Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME	
CLASS	2T

PHYSICS
Paper 2: Structured Questions

9749/2
25 August 2022
2 hours

Candidates answer on the Question Paper
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name and class 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		DIFFICULTY		
		L1	L2	L3
Q1	/ 11			
Q2	/ 8			
Q3	/ 11			
Q4	/ 9			
Q5	/ 7			
Q6	/ 5			
Q7	/ 7			
Q8	/ 22			
PAPER 2	/ 80			

This document consists of **21** printed pages and **1** blank page.

[Turn over

DATA

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 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	$T/K = T/^{\circ}C + 273.15$
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	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Answer **all** the questions in the spaces provided.

1 A cliff train cabin is used to carry passengers up a slope as shown in Fig.1.1.

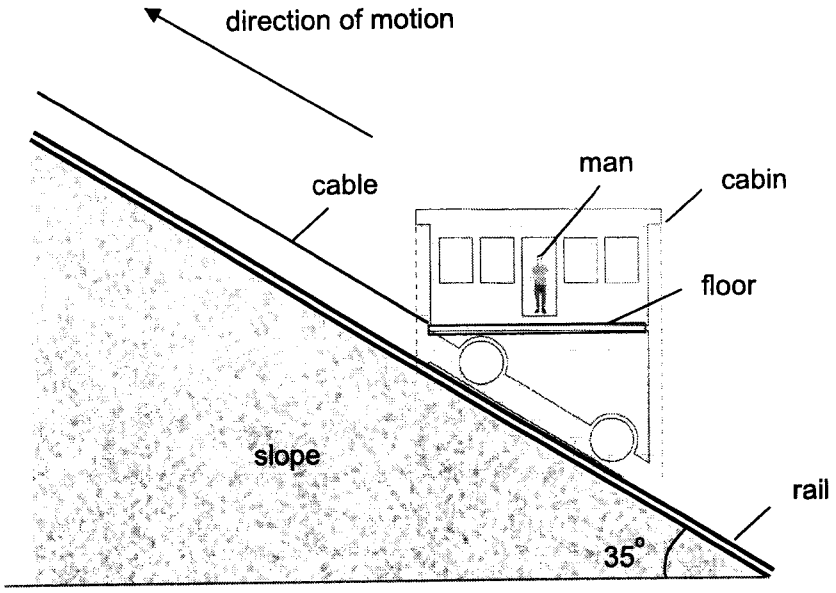

Fig. 1.1

The cable attached to the cabin pulls the cabin up the slope along the rail line which is inclined at 35° to the horizontal.

Initially, the cabin starts from rest and accelerates at 1.0 m s^{-2} for a time of 3.0 s. The cabin then moves at constant speed of 3.0 m s^{-1} for 100 s. Finally, the cabin decelerates to rest in 3.0 s.

The floor of the cabin is horizontal all the times. A man of mass 95 kg is standing upright on the floor of the cabin.

(a) Calculate the vertical height moved by the man during the initial acceleration of the cabin.

height = _____ m [3]

(b) **(i)** Calculate the normal reaction force acting on the man from the floor of the cabin when the cabin is moving at constant speed.

normal reaction = _____ N [1]

(ii) Explain your working in **(b)(i)**.

_____

_____ [1]

(c) Forces act on the man by the floor of the cabin.

(i) State the forces for the man as the cabin accelerates.

_____ [1]

(ii) Explain how these forces produce the acceleration of the man.

_____

_____ [2]

(d) The vertical height h of the man varies with time t. On the axes below, show qualitatively the variation with time t of height h for the motion of the man during

(i) the acceleration,

[1]

(ii) the constant speed,

[1]

(iii) the deceleration.

[1]

[Total: 11]

2 A stationary electron is in a uniform field of force.

(a) Describe the direction of the force on the electron relative to the direction of the field if the field is

(i) a gravitational field,

_____ [1]

(ii) an electric field,

_____ [1]

(iii) a magnetic field.

_____ [1]

(b) Describe and explain the path the electron will take when it moves at right angles to each field.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [5]

[Total: 8]

3 (a) (i) Explain what is meant by an *ideal gas*.

_____

_____ [2]

(ii) Use the kinetic theory of gases to explain why when the volume of an ideal gas decreases at constant temperature, the pressure of the gas increases.

_____

_____

_____

_____

_____

_____

_____ [4]

(b) A fixed amount of an ideal gas undergoes a cycle of changes A→B→C→A as shown in Fig. 3.1.

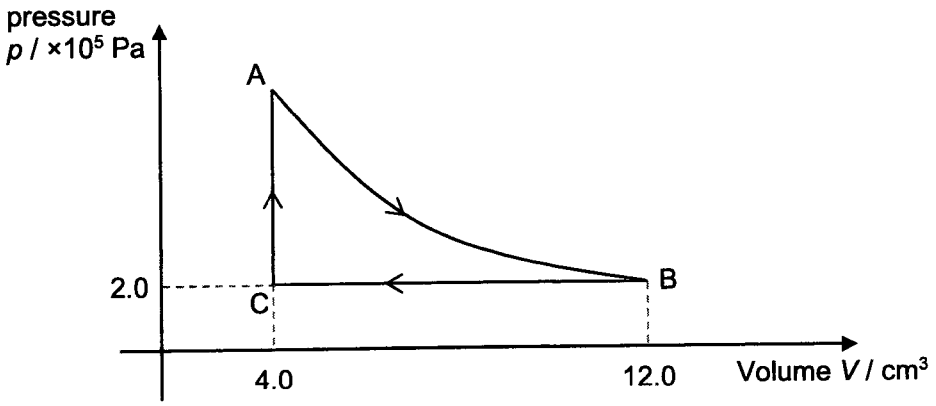

Fig. 3.1

(i) Determine the work done on the ideal gas during the process B→C.

work done on gas = _____ J [2]

(ii) Explain why there is a net thermal energy absorbed by the ideal gas when it undergoes a cycle of changes A→B→C→A.

[3]

[Total: 11]

4 The variation with potential difference *V of* current *I* in a resistor X is shown in Fig. 4.1.

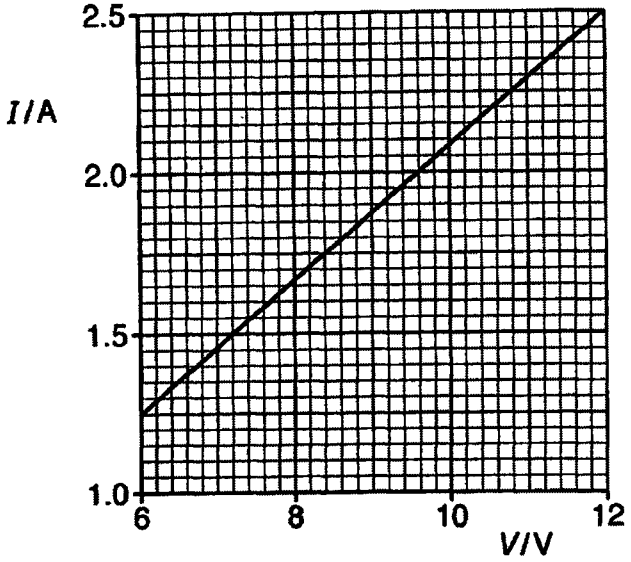

Fig. 4.1

(a) Use Fig. 4.1 to show that the resistance of X remains constant.

[2]

(b) In an attempt to obtain the graph of Fig. 4.1 for resistor X, a student sets up a circuit as shown in Fig. 4.2.

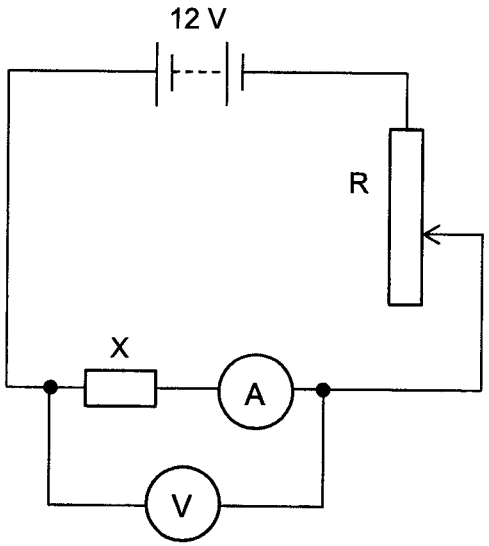

Fig. 4.2

The battery has an e.m.f. of 12 V and negligible internal resistance. The resistor R has a resistance that can be varied between 0 Ω and 2.0 Ω. The voltmeter and ammeter are both ideal.

State and explain why the circuit shown in Fig. 4.2 is inappropriate for obtaining data from $V = 6$ V to $V = 12$ V for the graph in Fig. 4.1.

_____

_____

_____

_____

_____ [2]

(c) In the space below, draw a circuit diagram using the same components as shown in Fig. 4.2 from which the graph of Fig. 4.1 may be determined.

[1]

(d) Calculate the difference in the power dissipated in resistor X when V is increased from 7.2 V to 9.6 V.

difference in power = _____ W [2]

(f) Suppose the battery has an internal resistance of 0.50 Ω, and R in Fig. 4.2 is adjusted to 0 Ω.

Calculate the terminal potential difference across the battery.

terminal potential difference = _____ V [2]

[Total: 9]

5 (a) When white light is incident on a single slit, a diffraction pattern is formed on a screen.

The central fringe of the diffraction pattern is coloured at the edges and has a white central region. Explain this observation.

_____

_____

_____ [2]

(b) (i) Explain what is meant by the *Rayleigh criterion* for the resolution of the images of two objects.

_____

_____

_____ [2]

(ii) The Griffith Observatory in Los Angeles includes an astronomical refracting telescope (Griffith telescope) with an objective lens of diameter 0.305 m.

Calculate the wavelength of light for which the Griffith telescope has a minimum angular resolution of 1.8×10^{-6} rad.

wavelength = _____ m [1]

(iii) The asteroid Apophis has a diameter of 325 m. It has been calculated that in the year 2029, its distance of closest approach to the Earth's surface will be 3.0×10^{4} km.

Supporting your answer with calculations, explain whether the Griffith telescope can resolve Apophis.

_____

_____ [2]

[Total: 7]

[Turn over

6 In an X-ray tube, electrons are produced from a filament heated by an electric current as shown in Fig. 6.1. A large accelerating potential difference is set up between the filament and the target material. The electrons are accelerated from the filament and hit the target material to emit X-ray photons.

