EUNOIA JUNIOR COLLEGE
JC1 PROMOTIONAL EXAMINATIONS 2023
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	3	-			REGISTRATION NUMBER		

PHYSICS

9749/02

Paper 2 Structured Questions

September/October 2023

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

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

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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

This document consists of **24** printed pages and **0** blank page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ 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,	$T\ /\ \text{K} = T\ /\ {}^\circ\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\ \omega \sqrt{\left(x_0^2 - x^2\right)}$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A car slides from rest (at point **A**) with a constant acceleration of 4.0 m s^{-2} along a rough slope before reaching the edge of a cliff (at point **B**) as shown in Fig 1.1. The slope is at an angle of 27° to the horizontal. The car slides 30 m along the slope before falling into the ocean (at point **C**) which is 40 m below the edge of the cliff.

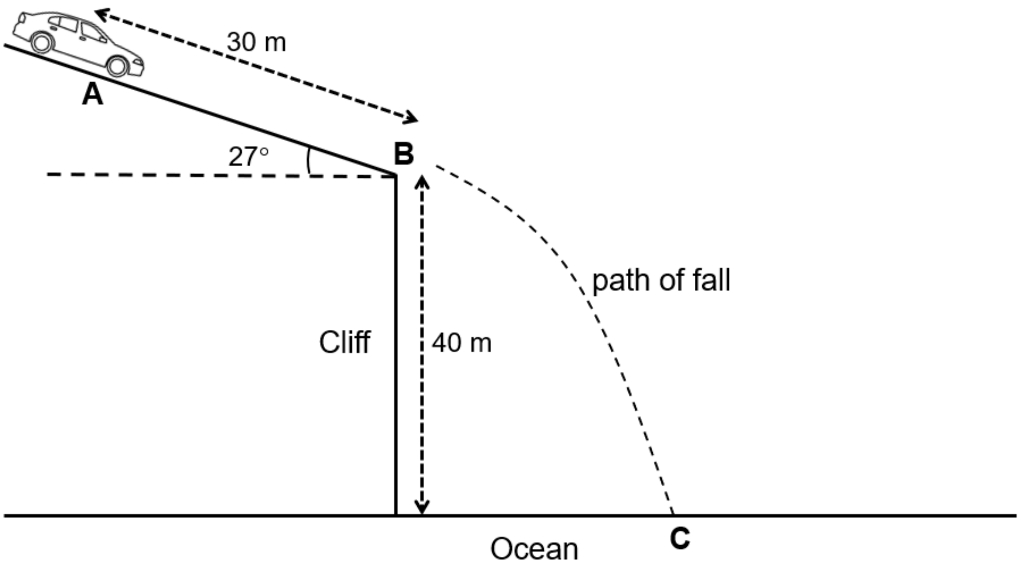

Fig. 1.1

(a) Define *velocity.*

.... [1]

(b) Show that the speed of the car at point **B** is 15.5 m s^{-1}.

[1]

(c) Calculate the velocity of the car at point **C**.

velocity = ………………………………… m s^{-1} [3]

direction = ……………………………………….. [1]

(d) Calculate the time taken for the car to fall from point **B** to point **C**.

time = ………………………………… s [2]

(e) Sketch the vertical acceleration, a_y, of the car against its horizontal displacement, d_x, from point **A** to point **C** on Fig.1.2.

Label the vertical axis with appropriate values taking the downward direction as positive.

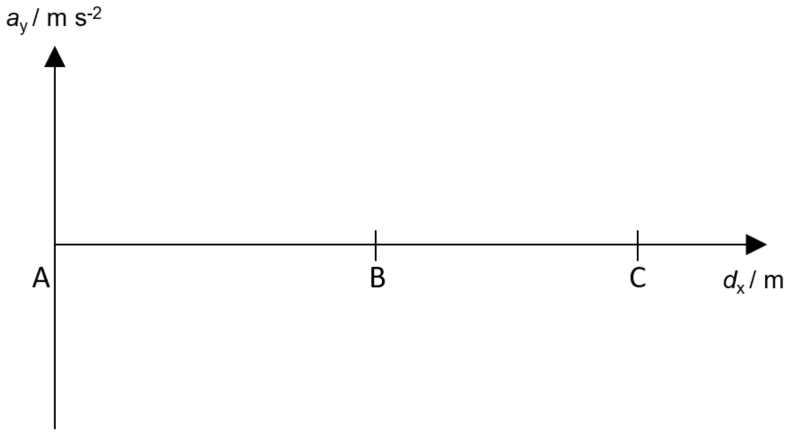

Fig. 1.2

[2]

[Total: 10]

2 An airplane is brought to rest on the deck of a stationary aircraft-carrier by an *arrester wire system*.

A hook on the underside of the airplane engages with a wire that is part of the system used to decelerate the airplane as shown in Fig 2.1. A constant deceleration of the airplane is maintained by wire braking systems at A and B.

