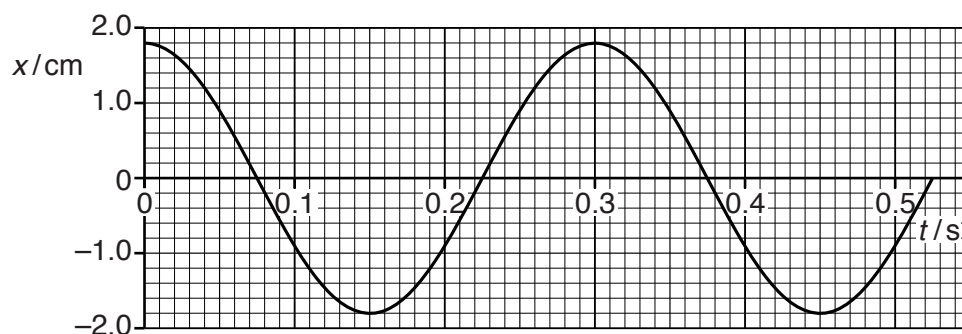


1. Question | 9702 Feb-March 2016 P4 V2 Q4

- 4 An object of mass 80 g oscillates with simple harmonic motion. The variation with time t of the displacement x of the object is shown in Fig. 4.1.

**Fig. 4.1**

- (a) Use Fig. 4.1 to determine the amplitude and the period of the oscillations.

amplitude = ... cm

period = ... s
[1]

- (b) Use Fig. 4.1 and your answers in (a) to calculate the kinetic energy of the object at time $t = 0.19$ s.

kinetic energy = ... J [3]

[Total: 4]

3 (a) State, by reference to displacement, what is meant by *simple harmonic motion*.

.....

.....

.....

..... [2]

(b) A mass is undergoing oscillations in a vertical plane.

The variation with displacement x of the acceleration a of the mass is shown in Fig. 3.1.

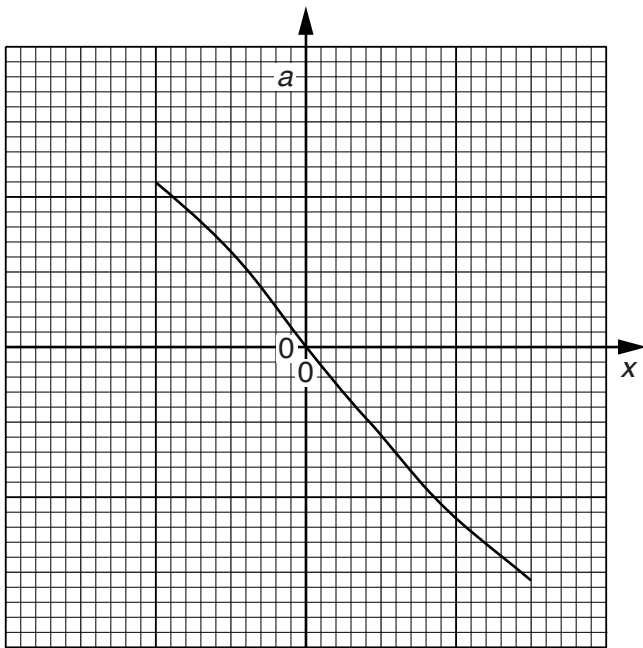


Fig. 3.1

State two reasons why the motion of the mass is not simple harmonic.

1.

.....

2.

.....

[2]

(c) A block of wood is floating in a liquid, as shown in Fig. 3.2.

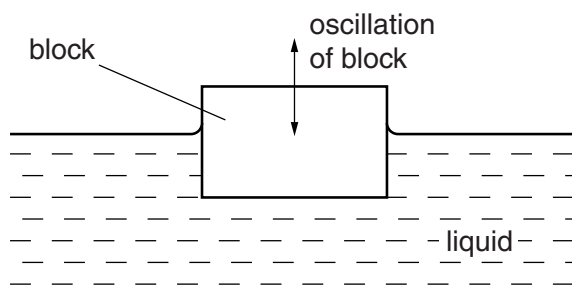


Fig. 3.2

The block is displaced vertically and then released.

The variation with time t of the displacement y of the block from its equilibrium position is shown in Fig. 3.3.

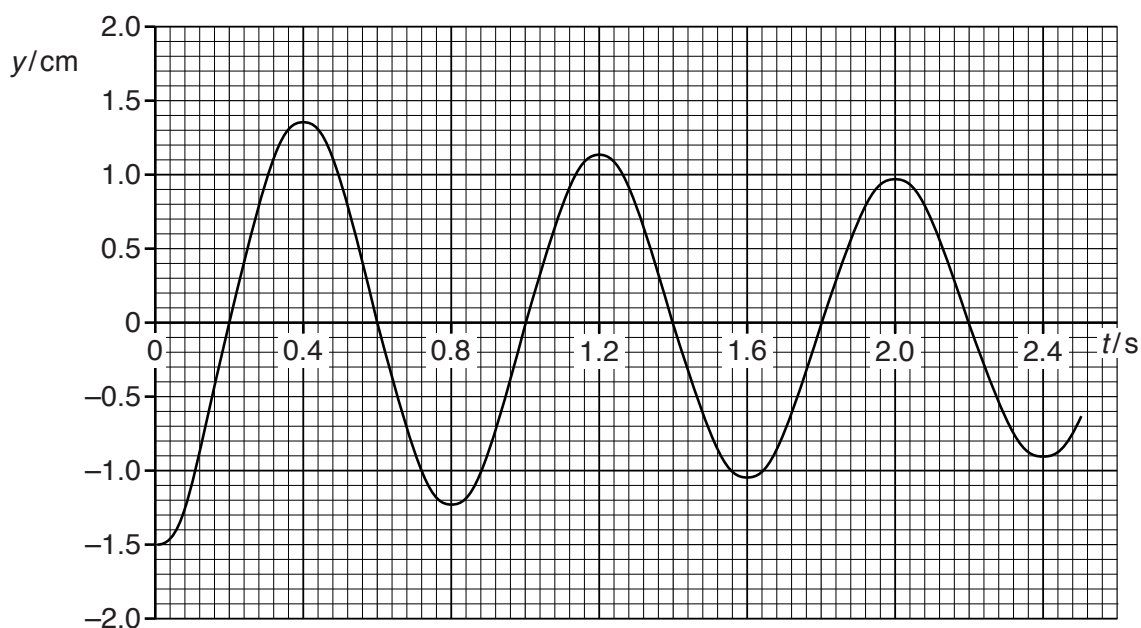


Fig. 3.3

Use data from Fig. 3.3 to determine

(i) the angular frequency ω of the oscillations,

$$\omega = \dots\dots\dots \text{rad s}^{-1} \quad [2]$$

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

2. Question part 3/3 | 9702 May-June 2016 P4 V1 Q3

(ii) the maximum vertical acceleration of the block.

maximum acceleration = ... ms^{-2} [2]

(iii) The block has mass 120 g.

The oscillations of the block are damped. Calculate the loss in energy of the oscillations of the block during the first three complete periods of its oscillations.

energy loss = ... J [3]

[Total: 11]

3. Question part 1/2 | 9702 May-June 2016 P4 V2 Q4

- 4 A metal block hangs vertically from one end of a spring. The other end of the spring is tied to a thread that passes over a pulley and is attached to a vibrator, as shown in Fig. 4.1.

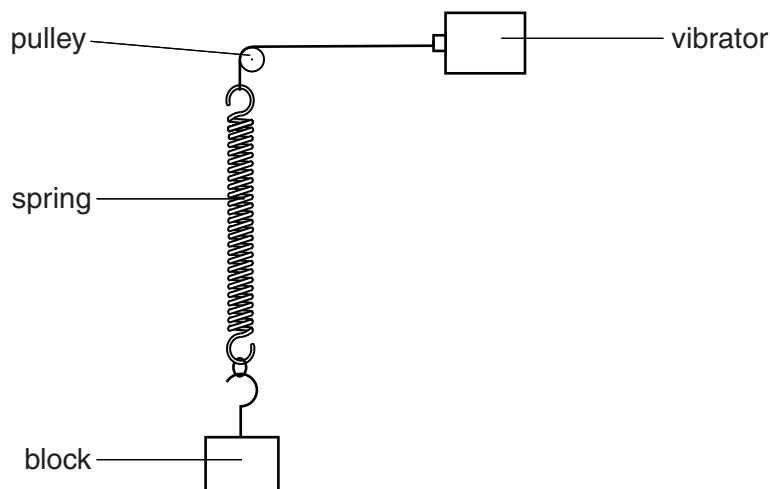


Fig. 4.1

- (a) The vibrator is switched off. The metal block of mass 120g is displaced vertically and then released. The variation with time t of the displacement y of the block from its equilibrium position is shown in Fig. 4.2.

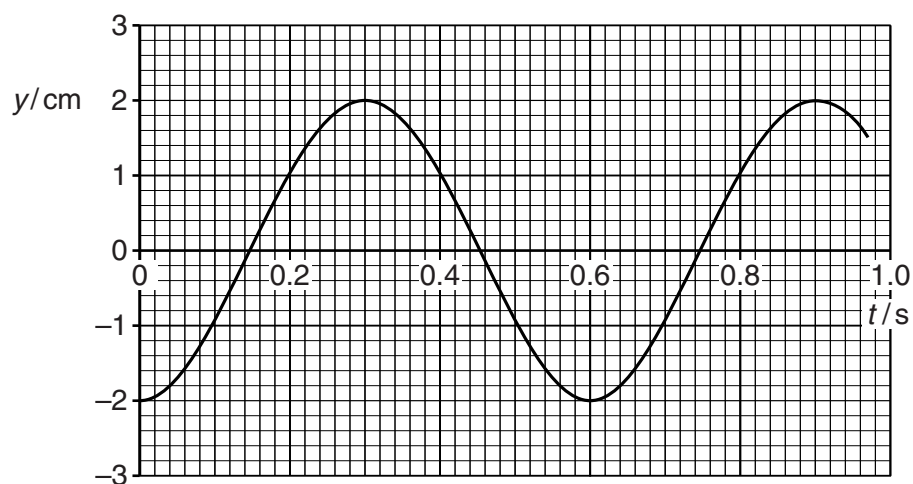


Fig. 4.2

For the vibrations of the block, calculate

- (i) the angular frequency ω ,

$$\omega = \dots\dots\dots \text{rad s}^{-1} \quad [2]$$

(ii) the energy of the vibrations.

energy = ...J [2]

(b) The vibrator is now switched on.

The frequency of vibration is varied from $0.7f$ to $1.3f$ where f is the frequency of vibration of the block in (a).

For the block, complete Fig. 4.3 to show the variation with frequency of the amplitude of vibration. Label this line A. [3]

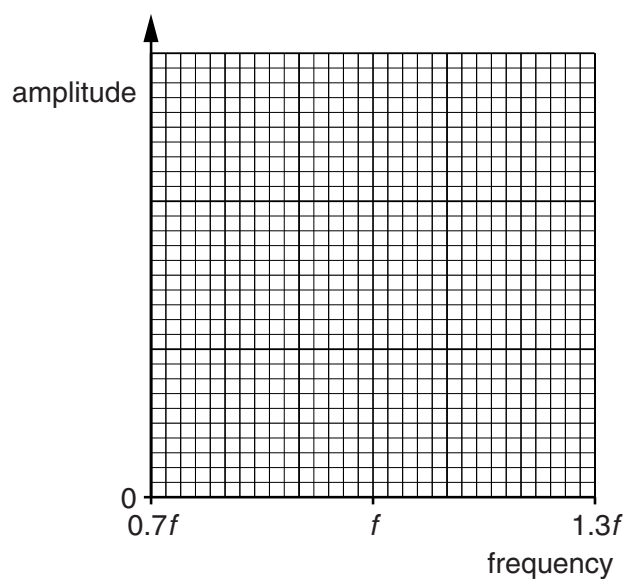


Fig. 4.3

(c) Some light feathers are now attached to the block in (b) to increase air resistance.

The frequency of vibration is once again varied from $0.7f$ to $1.3f$. The new amplitude of vibration is measured for each frequency.

On Fig. 4.3, draw a line to show the variation with frequency of the amplitude of vibration. Label this line B. [2]

[Total: 9]

3 (a) State, by reference to displacement, what is meant by *simple harmonic motion*.

.....

.....

.....

..... [2]

(b) A mass is undergoing oscillations in a vertical plane.

The variation with displacement x of the acceleration a of the mass is shown in Fig. 3.1.

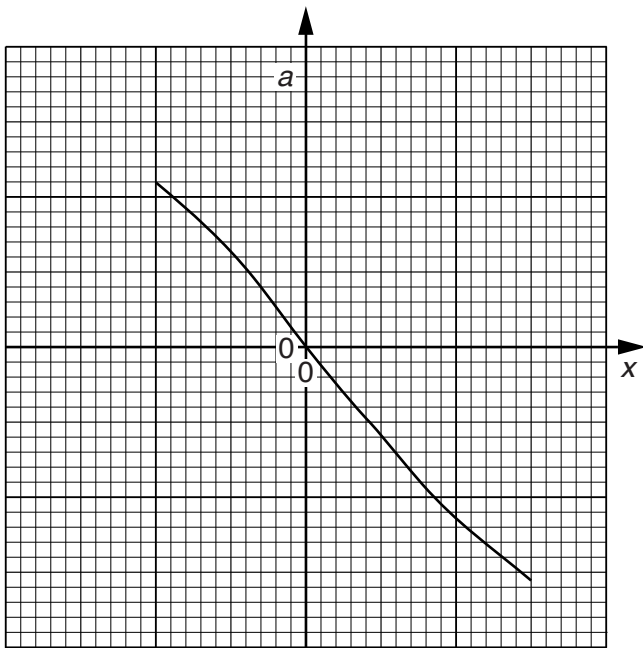


Fig. 3.1

State two reasons why the motion of the mass is not simple harmonic.

1.

.....

2.

.....

[2]

(c) A block of wood is floating in a liquid, as shown in Fig. 3.2.