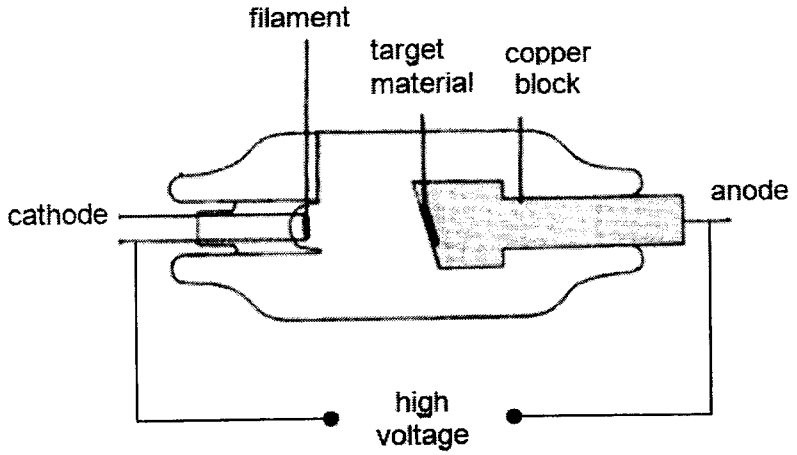

Fig. 6.1

A graph of intensity against wavelength of the emitted radiation is plotted as shown in Fig. 6.2 when the X-ray tube is operated at a voltage of 50 kV.

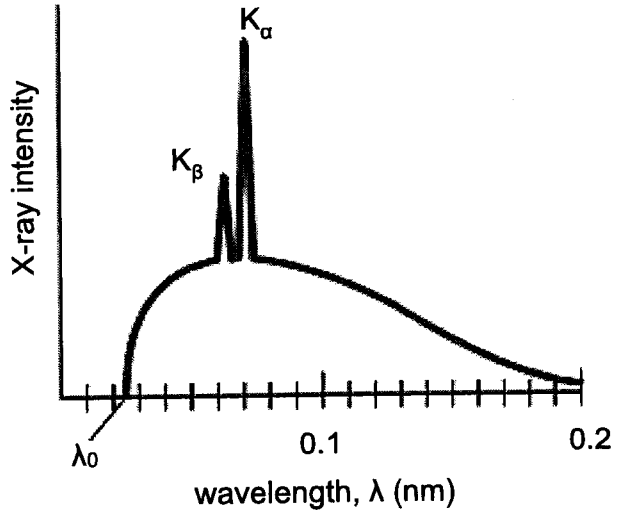

Fig. 6.2

(a) Explain why there is a minimum wavelength λ_0 for the emitted X-rays.

[2]

(b) Show that λ_0 equals to 0.024 nm.

[1]

(c) Sketch on Fig. 6.2 a graph to show the intensity variation with wavelength if the accelerating potential difference is reduced to one-quarter of its original value. [2]

[Total: 5]

7 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

The variation with nucleon number A of the binding energy per nucleon B_E is illustrated in Fig. 7.1.

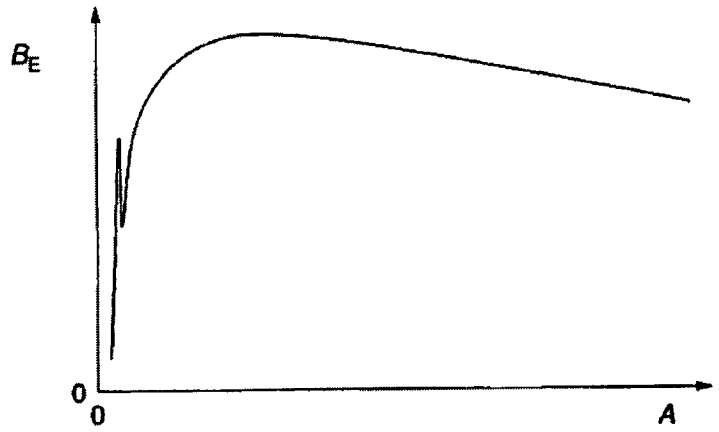

Fig. 7.1

(a) State an approximate value, in MeV, for the maximum binding energy per nucleon.

maximum binding energy per nucleon = _____ MeV [1]

(b) On Fig. 7.1, mark approximate positions for the nuclei of

(i) uranium-235 (label the position U),

(ii) barium-141 (label the position Ba),

(iii) Krypton-92 (label the position Kr).

[3]

(c) By reference to binding energy per nucleon, explain why energy is released in this fission reaction.

_____

_____

_____

_____

_____

_____

_____

_____ [3]

[Total: 7]

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

Torque from a Vehicle Engine

An internal combustion engine used on a vehicle operates over a limited rotational speed which can be controlled by the driver. As the driver increases the depression on the accelerator pedal, the input power to the engine will increase to a maximum when the throttle is fully opened. The power delivered to the wheels of the vehicle will also reach a maximum value.

The output torque of the engine is transmitted to the forward driving force on the vehicle's wheels. The transmission of the output torque of the engine is done through a gearbox which consists of several gear ratios capable of providing the required driving force to suit the different driving speeds and accelerations.

The gear ratio is the ratio of the rotational speed of the vehicle's engine to the rotational speed of the vehicle's wheel. A high gear ratio is required at low vehicle's speeds to provide a higher torque.

A vehicle starts to move off with the highest gear ratio, namely gear 1. As the vehicle's speed increases, the gear ratio changes from gear 1 to gear 4, with gear 4 being the lowest gear ratio. The lowest gear ratio is to provide for the maximum speed achievable. Thus, the forward driving force on the vehicle's wheels will change with the speed of the vehicle for different gears.

As the vehicle moves, it encounters a total resistive force that opposes its motion.

Fig. 8.1 shows how the speed of the vehicle affects the available force F at the wheels for different gears and the total resistive force on a 1200 kg vehicle when the input power to the engine is maintained at the maximum value. The available force is the maximum forward driving force that can be transmitted to the wheels.

To stop the vehicle quickly from a certain speed, the driver steps on the brake pedal to produce a braking force on the wheels, and at the same time, the power of the engine is removed completely. The maximum braking force of the car is 9300 N.

When a vehicle moves up an inclined slope, it encounters a climbing resistance that depends on the gradient of the slope. The gradient of the slope is defined as the ratio of the increase in height to the horizontal distance moved in percentage value.

The chart in Fig. 8.2 shows how the climbing resistance is affected by the gradient of the slope.