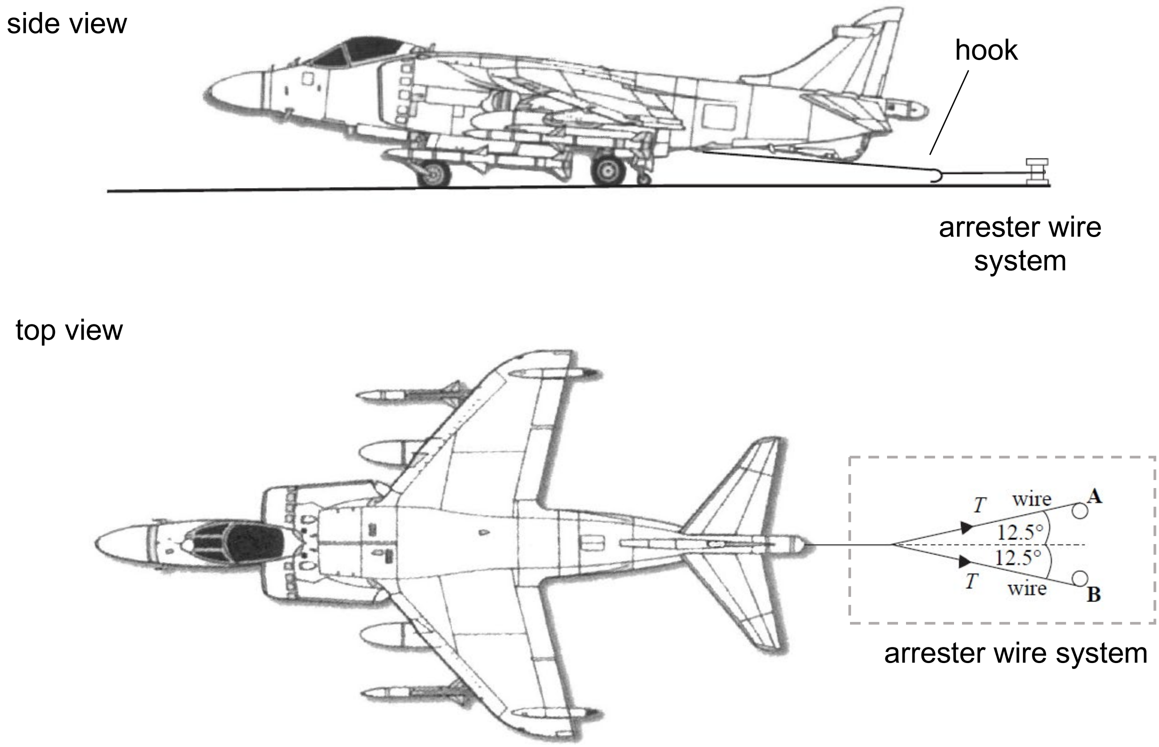

Fig. 2.1

(a) State Hooke's Law.

....

.... [1]

(b) During manufacture, the arrester wire is tested by being extended by 0.15 m. At this extension, the tension in the wire is 2.90×10^5 N. Calculate the energy stored in the wire.

Energy = ... J [2]

(c) Fig 2.2 below shows the variation with time of the velocity of an airplane of mass 2.8×10^4 kg landing on the stationary aircraft-carrier.