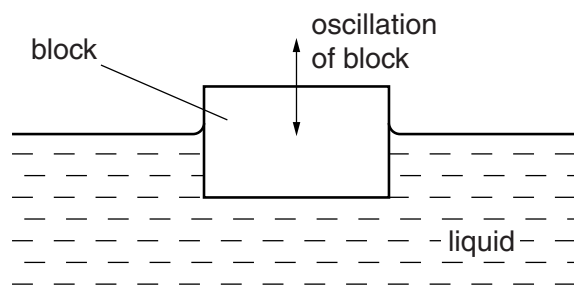


Fig. 3.2

The block is displaced vertically and then released.

The variation with time t of the displacement y of the block from its equilibrium position is shown in Fig. 3.3.

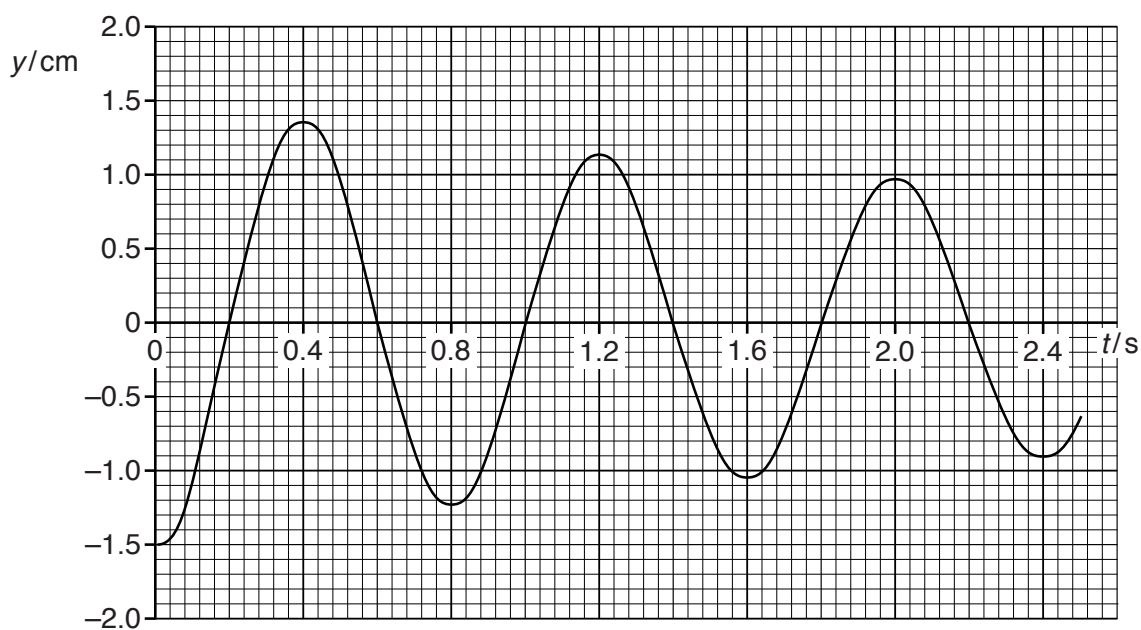


Fig. 3.3

Use data from Fig. 3.3 to determine

(i) the angular frequency ω of the oscillations,

$$\omega = \dots\dots\dots \text{rad s}^{-1} \quad [2]$$

9702 Physics Paper 4 - Oscillations

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4. Question part 3/3 | 9702 May-June 2016 P4 V3 Q3

(ii) the maximum vertical acceleration of the block.

maximum acceleration = ... ms^{-2} [2]

(iii) The block has mass 120 g.

The oscillations of the block are damped. Calculate the loss in energy of the oscillations of the block during the first three complete periods of its oscillations.

energy loss = ... J [3]

[Total: 11]

- 3** To demonstrate simple harmonic motion, a student attaches a trolley to two similar stretched springs, as shown in Fig. 3.1.

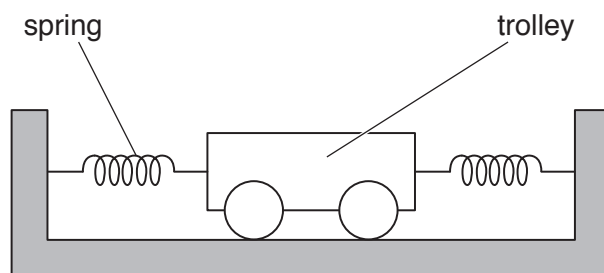


Fig. 3.1

The trolley has mass m of 810 g.

The trolley is displaced along the line of the two springs and then released. The subsequent acceleration a of the trolley is given by the expression

$$a = -\frac{2kx}{m}$$

where the spring constant k for each of the springs is 64 N m^{-1} and x is the displacement of the trolley.

- (a)** Show that the frequency of oscillation of the trolley is 2.0 Hz.

[3]

- (b)** The maximum displacement of the trolley is 1.6 cm.
Calculate the maximum speed of the trolley.

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

(c) The mass of the trolley is increased. The initial displacement of the trolley remains unchanged.

Suggest the change, if any, that occurs in the frequency and in the maximum speed of the oscillations of the trolley.

frequency:

maximum speed:

[2]

[Total: 7]

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- 4 A mass hangs vertically from a fixed point by means of a spring, as shown in Fig. 4.1.

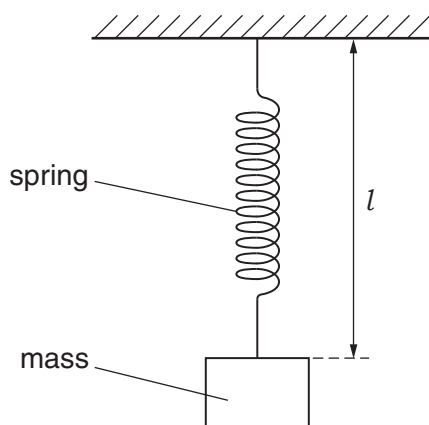


Fig. 4.1

The mass is displaced vertically and then released. The subsequent oscillations of the mass are simple harmonic.

The variation with time t of the length l of the spring is shown in Fig. 4.2.

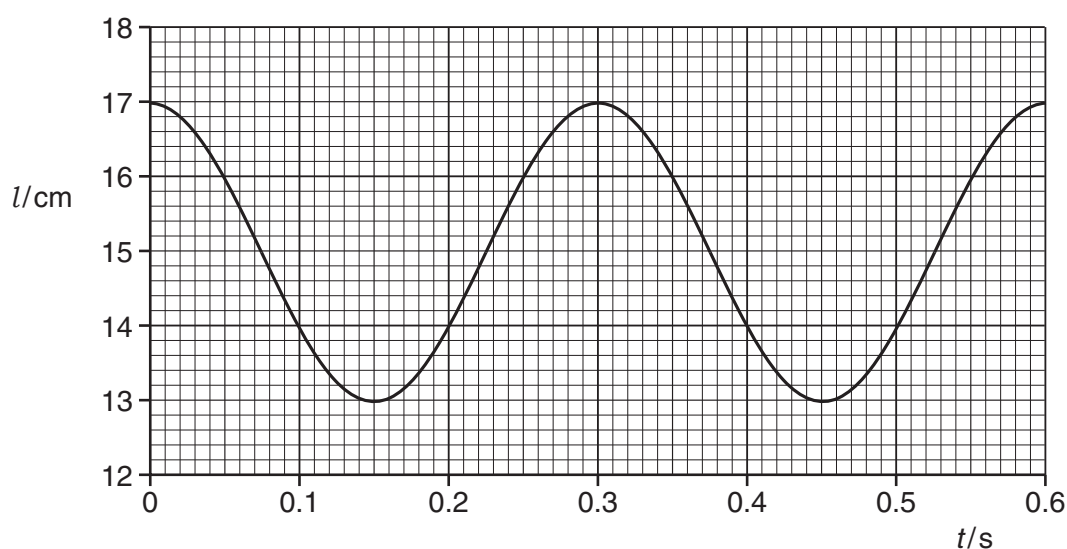


Fig. 4.2

(a) Use Fig. 4.2 to

- (i) state two values of t at which the mass is moving downwards with maximum speed,

$t = \dots\dots\dots$ s and $t = \dots\dots\dots$ s [1]

- (ii) determine, for these oscillations, the angular frequency ω ,

$$\omega = \dots\dots\dots \text{rad s}^{-1} \quad [2]$$

- (iii) show that the maximum speed of the mass is 0.42 ms^{-1} .

[2]

- (b) Use data from Fig. 4.2 and (a)(iii) to sketch, on the axes of Fig. 4.3, the variation with displacement x from the equilibrium position of the velocity v of the mass.

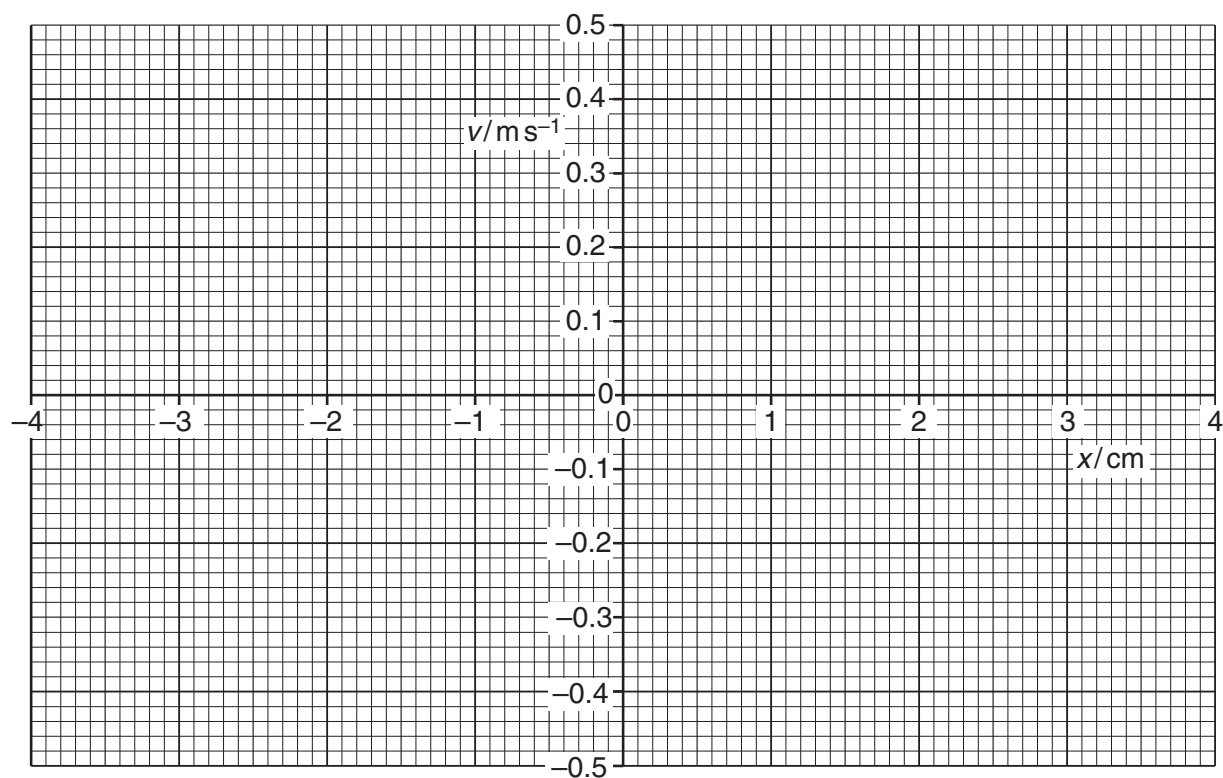


Fig. 4.3

[3]

[Total: 8]

- 3** To demonstrate simple harmonic motion, a student attaches a trolley to two similar stretched springs, as shown in Fig. 3.1.

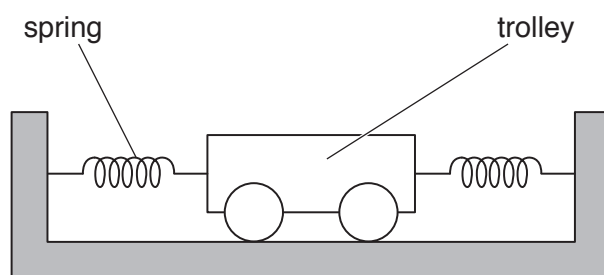


Fig. 3.1

The trolley has mass m of 810 g.

The trolley is displaced along the line of the two springs and then released. The subsequent acceleration a of the trolley is given by the expression

$$a = -\frac{2kx}{m}$$

where the spring constant k for each of the springs is 64 N m^{-1} and x is the displacement of the trolley.

- (a)** Show that the frequency of oscillation of the trolley is 2.0 Hz.

[3]

- (b)** The maximum displacement of the trolley is 1.6 cm.
Calculate the maximum speed of the trolley.

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

9702 Physics Paper 4 - Oscillations

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7. Question part 2/3 | 9702 Oct-Nov 2016 P4 V3 Q3

- (c)** The mass of the trolley is increased. The initial displacement of the trolley remains unchanged.

Suggest the change, if any, that occurs in the frequency and in the maximum speed of the oscillations of the trolley.

frequency:

maximum speed:

[2]

[Total: 7]

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8. Question part 1/2 | 9702 Feb-March 2017 P4 V2 Q3

- 3 A uniform beam is clamped at one end. A metal block of mass m is fixed to the other end of the beam causing it to bend, as shown in Fig. 3.1.

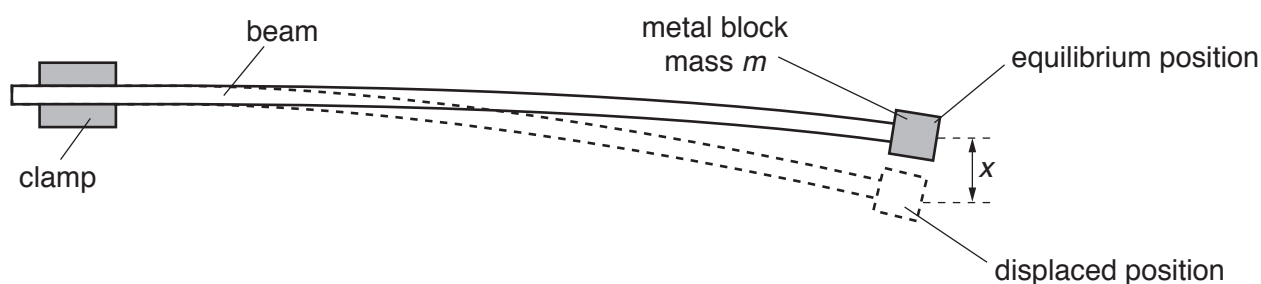


Fig. 3.1

The block is given a small vertical displacement and then released so that it oscillates with simple harmonic motion.