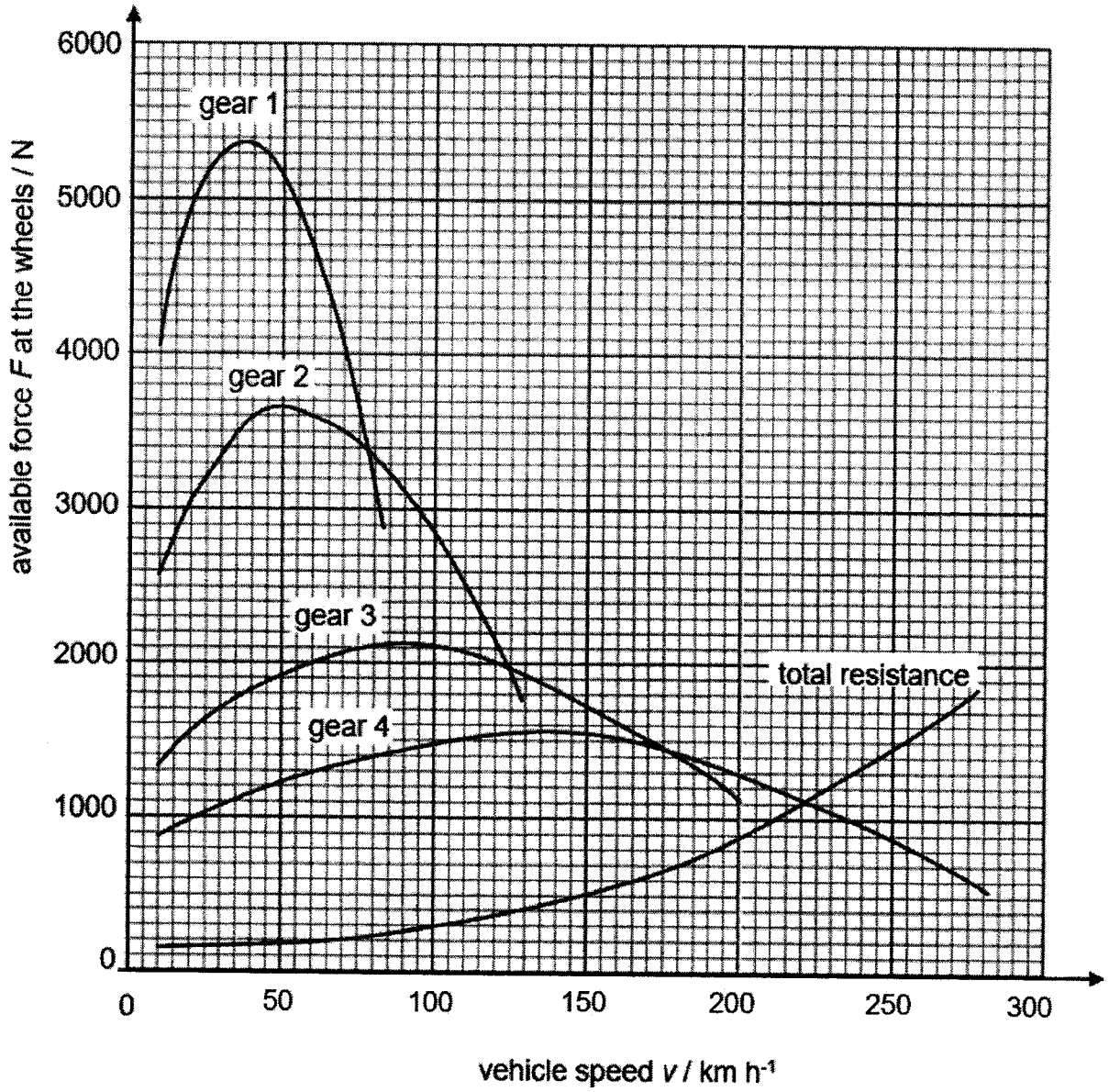

Fig. 8.1

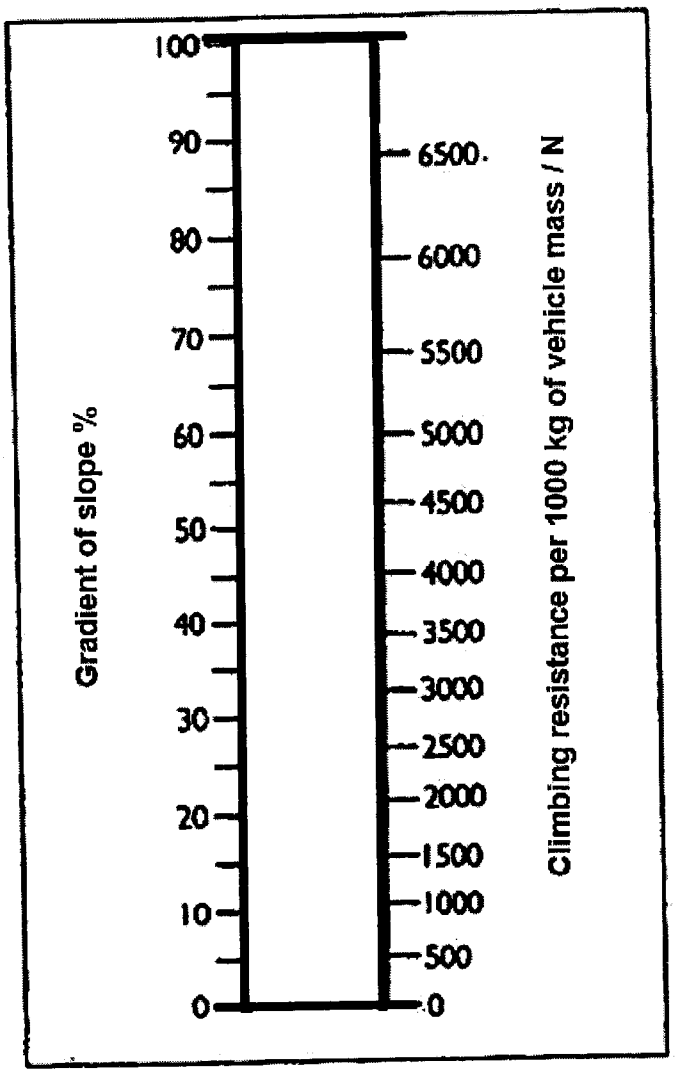

Fig. 8.2

(a) Explain why gear 1 is used to accelerate the vehicle from rest.

_____

_____ [1]

(b) Explain what is meant by the term *available force* at the wheels.

_____

_____ [1]

(c) The vehicle is travelling at 100 km h^{-1} on a horizontal road and gear 3 is engaged by a driver.

(i) State the available force at the wheels and the resistive force.

available force = _____ N

resistive force = _____ N [2]

(ii) Calculate the maximum acceleration.

maximum acceleration = _____ $m\ s^{-2}$ [2]

(iii) Explain why gear 3 is the optimum gear for maximum power output at a speed of 100 km h^{-1}.

_____

_____ [1]

(iv) The driver wishes to overtake another vehicle which is also travelling at 100 km h^{-1}. Explain whether he needs to change gear.

_____

_____ [2]

(d) **(i)** Starting from the definition of work done, show that the power output of the vehicle is given by the expression

power output = driving force x speed

[2]

(ii) Explain why for a given power delivered to the engine, the available force at the wheels for gear 3 is smaller than that for gear 2.

_____

_____

_____

_____ [2]

[Turn over

(e) State the maximum possible speed of the vehicle.

maximum possible speed = _____ km h^{-1} [1]

(f) The vehicle is moving up a slope inclined at 20° to the horizontal.

(i) Show that the gradient of the slope, in percentage, is 36%.

[1]

(ii) Use Fig. 8.2 to determine the climbing resistance on the car.

climbing resistance = _____ N [2]

(iii) Using the answer to **(f)(ii)** and **Fig. 8.1**, estimate and explain the maximum speed at which the vehicle can move up the slope.

_____

_____ [2]

(g) The vehicle is travelling up the slope with a speed of 40 km h^{-1}. The driver intends to stop the car by applying the maximum braking force.

Estimate the distance moved along the slope before the car stop.

distance moved = _____ m [3]

[Total: 22]

END OF PAPER 2

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME	
CLASS	2T

PHYSICS
Paper 3: Longer Structured Questions

9749/3
12 September 2022
2 hours

Candidates answer on the Question Paper
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

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Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

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

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
SECTION A				
Q1	/ 8			
Q2	/ 9			
Q3	/ 8			
Q4	/ 9			
Q5	/ 9			
Q6	/ 9			
Q7	/ 8			
SECTION B				
Q8	/ 20			
Q9	/ 20			
PAPER 3	/ 80			
PAPER 2	/ 80			
PAPER 1	/ 30			
PAPER 4	/ 55			
TOTAL (WEIGHTED)	%			

This document consists of **30** printed pages and **4** blank pages.

[Turn over

Data

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radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Section A

Answer **all** questions in the spaces provided.

1 Fig. 1.1 shows a hinged beam of length 60.0 cm held horizontally against a wall by a cord XY.

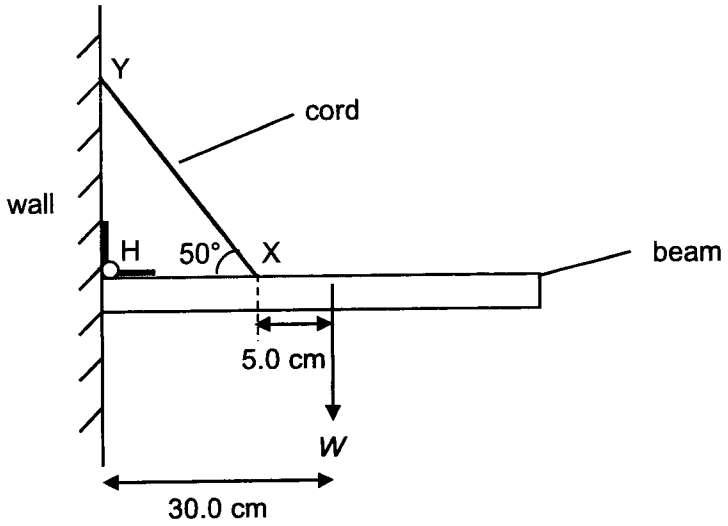

Fig. 1.1

The forces acting on the beam are its weight *W*, the force *T* exerted by the cord, and the force *R* exerted by the hinge H.

(a) In the space provided below, sketch a labelled vector triangle of the forces acting on the beam.

[2]

(b) The weight of the uniform beam is 40.0 N and the mass of the cord is negligible.

Calculate the magnitude of

(i) the tension T,

$T =$ _____ N [2]

(ii) the force R.

$R =$ _____ N [2]

(c) A brick is placed on the beam at X without the cord snapping. Subsequently, when the brick is shifted further away from the hinge along the beam, the cord snaps.

Explain why the cord snaps.

_____

_____

_____

_____ [2]

[Total: 8]

[Turn over

2 (a) State the principle of *conservation of linear momentum*.

[1]

(b) In a nuclear reactor, carbon atoms are used to slow down neutrons. A fast neutron collides head-on with a stationary carbon atom.

(i) Show that the impulse acted on the neutron is proportional to the final velocity of the carbon atom in such a collision.

[2]

(ii) In the collision between a neutron and a carbon atom, a neutron of mass 1.0 m with initial velocity u collides elastically head-on with a stationary carbon atom of mass 12 m. The final velocities of the neutron and the carbon atom are v and V respectively.

By considering the relative speeds between the neutron and carbon atom before and after their collision, show that the fraction of the kinetic energy that is retained by the neutron after such a collision is 0.72.

[3]

(iii) Explain why nuclei which are much more massive than carbon atoms are ineffective in slowing down neutrons in the nuclear reactor.

.....

.....

..... [2]

(iv) Explain why particles of similar mass to neutrons such as hydrogen nuclei are unsuitable for slowing down neutrons in the nuclear reactor.

.....

..... [1]

[Total: 9]

[Turn over

3 A light helical spring is suspended vertically from a fixed point as shown in Fig. 3.1.

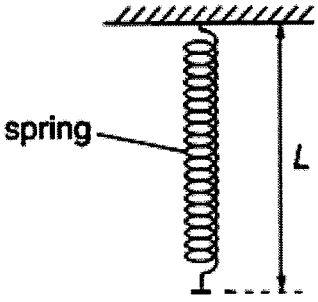

Fig. 3.1

A mass of weight 5.0 N is suspended from the spring of unstretched length 4.0 cm and then released from rest. The mass oscillates vertically.

The variation with resultant force F on the mass when L is between 4.0 cm and 8.0 cm is shown in Fig. 3.2 below.

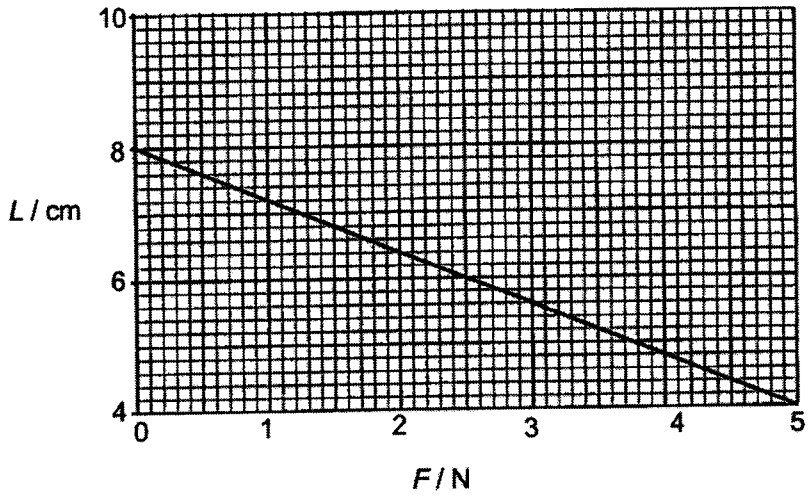

Fig. 3.2

(a) Explain why, as shown in Fig. 3.2, the resultant force on the mass increases as the length of the spring decreases from L = 8.0 cm to L = 4.0 cm.

[2]

(b) Calculate the force constant of the spring.

force constant = _____ $N\ m^{-1}$ [3]

(c) On Fig. 3.2, shade clearly the area of the graph that represents net work done on the mass when the mass has travelled from L = 8.0 cm to L = 6.0 cm. [1]

(d) Describe the energy changes in the spring-mass system when the mass moves from L = 8.0 cm to L = 6.0 cm.