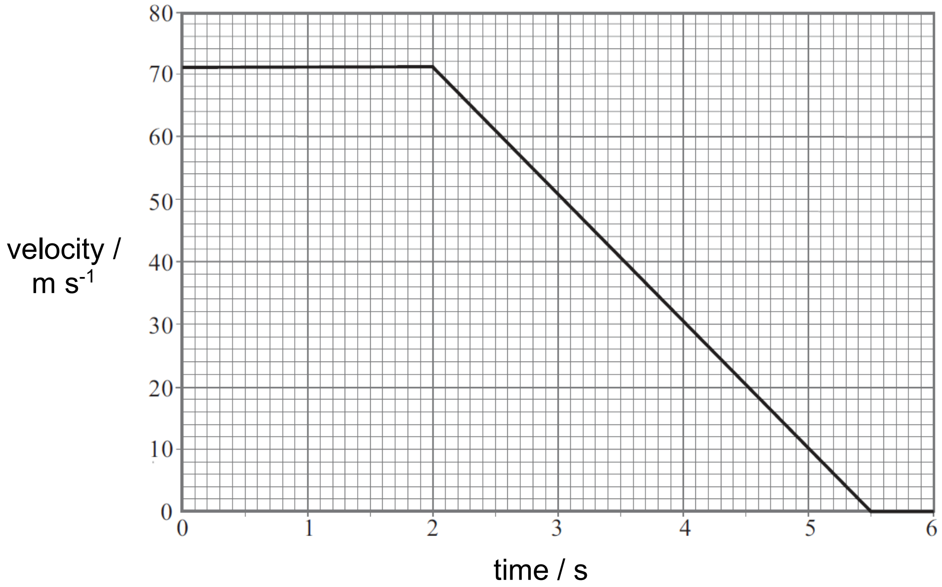

Fig. 2.2

Using Fig 2.2, calculate the tension *T* in the arrester wire at the position shown in Fig 2.1, when the angle between *T* and the horizontal axis is 12.5°. Assume that the tension in the arrestor wires provides the decelerating force.

T = ... N [3]

(d) While counterintuitive, the pilot will push the engines to full power as soon as the plane hits the aircraft carrier, to prepare to take off again in case the tailhook do not catch any of the arresting wires.

Identify all the forces acting on the airplane as it is rolling on the aircraft carrier and label them clearly in Fig 2.3 below. Assume that the wheels of the airplane are free-rolling and not engine-driven.

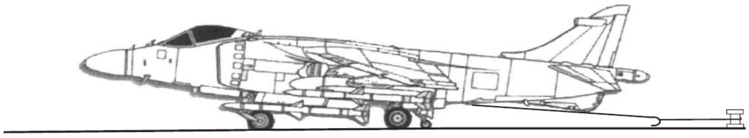

Fig. 2.3

[2]

[Total: 8]

3 Two balls X and Y are supported by long strings, as shown in Fig 3.1(a). Ball X has a mass of 50 g and ball Y has mass *m*.

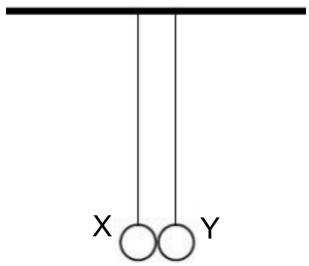

Fig. 3.1(a)

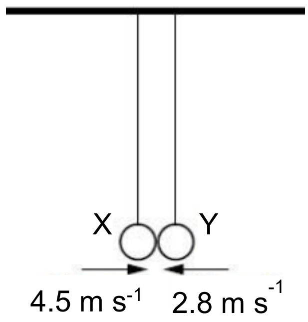

Fig. 3.1(b)

The balls are then pulled apart and released. Just before the balls collide, balls X and Y have speed of 4.5 m s^{-1} and 2.8 m s^{-1} respectively.

(a) Define *linear momentum*.

....

.... [1]

(b) When the collision is elastic, ball X rebounds at a speed of 1.8 m s^{-1}.

(i) Prove that the speed *v* of ball Y just after the collision is 5.5 m s^{-1} and state the direction of its motion.

direction : .... [2]

(ii) Calculate the mass *m* of Y.

m = ... g [2]

(c) When the collision between **X** and **Y** is perfectly inelastic, calculate the speed of ball **Y** just after the collision.

speed = ………………………………….. m s^{-1} [2]

[Total: 7]

4 **(a)** An object moves in a circular path at constant speed.

Explain why the object is considered to have acceleration.

....

....

.... [2]

(b) A ball bearing of mass m = 100 g is attached to the end of a massless rod of length R = 15 cm. The other end of the rod is attached to a smooth pin.

The ball is raised to position **P** so that the rod makes an angle of 30° above the horizontal, as shown in Fig 4.1.

