TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 Preliminary Examination

CANDIDATE NAME

CIVICS GROUP

H2 PHYSICS **9749/01**

Paper 1 Multiple Choice **22 September 2022**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

You do not need to submit this Booklet at the end of the examination.

Write in soft pencil.
Do not use paper clips, glue or correction fluid.
Write your name, class and index number on the Multiple Choice 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**, **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet.

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 **18** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ 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} J K^{-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	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T/K	=	T/°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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^{\,2} - x^2}$
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	=	$x_o \sin \omega t$
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	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** questions.

1 Which combinations of force and duration gives the lowest impulse?

A 1 meganewton for 1 nanosecond

B 1 giganewton for 1 microsecond

C 1 millinewton for 1 kilosecond

D 1 millinewton for 1 terasecond

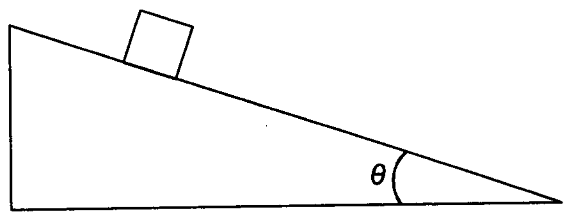
2 In a certain experiment, the angle α and the mass M are related by the following expression

$$\tan\alpha = \frac{P}{\sqrt{M}} + Q.$$

What are the units of P and Q ?

	units of P	units of Q
A	$kg^{-\frac{1}{2}}$	degrees
B	$kg^{-\frac{1}{2}}$	unitless
C	$kg^{\frac{1}{2}}$	degrees
D	$kg^{\frac{1}{2}}$	unitless

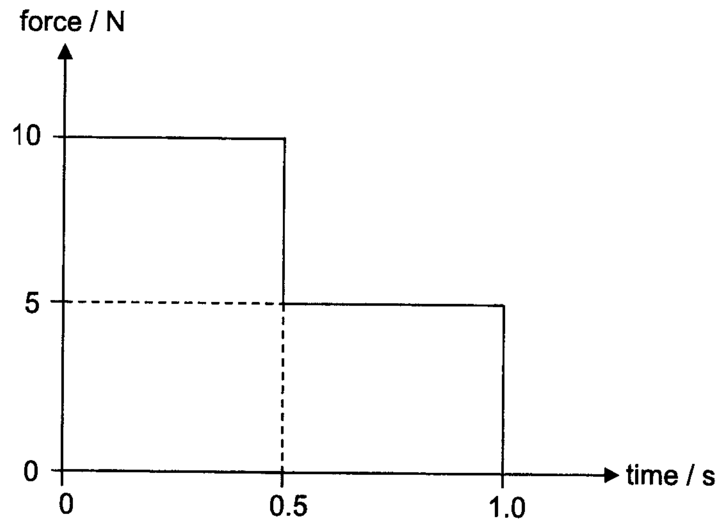
3 A block starts from rest and slides down a smooth incline.



What is the **vertical component** of acceleration, in terms of g and θ ?

A g **B** $g \sin\theta$ **C** $g \sin^2\theta$ **D** $g \sin\theta \cos\theta$

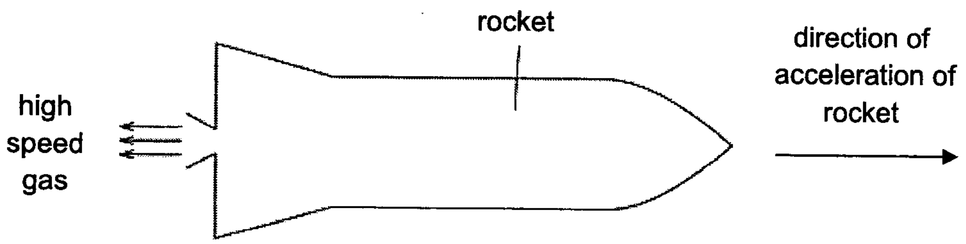
4 The force acting on a 3.0 kg mass varies with time as shown.
The object is initially moving at a velocity of 0.50 m s^{-1} in the same direction as the force.



What is the speed of the mass after 1.0 s?

A 2.5 m s^{-1} **B** 3.0 m s^{-1} **C** 5.0 m s^{-1} **D** 7.5 m s^{-1}

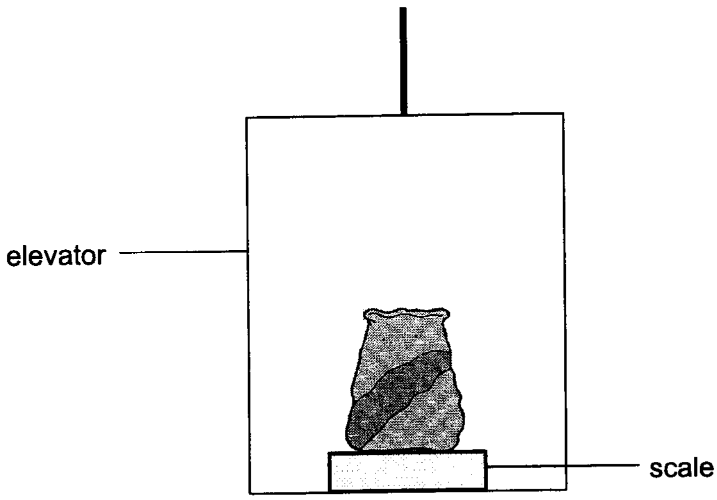
5 The engine of a rocket ejects gas at high speed and the rocket accelerates forward in the direction shown below.



Which of the following accounts for the acceleration of the rocket?

A The gas pushes on the air at the back of the rocket.
B The ejected gas creates a region of high pressure behind the rocket.
C The change in momentum of the gas gives rise to a force on the rocket.
D The momentum of the gas is equal but opposite in direction to the momentum of the rocket.

6 An elevator is used to either raise or lower sacks of rice. In the diagram, a sack of rice of mass 10 kg is placed on a scale in an elevator. The scale reads 12 kg when the elevator is accelerating.



Which of the following gives the magnitude and direction of the acceleration of the elevator?

A 0.20 m s^{-2} upwards

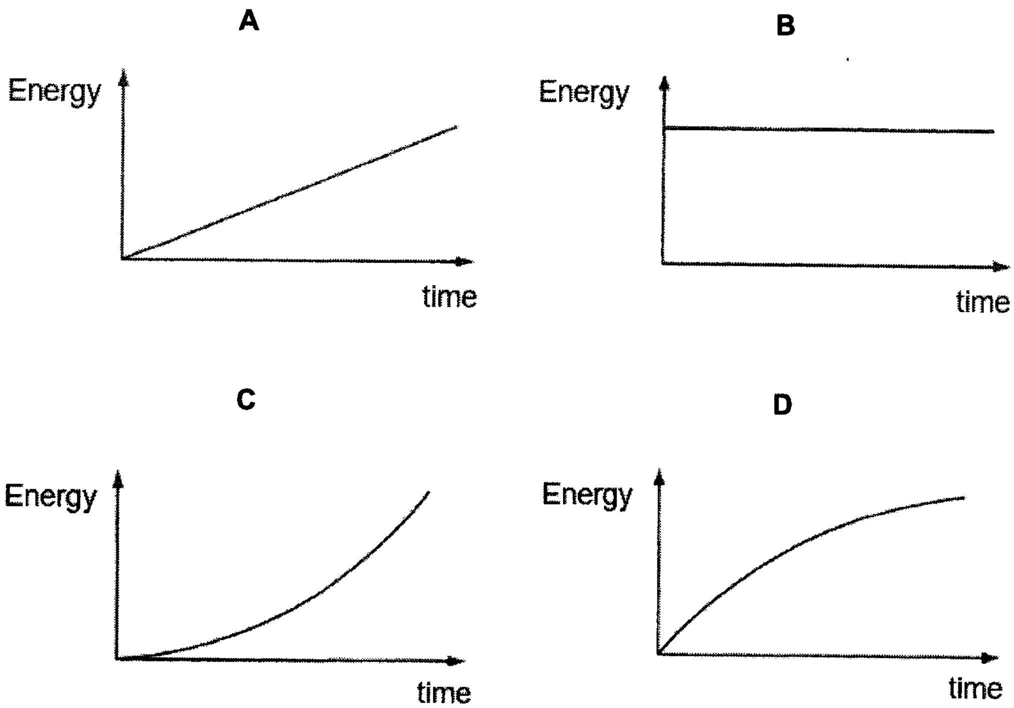
B 0.20 m s^{-2} downwards

C 2.0 m s^{-2} upwards

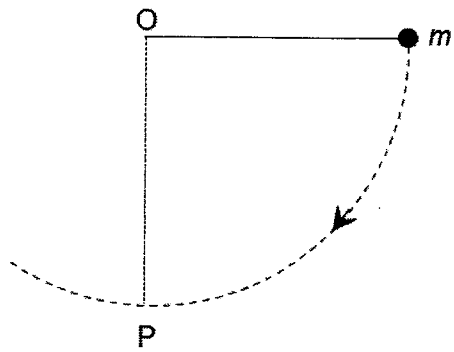
D 2.0 m s^{-2} downwards

7 A vehicle starts from rest and accelerates uniformly. No resistive forces act on the vehicle.

Which graph shows the variation with time of the energy output of the vehicle?



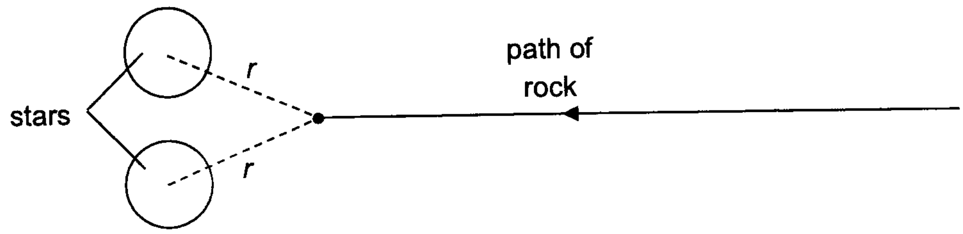
8 A small mass *m* is suspended from a fixed point O by a light, inextensible cord. The mass is raised until the cord is horizontal and it is then released from rest. It moves in an arc of a circle as shown.



What is the tension in the cord at the lowest point P?

A zero **B** mg **C** $2mg$ **D** $3mg$

9 Two stars, each of mass M, are isolated in space. A rock of mass m, initially at very slow speed a very long distance away, approaches the two stars as shown below.

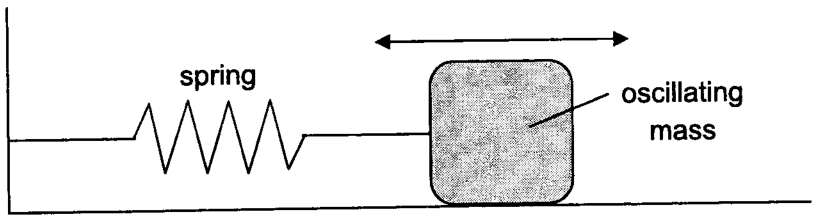


What is the speed of the rock when it reaches a distance r from the centres of the two stars as shown?

A $\sqrt{\frac{2GMm}{r}}$ **B** $\sqrt{\frac{4GMm}{r}}$ **C** $\sqrt{\frac{2GM}{r}}$ **D** $\sqrt{\frac{4GM}{r}}$

10 A mass-spring system is made to oscillate in simple harmonic motion on a smooth horizontal table as shown.

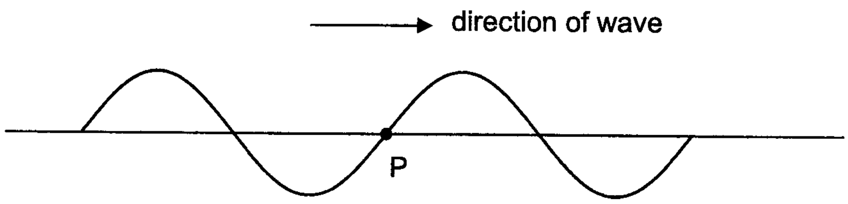
The mass of the block is 2.0 kg, the amplitude of oscillation is 5.0 cm and the frequency of the oscillation is 2.5 Hz.