The acceleration a of the block is given by the expression

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

where k is a constant for the beam and x is the vertical displacement of the block from its equilibrium position.

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

.....

[2]

- (b) For the beam, $k = 4.0 \text{ kg s}^{-2}$. Show that the angular frequency ω of the oscillations is given by the expression

$$\omega = \frac{2.0}{\sqrt{m}}.$$

[2]

- (c) The initial amplitude of the oscillation of the block is 3.0 cm.

Use the expression in (b) to determine the maximum kinetic energy of the oscillations.

maximum kinetic energy = ... J [3]

- (d) Over a certain interval of time, the maximum kinetic energy of the oscillations in (c) is reduced by 50%. It may be assumed that there is negligible change in the angular frequency of the oscillations.

Determine the amplitude of oscillation.

amplitude = ... m [2]

- (e) Permanent magnets are now positioned so that the metal block oscillates between the poles, as shown in Fig. 3.2.

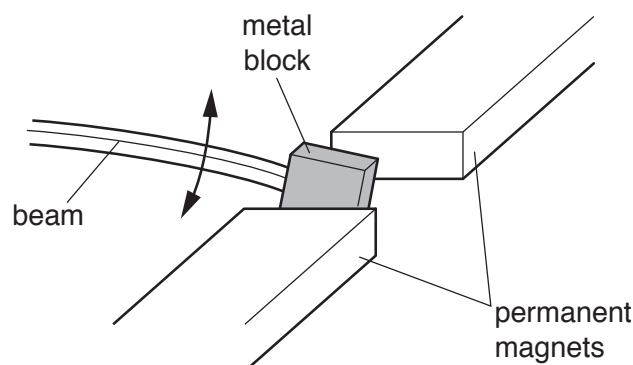


Fig. 3.2

The block is made to oscillate with the same initial amplitude as in (c). Use energy conservation to explain why the energy of the oscillations decreases more rapidly than in (d).

.....

.....

.....

.....

..... [3]

[Total: 12]

- 2 A bar magnet of mass 180g is suspended from the free end of a spring, as illustrated in Fig. 2.1.

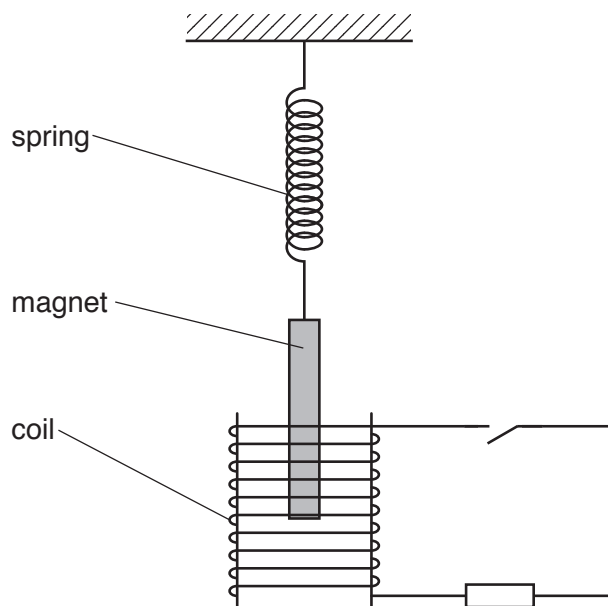


Fig. 2.1

The magnet hangs so that one pole is near the centre of a coil of wire.

The coil is connected in series with a resistor and a switch. The switch is open.

The magnet is displaced vertically and then allowed to oscillate with one pole remaining inside the coil. The other pole remains outside the coil.

At time $t = 0$, the magnet is oscillating freely as it passes through its equilibrium position. At time $t = 3.0\text{s}$, the switch in the circuit is closed.

The variation with time t of the vertical displacement y of the magnet is shown in Fig. 2.2.

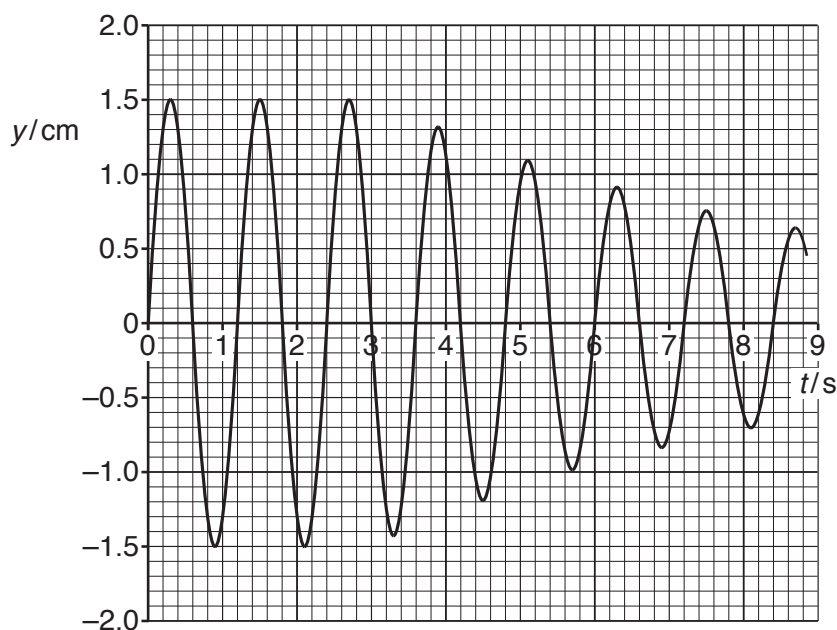


Fig. 2.2

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

9. Question part 2/2 | 9702 May-June 2017 P4 V1 Q2

- (a)** Determine, to two significant figures, the frequency of oscillation of the magnet.

frequency = ... Hz [2]

- (b)** State whether the closing of the switch gives rise to light, heavy or critical damping.

.....[1]

- (c)** Calculate the change in the energy ΔE of oscillation of the magnet between time $t = 2.7$ s and time $t = 7.5$ s. Explain your working.

$\Delta E =$ J [6]

[Total: 9]

- 2 A bar magnet of mass 180g is suspended from the free end of a spring, as illustrated in Fig. 2.1.

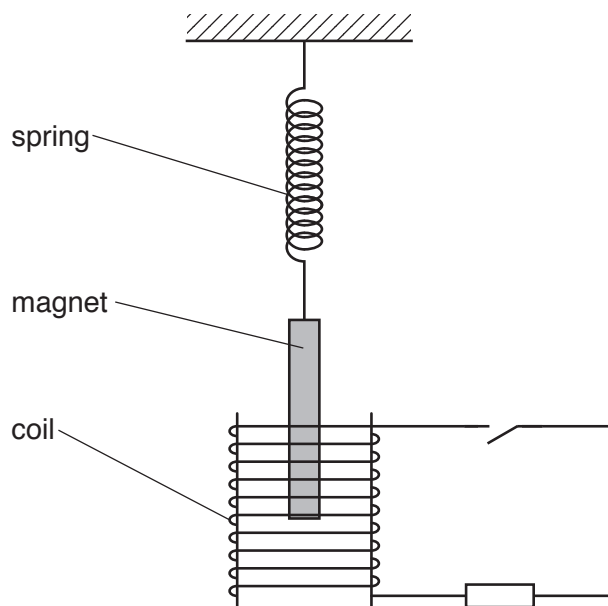


Fig. 2.1

The magnet hangs so that one pole is near the centre of a coil of wire.

The coil is connected in series with a resistor and a switch. The switch is open.

The magnet is displaced vertically and then allowed to oscillate with one pole remaining inside the coil. The other pole remains outside the coil.

At time $t = 0$, the magnet is oscillating freely as it passes through its equilibrium position. At time $t = 3.0$ s, the switch in the circuit is closed.

The variation with time t of the vertical displacement y of the magnet is shown in Fig. 2.2.

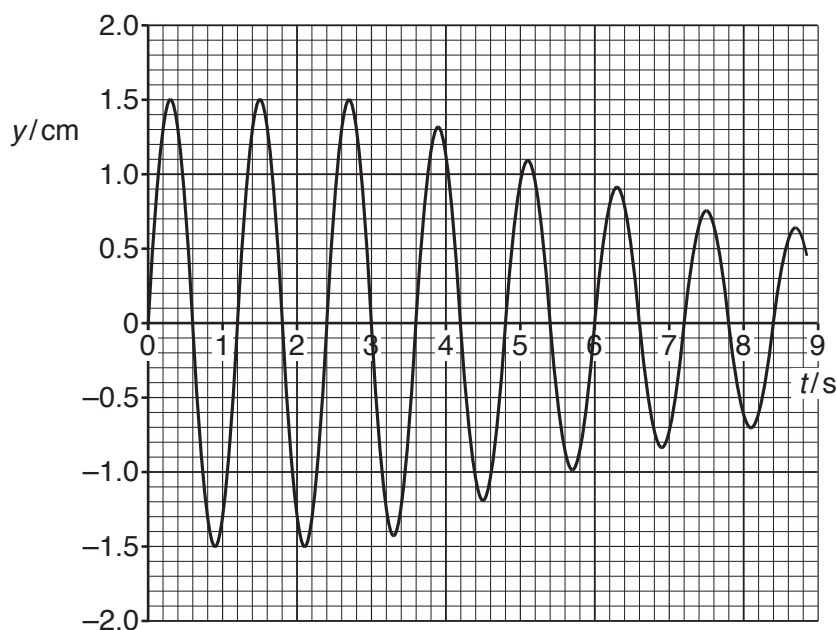


Fig. 2.2

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

10. Question part 2/2 | 9702 May-June 2017 P4 V3 Q2

- (a)** Determine, to two significant figures, the frequency of oscillation of the magnet.

frequency = ... Hz [2]

- (b)** State whether the closing of the switch gives rise to light, heavy or critical damping.

.....[1]

- (c)** Calculate the change in the energy ΔE of oscillation of the magnet between time $t = 2.7$ s and time $t = 7.5$ s. Explain your working.

$\Delta E =$ J [6]

[Total: 9]

- 2 (a) State, by reference to simple harmonic motion, what is meant by *angular frequency*.

.....
 [1]

- (b) A thin metal strip is clamped at one end so that it is horizontal. A load of mass M is attached to its free end. The load causes a displacement s of the end of the strip, as shown in Fig. 2.1.

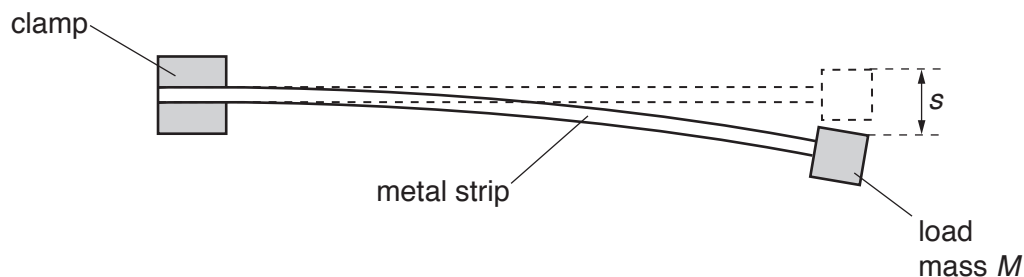


Fig. 2.1

The load is displaced vertically and then released. The load oscillates. The variation with the acceleration a of the displacement s of the load is shown in Fig. 2.2.

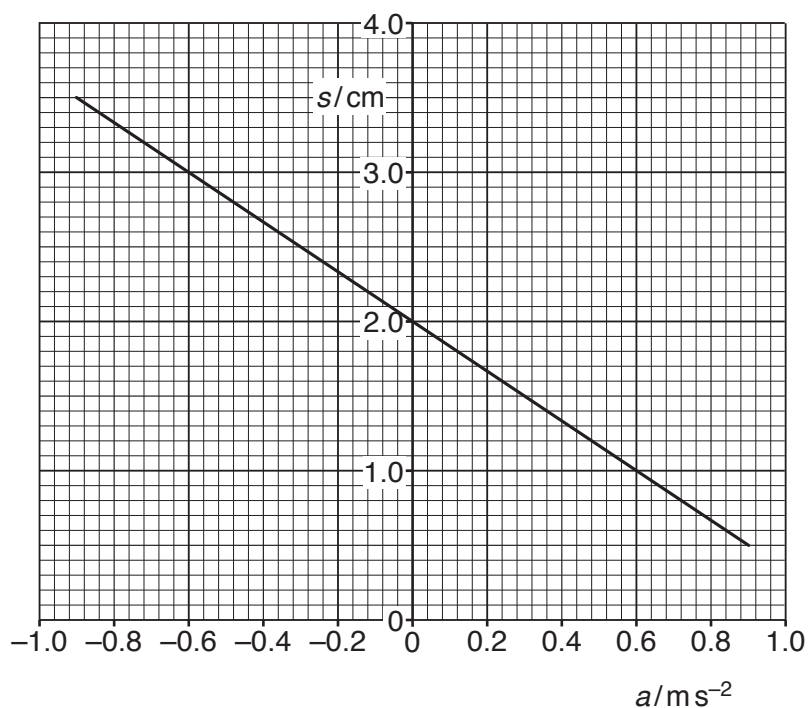


Fig. 2.2

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

11. Question part 2/2 | 9702 Oct-Nov 2017 P4 V1 Q2

(i) Use Fig. 2.2 to determine

1. the displacement of the load before it is made to oscillate,

displacement = ... cm

2. the amplitude of the oscillations of the load.

amplitude = ... cm
[2]

(ii) Show that the load is undergoing simple harmonic motion.