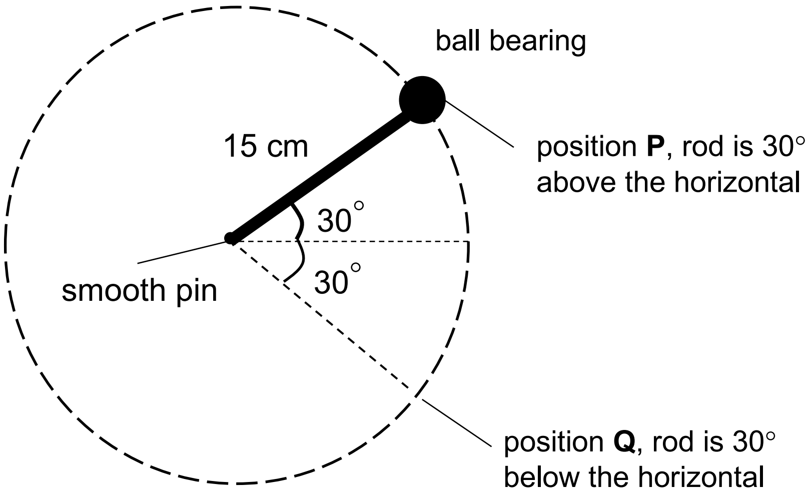

Fig. 4.1

The ball is then released from rest and moves past position **Q** in the process. Assume it experiences an air resistance of constant magnitude 0.14 N throughout its motion.

(i) Considering the motion of the ball bearing from **P** to **Q**,

1. show that the loss in gravitational potential energy of the ball bearing is 0.15 J,

[1]

2. show that work done against air resistance is 0.022 J,

[1]

3. hence calculate the velocity of the ball bearing at **Q**.

velocity = ………………………………… m s^{-1} [2]

(ii) Find the tension in the rod at **Q**.

tension = ………………………………… N [3]

[Total: 9]

5 **(a)** State *Newton's Law of Gravitation*.

....

.... [1]

(b) An asteroid of mass 2.0×10^6 kg is a distance 8.0×10^{10} m away from the centre of a planet of mass of 1.4×10^{30} kg.

(i) Calculate the gravitational force experience by the asteroid due to the planet.

force = ……………………………………. N [2]

(ii) Determine the change in potential energy of the asteroid when its distance from the centre of the planet is halved.

change in potential energy = ……………….J [2]

(iii) Fig. 5.1 shows the variation with distance x of the gravitational force F as the asteroid moves towards the planet from infinity to point **P**.

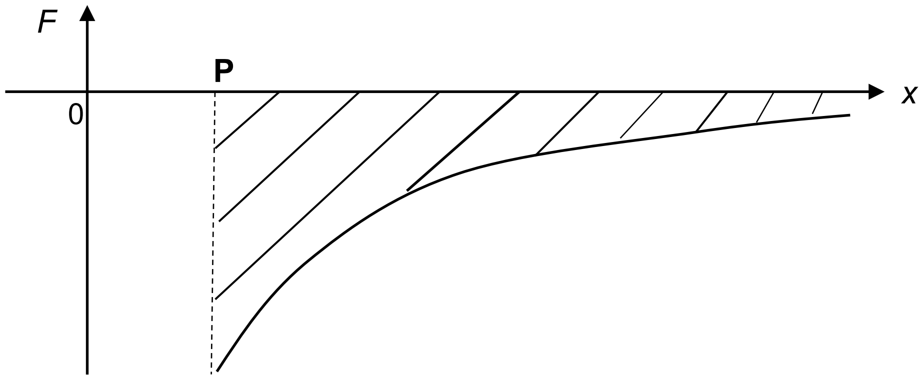

Fig. 5.1

With reference to the concepts of work and energy changes, explain the significance of the shaded area on the graph.

....

....

.... [2]

[Total: 7]

6 P, Q and R are 3 points in space as shown in Fig. 6.1. The points P and R are 1.0 m apart. A point source of sound at P emits 2.5 J of energy every second uniformly in all directions. At point Q, the intensity of the wave received from the source is 1.0 W m^{-2} and the amplitude of vibration of air molecules is 4.0 μm.