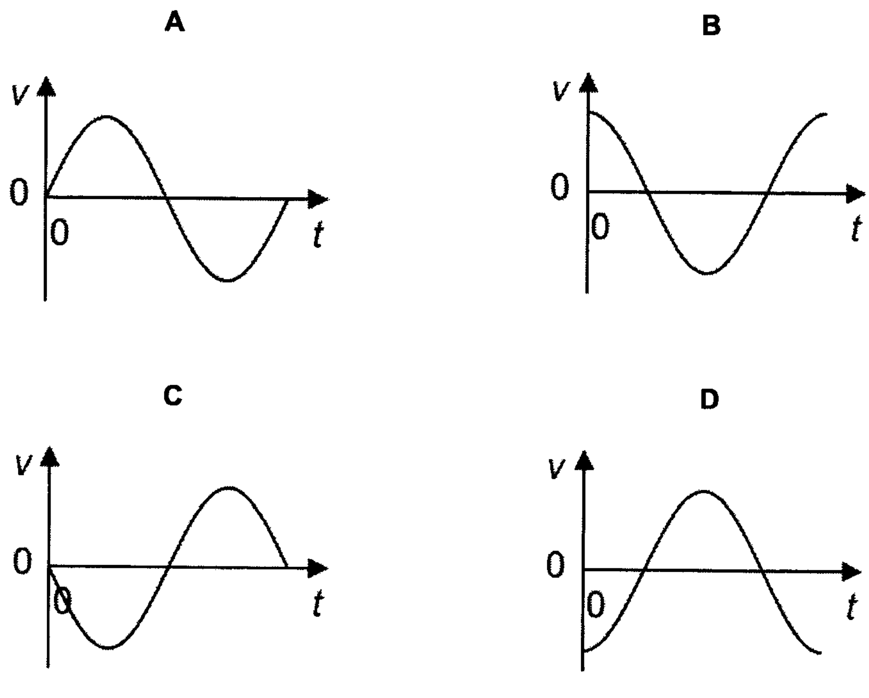
What is the potential energy in the spring when the kinetic energy of the mass is 0.36 J?

A 0.26 J **B** 0.36 J **C** 0.62 J **D** 6200 J

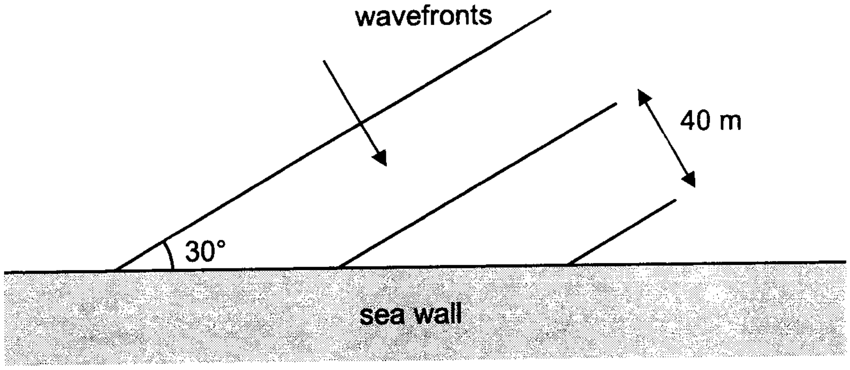
11 The diagram shows an instantaneous position at time $t = 0$ of a string as a transverse progressive wave travels along it from left to right. P is a point on the string.



Taking upwards as positive, which of the following graphs shows the variation with time t of the velocity v of point P?



12 Parallel water waves of wavelength 40 m strike a straight sea wall. The wavefronts make an angle of 30° with the wall as shown.



What is the difference in phase at any instant between the waves at two points 8.0 m apart along the wall?

A 36° **B** 62° **C** 72° **D** 90°

13 Sound from a small loudspeaker L reaches a point P by two paths which differ in length by 2.9 m. When the frequency of the sound is gradually increased, the resultant intensity at P goes through a series of maxima and minima. A maximum occurs when the frequency is 800 Hz and the next maximum occurs at 960 Hz.

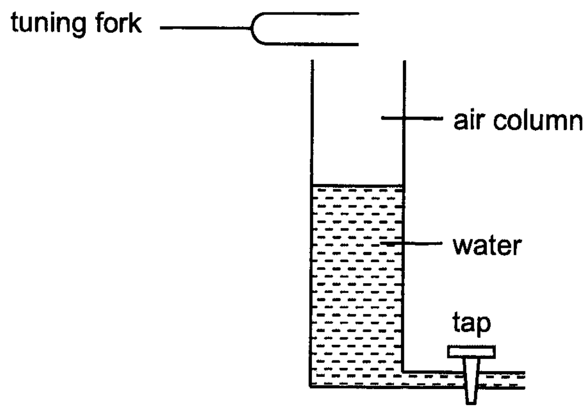
What is the speed of sound in the medium between L and P?

A 240 m s^{-1} **B** 340 m s^{-1} **C** 460 m s^{-1} **D** 2320 m s^{-1}

14 Under which conditions will the bright fringes of a double slit light interference pattern be farthest apart?

	distance between slits	distance from slits to screen	wavelength of source
A	small	small	short
B	small	large	long
C	large	small	short
D	large	small	long

15 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.



The tube is filled fully and then water is allowed to run out of it. Two consecutive resonances occur when the air column lengths are x and y.

What is the wavelength of the sound wave?

A $4x + 4y$ **B** $2x + 2y$ **C** $y - x$ **D** $2y - 2x$

16 The root-mean-square speed of the molecules of an ideal gas is c. If the gas is heated at constant volume so that its pressure is increased from p to $4p$, what is the new the root-mean-square speed?

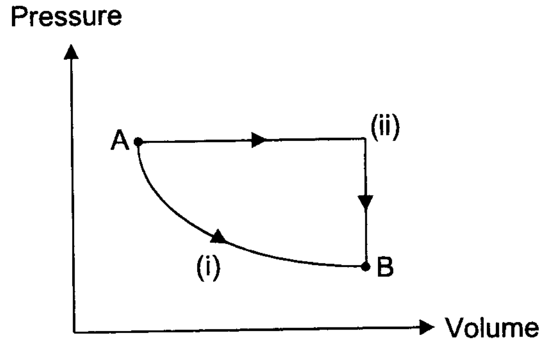
A $\frac{c}{16}$ **B** $2c$ **C** $4c$ **D** $16c$

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

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

A $\frac{1}{160}$ K **B** $\frac{1}{40}$ K **C** 40 K **D** 160 K

18 A system of ideal gas undergoes a change of state from A to B by either process (i) or process (ii) as shown.



Which of the following statements is correct?

A The work done by the gas is greater in (i) than in (ii).

B The work done by the gas is lesser in (i) than in (ii).

C The increase in internal energy in (i) is greater than in (ii).

D The increase in internal energy in (i) is lesser than in (ii).

19 Electric field strength is defined as force per unit positive charge on a small test charge.

Why is it necessary for the test charge to be small?

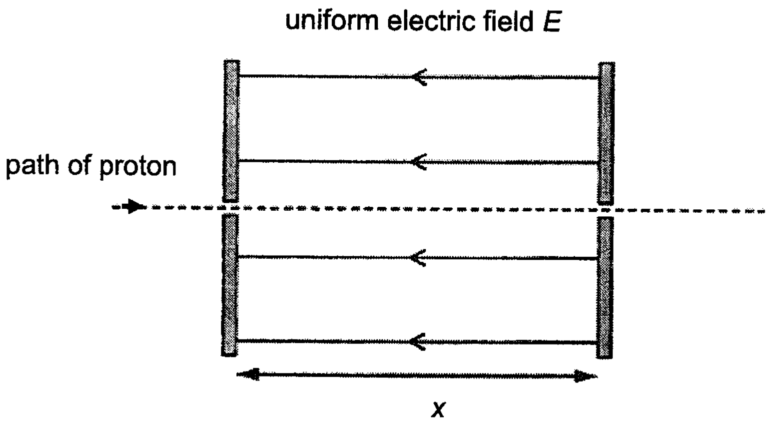
A The test charge does not distort the electric field.

B The force on the test charge is small.

C The test charge does not create any forces on the nearby charges.

D Coulomb's law for point charges is obeyed.

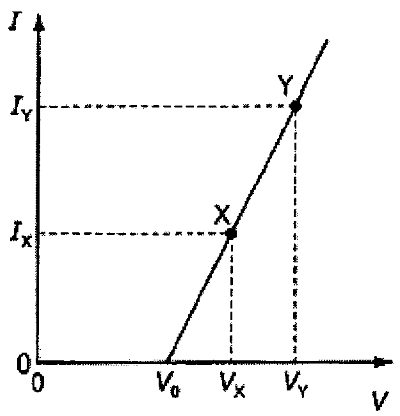
20 A proton of mass m and charge e travels through a uniform electric field of field strength E. It enters the field with velocity v and then travels a distance x in a direction opposite to the field, as shown.



What will be its speed when leaving the field?

A $v+\sqrt{\frac{eEx}{m}}$ **B** $v-\sqrt{\frac{eEx}{m}}$ **C** $\sqrt{v^2+\frac{2eEx}{m}}$ **D** $\sqrt{v^2-\frac{2eEx}{m}}$

21 The graph shows the variation with potential difference V of the current I in an electrical component.

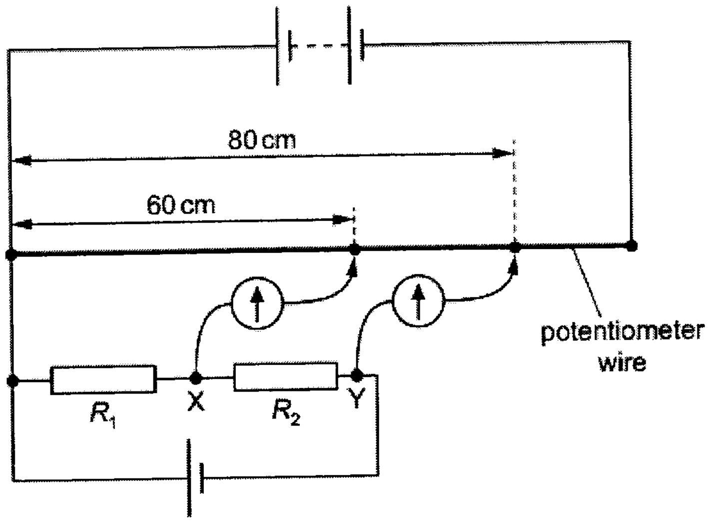


The resistance is measured for current I_Y and for current I_X.

What is the change in the resistance of the component?

A zero **B** $\frac{V_Y-V_X}{I_Y-I_X}$ **C** $\frac{V_Y}{I_Y}-\frac{V_X}{I_X}$ **D** $\frac{V_Y-V_0}{I_Y}-\frac{V_X-V_0}{I_X}$

22 Potential differences across two resistors of resistances R_1 and R_2 are compared using a one metre long potentiometer wire of uniform resistance in the electrical circuit shown.

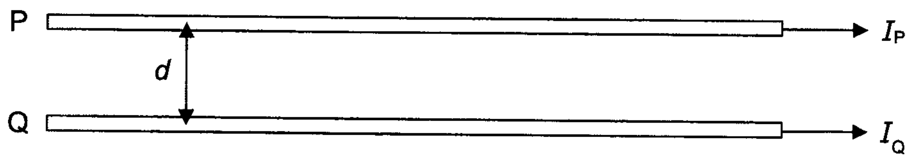


One galvanometer is connected from point X to the 60 cm mark. Another galvanometer is connected from point Y to the 80 cm mark. Both galvanometers read zero.

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

A 0.33 **B** 0.75 **C** 3.0 **D** 1.3

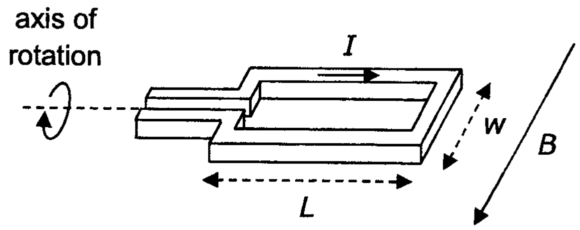
23 Two infinitely long, parallel conductors P and Q are carrying currents I_P and I_Q respectively. They are separated by a distance d.