_____

_____

_____

_____ [2]

[Total: 8]

4 (a) A revolving aluminium disc has small magnets equally spaced around its rim as shown in Fig. 4.1. The magnets are all aligned in the same direction with the north poles on the same side of the disc. The disc rotates at a constant angular velocity.

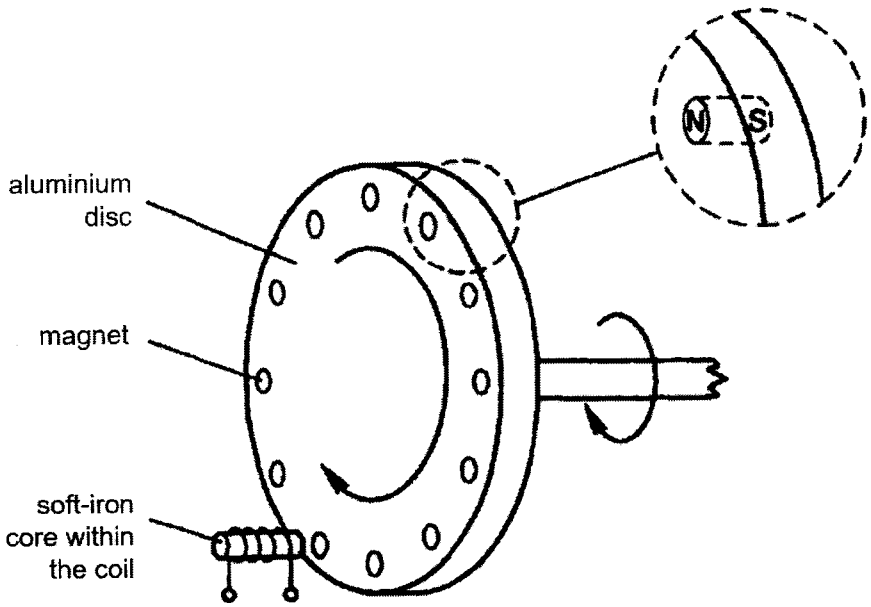

Fig. 4.1

A coil, wound on a soft-iron core, is fixed such that the north poles of the magnets pass close by the end of the coil without touching it. The terminals of the coil are connected to a detector which monitors the e.m.f. induced in the coil.

(i) As one magnet passes the coil, use the laws of electromagnetic induction to explain

1. why there is an induced e.m.f. in the coil,

_____

_____

_____

_____

_____

_____

_____

_____ [2]

2. why there is a reversal in the direction of the induced e.m.f.

_____

_____

_____

_____ [1]

(ii) On Fig. 4.2, sketch a graph to show the variation with time of the e.m.f. induced in the coil as one magnet passes the coil.

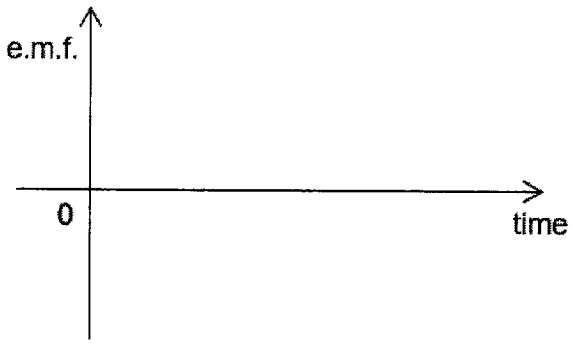

Fig. 4.2 [1]

(b) Fig. 4.3 and Fig. 4.4 show two views of a rectangular coil of height h and width d rotating with an angular speed ω about a vertical axis in a horizontal magnetic field of flux density B. At a certain instance of time t, the normal to the plane of the coil makes an angle of ωt with the magnetic field.

There are N turns in the coil.

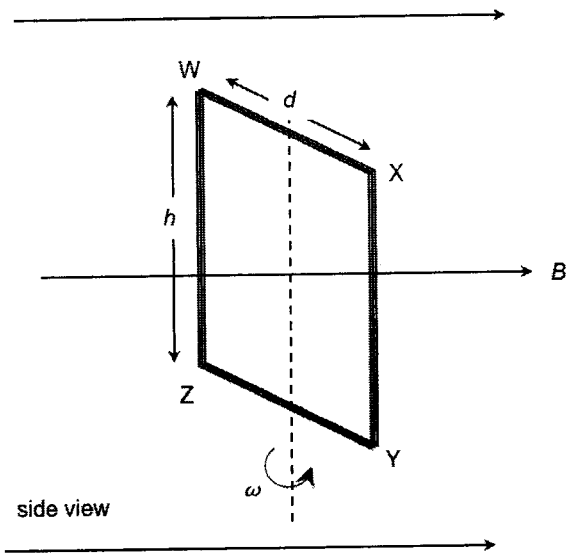

Fig. 4.3

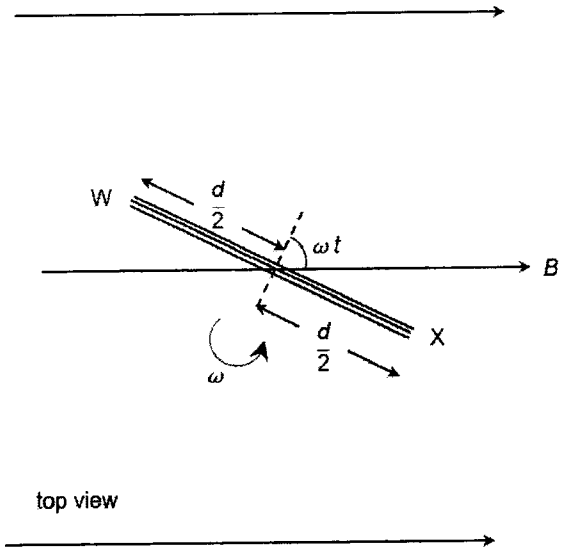

Fig. 4.4

(i) At time $t = 0$, the plane of the coil is perpendicular to the magnetic field.

Show that the magnitude of the induced e.m.f. E in the coil is given by

$$E = NBdh\omega \sin(\omega t)$$

[2]

(ii) The coil has dimension 30 cm by 24 cm and has 15 turns and the uniform magnetic field has flux density of 0.018 T.

The coil rotates with a frequency of 25 Hz.

Determine, for the coil,

1. the maximum induced e.m.f.,

maximum e.m.f. = _____ V [2]

2. the root-mean-square value of the induced e.m.f.

root-mean-square e.m.f. = _____ V [1]

[Total: 9]

[Turn over

5 (a) Fig. 5.1 shows two small loudspeakers, L_1 and L_2, separated by 15 cm. A microphone is moved along a line XY parallel to the line joining the two loudspeakers and at a perpendicular distance of 1.2 m away.

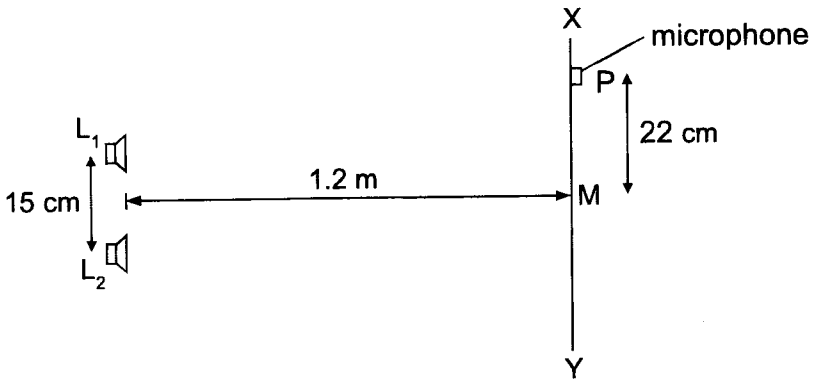

Fig. 5.1

The centre of the interference pattern formed along XY is at point M. When the microphone is moved from M to P by a distance of 22 cm, it detects three intensity maxima including the ones at M and P.

Given that the speed of sound in air is 330 m s^{-1}, determine the approximate frequency at which the speakers were driven. Express your answer to 2 significant figures.

frequency = _____ Hz [3]

(b) Fig. 5.2 shows a microwave transmitter T and a microwave receiver R placed at the same angle θ to the normal of a horizontal board A, which partially reflects and transmits microwaves. A similar horizontal board B is placed a distance d below board A, such that a high intensity signal is detected by receiver R. A metal sheet is placed between T and R to prevent microwaves from reaching R directly from T.

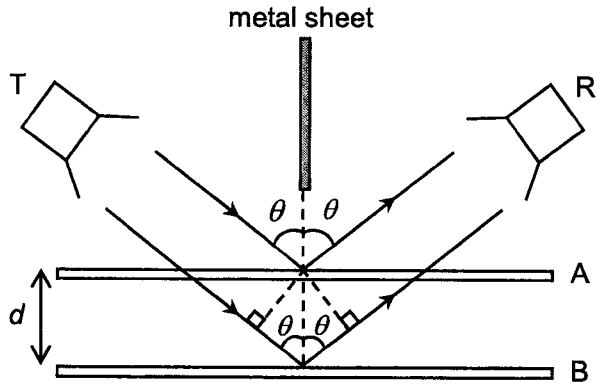

Fig. 5.2

The path difference between the two waves reflected off boards A and B is given by

$$2d \cos \theta$$

When a high intensity signal is detected by R,

$$2d \cos \theta = m\lambda$$

where m is a positive integer and refers to the order of constructive interference (m = 1, 2, 3, ...) and λ is the wavelength of the microwaves.

(i) State the phase difference, in radians, between the reflected microwaves from A and B at a point where a high intensity signal is detected.

phase difference = _____ rad [1]

(ii) When distance d is increased by lowering board B, alternating low and high intensity signals are detected by receiver R. Explain these observations.

_____

_____

_____

_____

_____

_____

_____

_____ [3]

[Turn over

(iii) Transmitter T and receiver R are now placed side-by-side and facing the boards normally, meaning that $\theta = 0°$.

As board B is moved 140 mm downwards at a constant speed, receiver R goes from the initial high intensity signal through nine high intensity signals and then to a final high intensity signal.

Determine the wavelength of these microwaves.

wavelength = _____ m [2]

[Total: 9]

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6 In a photoelectric experiment, an ultraviolet (UV) light source of constant intensity and single frequency is used. Two metal plates X and Y are contained in an evacuated glass container and are connected to a circuit as shown in Fig. 6.1. The UV source is placed at a distance away from X and Y.

