment.

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

(ii) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in (e)(i).

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

[Total: 13]

6

2 In this experiment, you will investigate an electrical circuit.

(a) Set up the apparatus as in Fig. 2.1. Use the $100\ \Omega$ resistor in place of the labelled resistor.

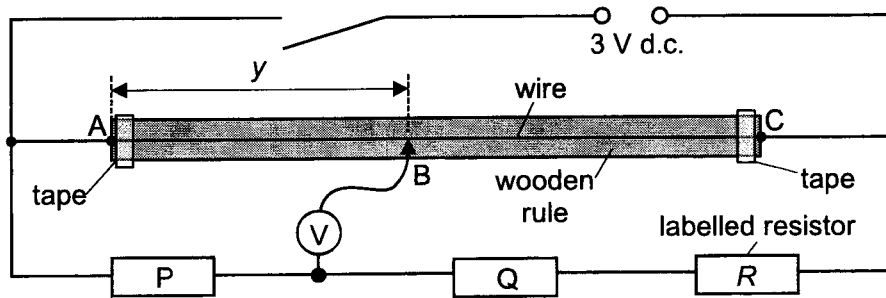


Fig. 2.1

Close the switch. Adjust the position of B until the voltmeter reading is as close as possible to zero. The distance between A and B is y , as shown in Fig. 2.1.

Measure and record y .

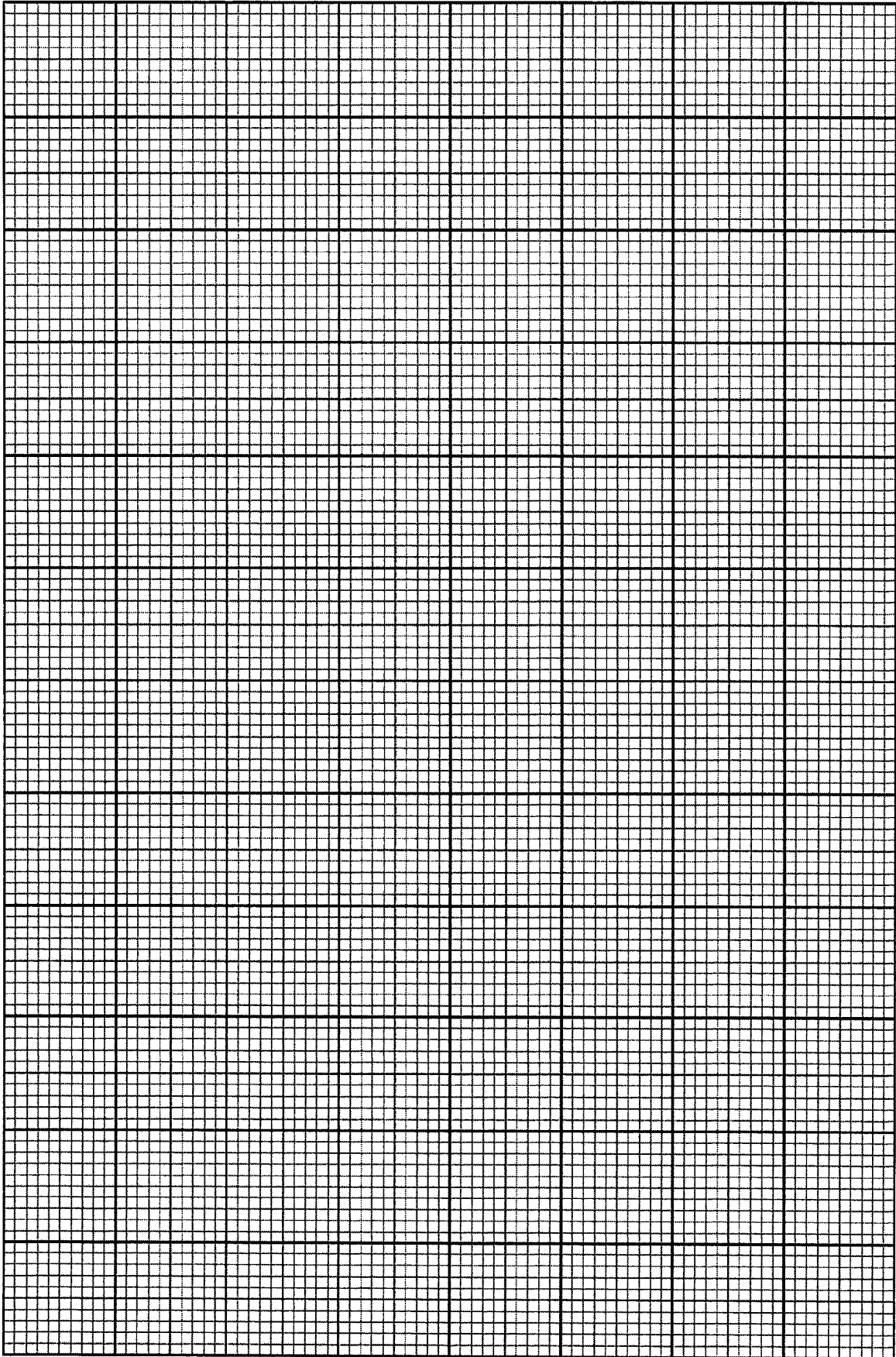
$y = \dots\dots\dots$
[1]

Open the switch.

(b) Vary the resistance of the labelled resistor, R and repeat (a).

Present your results clearly.