The magnetic force per unit length exerted by P on Q is

A $\frac{\mu_o}{2\pi d} I_P I_Q$ **B** $\frac{\mu_o}{2\pi d} {I_P}^2$ **C** $\frac{\mu_o}{2\pi d} {I_Q}^2$ **D** $\frac{\mu_o}{2\pi d} \frac{I_P}{I_Q}$

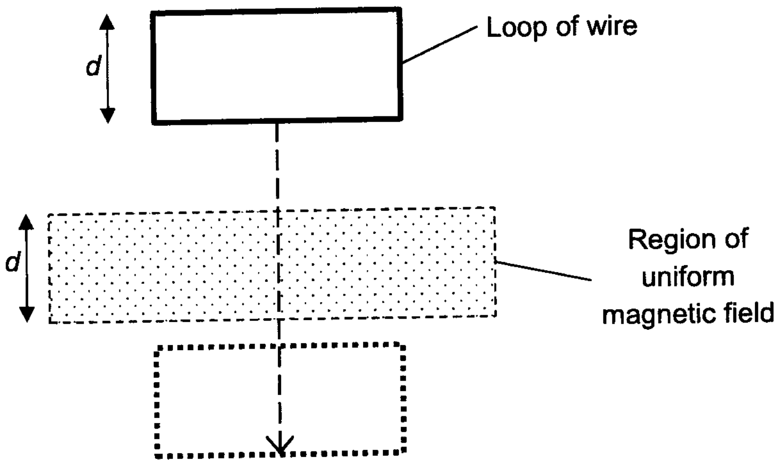
24 A rectangular coil of length L and width w carries a current I. It is placed completely in a uniform magnetic field of flux density B and the direction of the field is parallel to the width w, as shown below. The coil rotates about a horizontal axis.



What is the *maximum* torque experienced by the coil?

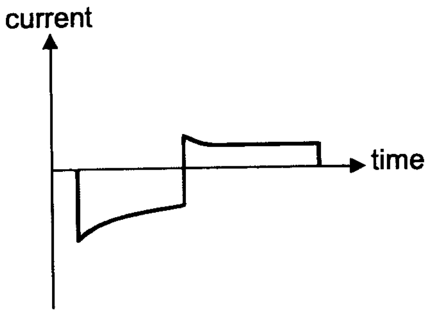
A $\frac{1}{2}BILw$ **B** $BILw$ **C** $2BILw$ **D** $4BILw$

25 A rectangular loop of wire is released from rest and falls vertically through a region of uniform magnetic field under the influence of gravity. The loop and the region of magnetic field have the same height *d* as shown in the diagram below.

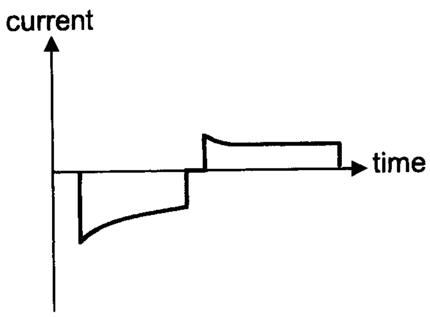


Which of the following graphs shows the flow of the current in the loop of the wire as it falls and passes through the region of magnetic field?

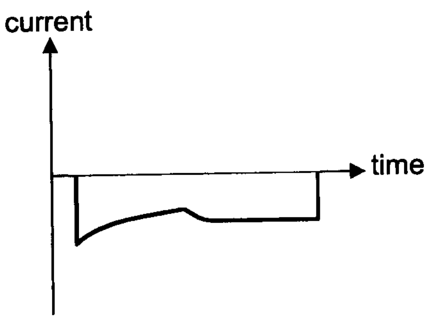
A



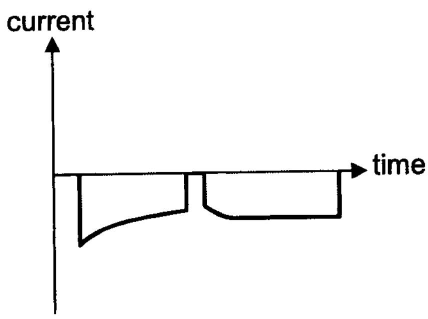
B



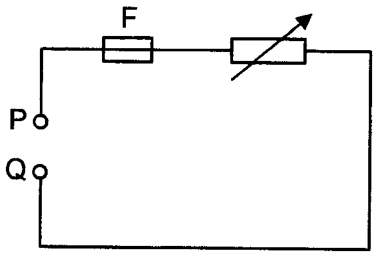
C



D



26 When a direct current supply of 120 V is connected to the terminals PQ in the circuit shown below, the fuse F breaks the circuit if the current just exceeds 12 A.



When the direct current supply is replaced with a 240 V r.m.s. alternating current source, an identical fuse breaks the circuit if the r.m.s. current just exceeds

A 6 A **B** 12 A **C** $12\sqrt{2}$ A **D** 24 A

27 In an ideal transformer, the most important purpose of the soft iron core is to

A reduce eddy currents.

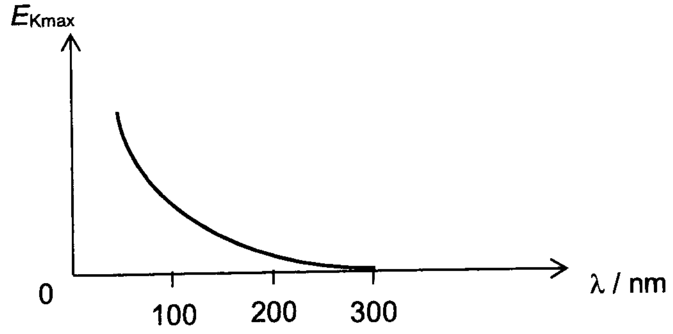
B reduce the resistance of the coils.

C reduce the effect of the Earth's magnetic field.

D increase the flux linkage between the coils when a current flows through it.

28 In a photoelectric experiment, the maximum kinetic energy of the ejected photoelectrons is measured for various wavelength of incident electromagnetic radiation.

A graph of this maximum kinetic energy, E_{Kmax}, against the wavelength λ of the incident electromagnetic radiation falling on the surface of a metal is shown below.



What is the work function for this metal?

A 2.07 eV **B** 4.14 eV **C** 6.63 eV **D** 7.96 eV

29 The x-coordinate of an electron is measured with an uncertainty of 0.20 mm and the minimum percentage uncertainty in a simultaneous measurement of v_x is 1.0 %. What is the x-component of the electron's velocity v_x?

A 3.6 m s^{-1} **B** 18 m s^{-1} **C** 360 m s^{-1} **D** 1800 m s^{-1}

30 A radioactive sample of element X has an activity of A.

Another radioactive sample of element Y with the same number of radioactive nuclei as the sample of X has an activity of 3A.

What is the ratio $\frac{\text{half life of X}}{\text{half life of Y}}$?

A 0.11 **B** 0.33 **C** 3.0 **D** 9.0

End of Paper

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 Preliminary Examination

CANDIDATE NAME

CIVICS GROUP

H2 PHYSICS **9749/02**

Paper 2 Structured Questions **14 September 2022**

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the 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.
The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions in this Question Paper.

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

For Examiners' Use	
1	/ 10
2	/ 10
3	/ 10
4	/ 10
5	/ 10
6	/ 10
7	/ 20
Deduction	
Total	/ 80

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Data

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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
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the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-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	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T/K	=	T/°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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm\,\omega\sqrt{x_o^{\,2} - x^2}$
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	=	$x_o \sin \omega t$
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	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

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

1 **(a)** The final velocity v, initial velocity u, acceleration a and displacement s of a body moving in a straight line at uniform acceleration is related by the equation

$$v^2 = u^2 + 2as$$

Show that this equation is homogenous.

[2]

(b) A horse-riding bowman starts from rest, and accelerates uniformly over a distance s and to a velocity v.
The measured values of s and v are

$$s = (5.0 \pm 0.2)\ \text{m}$$
$$v = (7.7 \pm 0.3)\ \text{m s}^{-1}$$

(i) Calculate the acceleration a of the horse.

a = ...m s^{-2} [1]

(ii) Calculate the absolute uncertainty of the acceleration of the horse, Δa.

Δa = ...m s^{-2} [2]

(iii) Express a together with its associated uncertainty.

$a \pm \Delta a$ = ...±............m s^{-2} [1]

(c) In a shooting competition, bowmen shoot at the centre of a target board 6 times. The target boards of two bowmen, A and B, are shown in Fig 1.1.

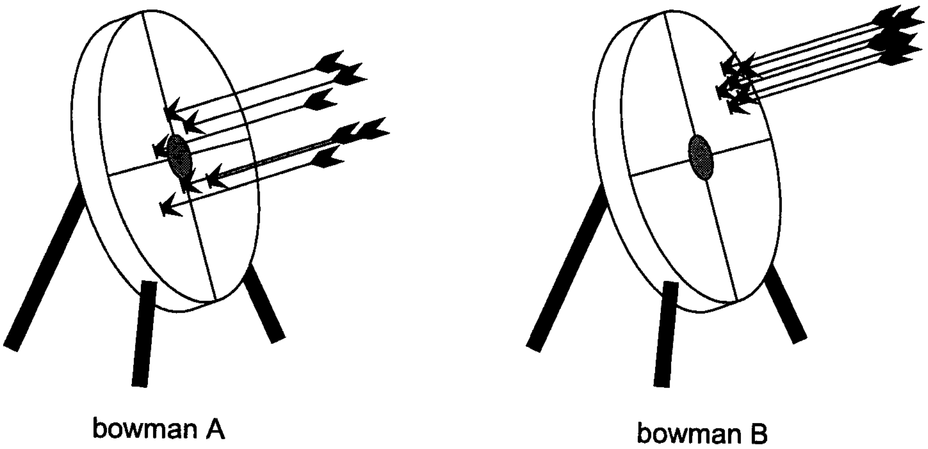


Fig 1.1

State and explain which of the bowmens' shooting is considered to be more

(i) accurate.

....

....

.... [2]

(ii) precise.

....

....

.... [2]

2 During a crash test, a remotely driven bus and a car are both travelling towards each other with the same speed of 70 km h^{-1} as shown in Fig. 2.1. The mass of the bus is five times that of the mass of the car. The vehicles collide head-on and become entangled together. Assume frictional forces with the road are negligible.

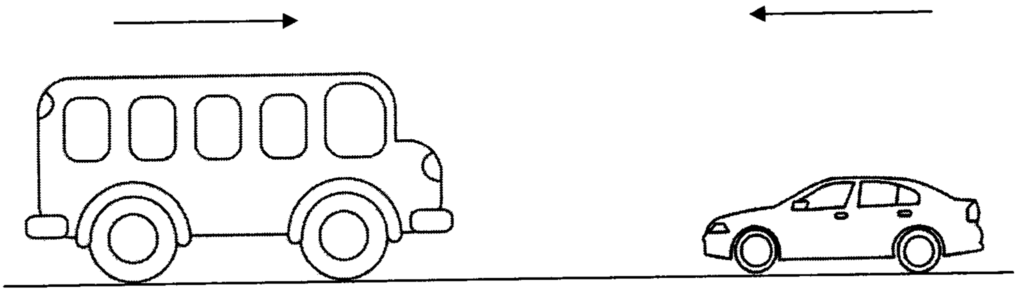


Fig. 2.1

(a) State and explain which vehicle experiences a larger impact force during the collision.

....

.... [1]

(b) Explain why it is not possible for both vehicles to be at rest simultaneously during the collision.

....

....

....

.... [2]

(c) Calculate the velocity of the entangled vehicles immediately after the collision.

speed = ... m s^{-1}

direction = ... [3]

(d) The dummies used in both the bus and car are of the same mass.
State and explain which dummy experiences a larger change in momentum.

....

....

....

.... [2]

(e) The total kinetic energy of the system decreases as a result of the collision.
Calculate the fraction of the kinetic energy lost by the car.

fraction of kinetic energy lost = ... [2]

3 **(a)** Explain the following terms with reference to the light diffracted by a diffraction grating that is used with a monochromatic light source.

(i) Diffraction

....

.... [1]

(ii) Coherence

....

.... [1]

(iii) Superposition

....

....

.... [2]

(b) A parallel beam of white light that consists of wavelengths from 350 nm to 650 nm is incident normally on a diffraction grating that has 500 lines per millimetre.

(i) Calculate the maximum angle in the second order spectrum.

maximum angle = ...° [2]

(ii) Calculate the minimum angle in the third order spectrum.

minimum angle = ...° [1]

(iii) Explain a problem with viewing the second or third order maxima of the white light with this diffraction grating.

....

....

.... [1]

(iv) Describe the changes, if any, in the appearance of the fringes for the wavelength used in **(b)(i)**, when a diffraction grating of 250 lines per millimetre is used.

....

....

....

.... [2]

4 A cell of electromotive force (e.m.f) of 0.48 V is connected to a metal wire, as shown in Fig. 4.1.

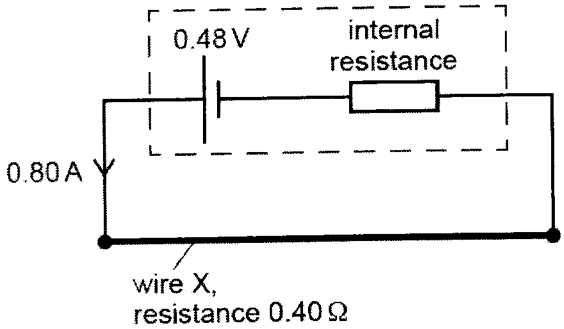


Fig. 4.1

The cell has internal resistance. The current in the cell is 0.80 A.