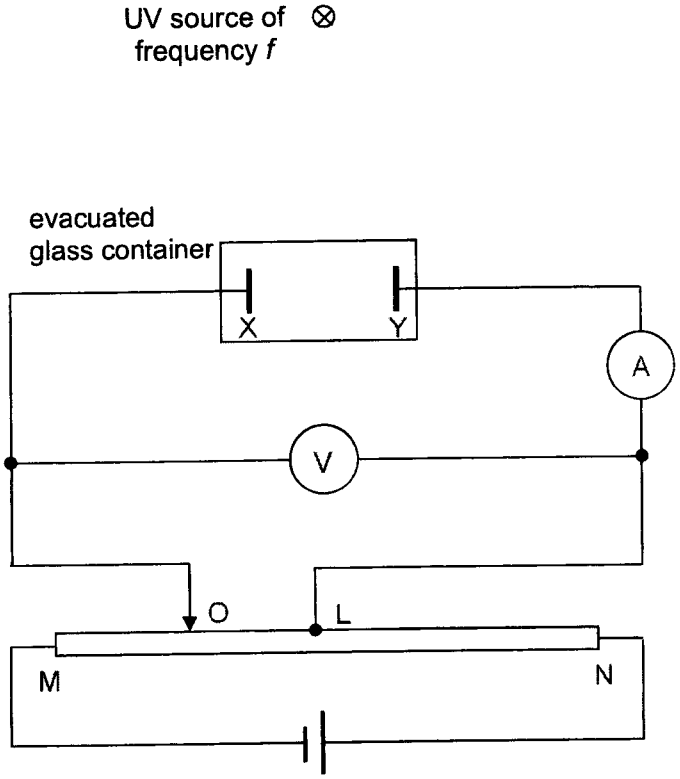

Fig. 6.1

The graph shown in Fig. 6.2 depicts the relationship between the voltmeter reading and the ammeter reading when metal plate X is the photoelectric emitter. No photoelectrons are emitted from Y.

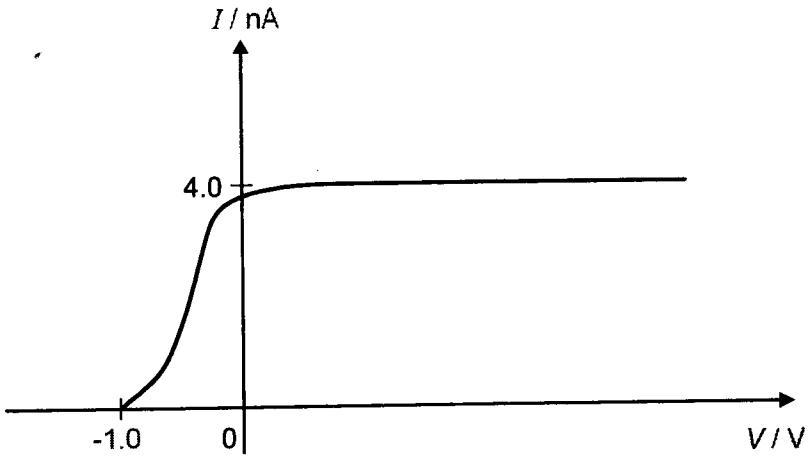

Fig. 6.2

(a) Explain why the current remains constant for positive values of *V*.

[3]

(b) Metal plate X is made of zinc with a work function of 3.8 eV. Using information from Fig. 6.2, determine the wavelength of the UV source.

wavelength = _____ m [2]

(c) Sketch, on Fig. 6.2, the graph when the experiment was repeated with UV light source of the same frequency but with intensity one-quartered. [2]

(d) The UV light source was replaced with another light source of higher frequency. The graph in Fig. 6.3 was obtained when the experiment was conducted using the higher frequency light source.

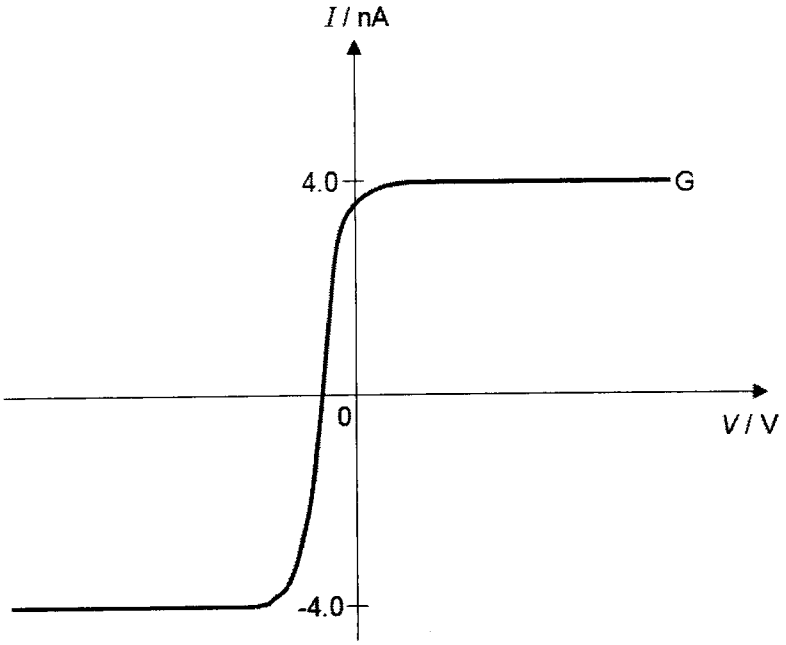

Fig. 6.3

Explain which metal plate, X or Y, has a greater work function energy.

[2]

[Total: 9]

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7 **(a)** State experimental evidence to suggest that the process of radioactive decay is

(i) random;

.....

..... [1]

(ii) spontaneous.

.....

..... [1]

(b) Uranium-238 decays into lead-206 by several stages. Lead-206 is a stable isotope. The overall decay can be represented by the following equation:

$$^{238}_{92}U \rightarrow {}^{206}_{82}Pb + \text{decay products}$$

It is suggested that **all** of the decay products are alpha particles.

Use the equation to show that this cannot be correct.

[2]

(c) Technetium-99, $^{99}_{43}Tc$, decays to ruthenium-99, $^{99}_{44}Ru$.

The half-life of technetium-99 is 4.00×10^6 years. Ruthenium-99 is a stable nuclide.

(i) Write down the nuclear equation representing this decay. State also the name(s) of the products other than ruthenium-99 that is/are formed.

Equation: .....

Name(s) of additional product(s): ..... [2]

(ii) On the axes of Fig. 7.1, sketch a graph to show how the ratio

$$R = \frac{\text{number of ruthenium-99 nuclei}}{\text{number of technetium-99 nuclei}}$$

will change in a sample with time t.

Take $t = 0$ to be the instant of creation of ruthenium-99.

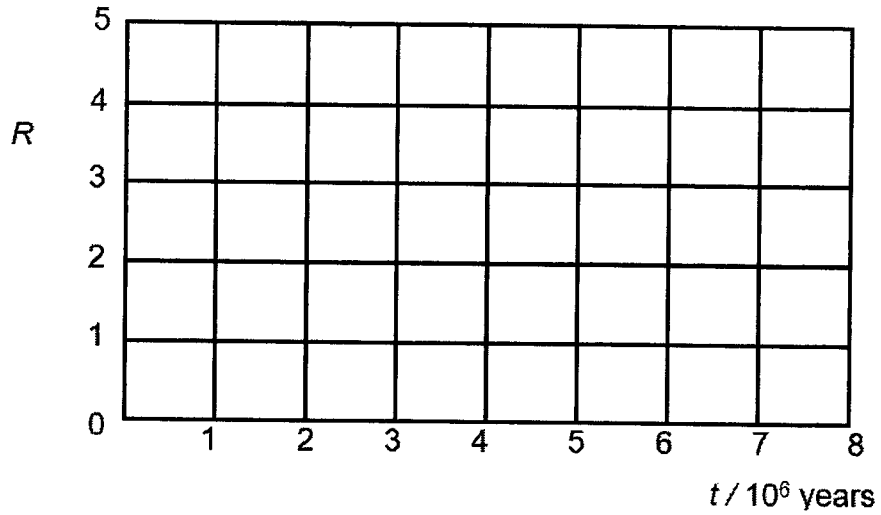

Fig. 7.1

[2]

[Total: 8]

[Turn over

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Section B

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

8 **(a)** Explain what is meant by an *electric field*.

.....

..... [1]

(b) The charges on an isolated metal sphere are uniformly distributed on its surface. Fig. 8.1 shows a positively charged metal sphere A.

On Fig. 8.1, draw the charge distribution on the sphere and the electric field around it.

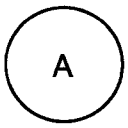

Fig. 8.1 [1]

(c) A negatively charged metal sphere B is brought close to the positively charged metal sphere A as shown in Fig. 8.2. The charge on metal sphere B is twice that of the charge on metal sphere A.

On Fig. 8.2, draw the charge distribution on the spheres and the electric field around the spheres.

Fig. 8.2 [3]

(d) Point P is at a distance x from the centre of sphere A along the line joining the centres of the two spheres as shown in Fig. 8.3. The radius of A and B is 15 mm and the distance between the centres of the spheres is 80 mm.

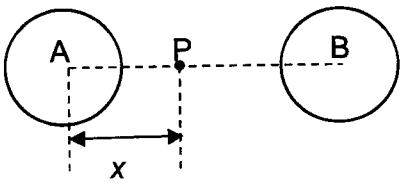

Fig. 8.3

The variation with x of the electric potential V at P is shown in Fig. 8.4.