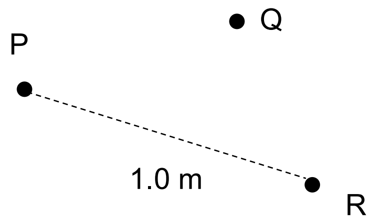

Fig. 6.1 (not drawn to scale)

(a) Show that the intensity of the wave received at R due to the source at P is 0.20 W m^{-2}.

intensity = ………………………………… W m^{-2} [1]

(b) Calculate the amplitude of vibration of air molecules at R due to the source at P.

amplitude = ………………………………… m [2]

(c) Small identical detectors are placed at Q and R such that their surface areas are perpendicular to the direction of travel of the wave at both positions. The detector at Q has twice the surface area of that at R.

Determine the ratio of

$$\frac{\text{power received by detector at R}}{\text{power received by detector at Q}}$$

ratio = ………………………………… [2]

(d) State the assumption in the calculations done.

....

.... [1]

[Total: 6]

7 **(a)** By stating the definitions of frequency *f* and wavelength λ of a wave, deduce the speed of wave $v = f\lambda$.

Frequency: ....

Wavelength: ....

[3]

(b) Stationary sound waves are investigated using the setup shown in Fig. 7.1. The sound produced by the loudspeaker has a frequency of 5.0×10^3 Hz. As a sound sensor connected to an oscilloscope is moved from positions A to B, loud sounds are heard at consecutive positions of P and Q.

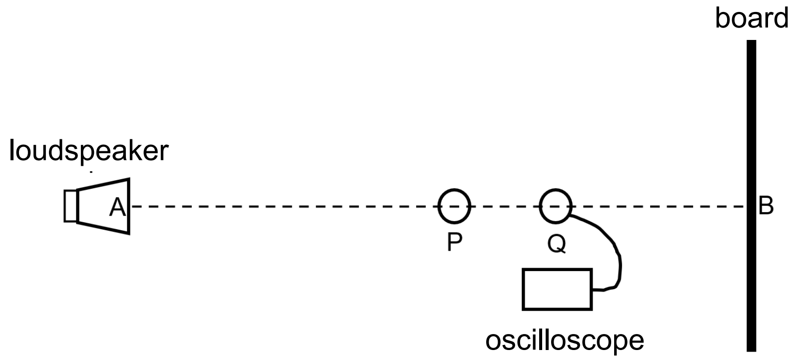

Fig. 7.1

Fig. 7.2 shows the positions of air molecules along part of the path AB at a particular instant in time.

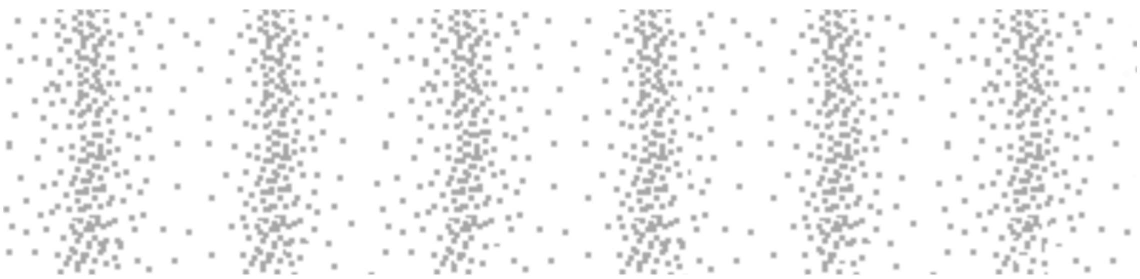

Fig. 7.2 (not to scale)

(i) On Fig. 7.2, indicate with a cross one possible position of P and another cross one possible position of Q. Label clearly the two positions P and Q. [1]

(ii) The distance PQ is 3.2 cm. Calculate the speed of the sound produced by the loudspeaker.

speed = ………………………………… m s^{-1} [1]

(iii) The time base of the oscilloscope is set at 0.050 ms div^{-1} and the Y-gain at 0.10 V div^{-1}. The maximum amplitude of the waveform is 0.30 V.

Draw on Fig. 7.3 the wave form displayed on the oscilloscope screen when the microphone is positioned at Q.

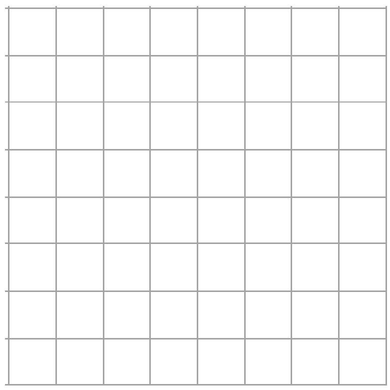

Fig. 7.3

[2]

[Total: 7]

8 **(a)** A mass *m* hangs vertically from a fixed point by means of the spring, as shown in Fig. 8.1.