Wire X has length of 3.0 m, cross-sectional area 1.3×10^{-7} m^2 and resistance of 0.40 Ω.

(a) There are 3.2×10^{22} free electrons contained in the volume of wire X.

For wire X, calculate

(i) the number density *n* of the free electrons.

n = ... m^{-3} [1]

(ii) the average drift velocity of the free electrons.

average drift velocity = ... m s^{-1} [2]

(b) **(i)** Determine the internal resistance of the battery.

internal resistance = ... Ω [2]

(ii) Determine the percentage power loss in the internal resistance.

percentage loss = ... [1]

(c) A wire Y has the same cross-sectional area as wire X and is made of the same material. Wire Y is shorter than wire X.

Wire X in the circuit is replaced by wire Y. Assume that wire Y has the same temperature as wire X.

(i) State and explain whether the average drift velocity of the free electrons in wire Y is greater than, the same as, or less than that in wire X.

....

....

....

.... [2]

(ii) State and explain whether the efficiency of the battery increases, stays the same or decreases when compared to that in wire X.

....

....

....

.... [2]

5 **(a)** A solenoid of length 0.35 m and 400 turns is placed in a vacuum and a current of 2.3 A is passed through it.

Show that the magnetic flux density inside the coil is 3.3 mT.

[1]

(b) A proton enters the solenoid in **(a)** at a speed of 4200 m s^{-1}, at an angle of 57°, as shown in Fig 5.1. The proton moves in a helical path of constant radius inside the solenoid. It exits the other side of the solenoid.

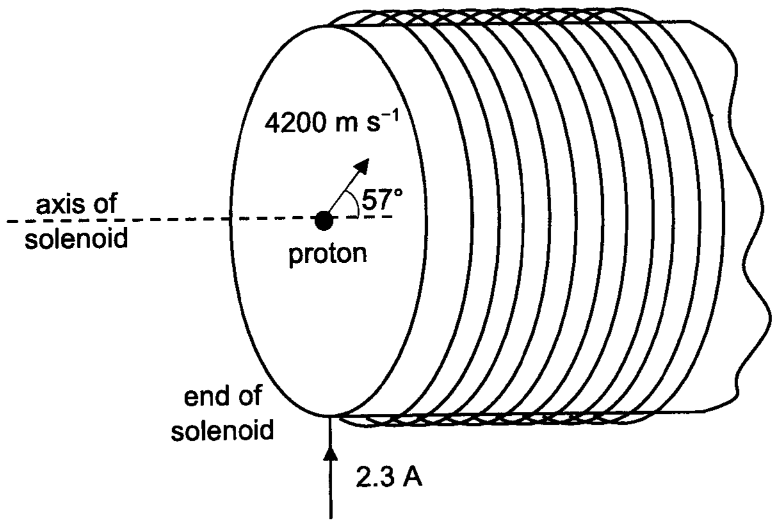


Fig. 5.1

(i) Explain why the proton will move in a helical path inside the solenoid.

....

....

....

.... [2]

(ii) Show that the period of the helix is 20 μs.

[3]

(iii) Calculate the time taken for the proton to exit the solenoid.

time = ... s [1]

(iv) Hence, calculate the number of complete cycles of the helix.

number of complete cycles = ... [1]

(v) When the proton exits the solenoid, it moves in a spiral with increasing radius. Explain why this occurs.

....

....

....

.... [2]

6 In nuclear physics, a *decay chain* refers to a sequence of radioactive decays where an element undergoes a series of decays until eventually a stable isotope is reached.

Fig 6.1 shows a decay chain where radium-224 decays into a stable isotope of lead through a series of alpha and beta decays.

isotope	decay product	decay mode	half life
$^{224}_{88}Ra$ radium-224	radon-220	alpha	3.63 days
radon-220	polonium-216	alpha	55.6 seconds
polonium-216	lead-212	alpha	0.145 seconds
lead-212	bismuth	beta	10.6 hours
bismuth	thallium	alpha	60.6 minutes
thallium	lead (stable)	beta	3.05 minutes

Fig. 6.1

(a) State the number of protons and neutrons for the final stable nuclide of lead.

number of protons = ...

number of neutrons = ... [2]

(b) A sample of 12 mg of pure radium-224 is prepared for a decay chain experiment.

(i) Calculate the initial activity, A_o of the sample of radium-224.

initial activity A_o = ... s^{-1} [4]

(ii) Calculate the mass of radium-224 remaining after 6.0 days.

mass = ... mg [2]

(iii) After some time, an analysis of the radioactive sample shows that the concentration of lead-212 in the sample is much higher than the concentration of radon-220 in the sample.

Explain this observation.

....

....

....

.... [2]

7 A bridge is constructed across a river in the way shown in Fig. 7.1. Two towers were sunk into the river bed and the roadway, which is supported by many cables, was made in stages. One end of each cable is attached to the roadway, passes over a tower and its other end is also attached to the roadway. Each cable is therefore an inverted V. As you pass over the bridge there are cables on both your right hand side and your left hand side. Having many cables is a much better system than that of a traditional suspension bridge which relies on the immense tensile strength of one pair of cables taking the entire load.

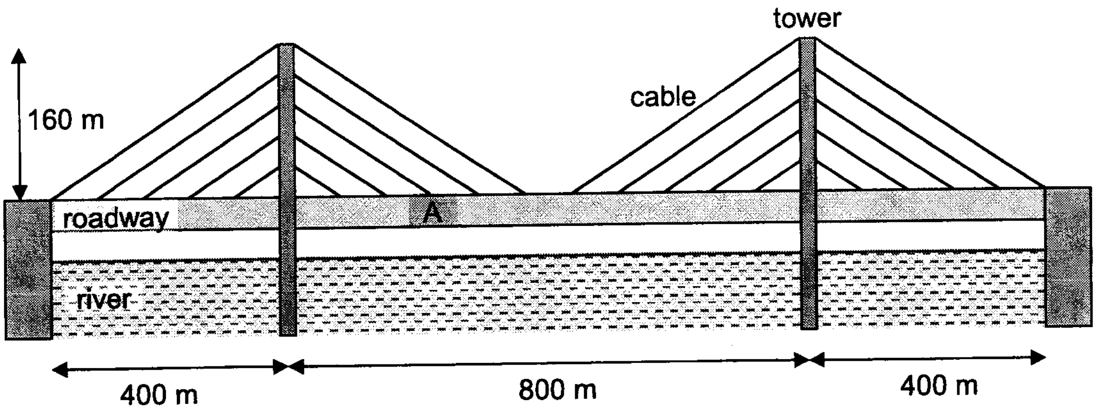


Fig. 7.1 (showing some of the cables)

Simplified data concerning the bridge are given below.

Length of bridge supported by the towers	= 1600 m
Height of tower above roadway	= 160 m
Total mass of all the cables	= 1.4×10^6 kg
Mass of roadway	= 8.5×10^6 kg
Maximum mass of load of traffic (assume uniform distribution)	= 11.5×10^6 kg
Horizontal distance between cables	= 20 m
Vertical distance between cables	= 8.0 m
Number of cables	= 80

(a) What reason does the paragraph give for the construction with many inverted V cables?

....

....

.... [2]

(b) Calculate the maximum total mass which each of the two towers may need to support.

mass = ... kg [2]

(c) Calculate the mass of 20 m of roadway and the traffic which those 20 m of roadway may have to support.

mass = ... kg [2]

(d) Calculate the angle between a cable and the horizontal.

angle to horizontal = ...° [2]

(e) Fig. 7.2 shows a close-up view of the fully laden 20 m section of road at A.
On Fig. 7.2, draw and label the forces acting on this road section and explain how this road section is in equilibrium.

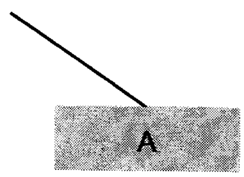


Fig 7.2

....

.... [4]

(f) Calculate the tension in a cable when the bridge is fully laden. (The tension in all cables is assumed to be the same.)

tension = ... N [3]

(g) The force constant of the cable is 7.0×10^6 N m^{-1}.
Calculate the increase in the extension of the cable when the tension in it increases by 5.2×10^5 N.

increase in extension = ... m [2]

(h) Suggest why the maximum tension allowed in the cable is well below the breaking tension.

....

.... [1]

(i) Explain where is there likely to be a tension in the roadway.

....

....

.... [2]

End of Paper

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 Preliminary Examination

CANDIDATE NAME

CIVICS GROUP

H2 PHYSICS **9749/03**

Paper 3 Longer Structured Questions **21 September 2022**

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the 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.
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		Percentage
Subtotal P1		/ 15
Subtotal P2		/ 30
Paper 3		
1	/ 9	
2	/ 10	
3	/ 10	
4	/ 10	
5	/ 10	
6	/ 11	
7	/ 20	
8	/ 20	
Deduction		
Subtotal P3		/ 35
Subtotal P4		/ 20
Grand total		/ 100

This document consists of **28** printed pages and **4** blank pages.

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} J K^{-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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T/°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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{x_o^2 - x^2}$
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	=	$x_o \sin \omega t$
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	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 **(a)** **(i)** State Archimedes' principle.

....

....

.... [1]

(ii) Explain why an object submerged in a fluid experiences upthrust.

....

....

....

.... [2]

(b) A mini submarine has a mass of 4800 kg and total volume 5.0 m^3. To dive into the sea, it takes on mass in the form of seawater into its ballast tank.

Fig. 1.1(a), Fig. 1.1(b) and Fig. 1.1(c) show a simplified cross sectional diagram of the mini submarine when it is at the surface of the sea, diving and submerged respectively.

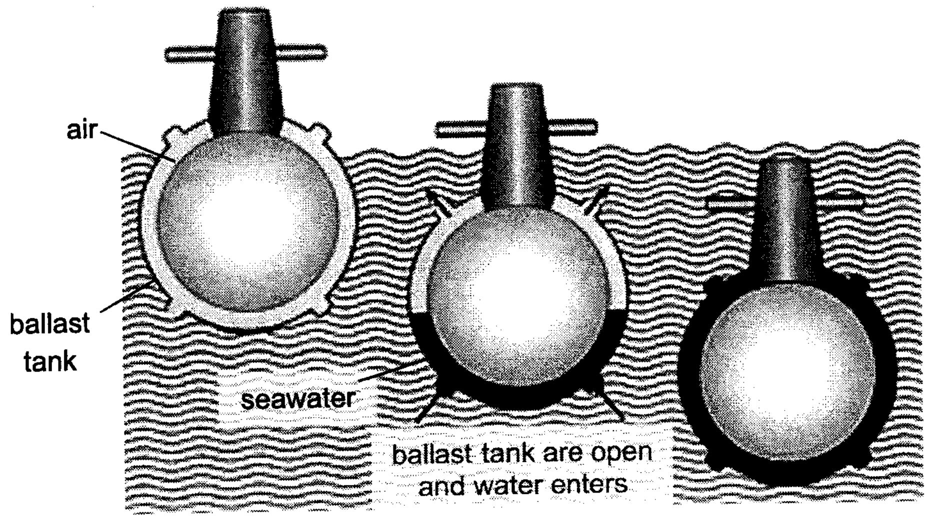


Fig. 1.1(a) **Fig.1.1(b)** **Fig. 1.1(c)**

Calculate the mass of seawater that the fully submerged mini submarine must take on if it is to descend at a constant speed, when the average resistive force acting on it is 1100 N. Assume the density of seawater is 1030 kg m^{-3}.

mass of seawater = ... kg [2]

(c) **(i)** Calculate the pressure at a sea depth of 200 m.
Assume the atmospheric pressure is 1.01×10^5 Pa.

pressure = ... Pa [2]

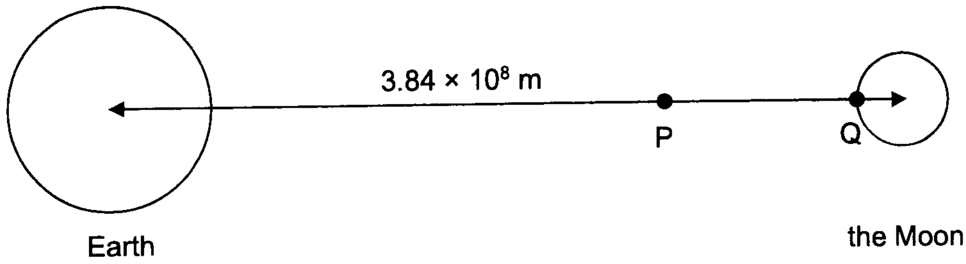
(ii) The mini submarine in **(b)** dived to a sea depth of 200 m. It has a circular porthole (window) having a diameter of 30 cm.