[4]



8

(c) It is suggested that the quantities y and R are related by the equation

$$\frac{1}{y} = aR + b$$

where a and b are constants.

Plot a graph to determine the values of a and b .

$a = \dots\dots\dots$

$b = \dots\dots\dots$

[5]

- (d) (i) Measure and record the length W of the wire between the crocodile clips A and C.

$W = \dots\dots\dots$

- (ii) Resistor P has resistance P .

Calculate the value of P using the relationship

$$a = \frac{1}{PW}$$

$P = \dots\dots\dots$
[1]

- (e) The wire mounted between points A and C is shortened and the experiment is repeated.

Sketch a line on your graph grid on page 7 to show the expected result.

Label this line S. [1]

[Total: 12]

- 3 In this experiment, you will investigate the change in shape of a rubber band when masses are hung from it.

(a) Set up the apparatus as shown in Fig. 3.1.

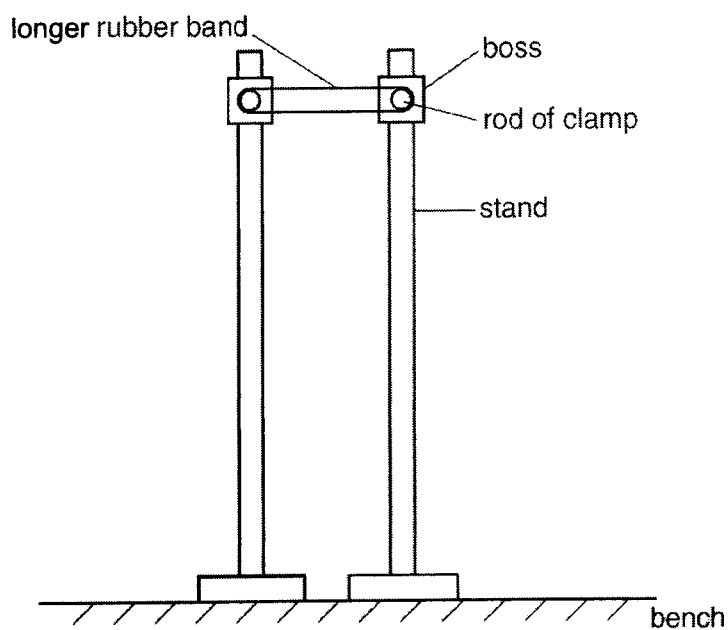


Fig. 3.1

The rods of the two clamps must be at the same height above the bench.

Place both rods through the **longer** rubber band.

Position the stands so that the rubber band just has no slack.

(b) Record the mass m of the mass hanger.

$m = \dots\dots\dots$

11

- (c) (i) Suspend the mass hanger from the centre of the lower part of the rubber band as shown in Fig. 3.2.

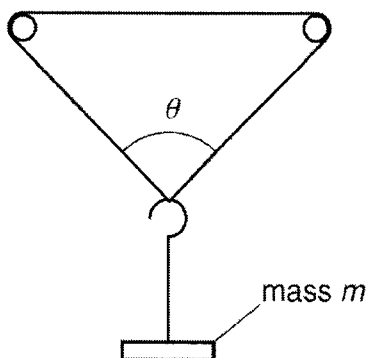


Fig. 3.2

- (ii) Measure and record the angle θ as shown in Fig. 3.2.

$\theta = \dots\dots\dots$
[1]

- (iii) Estimate the percentage uncertainty in your value of θ .

percentage uncertainty = $\dots\dots\dots$
[1]

- (iv) Calculate $\tan^2 \frac{\theta}{2}$.

$\tan^2 \frac{\theta}{2} = \dots\dots\dots$
[1]

12

(d) (i) Add the slotted mass to the mass hanger.

Record the total mass m of the mass hanger and slotted mass.

$m = \dots\dots\dots$

(ii) For this total mass, repeat (c)(i), (c)(ii) and (c)(iv).

$\theta = \dots\dots\dots$

$\tan^2 \frac{\theta}{2} = \dots\dots\dots$

[1]

13

(e) It is suggested that the relationship between m and θ is

$$m = \frac{k}{\tan^2 \frac{\theta}{2}}$$

where k is a constant.

(i) Using your data, calculate two values of k .

first value of k =

second value of k =

[2]

(ii) Justify the number of significant figures given in your values of k .

.....

 [1]

(iii) Explain whether your results in (e)(i) support the suggested relationship.

Justify your conclusion by referring to your answer in (c)(iii).

.....

 [2]

- (f) You have been provided with another rubber band of **shorter** length.

Use the rubber bands provided to determine the effect of length on θ for the same mass being suspended from the centre of the lower part of the rubber band.

- (i) State and explain your choice of mass to be used in your investigation.
- (ii) Tabulate your results.
- (iii) Suggest a possible trend based on your results. Explain how you can improve the validity of your suggestion.

.....

.....

.....

.....

..... [5]

16

- 4 The boiling point of a solution of table salt varies with pressure.

It is suggested that the relationship between the Celsius temperature θ at which the water of the solution starts to boil and the air pressure P is

$$\theta = k\sigma^n P^q$$

where σ is the density of the solution at room temperature and pressure, and n , k and q are constants.

Design an experiment to determine the values of n and q .

Draw a diagram to show the arrangement of your equipment. Pay particular attention to

- the equipment you would use
- the procedure to be followed
- the control of variables
- any precautions that should be taken with your experiment.