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

(iii) Calculate the frequency of oscillation of the load.

frequency = ... Hz [3]

[Total: 9]

3 (a) (i) Define the *radian*.

.....

[2]

(ii) State, by reference to simple harmonic motion, what is meant by *angular frequency*.

.....
[1]

(b) A thin metal strip, clamped horizontally at one end, has a load of mass M attached to its free end, as shown in Fig. 3.1.

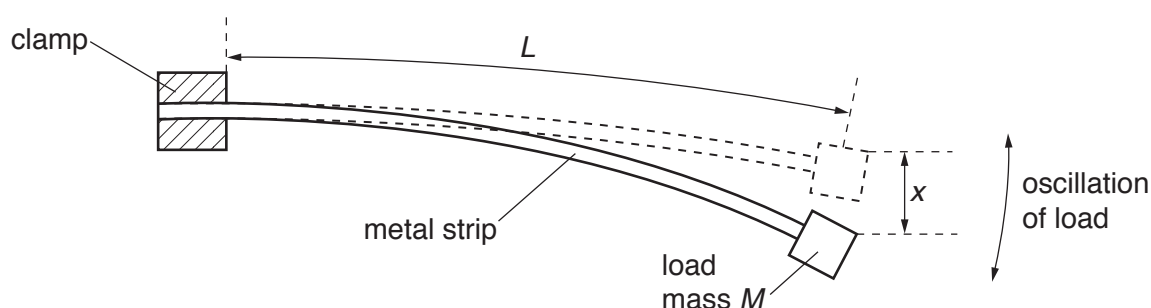


Fig. 3.1

The metal strip bends, as shown in Fig. 3.1.

When the free end of the strip is displaced vertically and then released, the mass oscillates in a vertical plane.

Theory predicts that the variation of the acceleration a of the oscillating load with the displacement x from its equilibrium position is given by

$$a = -\left(\frac{c}{ML^3}\right)x$$

where L is the effective length of the metal strip and c is a positive constant.

(i) Explain how the expression shows that the load is undergoing simple harmonic motion.

.....

[2]

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

12. Question part 2/2 | 9702 Oct-Nov 2017 P4 V2 Q3

- (ii) For a metal strip of length $L = 65\text{ cm}$ and a load of mass $M = 240\text{ g}$, the frequency of oscillation is 3.2 Hz .
Calculate the constant c .

$c = \dots\dots\dots \text{ kg m}^3\text{ s}^{-2}$ [3]

[Total: 8]

- 2 (a) State, by reference to simple harmonic motion, what is meant by *angular frequency*.

.....
 [1]

- (b) A thin metal strip is clamped at one end so that it is horizontal. A load of mass M is attached to its free end. The load causes a displacement s of the end of the strip, as shown in Fig. 2.1.

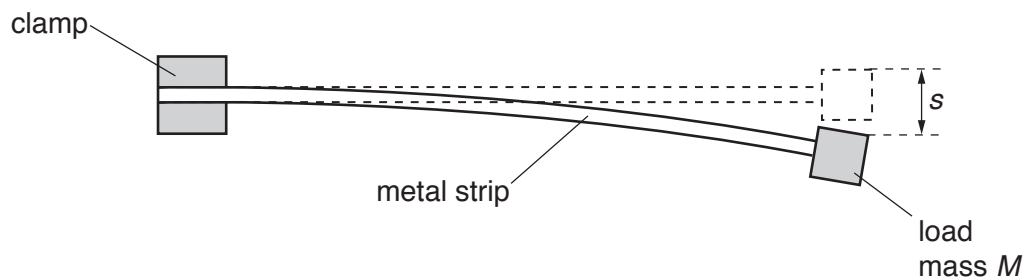


Fig. 2.1

The load is displaced vertically and then released. The load oscillates. The variation with the acceleration a of the displacement s of the load is shown in Fig. 2.2.

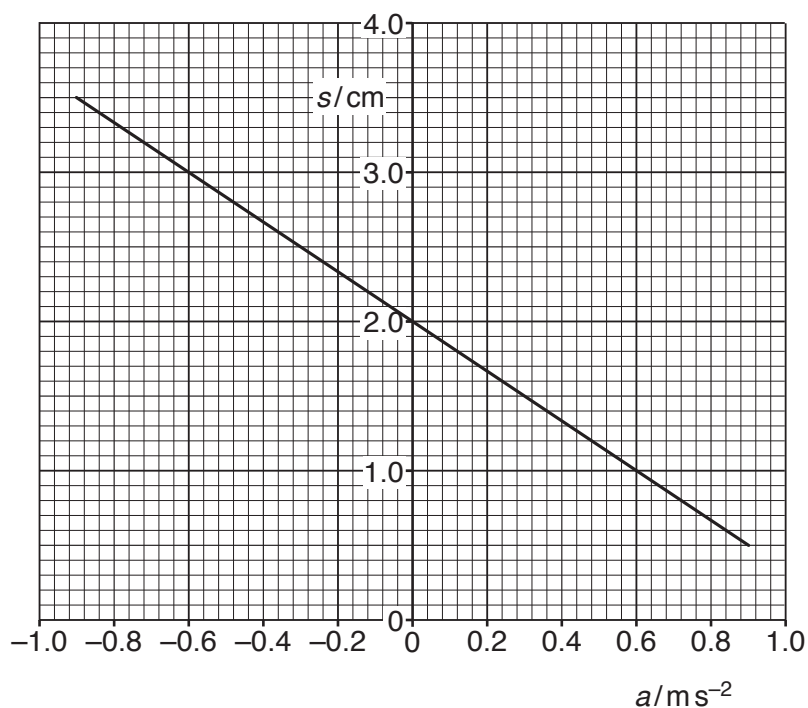


Fig. 2.2

13. Question part 2/2 | 9702 Oct-Nov 2017 P4 V3 Q2

(i) Use Fig. 2.2 to determine

1. the displacement of the load before it is made to oscillate,

displacement = ... cm

2. the amplitude of the oscillations of the load.

amplitude = ... cm
[2]

(ii) Show that the load is undergoing simple harmonic motion.

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

(iii) Calculate the frequency of oscillation of the load.

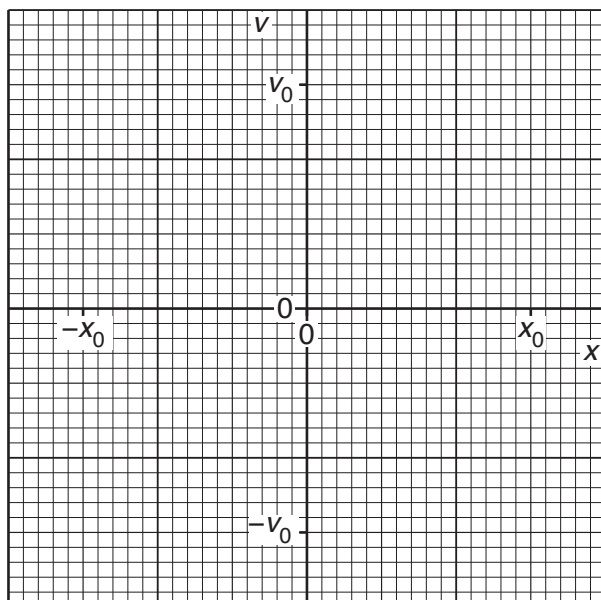
frequency = ... Hz [3]

[Total: 9]

14. Question part 1/3 | 9702 Feb-March 2018 P4 V2 Q3

- 3 (a)** A mass is undergoing simple harmonic motion with amplitude x_0 . The maximum velocity of the mass has magnitude v_0 .

On Fig. 3.1, show the variation with displacement x of the velocity v of the mass.

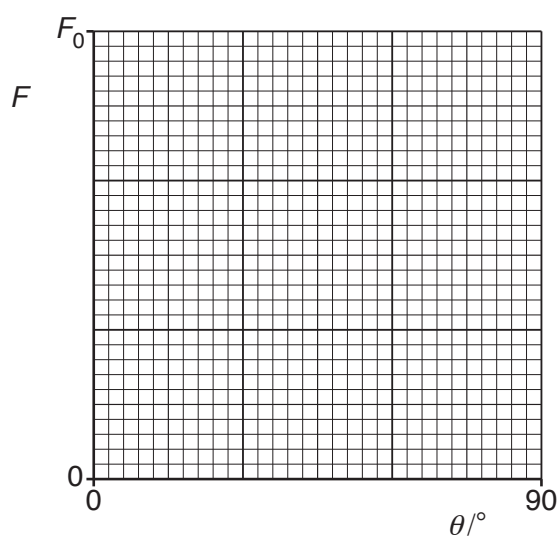
**Fig. 3.1**

[2]

- (b)** A straight stiff wire carries a constant current in a region of uniform magnetic flux density.

The angle θ between the direction of the current and the direction of the magnetic field is varied. The maximum force on the wire is F_0 .

On Fig. 3.2, show the variation with angle θ of the force F on the wire for values of θ between 0° and 90° .

**Fig. 3.2**

[2]

- (c) A sinusoidal supply has frequency 250 Hz and r.m.s. potential difference 2.8 V.

On the axes of Fig. 3.3, show quantitatively the variation with time t of the voltage V for one cycle of the varying voltage.

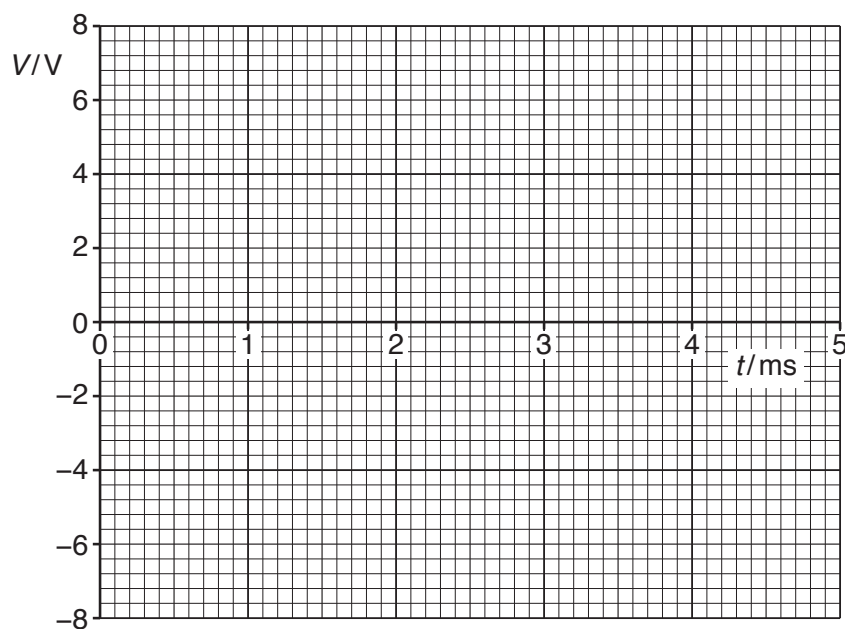


Fig. 3.3

[2]

(d) One particular fission reaction may be represented by the equation



The variation with nucleon number A of the binding energy per nucleon B_{E} is shown in Fig. 3.4.

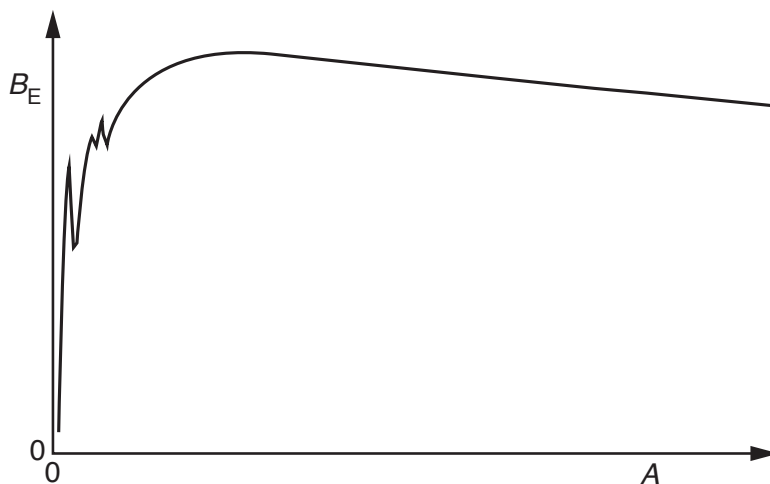


Fig. 3.4

On Fig. 3.4, mark on the line the position of

- (i) the nucleus ${}_{92}^{235}\text{U}$ (label this point U),
- (ii) the nucleus ${}_{56}^{141}\text{Ba}$ (label this point Ba),
- (iii) the nucleus ${}_{36}^{92}\text{Kr}$ (label this point Kr).

[2]

[Total: 8]

- 4 (a) Explain what is meant by the *natural frequency of vibration* of a system.

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

- (b) A block of metal is fixed to one end of a vertical spring. The other end of the spring is attached to an oscillator, as shown in Fig. 4.1.

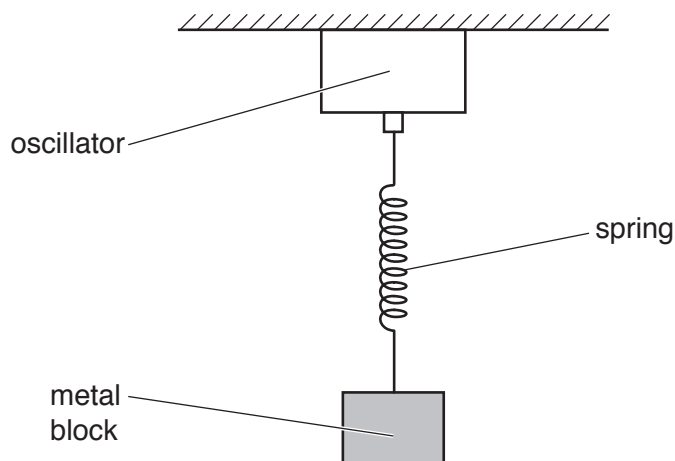


Fig. 4.1

The amplitude of oscillation of the oscillator is constant.

The variation of the amplitude x_0 of the oscillations of the block with frequency f of the oscillations is shown in Fig. 4.2.