Calculate the force which the frame of the porthole needs to exert to counterbalance the force exerted by the water at this depth.
Assume that inside the submarine is at atmospheric pressure.

force = ... N [2]

2 Earth's only natural satellite is called "the Moon" and is the only other place in the solar system besides Earth where humans have set foot.

Fig 2.1 provides some astronomical data for the Earth and the Moon.



Astronomical Data:	
Mass of the Earth:	5.98×10^{24} kg
Mass of the Moon:	7.35×10^{22} kg
Radius of the Earth:	6.38×10^{6} m
Radius of the Moon:	1.74×10^{6} m
Distance from the centre of the Earth to the centre of the Moon:	3.84×10^{8} m

Fig 2.1

(a) Define *gravitational potential.*

....

....

.... [2]

(b) Show that the gravitational potential at point Q on the surface of the Moon due to both the Earth and the Moon is -3.86×10^{6} J kg^{-1}.

[2]

(c) The table in Fig 2.2 shows the values of the gravitational potential between the surface of the Earth and the surface of the Moon.

The distances are measured from the surface of the Earth.

Distance from surface of Earth / 10^8 m	Gravitational Potential / 10^6 J kg^{-1}	Remarks
0.00	-62.5	At the surface of the Earth
1.99	-1.97	---
2.00	-1.96	Point P
2.01	-1.95	---
3.40	-1.28	Neutral point
3.76	-3.86	Point Q on the surface of the Moon

Fig 2.2

(i) Using data from Fig 2.2, estimate the magnitude of the gravitational field strength at point P, at a distance of 2.00×10^8 m from the surface of the Earth.

magnitude of gravitational field strength = ... N kg^{-1} [2]

(ii) Hence, calculate the linear speed of an object which is in circular orbit around the Earth at point P.

speed = ... m s^{-1} [2]

(d) A spacecraft is launched from the Earth to the moon.

Using the data in Fig 2.2, estimate the minimum kinetic energy with which this spacecraft of mass 1000 kg would need to be launched in order to reach the surface of the Moon.

Neglect any energy losses from air resistance in the Earth's atmosphere.

kinetic energy = ... J [2]

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3 A cylinder enclosed by a gas-tight and frictionless piston of negligible mass, contains 0.600 m^3 of air with a density of 1.28 kg m^{-3} at 275 K.

The air inside the cylinder is then heated to 390 K. During the heating process, the air expands at constant pressure until the piston reaches a new equilibrium position as shown in Fig. 3.1.

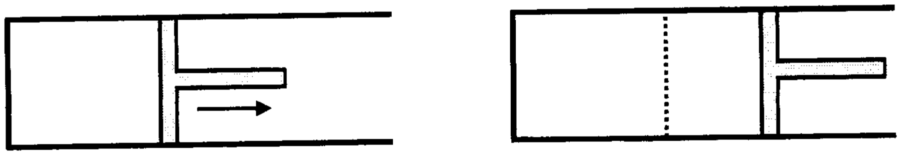


Fig. 3.1

The air is assumed to be an ideal gas. The specific heat capacity of the air under the conditions in which it is heated is 1000 J kg^{-1} K^{-1}.
Atmospheric pressure is 1.03 × 10^5 Pa.

(a) Explain what is meant by the internal energy of a system.

....

.... [1]

(b) **(i)** Calculate the heat energy required to raise the temperature of air from 275 K to 390 K.

heat energy = ... kJ [2]

(ii) Show that the work done on the atmosphere during this process is 25.8 kJ.

[2]

(iii) Hence, determine the increase in the internal energy of the air in the piston during this process.

increase in the internal energy = ... kJ [2]

(c) The air in the cylinder is now compressed suddenly by applying an external force on the piston. Explain whether the temperature of the air in the cylinder increases, decreases or remains constant.

....

....

....

....

....

.... [3]

4 A proton moves in a straight line through a vacuum with a constant speed of 3.9×10^6 m s^{-1}. It enters a uniform electric field at point A, as shown in Fig. 4.1.

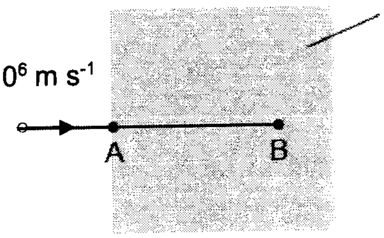


Fig. 4.1

The proton continues to move in a straight line until it is brought to rest at point B in the electric field. The distance AB is 0.032 m.

(a) State the direction of the electric field.

.... [1]

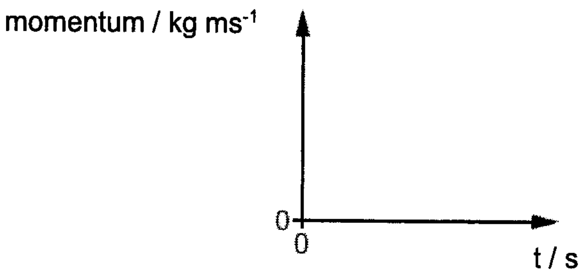
(b) Calculate the deceleration of the proton.

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

(c) Calculate the electric field strength.

field strength = ... N C^{-1} [2]

(d) The proton is at point A at time $t = 0$.
On Fig. 4.2, sketch the variation with time t of the momentum of the proton as it travels from point A to point B. Label suitable values on your axis.



[3]

Fig. 4.2

(e) The region of uniform field is replaced by a positive point charge, placed at point B, where its magnitude is 10 times the charge of the proton, as shown in Fig. 4.3.

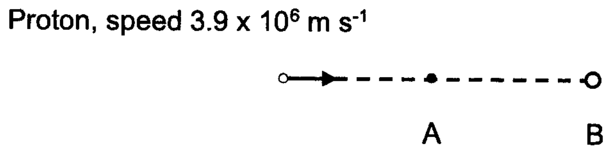


Fig. 4.3

(i) Describe one difference in motion for the proton illustrated in Fig. 4.1 and Fig 4.3. considering it is at point A at time $t = 0$.

....

.... [1]

(ii) On Fig. 4.4, sketch the variation with time t of the momentum of the proton as it travels from point A towards point B.
Numerical values are not required.

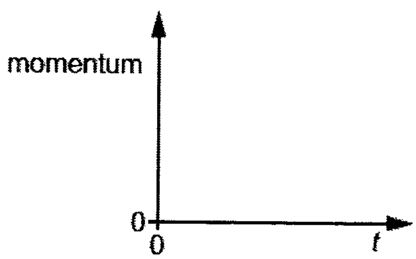


Fig. 4.4 [1]

5 Electrical transformers are widely used in industries. Fig. 5.1 illustrates a version of a transformer.

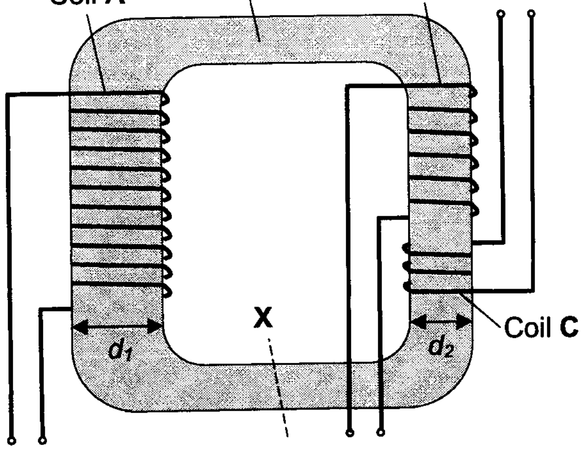


Fig. 5.1

The terminals of coil **A** is connected to a 240 V r.m.s. alternating current source.
The ratio of the number of turns of wire in the coils of coil **A** : **B** : **C** is 11 : 6 : 3.
The thickness d_1 is twice of d_2.

(a) **(i)** Define magnetic flux.

....

.... [1]

(ii) The magnetic flux produced by coil **A** is ϕ_A and the magnetic flux through coil **B** is ϕ_B. State the relation between ϕ_A and ϕ_B.

.... [1]

(iii) Explain why an induced e.m.f. is produced in the terminals of coil **B**.

....

....

....

....

.... [2]

(iv) Determine the induced e.m.f. ε_B in coil **B**.

induced e.m.f. ε_B = ... V [2]

(b) Due to an impact on the transformer, a gap is formed in the soft iron core along the dashed line labelled **X** as shown in Fig. 5.1.
State and explain how the gap affects the maximum e.m.f. induced in coil **C**.

....

....

....

....

.... [2]

(c) Before the impact, the e.m.f. induced in coil **C** is given by the expression

$$\mathcal{E}_C = \mathcal{E}_0 \cos\left(\frac{2\pi}{T}t\right)$$

Fig. 5.2 below shows the terminals of coil **C** connected to three diodes and a resistor *R*.

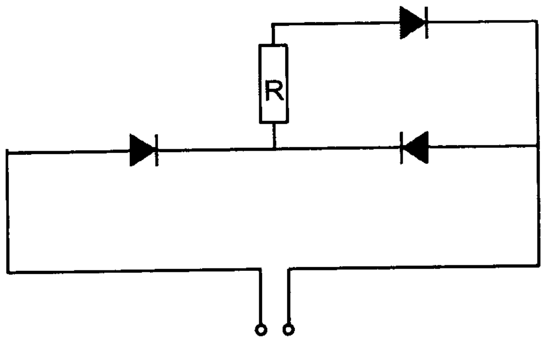
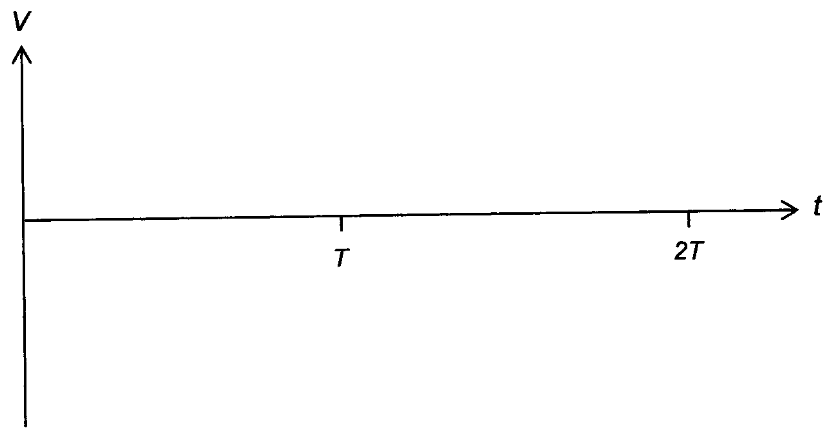


Fig. 5.2

On the axes given below, sketch and label the voltage-time graph of the resistor for two cycles when all three diodes are in use.
Numerical values are not required.



[2]

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6 **(a)** Fig. 6.1 shows some of the energy levels for an atom of hydrogen.

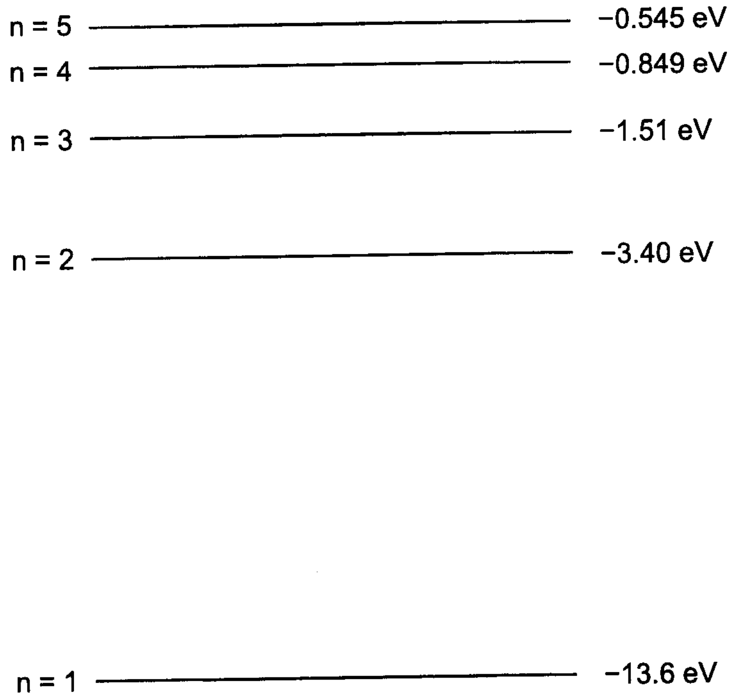

Fig. 6.1 (not to scale)

(i) An electron of the hydrogen atom is in the ground state.