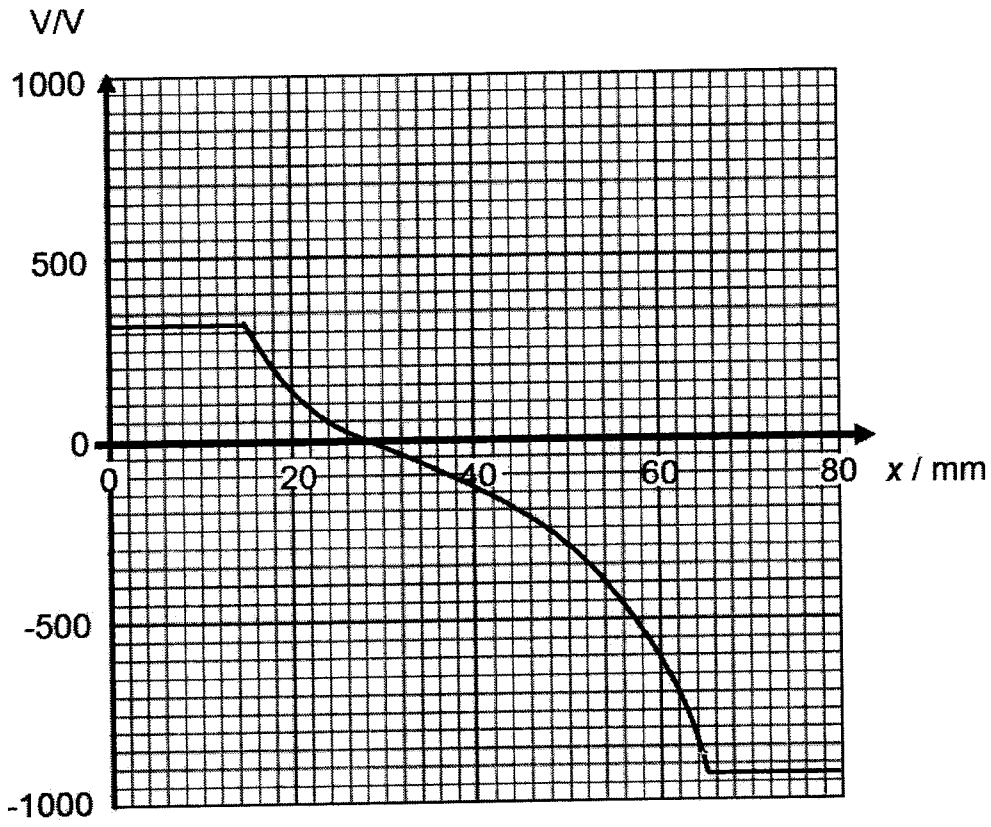

Fig. 8.4

(i) Determine the magnitude of the electric field strength at P where x = 40 mm.

magnitude of the electric field strength = _____ V m^{-1} [2]

(ii) An electron is initially at rest at point P where x = 40 mm.

1. Describe and explain the motion of the electron as it travels 20 mm along the line joining the centres of the spheres.

_____

_____

_____

_____

_____ [3]

2. Determine the speed of the electron when it has travelled 20 mm along the line joining the centres of the spheres.

speed of electron = _____ $m\ s^{-1}$ [3]

(e) An electron is projected along the line XY into a region of uniform electric field between two charged parallel plates of length 20.0 cm separated by 8.0 cm, as shown in the Fig. 8.5. The potential difference between the two plates is 200 V. Between the plates, the electron travels along a curved path and exit the region between the plates at point Q which is 3.0 cm from the line XY.

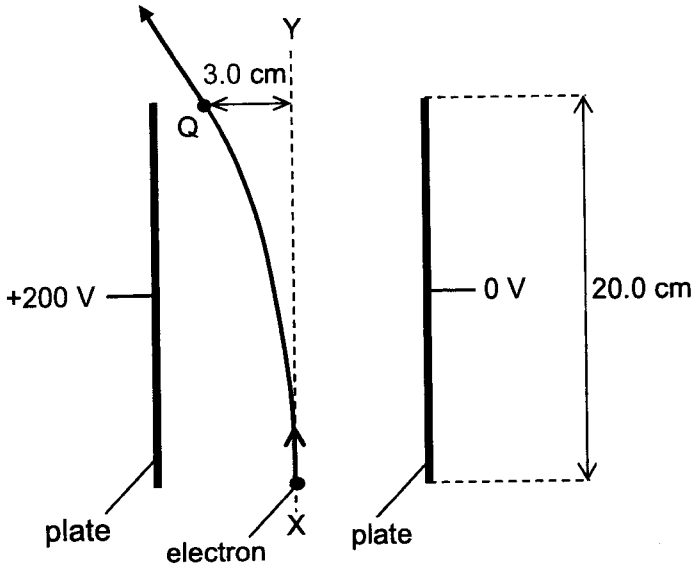

Fig. 8.5

(i) Calculate the electric field strength between the two plates.

electric field strength = _____ $V\ m^{-1}$ [1]

(ii) Calculate the initial speed of the electron projected into the electric field.

speed = _____ $m\ s^{-1}$ [4]

(iii) A proton is now projected into the same electric field and with the same velocity as that of the electron.

Explain why the deflection of the proton is much lesser compared to the deflection of the electron.

.....

.....

.....

.....

..... [2]

[Total: 20]

[Turn over

9 (a) A satellite orbits the Earth of mass M in a circular path of radius r.

(i) Show that the period T of the satellite is given by the expression

$$T^2 = \frac{4\pi^2}{GM} r^3$$

[3]

(ii) A satellite is orbiting the Earth above the equator with a period of 28 hours. The mass of the Earth is 5.98×10^{24} kg.

1. Calculate the radius of the satellite's orbit.

radius = _____ m [2]

2. The mass of the satellite is m.

For the satellite in orbit, show that its kinetic energy E_K is given by

$$E_K = \frac{GMm}{2r}$$

[2]

3. Hence, determine the kinetic energy of the satellite which has a mass of 1200 kg.

kinetic energy = _____ J [1]

4. The satellite is then moved into a new orbit, gaining 1.14×10^9 J of gravitational potential energy in the process.

Calculate the satellite's loss in kinetic energy.

loss in kinetic energy = _____ J [3]

(b) A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 9.2.

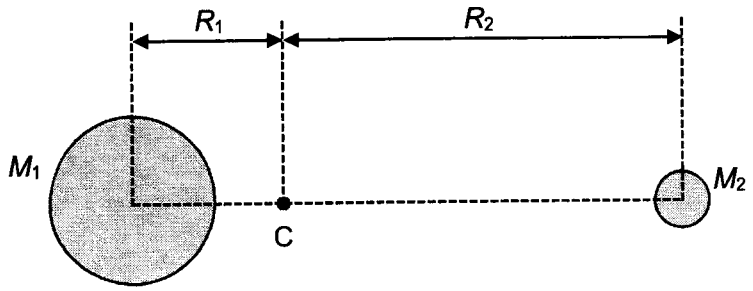

Fig. 9.2

The star of mass M_1 has a circular orbit of radius R_1, and the star of mass M_2 has a circular orbit of radius R_2. Rotating about point C, both stars have the same angular speed of 4.98×10^{-8} rad s^{-1}.

(i) Explain why the centripetal force acting on the two stars are equal in magnitude.

.....

.....

.....

..... [2]

(ii) Calculate the period of orbit of each star.

period = ... years [2]

(iii) Show that the ratio of the masses of the stars is given by the expression

$$\frac{M_1}{M_2} = \frac{R_2}{R_1}$$

[1]

(iv) Given that $\frac{M_1}{M_2} = 3.0$ and the separation between the stars is 3.2×10^{11} m, calculate the radius R_1.

$R_1 =$ _____ m [2]

(v) A planet orbits around the star of mass M_1 in the binary star system.

Suggest why the orbit of the planet is not circular.

.....

.....

.....

..... [2]

[Total: 20]

-- END OF PAPER 3 –

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NAME: _____ CLASS: _____ INDEX: _____

CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
Higher 2

PHYSICS
Paper 4: Practical

9749/04
19 AUG 2022
2 hour 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST
Write your name and class 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, 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 assessment, fasten all your work securely together.
The number of marks is given in brackets [ ] at end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 9
2	/ 14
3	/ 21
4	/ 11
Total	/ 55

This document consists of **20** printed pages and **4** blank pages.

[Turn over

1 In this experiment, you will investigate the potential difference across a current-carrying wire.

You have been provided with three wires A, B and C attached onto the respective cards.

(a) Wire A has a diameter *D*.

Without detaching the wire from the card, measure and record *D*.

D = ... [1]

(b) Set up the circuit shown in Fig. 1.1.

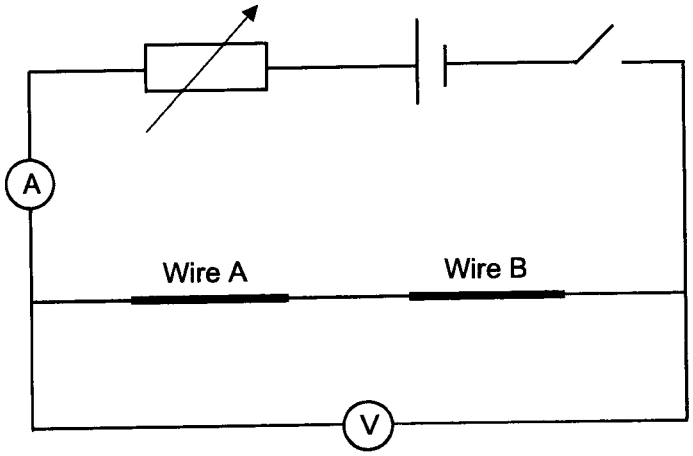

Fig. 1.1

Adjust the rheostat to approximately the middle of its range.

Close the switch.

(i) Record the ammeter reading.

ammeter reading = ... [1]

(ii) Record the voltmeter reading, *V*.

V = ... [1]

Open the switch.

(c) **(i)** Wire B has a diameter d.

Measure and record d.

d = ... [1]

(ii) The diameter D of Wire A and the diameter d of Wire B are related by G, through

$$G = \frac{D^2 + d^2}{D^2 d^2}.$$

Calculate G for Wire A and Wire B.

G = ... [1]

(d) Replace Wire B with Wire C.

Close the switch.

Adjust the rheostat so that the ammeter reading is as close as possible to the reading in **(b)**.

Record the voltmeter reading V.

V = ... [1]

(e) **(i)** Wire C has a diameter d_C.

Measure and record d_C.

d_C = ...

(ii) Use the expression in **(c)(ii)** to calculate G for Wire A and Wire C.

G = ... [1]

(f) It is suggested that the relationship V and G is

$$V = kG$$

where k is a constant.

Using your data, calculate two values of k.

first value of k = ...

second value of k = ...

[1]

(g) It is suggested that the percentage uncertainty in the values of k is 4%, which is determined from the percentage uncertainties of V and G, as well as other experimental factors.

Using this uncertainty, explain whether your results support the relationship in **(f)**.

.....

.....

.....