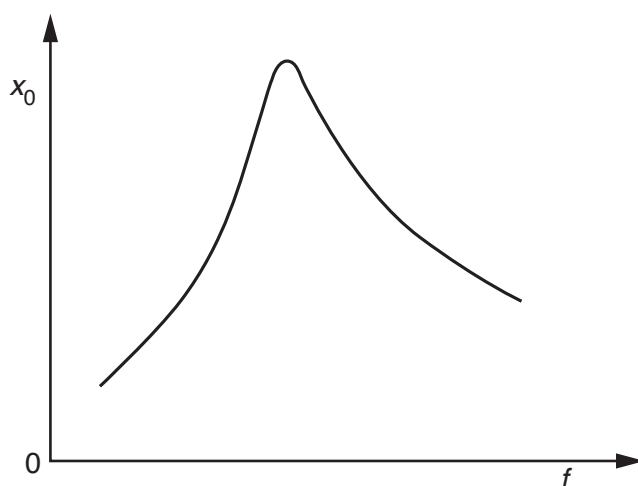


Fig. 4.2

(i) Name the effect shown in Fig. 4.2.

.....[1]

(ii) State and explain whether the block is undergoing damped oscillations.

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

(c) State **one** example in which the effect shown in Fig. 4.2 is useful.

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

[Total: 5]

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16. Question part 1/2 | 9702 May-June 2018 P4 V1 Q2

- 2 A metal plate is made to vibrate vertically by means of an oscillator, as shown in Fig. 2.1.

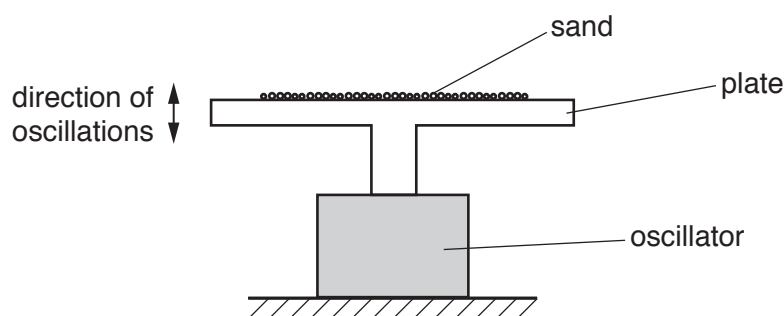


Fig. 2.1

Some sand is sprinkled on to the plate.

The variation with displacement y of the acceleration a of the sand on the plate is shown in Fig. 2.2.

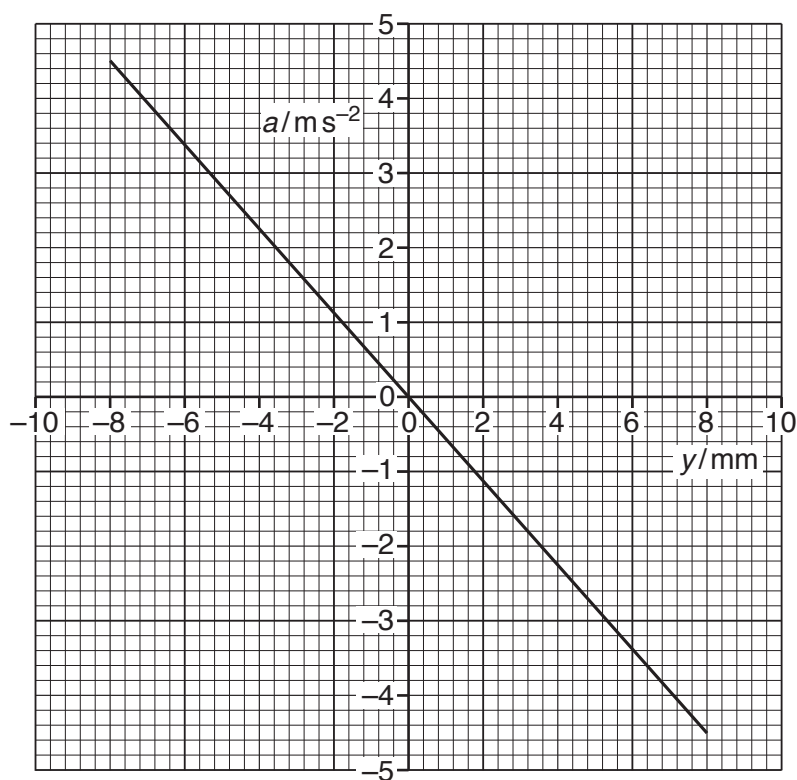


Fig. 2.2

- (a) (i) Use Fig. 2.2 to show how it can be deduced that the sand is undergoing simple harmonic motion.

.....

.....

.....

.....[2]

- (ii) Calculate the frequency of oscillation of the sand.

frequency = ... Hz [2]

- (b) The amplitude of oscillation of the plate is gradually increased beyond 8 mm. The frequency is constant.

At one amplitude, the sand is seen to lose contact with the plate.

For the plate when the sand first loses contact with the plate,

- (i) state the position of the plate,

.....[1]

- (ii) calculate the amplitude of oscillation.

amplitude = ... mm [3]

[Total: 8]

- 4 (a) State two conditions necessary for a mass to be undergoing simple harmonic motion.

1.

.....

2.

.....

[2]

- (b) A trolley of mass 950g is held on a horizontal surface by means of two springs attached to fixed points P and Q, as shown in Fig. 4.1.

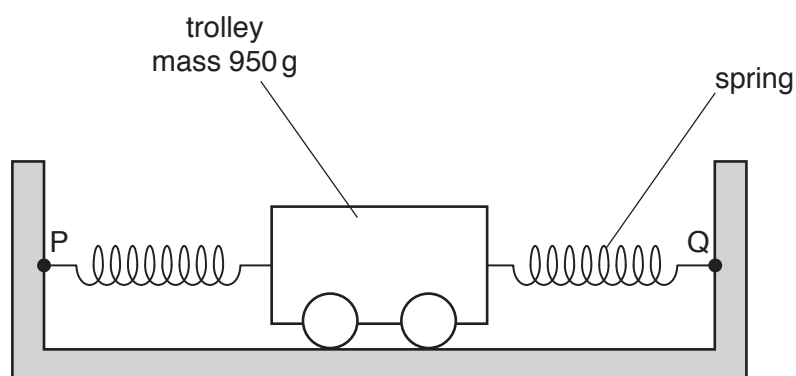


Fig. 4.1

The springs, each having a spring constant k of 230 N m^{-1} , are always extended.

The trolley is displaced along the line of the springs and then released.

The variation with time t of the displacement x of the trolley is shown in Fig. 4.2.

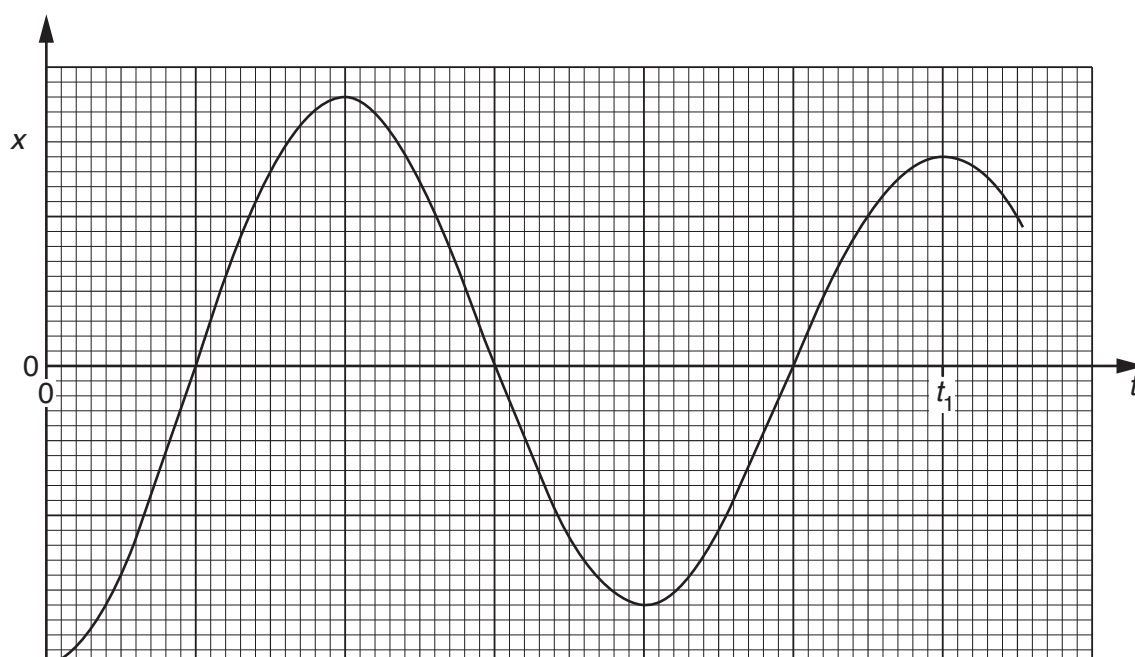


Fig. 4.2

- (i) 1. State and explain whether the oscillations of the trolley are heavily damped, critically damped or lightly damped.

.....
.....

2. Suggest the cause of the damping.

.....
.....
.....

[3]

- (ii) The acceleration a of the trolley of mass m may be assumed to be given by the expression

$$a = -\left(\frac{2k}{m}\right)x.$$

1. Calculate the angular frequency ω of the oscillations of the trolley.

$\omega =$ rad s^{-1} [3]

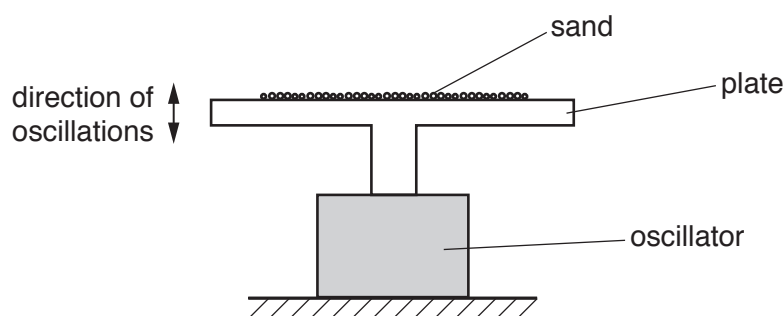
2. Determine the time t_1 shown on Fig. 4.2.

$t_1 =$ s [2]

[Total: 10]

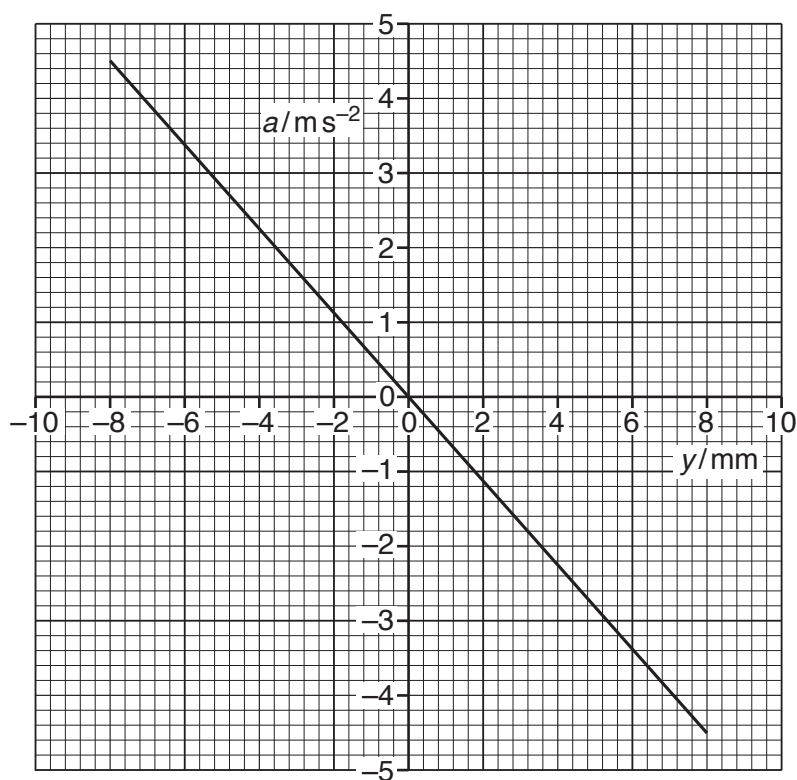
18. Question part 1/2 | 9702 May-June 2018 P4 V3 Q2

- 2 A metal plate is made to vibrate vertically by means of an oscillator, as shown in Fig. 2.1.

**Fig. 2.1**

Some sand is sprinkled on to the plate.

The variation with displacement y of the acceleration a of the sand on the plate is shown in Fig. 2.2.

**Fig. 2.2**

- (a) (i) Use Fig. 2.2 to show how it can be deduced that the sand is undergoing simple harmonic motion.

.....

.....

.....

.....[2]

- (ii) Calculate the frequency of oscillation of the sand.

frequency = ... Hz [2]

- (b) The amplitude of oscillation of the plate is gradually increased beyond 8 mm. The frequency is constant.

At one amplitude, the sand is seen to lose contact with the plate.

For the plate when the sand first loses contact with the plate,

- (i) state the position of the plate,

.....[1]

- (ii) calculate the amplitude of oscillation.

amplitude = ... mm [3]

[Total: 8]

- 3** A U-tube contains liquid, as shown in Fig. 3.1.

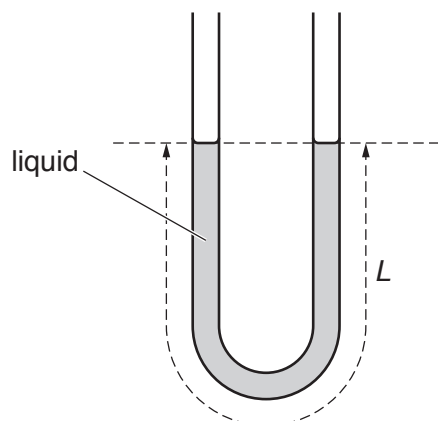


Fig. 3.1

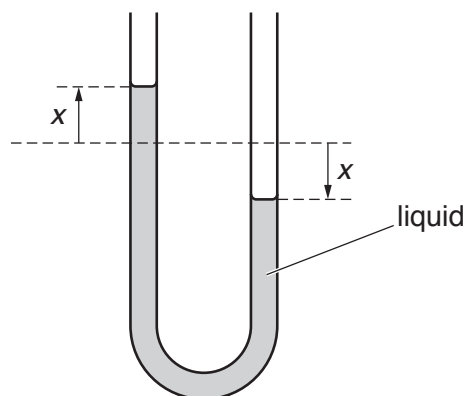


Fig. 3.2

The total length of the column of liquid in the tube is L .