1. Determine the amount of energy required to remove this electron from the atom.

energy = ... J [1]

Explain the possible result of the following interaction on the electron of the hydrogen atom.

2. An incident electron of 11.0 eV collides with the atom.

....

....

.... [1]

3. A photon of energy of 11.0 eV passes through the atom.

....

....

.... [1]

(ii) If an electron of the hydrogen atom at energy level n = 4 returns directly to the ground state, describe what will happen.
Show your working clearly.

....

.... [3]

(b) Fig. 6.2 shows how X-rays are produced inside an X-ray tube.
The electrons, emitted from the filament at the cathode, are accelerated from rest using an accelerating voltage V to strike a heavy metal target at the anode.
As a result, X-rays are produced.

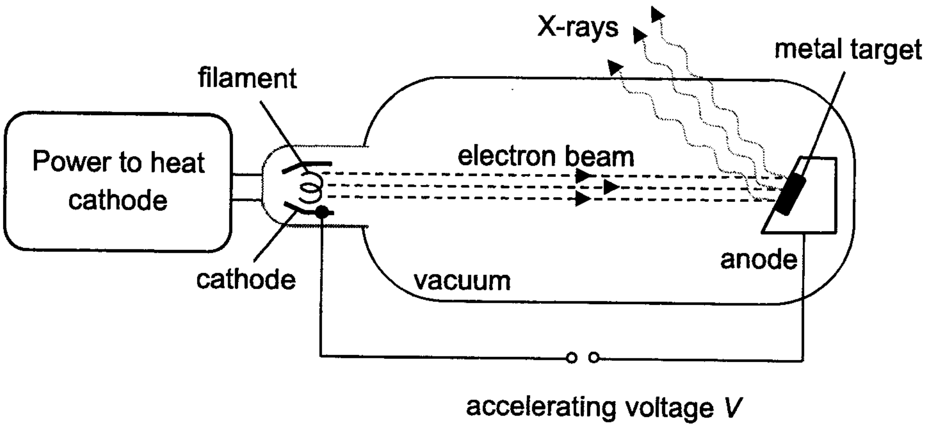

Fig. 6.2

Fig. 6.3 shows a graph of relative intensity I against wavelength λ of emitted radiation, featuring emission line spectrum superimposed on a continuous spectrum.

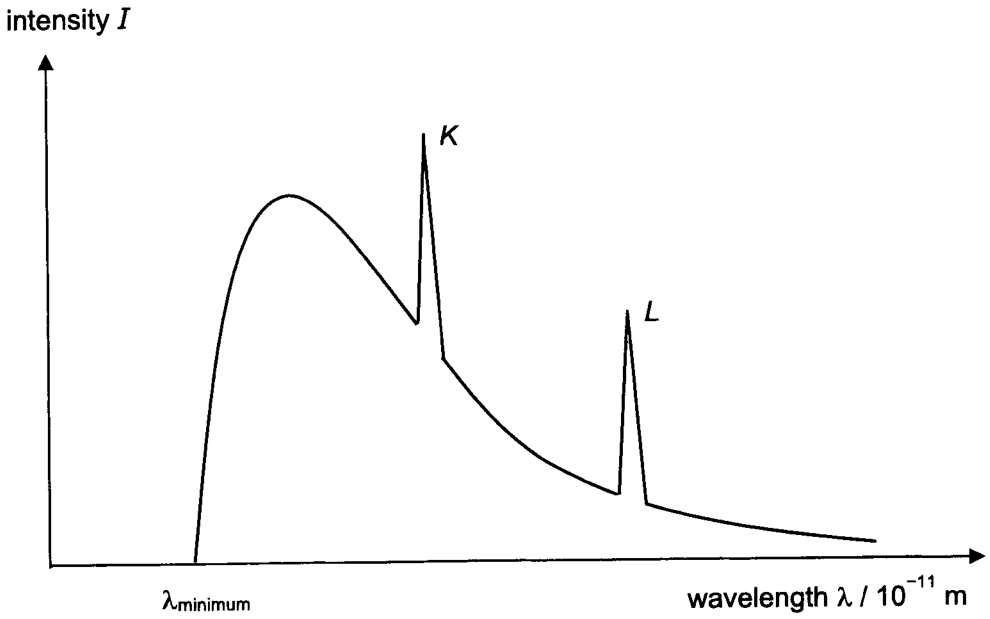

Fig. 6.3

(i) If the accelerating voltage V used is 105 kV, calculate the minimum wavelength $\lambda_{minimum}$.

$\lambda_{minimum}$ = ... m [3]

(ii) The target metal is replaced with another metal of higher atomic number and the current in the filament is reduced.

On Fig. 6.3, sketch a graph to show how intensity of the X-rays emitted varies with wavelength. Label your graph P. [2]

End of Section A

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Section B

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

7 **(a)** Fig. 7.1 shows two sources S_1 and S_2 emitting waves of the same wavelength. The lines represent crests. The sources are coherent and are 6.0 cm apart.

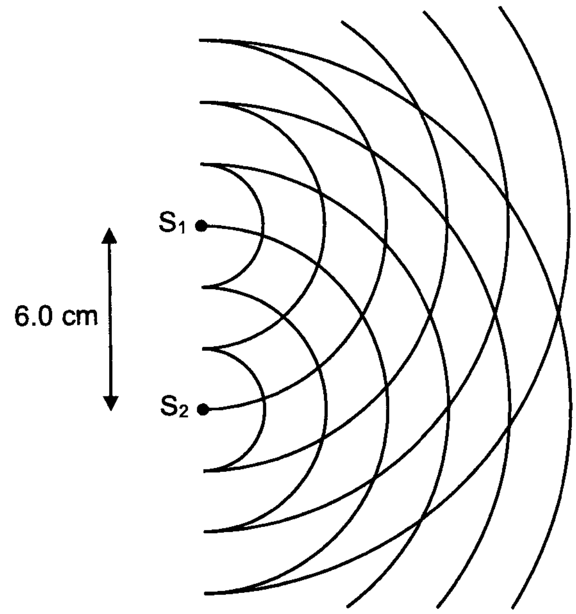

Fig. 7.1

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

....

.... [1]

(ii) Other than being coherent, state 2 other conditions that must be satisfied for waves from the two sources to produce an observable interference pattern.

1...

....

2...

.... [2]

(iii) On Fig. 7.1, draw a line passing through the points where the path difference is zero and label the line C.

[1]

(iv) On Fig. 7.1, mark a point where the path difference is one and a half wavelength, label the point P.

Draw a line passing through point P and other points where the path difference is one and half wavelength and label the line D.

[2]

(v) Show that the wavelength of the waves is 2.0 cm.

[1]

(b) A screen is placed 15 cm from the sources as shown in Fig. 7.2. Point O is equidistant from the sources. Point X is at the first maxima from O and Point Y is the first minima from X. The distance OX is 5.4 cm.

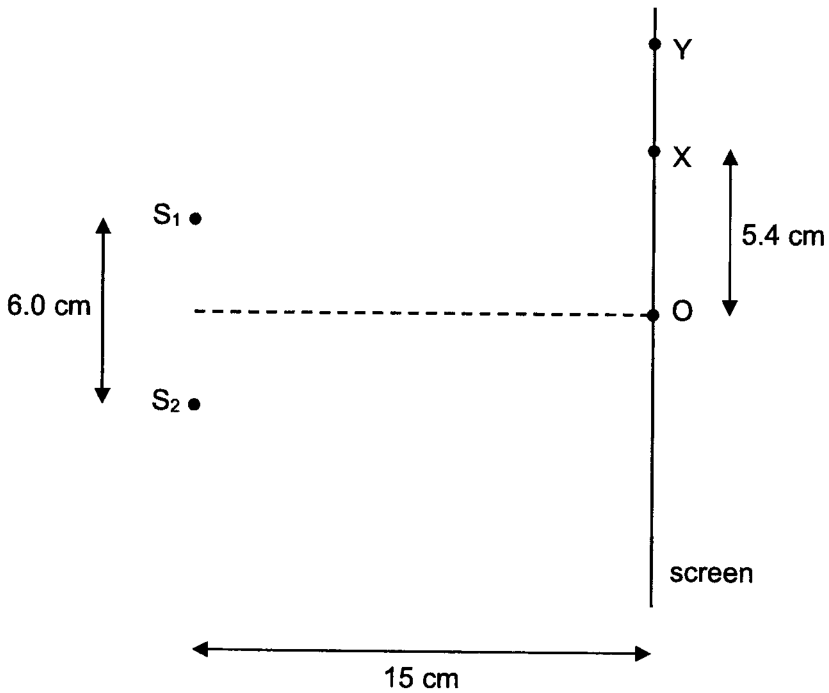

Fig. 7.2

(i) Show quantitatively that X is the point of the first maxima from O.

[2]

(ii) State the path difference $S_2Y - S_1Y$.

path difference = ... cm [1]

(iii) Hence calculate the distance OY.

OY = ... cm [2]

Each source has power 20 W and emits waves in all directions in three dimensions.

(iv) Show that the intensity at O due to S_1 is 68 W m^{-2}.

[1]

(v) Hence, calculate the resultant intensity at O.

intensity at O = ... W m^{-2} [1]

(c) On the line between S_1 and S_2, a stationary wave is formed where S_1 is an antinode.

(i) State the distance from S_1, on the line between S_1 and S_2, where the first antinode from S_1 is found.

distance from S_1 = ... cm [1]

(ii) A detector moves from S_1 to S_2 at a constant speed of 3.0 cm s^{-1}. Determine the rate of fluctuations picked up by the detector.

rate of fluctuations = ... s^{-1} [1]

(d) Two light sources L_1 and L_2 emitting light of wavelength 500 nm and separated 6.0 cm apart are to be observed by an observer 15 km away through a single slit of slit width 0.10 m as shown in Fig. 7.3.

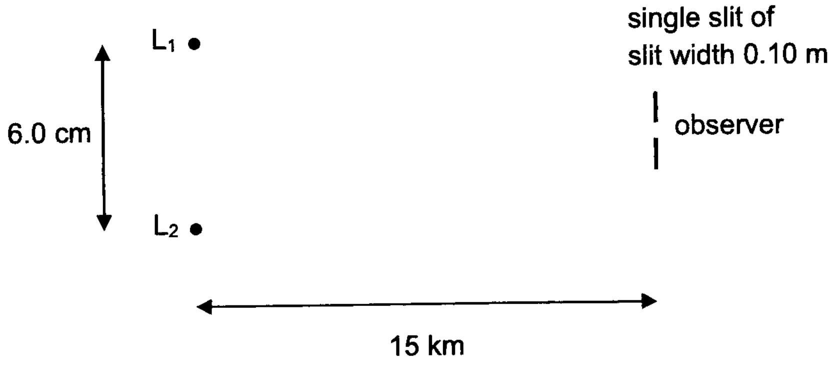

Fig. 7.3

(i) Calculate the limiting angle of resolution of the slit.

limiting angle = ... rad [2]

(ii) Calculate the angle of separation of the two light sources relative to the observer.

angle of separation = ... rad [1]

(iii) Hence, explain whether the two sources can be resolved.

....

.... [1]

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8 A student attempts to create his own loudspeaker by attaching a paper cone to a magnet, which is connected to a spring vertically as shown in Fig 8.1.

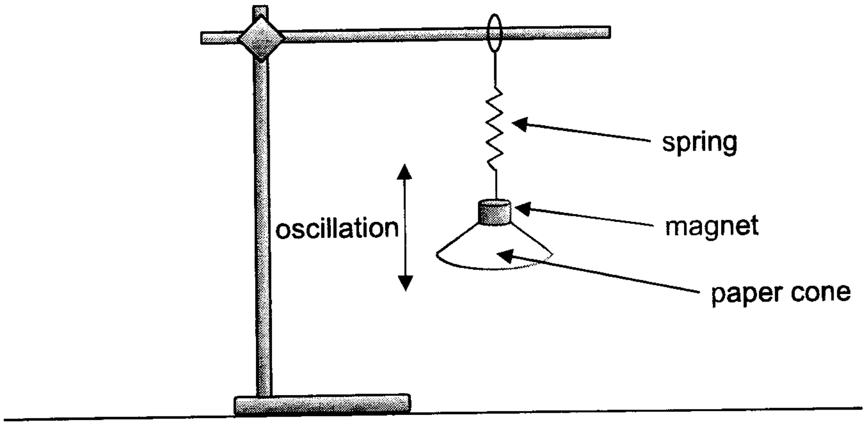


Fig 8.1

When the magnet is displaced a small distance and released, it oscillates up and down.