The mass is displaced vertically and then released.

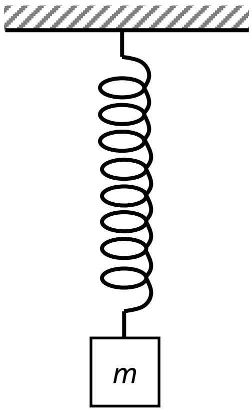

Fig. 8.1

The acceleration *a* of the mass is given by the expression

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

where *k* is the spring constant for the spring and *x* is the vertical displacement of the mass from its equilibrium position.

Explain how it can be deduced from the expression that the block moves with simple harmonic motion.

....

....

.... [2]

(b) A spring has an unstretched length of 12.0 cm. The force F required to extend the spring to a length L is measured. The variation with the length L of the force F is shown in Fig. 8.2 below.

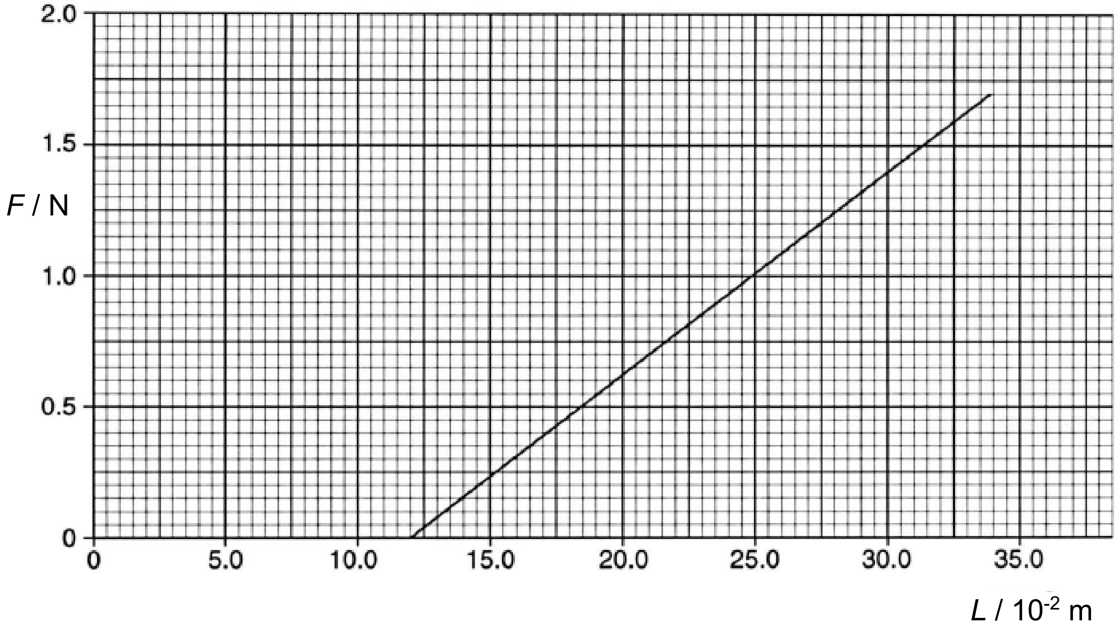

Fig. 8.2

One end of the spring is fixed, and an object M of weight 1.40 N is hung vertically from the other end. The object M is pulled down and then released. The object oscillates vertically.

The variation with time t of the length L of the spring is shown in Fig. 8.3.