The column of liquid is displaced so that the change in height of the liquid in each arm of the U-tube is x , as shown in Fig. 3.2.

The liquid in the U-tube then oscillates with simple harmonic motion such that the acceleration a of the column is given by the expression

$$a = -\left(\frac{2g}{L}\right)x$$

where g is the acceleration of free fall.

- (a)** Calculate the period T of oscillation of the liquid column for a column length L of 19.0 cm.

$T = \dots\dots\dots$ s [3]

(b) The variation with time t of the displacement x is shown in Fig. 3.3.

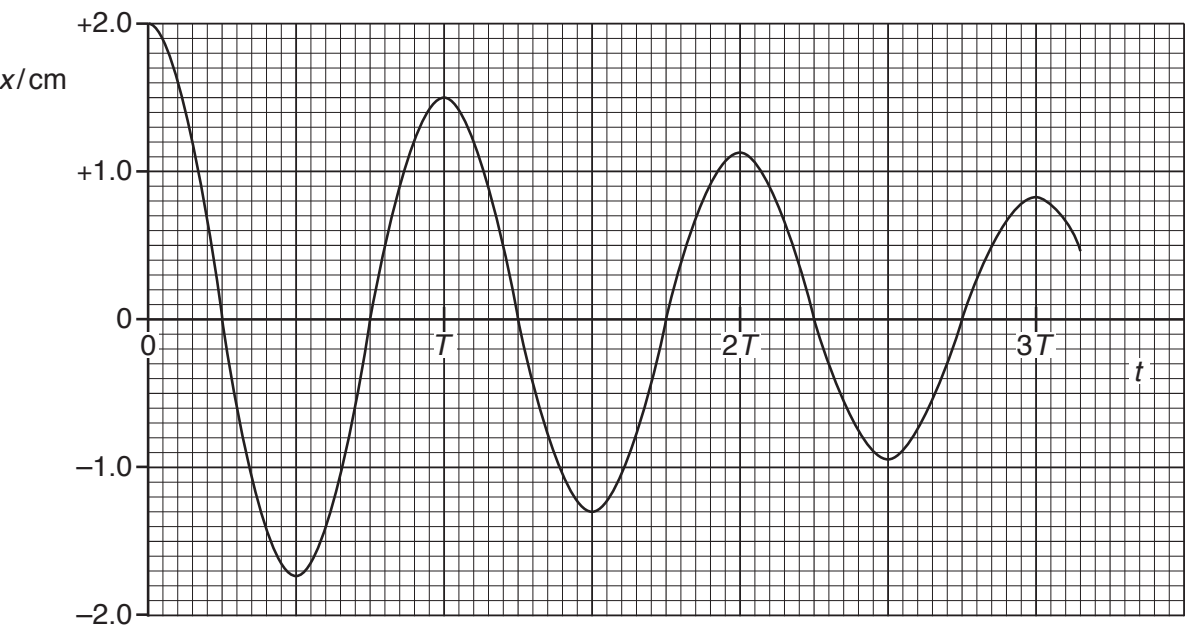


Fig. 3.3

The period of oscillation of the liquid column of mass 18.0 g is T .

The oscillations are damped.

(i) Suggest one cause of the damping.

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

(ii) Calculate the loss in total energy of the oscillations during the first 2.5 periods of the oscillations.

energy loss = ... J [3]

[Total: 7]

- 4 A U-tube contains liquid, as shown in Fig. 4.1.

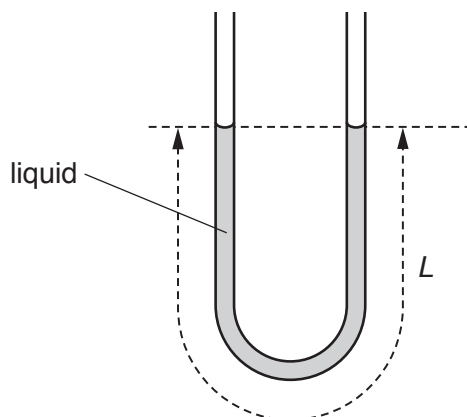


Fig. 4.1

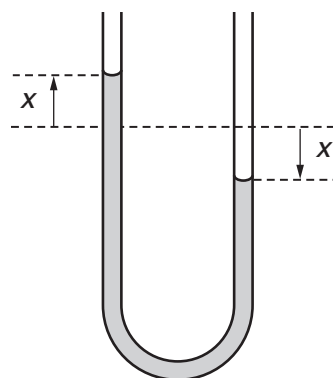


Fig. 4.2

The total length of the liquid column is L .

The column of liquid is displaced so that the change in height of the liquid level from the equilibrium position in each arm of the U-tube is x , as shown in Fig. 4.2.

The liquid in the U-tube then oscillates such that its acceleration a is given by the expression

$$a = -\left(\frac{2g}{L}\right)x$$

where g is the acceleration of free fall.

- (a) Show that the liquid column undergoes simple harmonic motion.

(b) The variation with time t of the displacement x is shown in Fig. 4.3.

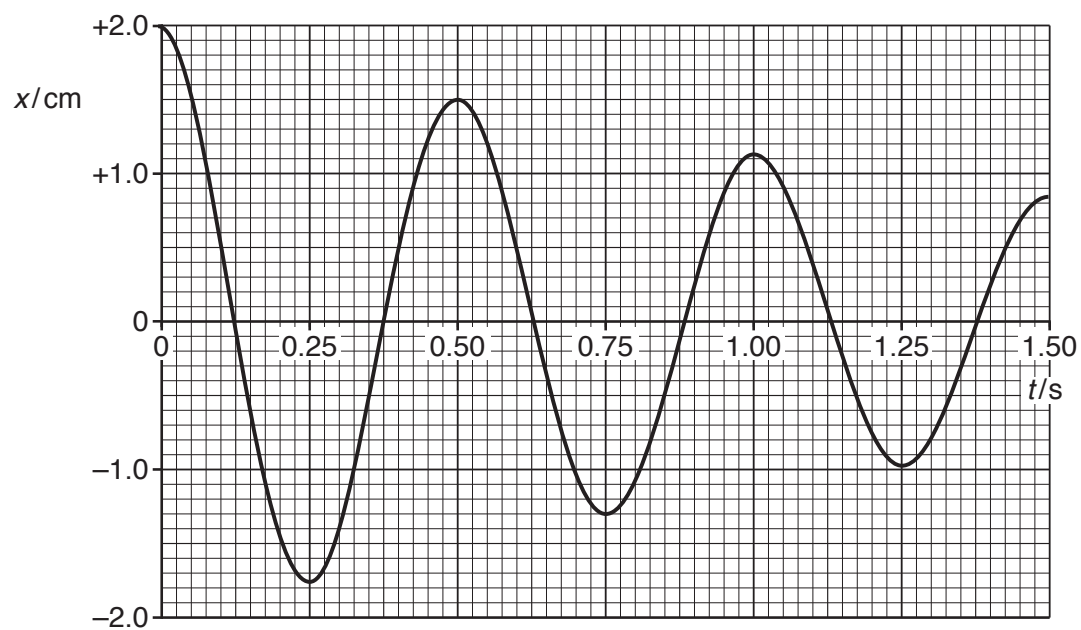


Fig. 4.3

Use data from Fig. 4.3 to determine the length L of the liquid column.

$L = \dots\dots\dots$ m [3]

(c) The oscillations shown in Fig. 4.3 are damped.

(i) Suggest one cause of this damping.

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

(ii) Calculate the ratio

$$\frac{\text{total energy of oscillations after 1.5 complete oscillations}}{\text{total initial energy of oscillations}}$$

ratio = ... [2]

[Total: 8]

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- 3 A U-tube contains liquid, as shown in Fig. 3.1.

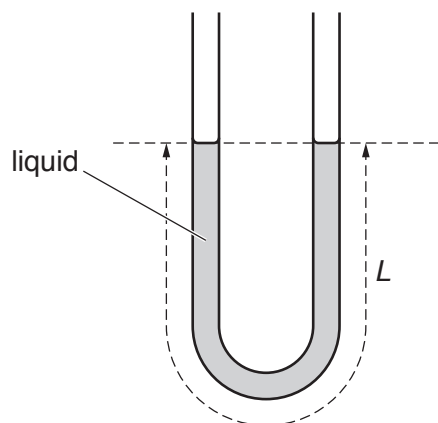


Fig. 3.1

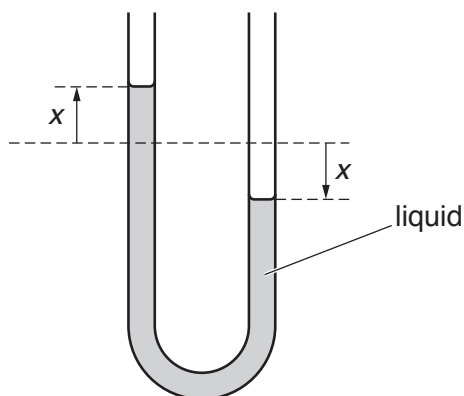


Fig. 3.2

The total length of the column of liquid in the tube is L .

The column of liquid is displaced so that the change in height of the liquid in each arm of the U-tube is x , as shown in Fig. 3.2.

The liquid in the U-tube then oscillates with simple harmonic motion such that the acceleration a of the column is given by the expression

$$a = -\left(\frac{2g}{L}\right)x$$

where g is the acceleration of free fall.

- (a) Calculate the period T of oscillation of the liquid column for a column length L of 19.0 cm.

$T = \dots\dots\dots$ s [3]

(b) The variation with time t of the displacement x is shown in Fig. 3.3.

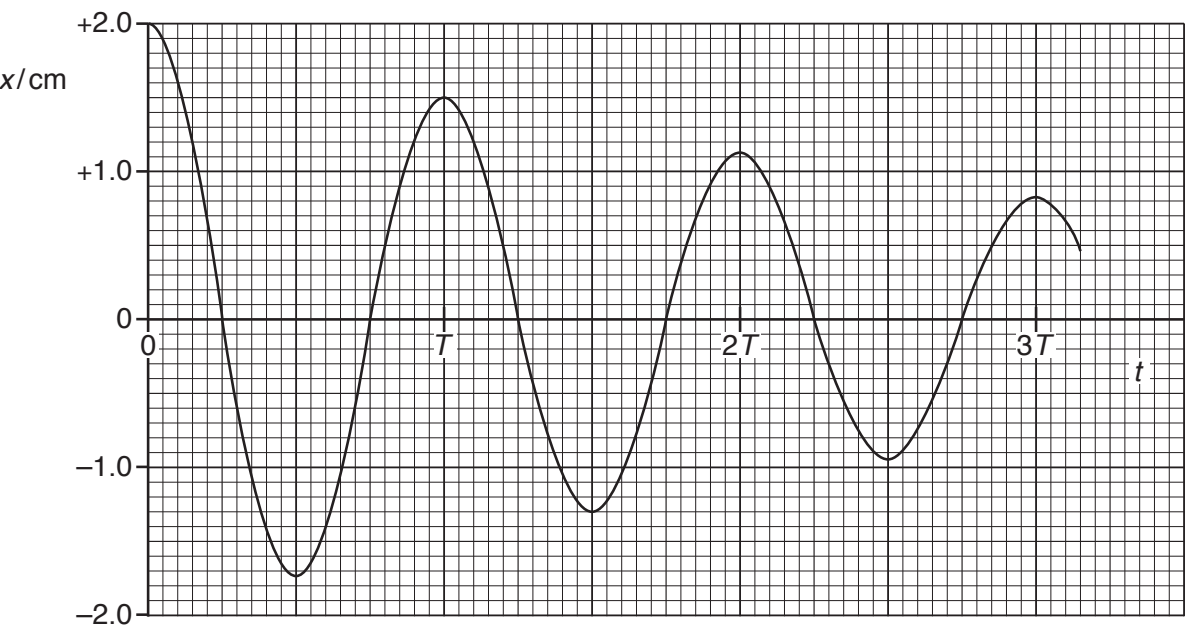


Fig. 3.3

The period of oscillation of the liquid column of mass 18.0 g is T .

The oscillations are damped.

(i) Suggest one cause of the damping.

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

(ii) Calculate the loss in total energy of the oscillations during the first 2.5 periods of the oscillations.

energy loss = ... J [3]

[Total: 7]

- 3** A cylindrical tube, sealed at one end, has cross-sectional area A and contains some sand. The total mass of the tube and the sand is M .

The tube floats upright in a liquid of density ρ , as illustrated in Fig. 3.1.

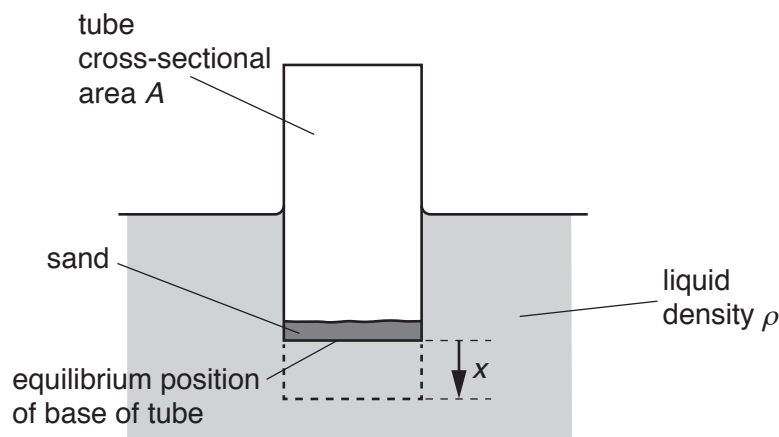


Fig. 3.1

The tube is pushed a short distance into the liquid and then released.