The vertical displacement of the magnet from its equilibrium position is *x*. The acceleration of the magnet is given by the expression

$$a = -\frac{k}{m}x$$

where *k* is the force constant of the spring and *m* is the mass of the magnet and paper cone.

(a) Explain, with reference to the acceleration of the magnet and paper cone, why the oscillation of the magnet is simple harmonic.

....

....

....

.... [2]

(b) The force constant of the spring is 35 kN m^{-1} and the mass of the magnet and paper cone is 20 g.

(i) Show that the frequency of oscillation of the magnet and paper cone is 210 Hz.

[2]

(ii) The amplitude of oscillation of the magnet, x_0 is 0.20 mm.
Calculate the maximum resultant force on the magnet and paper cone.

maximum resultant force = ... N [2]

(iii) Hence, calculate the maximum tension in the spring.

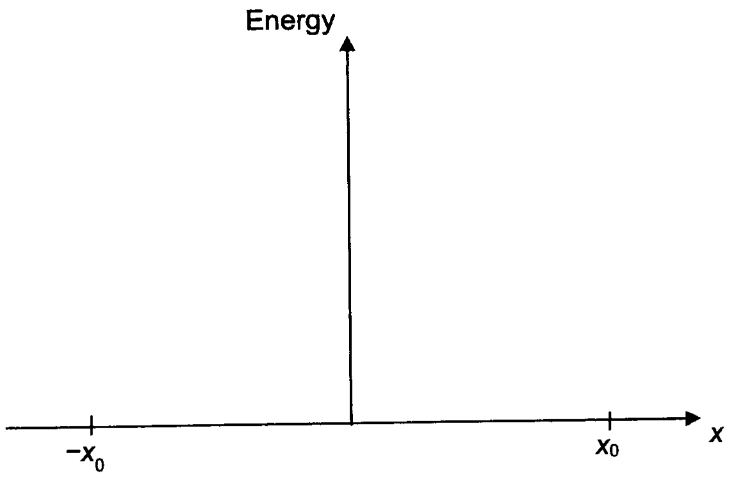
maximum tension = ... N [2]

(iv) Calculate the maximum kinetic energy of the oscillation.

maximum kinetic energy = ... J [2]

(v) As the magnet oscillates, the spring remains extended throughout the oscillation. On the axes below, sketch graphs to show the variation with vertical displacement from the equilibrium position, x of:
1. the kinetic energy of the magnet and paper cone, E_k
2. the elastic potential energy in the spring, E_s
3. the gravitational potential energy of the magnet and paper cone, E_g

Take displacement downwards as positive.



[3]

(c) The student now assembles a solenoid coil near the magnet and paper cone, as shown in Fig 8.2.

He then passes a sinusoidal alternating current through the solenoid and this causes the magnet and paper cone to oscillate and make a sound.

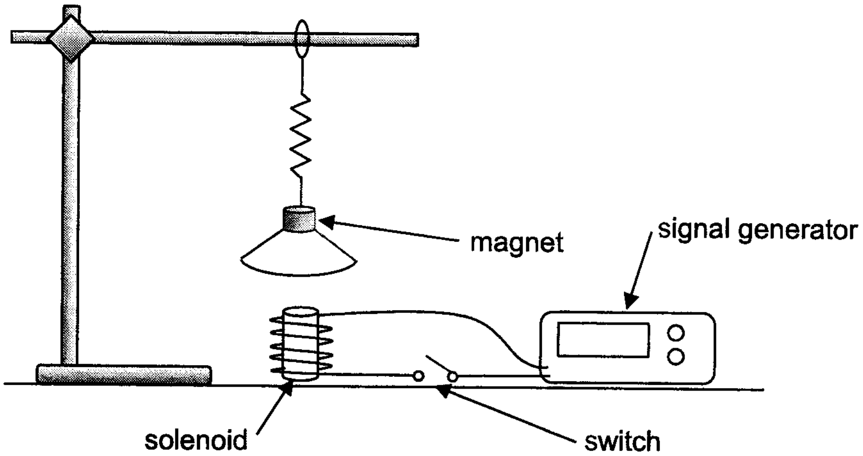


Fig 8.2

(i) State and explain the frequency of the alternating current that produces the loudest sound.

....

....

....

.... [2]

(ii) The switch is then opened.

Explain why the oscillations of the magnet and paper cone eventually come to a stop.

....

....

....

.... [2]

(iii) The student then modifies the loudspeaker by adding a small mass to the magnet and paper cone.

Explain the effect of this change on the frequency of the alternating current that causes the speaker to generate the loudest sound in **(c)(i)**.

....

....

....

.... [2]

(iv) Loudspeakers that are produced commercially are often found to consist of several speakers of different masses, as shown in Fig 8.3.

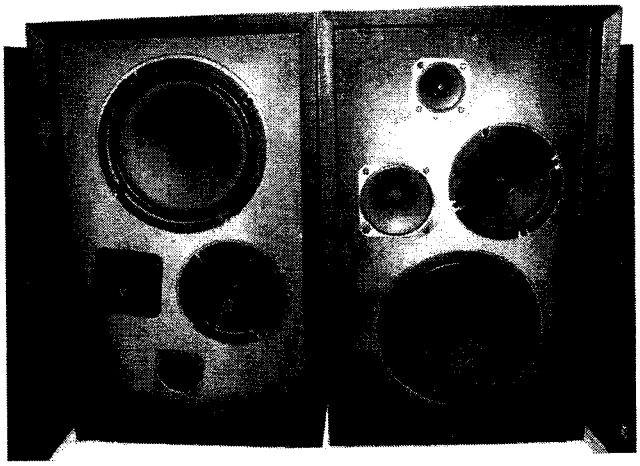


Fig 8.3

Suggest why this might be so.

....

....

.... [1]

End of Section B

TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME	
CIVICS GROUP	

H2 Physics **9749/04**

Paper 4 Practical

25 August 2022

2 hours 30 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page, page **11** and **17**.
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** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in 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.

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

Shift
Laboratory

For Examiner's Use	
1	/10
2	/13
3	/20
4	/12
Total	/55

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

1 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

(a) **(i)** Connect the circuit shown in Fig. 1.1. The light-emitting diode (LED), which is soldered (attached) to the 200 Ω resistor, should be connected the right way round so that light is emitted.

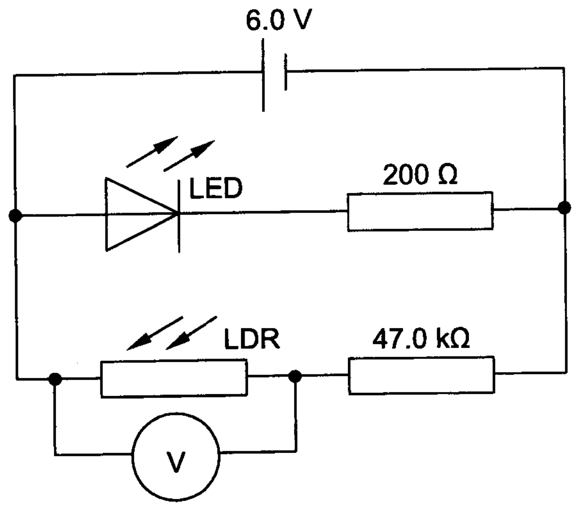


Fig. 1.1

(ii) You are provided with a black straw of approximate length of 4 cm.

(iii) Use the straw and clear adhesive tape to make a cylinder that fits neatly over the LDR and LED.

Cut the cylinder into two halves of approximately 2 cm each and fit the 2 cylinders over the LDR and LED, as shown in Fig. 1.2.

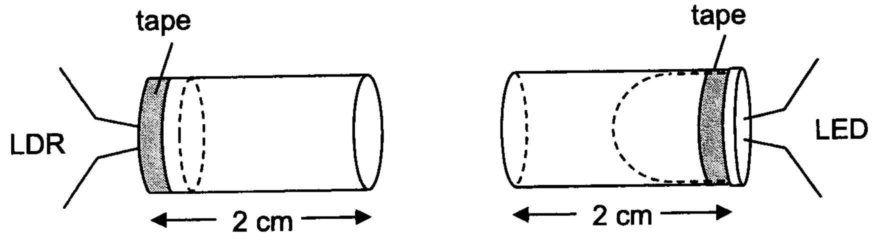


Fig. 1.2

(b) Place the cylinders together, as shown in Fig. 1.3.

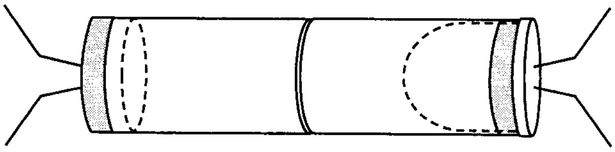


Fig. 1.3

Record the voltmeter reading V_0.

V_0 = ... [1]

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

Using a micrometer screw gauge, determine the thickness of one layer of tracing paper.

thickness of one layer = ... [2]

(d) **(i)** Place four layers of tracing paper between the LED and the LDR as shown in Fig. 1.4.

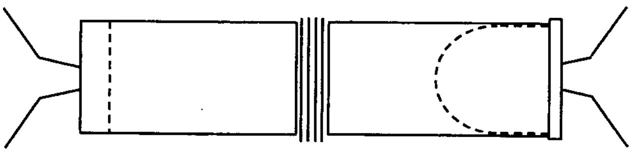


Fig. 1.4

Record the voltmeter reading V.

V = ...

(ii) Repeat **(d)(i)** using eight layers of tracing paper.

V = ... [1]

(e) Comment on the trend of your results.

....

.... [1]

(f) **(i)** State and explain **one** significant source of error or limitation of the procedures for this experiment.

....

....

....

.... [1]

(ii) Suggest **one** improvement that could be made to the experiment to address the error or limitation identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

....

.... [1]

(g) Suggest changes that could be made to the experiment to investigate how the light detected by a LDR depends on the angle between the polarising axes of a pair of polarising filters.

You may assume that a pair of **unmarked** polarising filters is available.

You may draw a diagram to show how the apparatus would be arranged.

....

....

....

....

....

....

....

.... [3]

[Total: 10 marks]

2 In this experiment you will investigate how the motion of a metre rule depends on the length of the string loops used to suspend it.

(a) Measure and record the width *w* of one of the metre rules, as shown in Fig. 2.1.

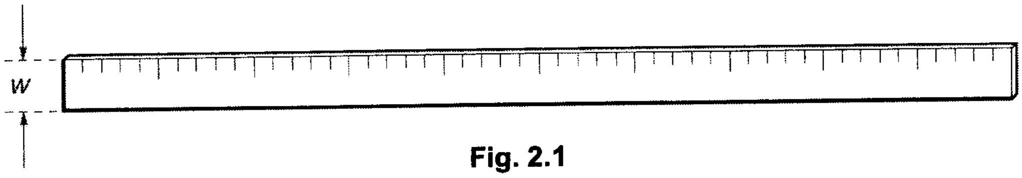


Fig. 2.1

w = ... [1]

(b) **(i)** Select the two longer pieces of string.

(ii) Tie the ends of one piece of string to make a loop.

(iii) Measure and record the length *l* of this loop, as shown in Fig. 2.2.

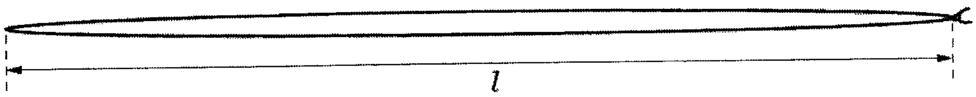


Fig. 2.2

l = ... [1]

(iv) Repeat **(ii)** with the other long piece of string.

The length of this loop should be the same as that in **(iii)**.

(c) (i) Use the stands to set up the two metre rules and the two loops of string as shown in Fig. 2.3.