..... [1]

Total: [9]

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2 In this experiment you will investigate the equilibrium position of a half-metre rule supported by a spring.

(a) Attach the spring tied to the string and the 20 cm length of string to the half-metre rule as shown in Fig. 2.1.

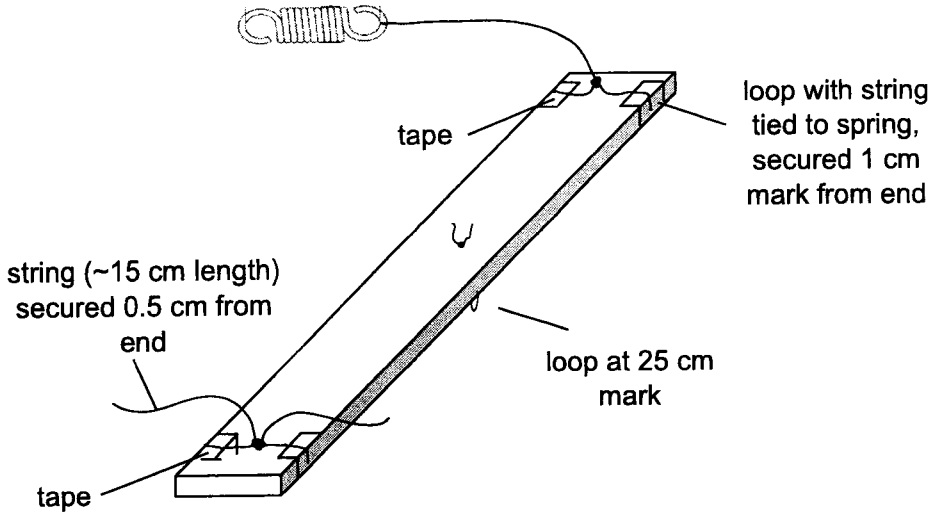


Fig. 2.1

Assemble the apparatus as shown in Fig. 2.2, using a mass *m* of 300 g.

Ensure that the mass hanger and masses are not touching the bench.

The upper string must be parallel to the bench.

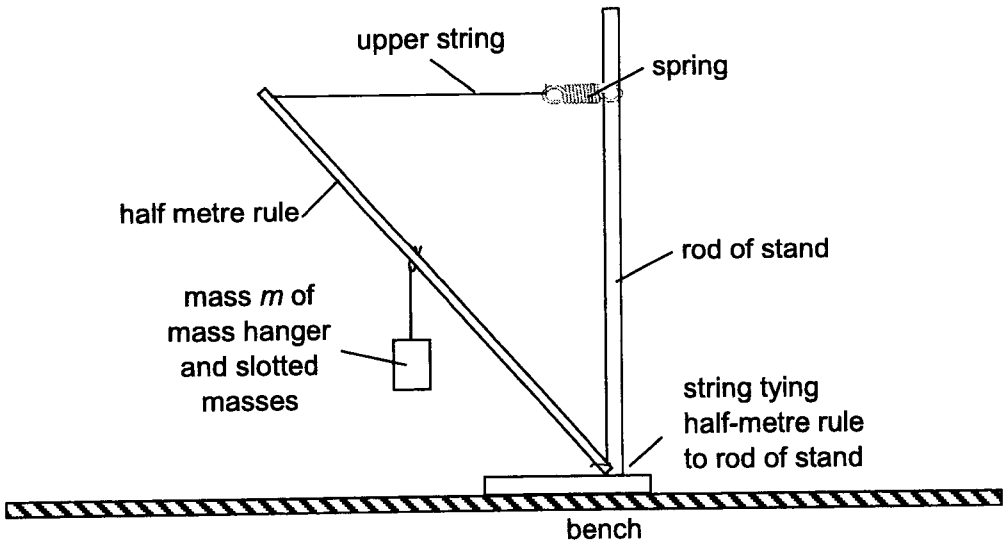


Fig. 2.2

(b) Fig. 2.3 shows the measurements you will take.

Point **A** is where the line of the upper string meets the half-metre rule.

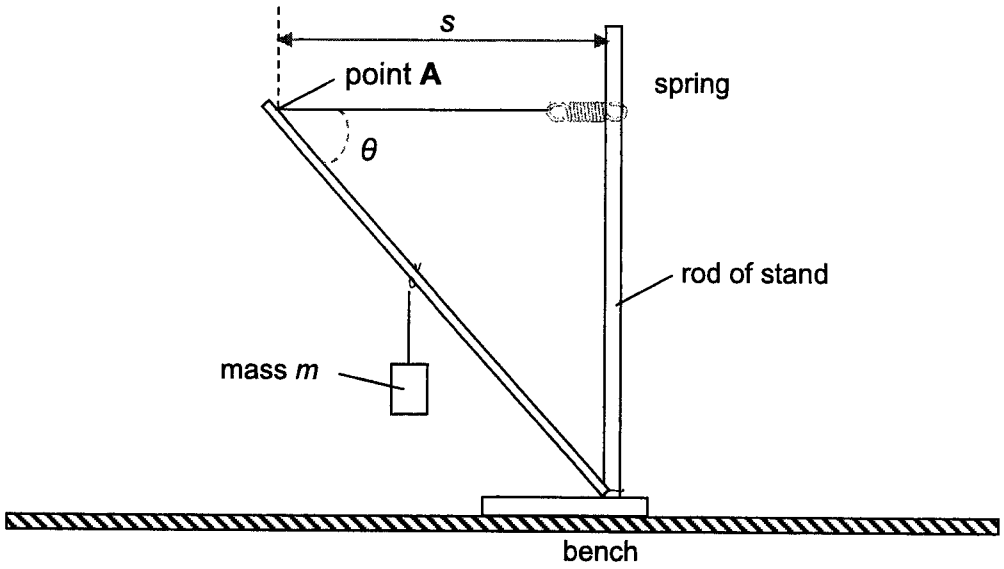


Fig. 2.3

(i) *M* is the mass of the half-metre rule as written on the card on the bench.

Record the value of *M*.

M = ...

(ii) Record the total mass *m* of the mass hanger and masses.

m = ...

(iii) Measure and record the distance *s* between the rod of the stand and **A**, as shown in Fig. 2.3.

s = ... [1]

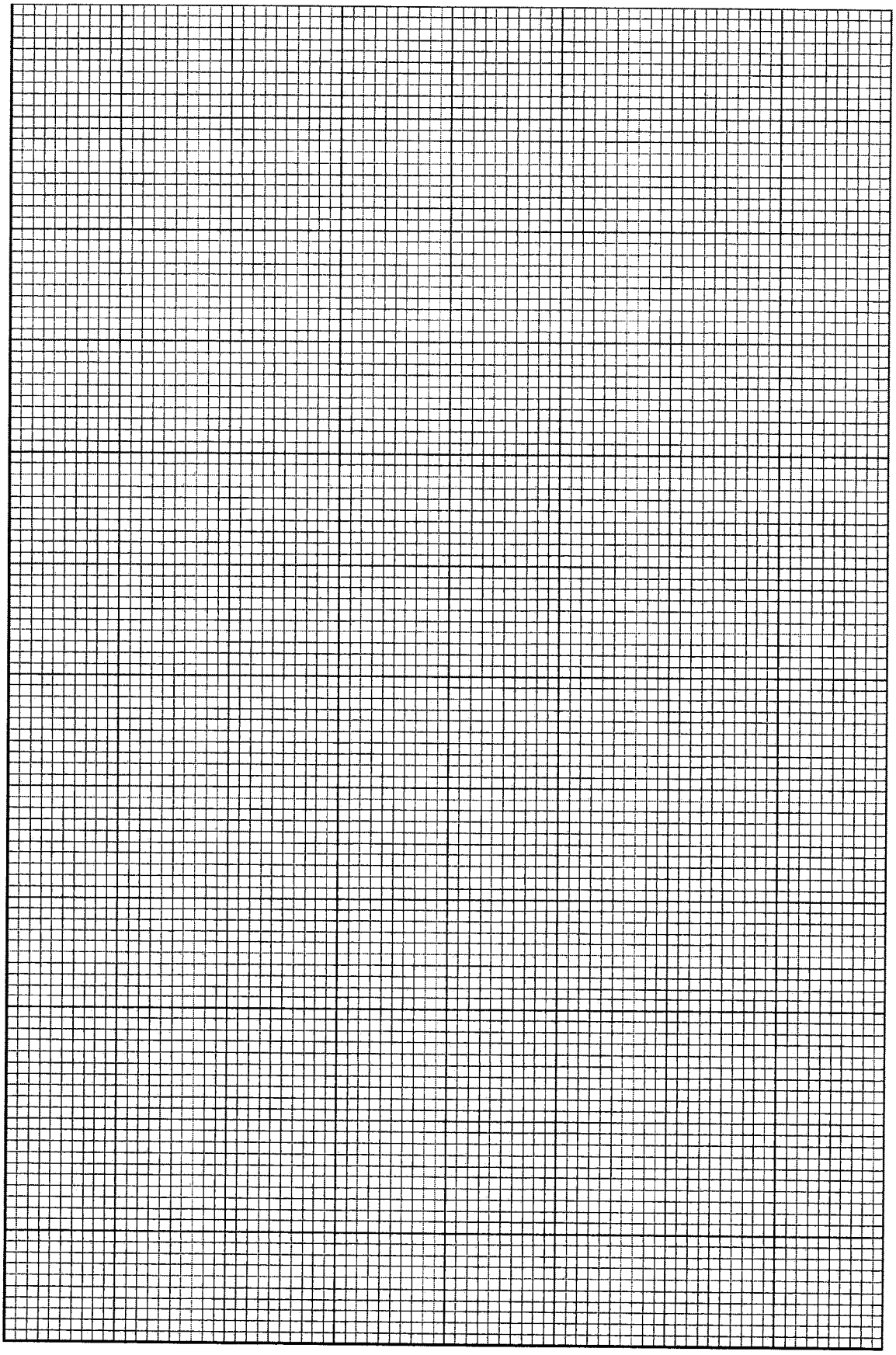
(iv) Measure and record the angle *θ*, as shown in Fig. 2.3.

θ = ... [1]

[Turn over

(c) Change the value of m and repeat **(b)(ii)**, **(b)(iii)**, and **(b)(iv)** to obtain further sets of values of m, s, and θ.

[6]



(d) It is suggested that m, s and θ are related by the expression

$$\frac{m+M}{tan\theta} = Ps - Q$$

where P and Q are constants.