- (a) (i)** State the two forces that act on the tube immediately after its release.

.....
 [1]

- (ii)** State and explain the direction of the resultant force acting on the tube immediately after its release.

.....

 [2]

- (b)** The acceleration a of the tube is given by the expression

$$a = -\left(\frac{A\rho g}{M}\right)x$$

where x is the vertical displacement of the tube from its equilibrium position.

Use the expression to explain why the tube undergoes simple harmonic oscillations in the liquid.

.....

 [2]

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

22. Question part 2/2 | 9702 Feb-March 2019 P4 V2 Q3

- (c)** For a tube having cross-sectional area A of 4.5 cm^2 and a total mass M of 0.17 kg , the period of oscillation of the tube is 1.3 s .

- (i)** Determine the angular frequency ω of the oscillations.

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

- (ii)** Use your answer in **(i)** and the expression in **(b)** to determine the density ρ of the liquid in which the tube is floating.

$$\rho = \dots\dots\dots \text{ kg m}^{-3} \text{ [3]}$$

[Total: 10]

23. Question part 1/2 | 9702 May-June 2019 P4 V1 Q3

- 3** A hollow tube, sealed at one end, has a cross-sectional area A of 24 cm^2 .
The tube contains sand so that the total mass M of the tube and sand is 0.23 kg .

The tube floats upright in a liquid of density ρ , as illustrated in Fig. 3.1.

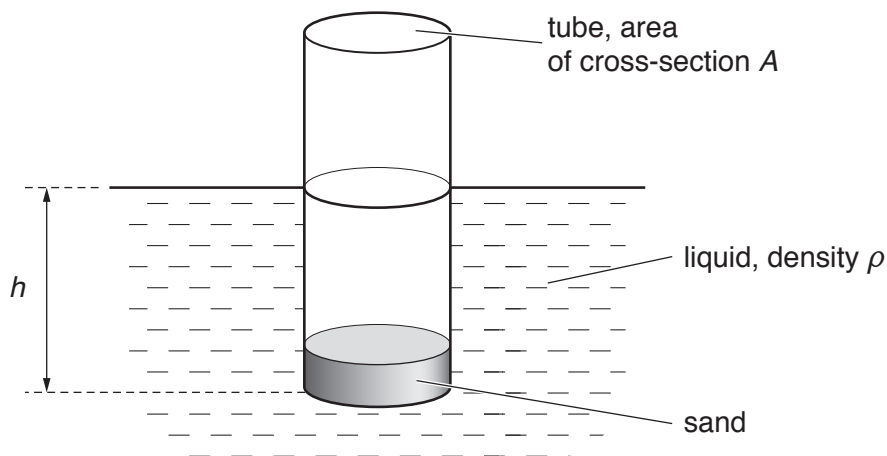


Fig. 3.1

The depth of the bottom of the tube below the liquid surface is h .

The tube is displaced vertically and then released. The variation with time t of the depth h is shown in Fig. 3.2.

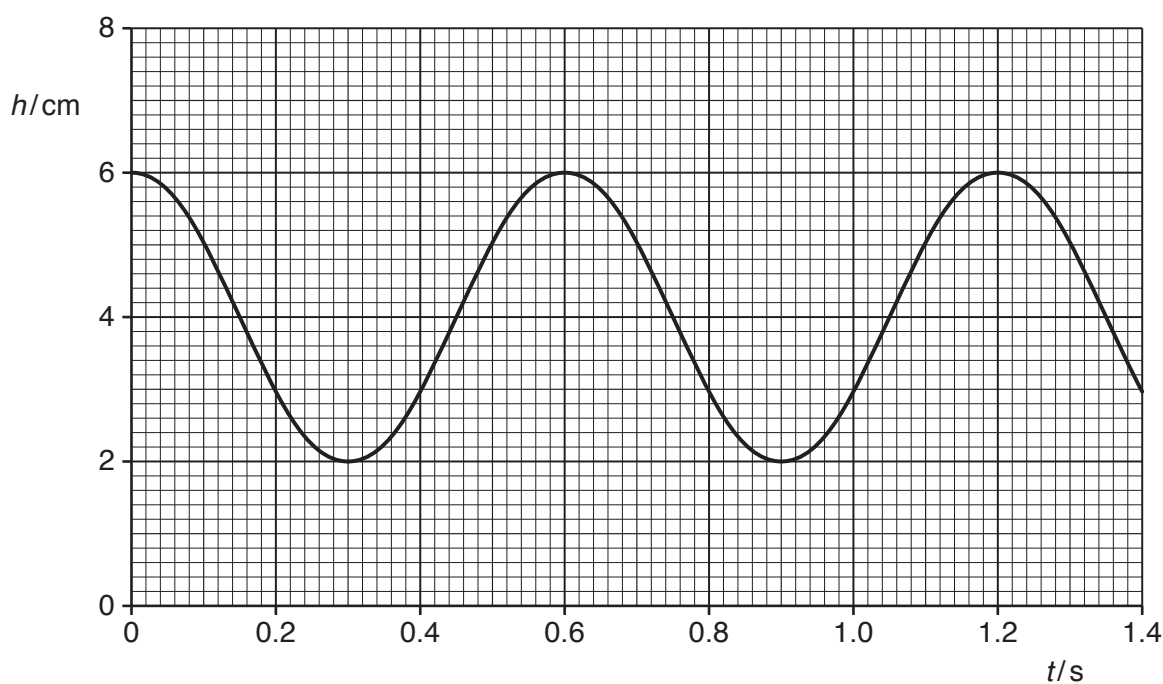


Fig. 3.2

- (a) Determine:
- (i) the amplitude, in metres, of the oscillations

amplitude = ... m [1]

(ii) the frequency of oscillation of the tube in the liquid

frequency = ...Hz [2]

(iii) the acceleration of the tube when h is a maximum.

acceleration = ...ms⁻² [2]

(b) The frequency f of oscillation of the tube is given by the expression

$$f = \frac{1}{2\pi} \sqrt{\left(\frac{A\rho g}{M}\right)}$$

where g is the acceleration of free fall.

Calculate the density ρ of the liquid in which the tube is floating.

$\rho =$ kg m⁻³ [2]

(c) The oscillations illustrated in Fig. 3.2 are undamped. In practice, the liquid does cause light damping.

On Fig. 3.2, draw a line to show light damping of the oscillations for time $t = 0$ to time $t = 1.4$ s.
[3]

[Total: 10]

- 3** A spring is hung vertically from a fixed point. A mass M is hung from the other end of the spring, as illustrated in Fig. 3.1.

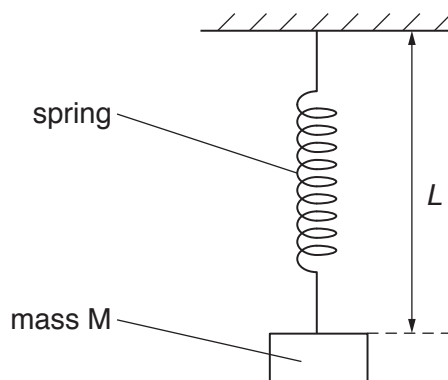


Fig. 3.1

The mass is displaced downwards and then released. The subsequent motion of the mass is simple harmonic.

The variation with time t of the length L of the spring is shown in Fig. 3.2.

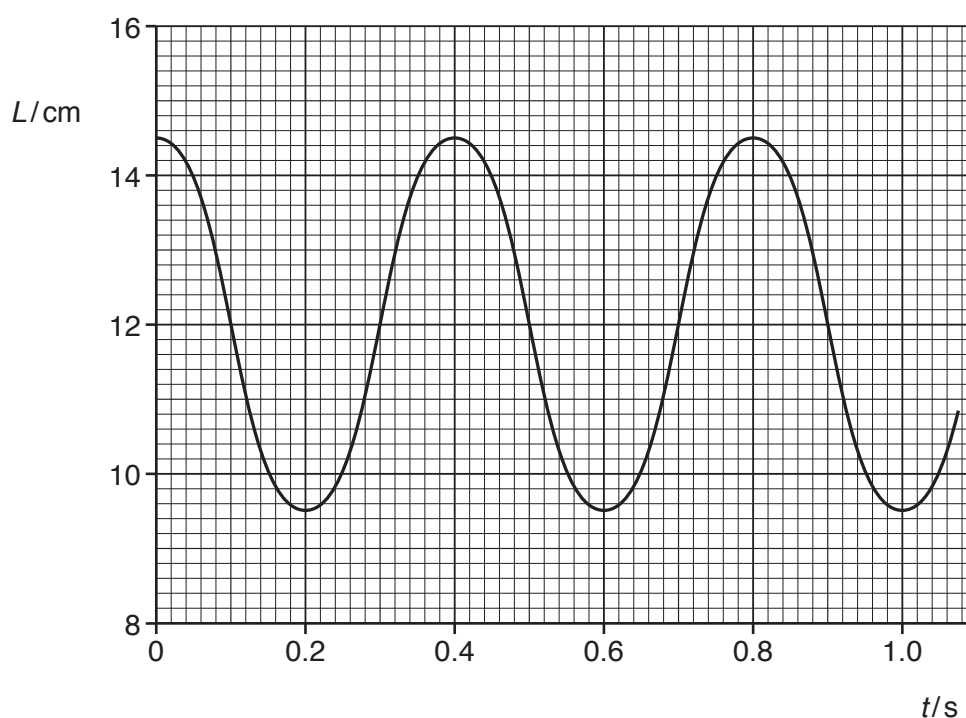


Fig. 3.2

(a) State:

- (i)** one time at which the mass is moving with maximum speed

time = ... s [1]

- (ii)** one time at which the spring has maximum elastic potential energy.

time = ... s [1]

24. Question part 2/3 | 9702 May-June 2019 P4 V2 Q3

(b) Use data from Fig. 3.2 to determine, for the motion of the mass:

(i) the angular frequency ω

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

(ii) the maximum speed

maximum speed = $\dots\dots\dots \text{m s}^{-1}$ [2]

(iii) the magnitude of the maximum acceleration.

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

- (c) The mass M is now suspended from two springs, each identical to that in Fig. 3.1, as shown in Fig. 3.3.

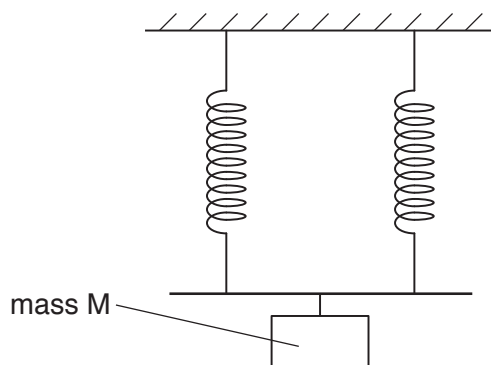


Fig. 3.3

Suggest and explain the change, if any, in the period of oscillation of the mass. A numerical answer is not required.

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

[Total: 10]

25. Question part 1/2 | 9702 May-June 2019 P4 V3 Q3

- 3** A hollow tube, sealed at one end, has a cross-sectional area A of 24 cm^2 .
The tube contains sand so that the total mass M of the tube and sand is 0.23 kg .

The tube floats upright in a liquid of density ρ , as illustrated in Fig. 3.1.

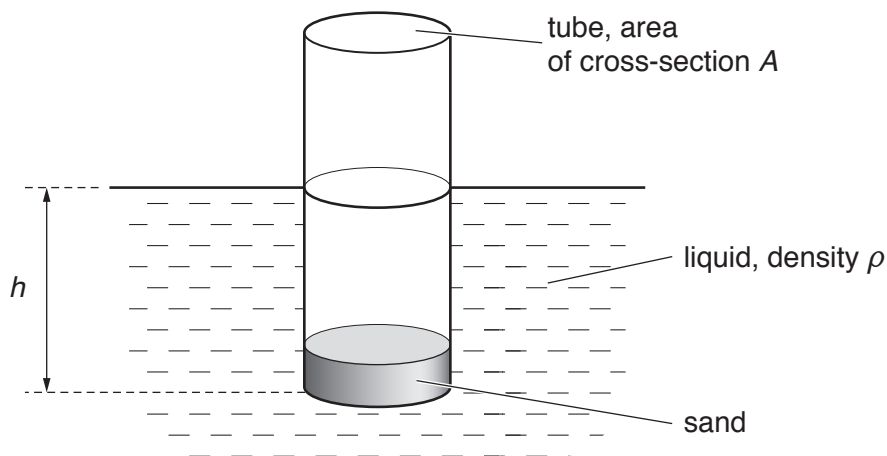


Fig. 3.1

The depth of the bottom of the tube below the liquid surface is h .

The tube is displaced vertically and then released. The variation with time t of the depth h is shown in Fig. 3.2.