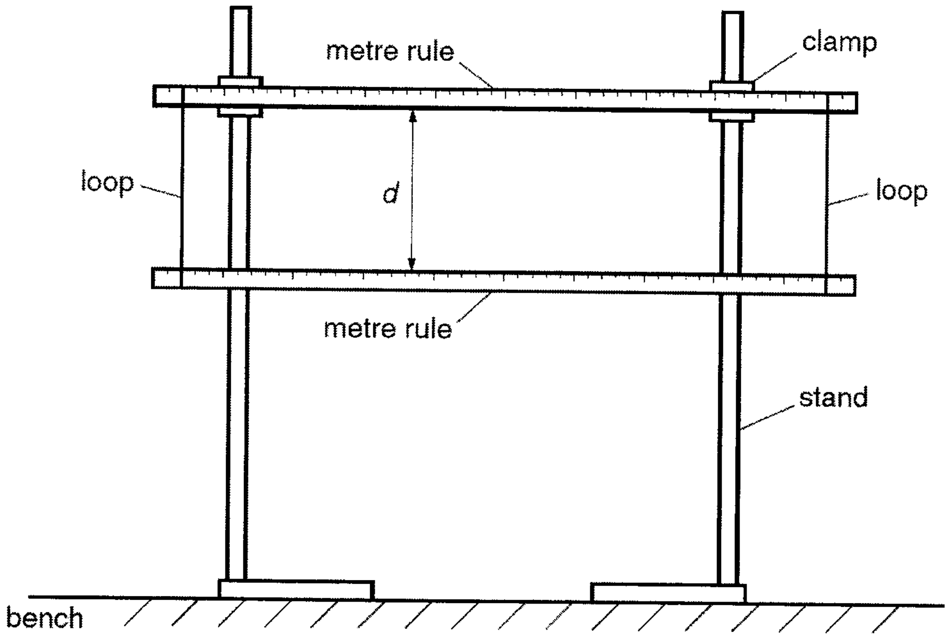


Fig. 2.3

The rules should be horizontal with the scale markings facing you.

The loops should be vertical, parallel to each other and placed at the 5 cm and 95 cm marks on both rules.

(ii) Using your values in **(a)** and **(b)(iii)**, determine the distance d using the relationship

$$d = l - 2w.$$

d = ... [1]

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

percentage uncertainty = ... [1]

(d) Move the left end of the bottom rule towards you and the right end away from you. Release the rule and watch the movement.

The left end of the rule will move away from you and back towards you, completing a swing. The time taken for one complete swing is *T*.

By timing several of these complete swings, determine an accurate value for *T*.

T = ... [2]

(e) Repeat **(b)**, **(c)(i)**, **(c)(ii)** and **(d)** for the shorter lengths of string.

T = ... [3]

(f) It is suggested that the relationship between T and d is

$$T^2 = kd$$

where k is a constant.

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

first value for k = ...

second value for k = ... [1]

(ii) Justify the number of significant figures that you have given for your values of k.

....

....

....

.... [1]

(iii) State whether the results of your experiment support the suggested relationship. Justify your conclusion by referring to your answer in **(c)(iii)**.

....

....

....

.... [2]

[Total: 13 marks]

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Candidate Name: ____________________ **Civics Group:** __________

3 In this experiment, you will apply several forces to a metre rule.

(a) Measure and record the length l_0 of the unstretched spring, as shown in Fig. 3.1. Use a metre rule for this measurement.

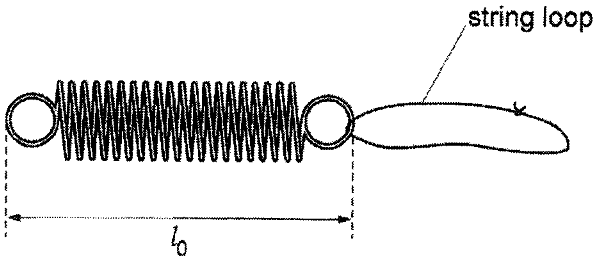

Fig. 3.1

l_0 = ... [1]

(b) One of the metre rules has a rubber band wrapped around its centre. Record the distance L from one end of the metre rule to the rubber band, as shown in Fig. 3.2.

Do not adjust the position of the rubber band throughout the experiment.

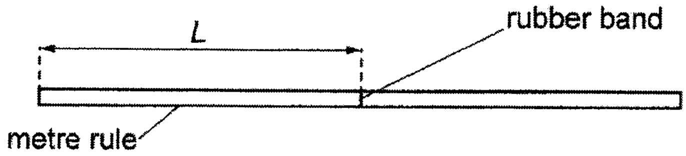

Fig. 3.2

L = ...

(c) Measure and record the diameter d of one of the slotted masses, as shown in Fig. 3.3. Use a vernier caliper for this measurement.

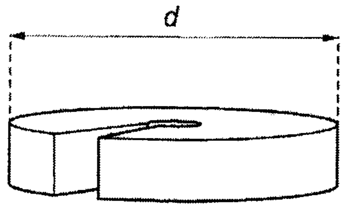

Fig. 3.3

d = ... [2]

(d) (i) Set up the apparatus as shown in Fig. 3.4.

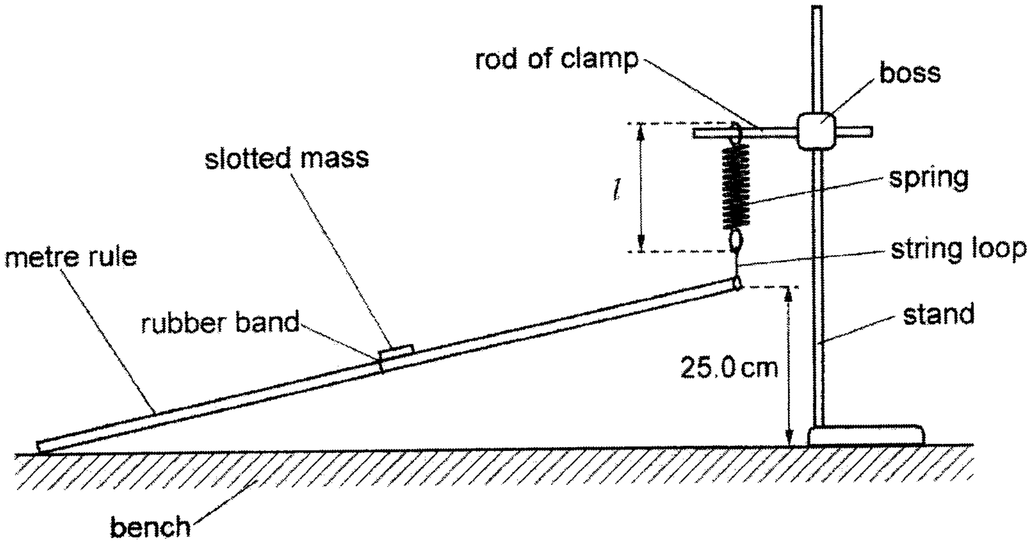

Fig. 3.4

One of the slotted masses should be placed on the metre rule and be resting against the rubber band.

(ii) Adjust the apparatus so that the bottom edge of the raised end of the metre rule is 25.0 cm above the bench and the spring is vertical.

Measure and record the length l of the stretched spring.

l = ...

(iii) Calculate e where $e = l - l_0$.

e = ... [1]

(e) Place a second mass next to the first mass, as shown in Fig. 3.5.

Repeat **(d)(ii)** and **(d)(iii)**.

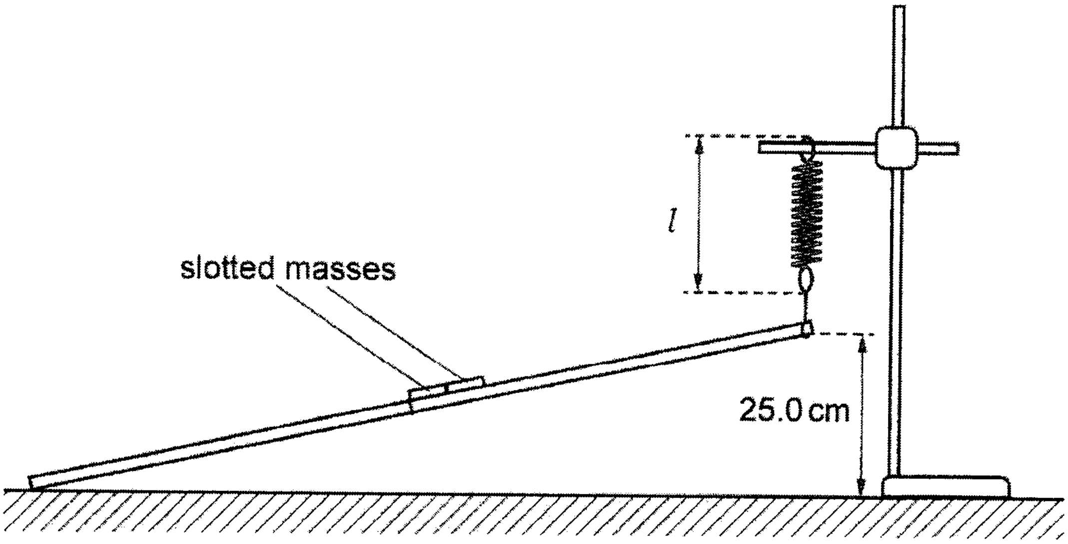

Fig. 3.5

l = ...

e = ...

(f) (i) Add further slotted masses next to the masses already on the metre rule.

Repeat **(d)(ii)** and **(d)(iii)** for each additional mass.

For each set of measurements, record the value of n where n is the number of slotted masses on the rule.

[4]

(ii) Plot a graph of e against n. Draw a curve through your points. [3]

(iii) Draw a tangent to the curve at n = 3. [1]

(iv) Determine the gradient G of the tangent.

G = ... [1]

(g) State with justification if there are any anomalous data or result that you may have obtained.

....

....

.... [1]

(h) **(i)** Use the Newton meter to determine the weight W of one slotted mass.

W = ... [1]

(ii) G and n are related by the expression

$$G = \frac{W}{2kL}(dn + L)$$

where k is the spring constant of the spring and n = 3.

Calculate k.

k = ... [3]

(iii) The experiment is repeated with two **identical** springs of k value obtained from **h(ii)**. The springs are connected as shown in Fig. 3.6.

Fig. 3.6

State and explain the effect on G.

....

....

.... [2]

[Total: 20 marks]

Candidate Name: ______________________ **Civics Group:** __________

4 Engineers have explored the use of electromagnetic braking in controlling the velocities of vehicles on sloped metal surfaces.

A model of a trolley which uses electromagnetic braking is shown in Fig 4.1. The trolley has a magnet attached and is placed on a thick aluminium sheet. The trolley is released from rest and travels down the slope. Due to electromagnetic braking, the trolley eventually reaches terminal velocity as it travels down the slope.

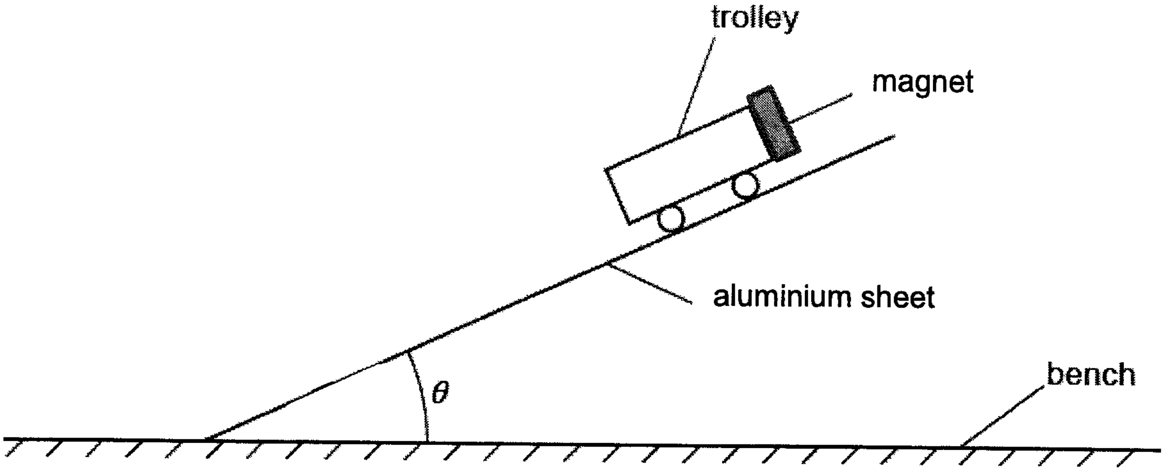

Fig. 4.1

The angle between the sheet and the bench is θ. The terminal velocity of the trolley near the bottom of the slope is v_T. The magnetic flux density between the magnet and the aluminium sheet is B.

It is suggested that v_T is related to θ and B by the relationship

$$v_T = k\left(\sin\theta\right)^p B^q$$

where k, p, q are constants.

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

You are provided with a toy trolley, a thick aluminium sheet, as well as several magnets of different magnetic flux density.

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

- the equipment you would use,
- the procedure to be followed,
- how you would measure the terminal velocity of the trolley.
- the control of variables,
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

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[Total: 12 marks]

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