Plot a suitable graph to determine the values of P and Q.

P = _____

Q = _____

[6]

Total [14]

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3 In this experiment, you will investigate the motion of chains of paper clips.

You are provided with two chains of 15 paper clips with two spheres of modelling clay.

(a) Measure and record the length L of one paper clip as shown in Fig. 3.1.

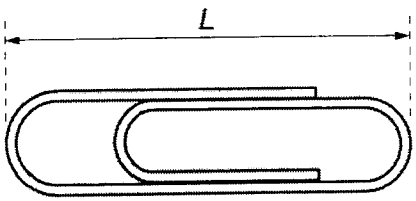

Fig. 3.1

L = _____ [1]

(b) Set up the apparatus as shown in Fig. 3.2.

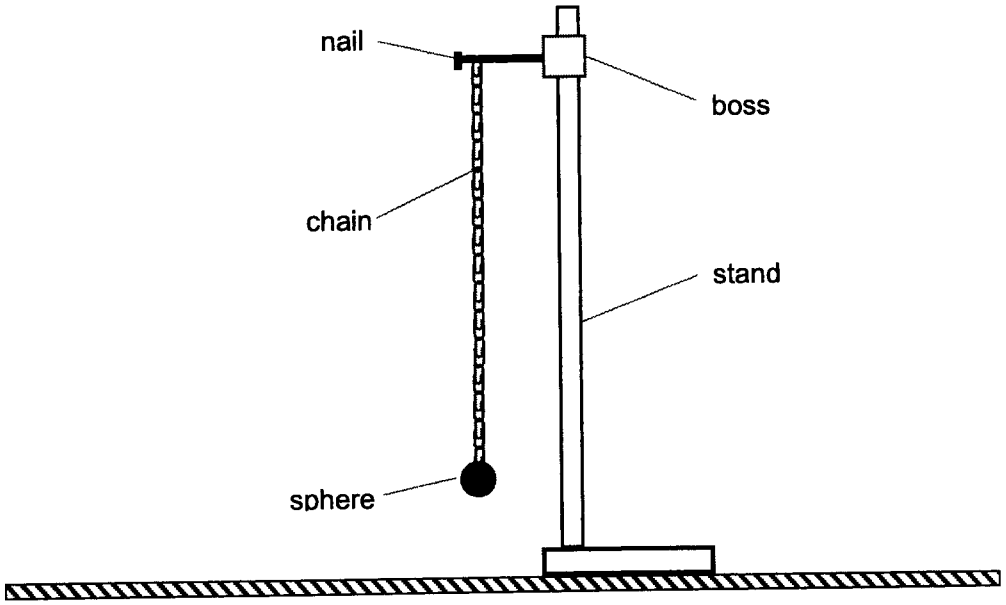

Fig. 3.2

Suspend the chain from the nail. The number n of the paper clips below the nail should be 15.

Move the sphere of modelling clay towards you a distance of approximately 5 cm.

Release the sphere. The chain will oscillate.

(i) Determine the period T of the oscillations.

$T =$ _____ [1]

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

percentage uncertainty of $T =$ _____ [1]

(iii) The period of the oscillations of a simple pendulum is

$$T_P = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum.

Taking $g = 9.81\ \text{m s}^{-2}$, calculate a value for period of the chain pendulum oscillations in Fig. 3.2.

$T_P =$ _____ [1]

(iv) Justify the number of significant figures that you have given for your value of T_P in **(b)(iii)**.

_____

_____

_____ [1]

[Turn over

(v) It is suggested that the oscillation of the chain in **(b)(i)** is different from the oscillation of a simple pendulum.

State whether your results in **(b)(i)** and **(b)(iii)** support the suggestion.

Justify your conclusion by referring to your value in **(b)(ii)**.

_____

_____

_____

_____ [1]

(c) Set up two chain pendulums side by side as shown in Fig. 3.3.

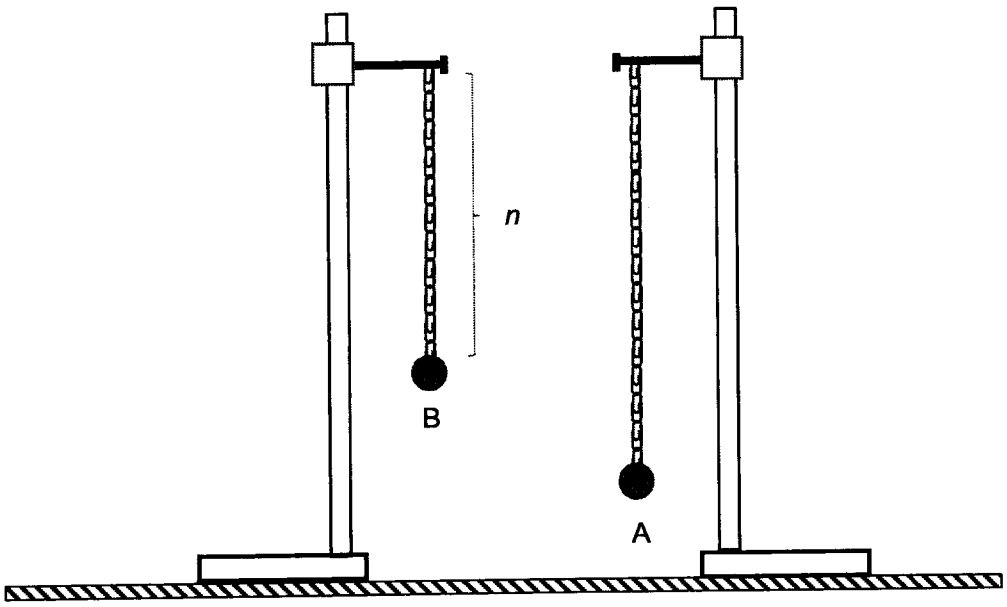

Fig. 3.3

Set chain A with 15 paper clips.

Set Chain B with n paper clips such that $n = 7$.

Record n.

n = _____

(d) Set both pendulums into motion with small oscillations.

Start the stopwatch when the two pendulums are lined up in phase.

Measure the time t taken before the next occasion when the two pendulums are in phase again.

$t =$ _____ [1]

(e) Increase the value of n and repeat **(d)** to obtain further sets of values of t until $n \leq 14$.

[3]

(f) **(i)** Plot t against n on Fig. 3.4. The graph obtained should be a curve.

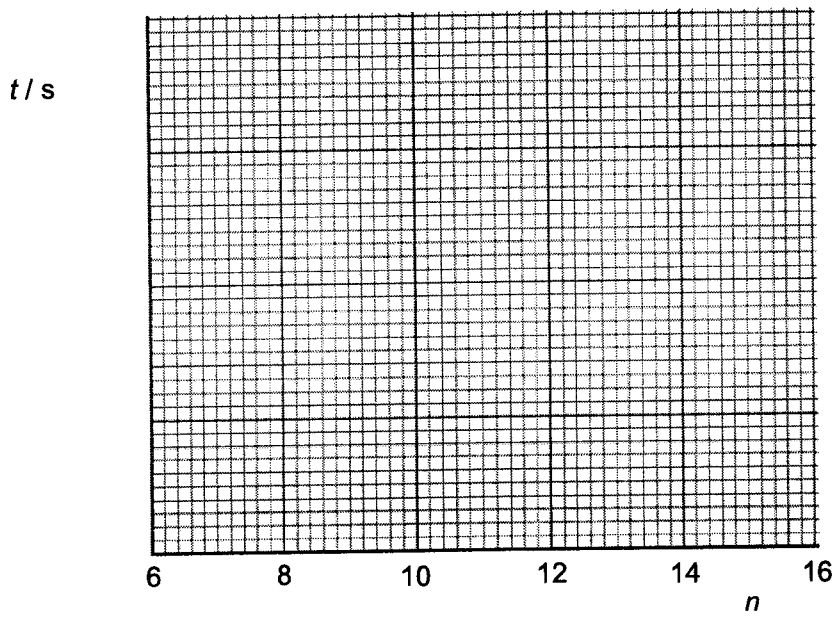

Fig. 3.4

[3]

(ii) Explain why the graph in Fig. 3.4 does not have a t value at $n = 15$.

_____

_____

_____

_____

_____ [2]

(g) **(i)** Theory suggests that

$$t = A\frac{\sqrt{Cn}}{\sqrt{C}-\sqrt{n}}$$

where A and C are constants.

State the graph to plot to obtain a straight line to determine values for constants A and C, assuming that the theory is correct.

_____

_____ [1]

(ii) State expressions for the gradient and y-intercept of the straight line.

gradient = _____

y-intercept = _____

[1]

(h) The physics of the oscillations of a hanging chain without the spherical modelling clay as shown in Fig. 3.5 is studied by Daniel Bernoulli in 1732, which led to the introduction of Bessel Functions.

Fig. 3.5

It was theorised that the period T of the oscillations depends on the mass per unit length, which is known as the linear mass density ρ of the chain.

Explain how you would investigate the relationship between the period T of the oscillations and the linear mass density of the chain.

Your account should include:

- your experimental procedure
- control of variables
- how you would determine the linear mass density ρ of the chain
- how you would use your results to deduce the relationship of T and ρ.

[4]

Total [21]

4 Gases can absorb light of certain wavelengths as observed in the absorption line spectra.

A substance that consists of atoms and molecules may dissolve in water to form a solution which is also observed to absorb light of certain wavelengths.

The amount of light of a particular wavelength after passing through such a solution depends on the concentration c of the substance in water. The concentration c is defined as the mass of substance dissolved in per unit volume of water.

The intensity I detected from a light source of a particular wavelength after the absorption by the solution is given by the equation

$$I = kc^nL^m$$

where k, n and m are constants. L is the path length that the light takes to pass through the solution.

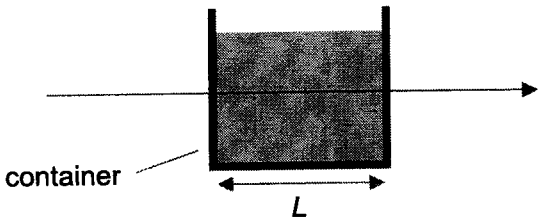

Fig. 4.1

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

You are provided with containers of different sizes and a monochromatic laser light source. You also provided with the substance to be dissolved in water and the solution absorbs the laser light provided.

Draw a diagram to show the arrangement of your apparatus. You should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) how the concentration of the solution and the path lengths are measured
(d) the control of variables
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[11]

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