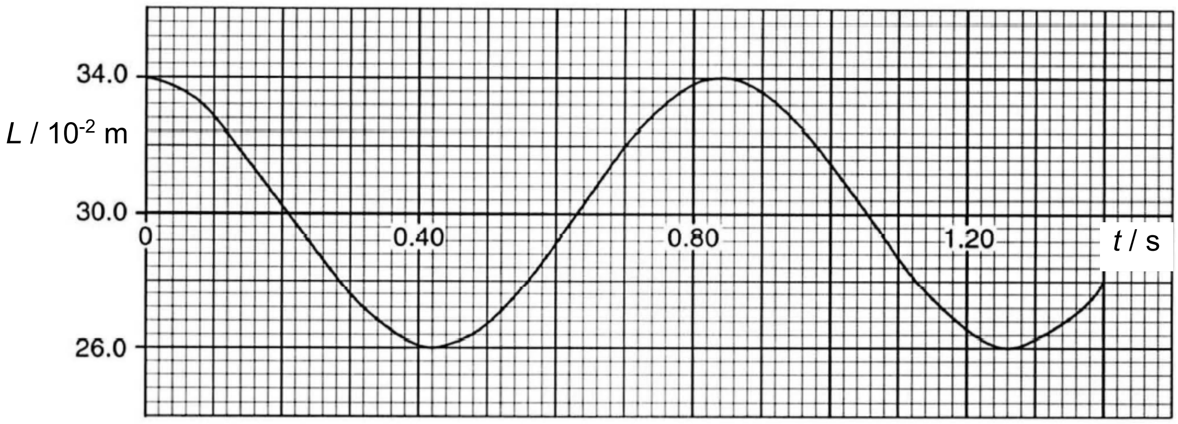

Fig. 8.3

(i) Calculate the

1. maximum speed of M,

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

2. kinetic energy of M when the length of the spring is 32.0 cm,

kinetic energy = ………………………………… J [2]

3. the total energy of the spring-mass-Earth system. You may assume that gravitational potential energy of the system is zero when M reaches the lowest point in its oscillations.

total energy = ………………………………… J [2]

(ii) The object M consists of 2 parts connected by a stiff wire of negligible mass and volume. The lower part of M is immersed in a liquid as shown in Fig. 8.4.

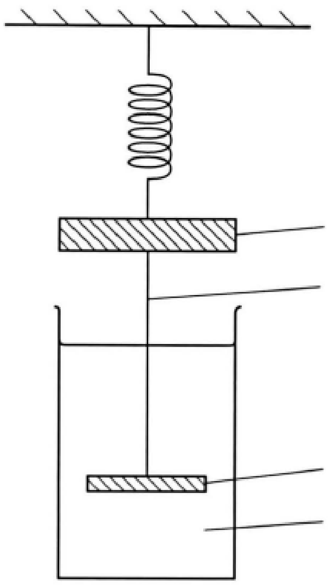

Fig. 8.4

The liquid has a density of 1000 kg m^{-3}. The volume of the part of M that is immersed in the liquid is 20 cm^3.

1. Determine the new length of the spring.

length = ………………………………… m [3]

2. The object M is pulled down by 4.0 cm and then released. The lower part of M remains immersed in the liquid at all times.

State 2 differences that would be seen in the oscillations when compared with those in Fig. 8.3.

1. ....

2. ....[2]

[Total: 13]

9 **(a)** State the *principle of superposition*.

....

.... [1]

(b) State the 3 conditions required for 2 waves to form an interference pattern.

1. ....

2. ....

3...[3]

(c) M_1 and M_2 are two microwave sources emitting microwaves of the same wavelength. They are placed in front of two slits S_1 and S_2 respectively, which are 10 cm apart, as shown in Fig. 9.1.

AB is a line parallel to the plane of S_1 and S_2, and 100 cm from it. P is a point on AB that is equidistant from S_1 and S_2.

A microwave detector moving along AB records the intensity at different locations on AB.

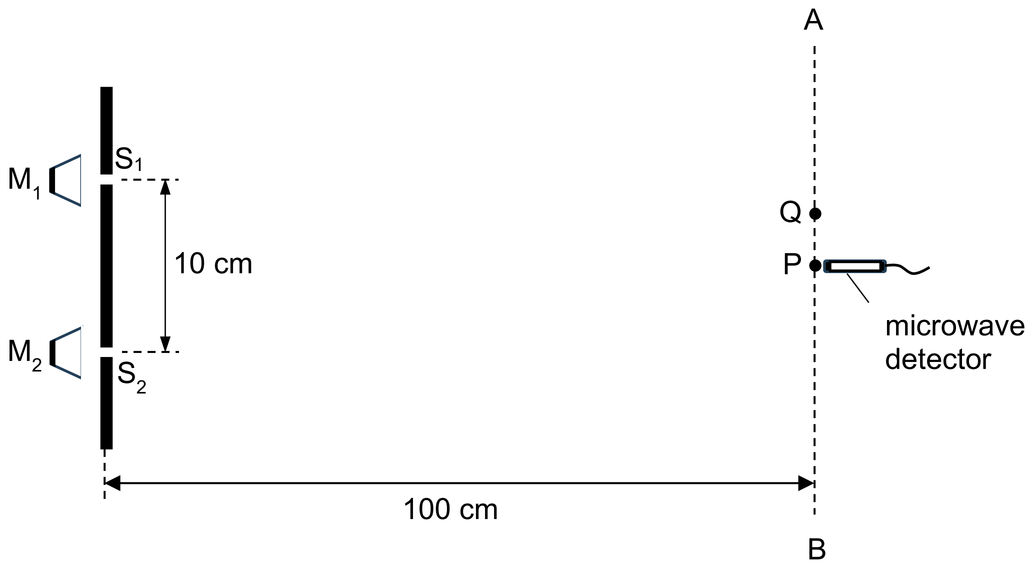

Fig. 9.1 (not to scale)

Fig. 9.2 shows the variation with distance *x* from P of the intensity *I* recorded by the microwave detector.

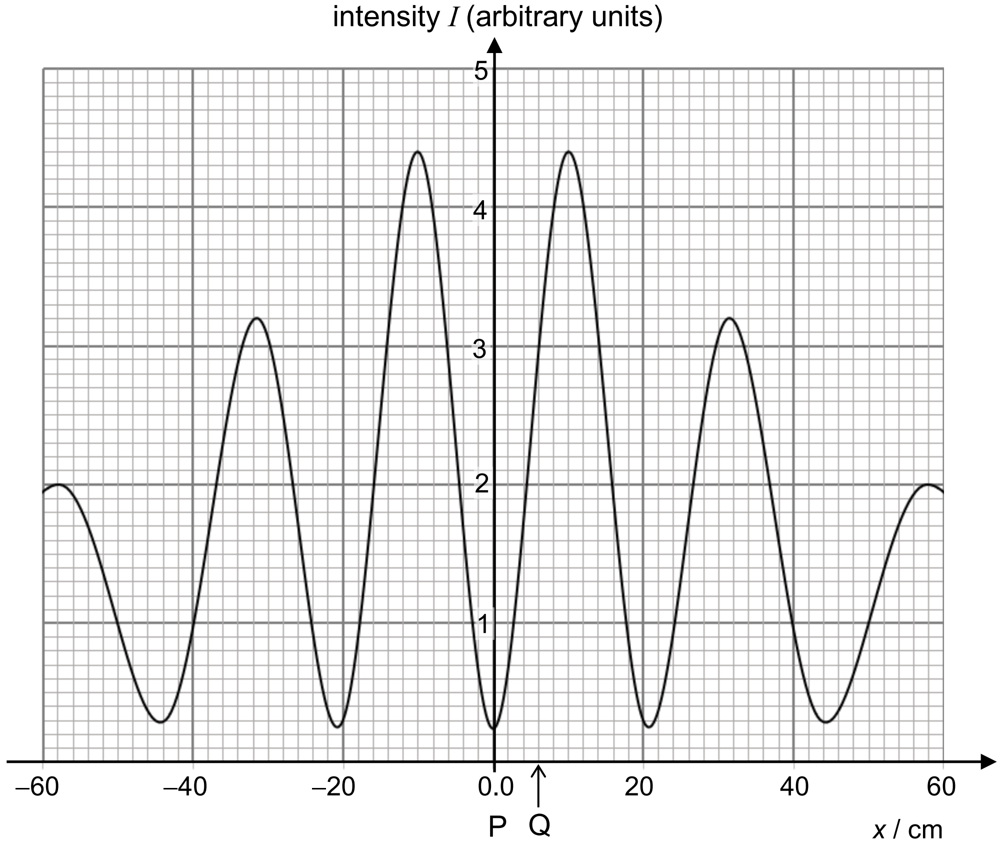

Fig. 9.2

(i) Use Fig. 9.2 to explain how it can be deduced that the microwaves passing through S_1 and S_2

1. are coherent waves,

.... [1]

2. are antiphase to each other,

.... [1]

3. do not have the same amplitude,

.... [1]

(ii) Use Fig. 9.2 to calculate the wavelength λ of the microwave.

λ = ………………………………….m [3]

(iii) Point Q is a point on AB. Its position is indicated on Fig. 9.1 and Fig. 9.2. Determine the phase difference between the waves from the double slit when the waves meet at point Q.

phase difference = …………………. rad [2]

(iv) Suggest why the higher order maxima on Fig. 9.2 have lower intensities.

.... [1]

[Total: 13]