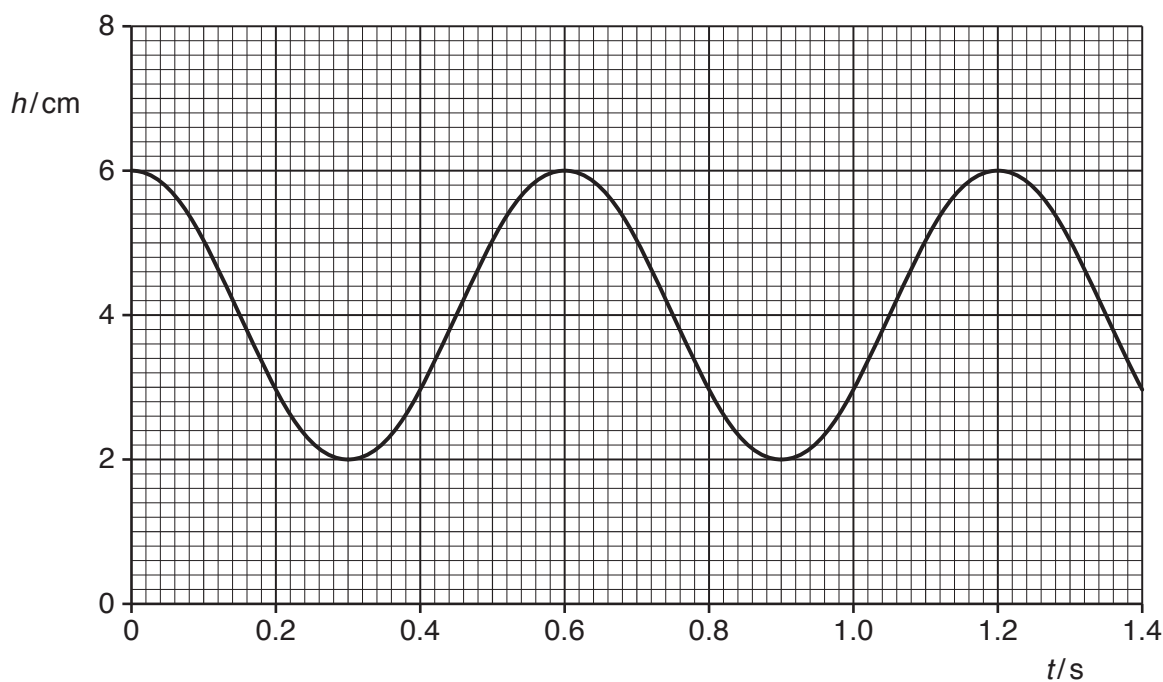


Fig. 3.2

(a) Determine:

- (i)** the amplitude, in metres, of the oscillations

amplitude = ... m [1]

(ii) the frequency of oscillation of the tube in the liquid

frequency = ...Hz [2]

(iii) the acceleration of the tube when h is a maximum.

acceleration = ...ms⁻² [2]

(b) The frequency f of oscillation of the tube is given by the expression

$$f = \frac{1}{2\pi} \sqrt{\left(\frac{A\rho g}{M}\right)}$$

where g is the acceleration of free fall.

Calculate the density ρ of the liquid in which the tube is floating.

$\rho =$ kg m⁻³ [2]

(c) The oscillations illustrated in Fig. 3.2 are undamped. In practice, the liquid does cause light damping.

On Fig. 3.2, draw a line to show light damping of the oscillations for time $t = 0$ to time $t = 1.4$ s.
[3]

[Total: 10]

- 4 A mass is suspended vertically from a fixed point by means of a spring, as illustrated in Fig. 4.1.

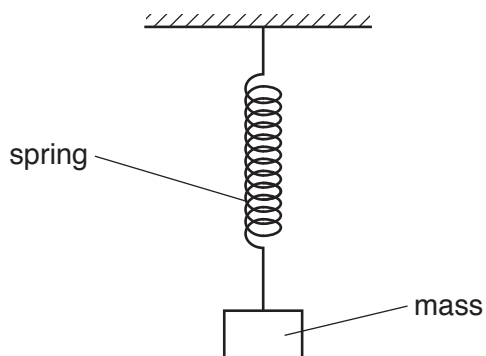


Fig. 4.1

The mass is oscillating vertically. The variation with displacement x of the acceleration a of the mass is shown in Fig. 4.2.

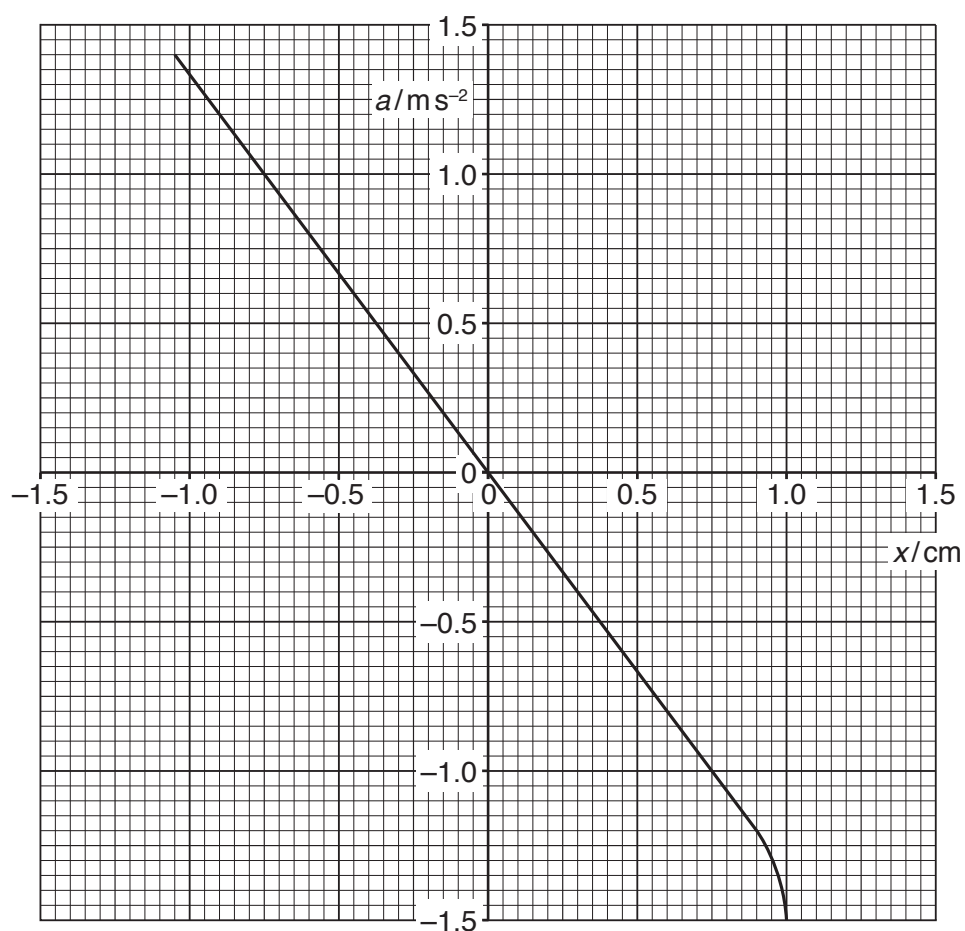


Fig. 4.2

- (a) (i) State what is meant by the *displacement* of the mass on the spring.

.....
 [1]

(ii) Suggest how Fig. 4.2 shows that the mass is not performing simple harmonic motion.

.....

..... [1]

(b) (i) The amplitude of oscillation of the mass may be changed.

State the maximum amplitude x_0 for which the oscillations are simple harmonic.

$x_0 =$ cm [1]

(ii) For the simple harmonic oscillations of the mass, use Fig. 4.2 to determine the frequency of the oscillations.

frequency = ... Hz [3]

(c) The maximum speed of the mass when oscillating with simple harmonic motion of amplitude x_0 is v_0 .

On Fig. 4.3, show the variation with displacement x of the velocity v of the mass for displacements from $+x_0$ to $-x_0$.

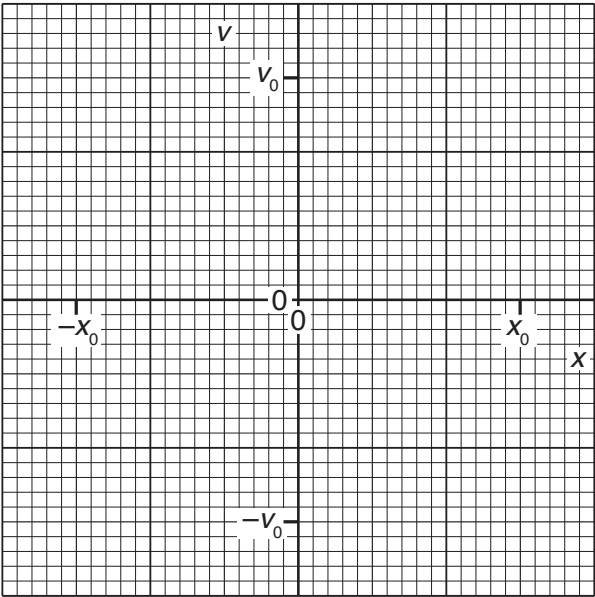


Fig. 4.3

[2]

[Total: 8]

- 4 A ball of mass M is held on a horizontal surface by two identical extended springs, as illustrated in Fig. 4.1.

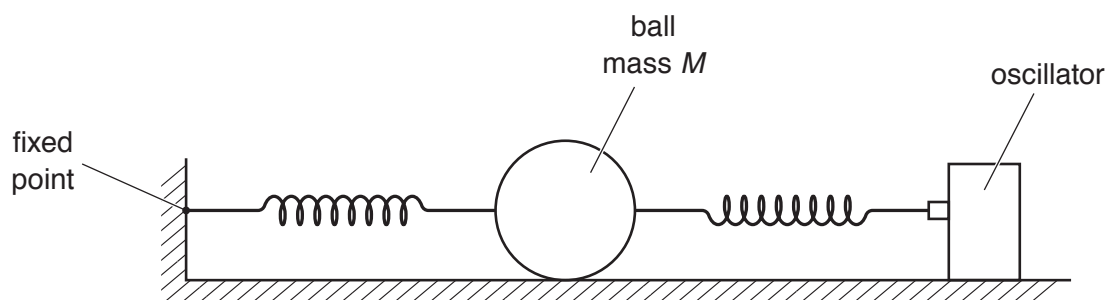


Fig. 4.1

One spring is attached to a fixed point. The other spring is attached to an oscillator.

The oscillator is switched off. The ball is displaced sideways along the axis of the springs and is then released. The variation with time t of the displacement x of the ball is shown in Fig. 4.2.

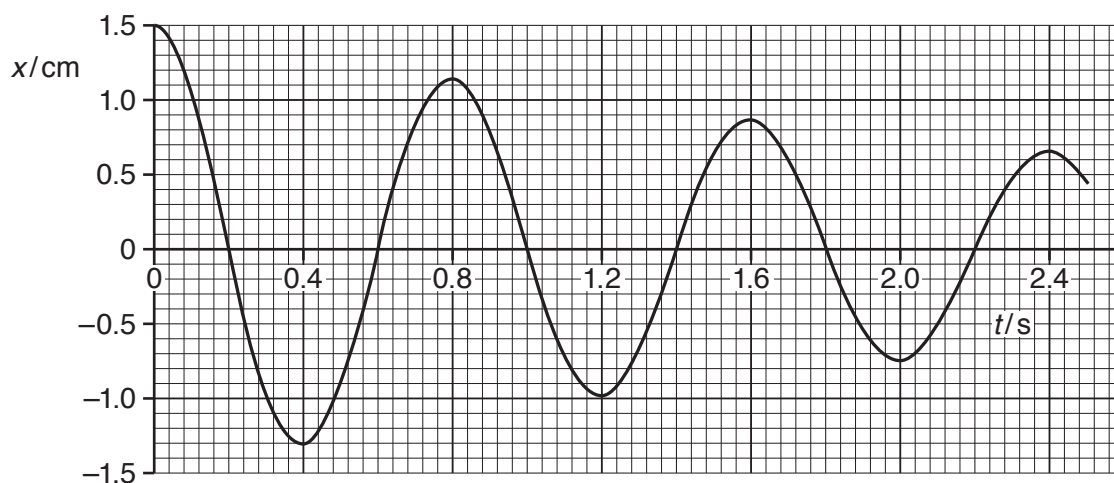


Fig. 4.2

(a) State:

- (i) what is meant by *damping*

.....
 [1]

- (ii) the evidence provided by Fig. 4.2 that the motion of the ball is damped.

.....
 [1]

- (b)** The acceleration a and the displacement x of the ball are related by the expression

$$a = -\left(\frac{2k}{M}\right)x$$

where k is the spring constant of one of the springs.

The mass M of the ball is 1.2 kg.

- (i)** Use data from Fig. 4.2 to determine the angular frequency ω of the oscillations of the ball.

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

- (ii)** Use your answer in **(i)** to determine the value of k .

$$k = \dots\dots\dots \text{N m}^{-1} \text{ [2]}$$

(c) The oscillator is switched on. The amplitude of oscillation of the oscillator is constant.

The angular frequency of the oscillations is gradually increased from 0.7ω to 1.3ω , where ω is the angular frequency calculated in (b)(i).

(i) On the axes of Fig. 4.3, show the variation with angular frequency of the amplitude A of oscillation of the ball.

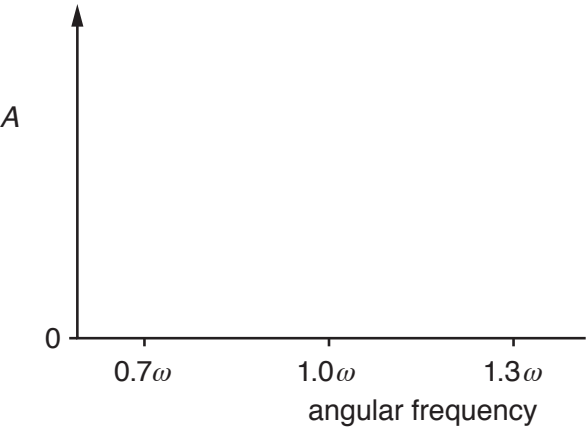


Fig. 4.3

[2]

(ii) Some sand is now sprinkled on the horizontal surface.

The angular frequency of the oscillations is again gradually increased from 0.7ω to 1.3ω .

State **two** changes that occur to the line you have drawn on Fig. 4.3.

1.
-
2.
-

[2]

[Total: 10]

- 4 A mass is suspended vertically from a fixed point by means of a spring, as illustrated in Fig. 4.1.

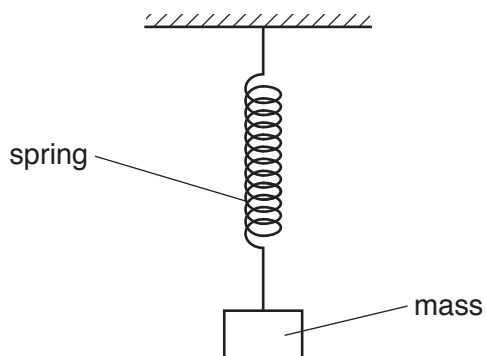


Fig. 4.1

The mass is oscillating vertically. The variation with displacement x of the acceleration a of the mass is shown in Fig. 4.2.

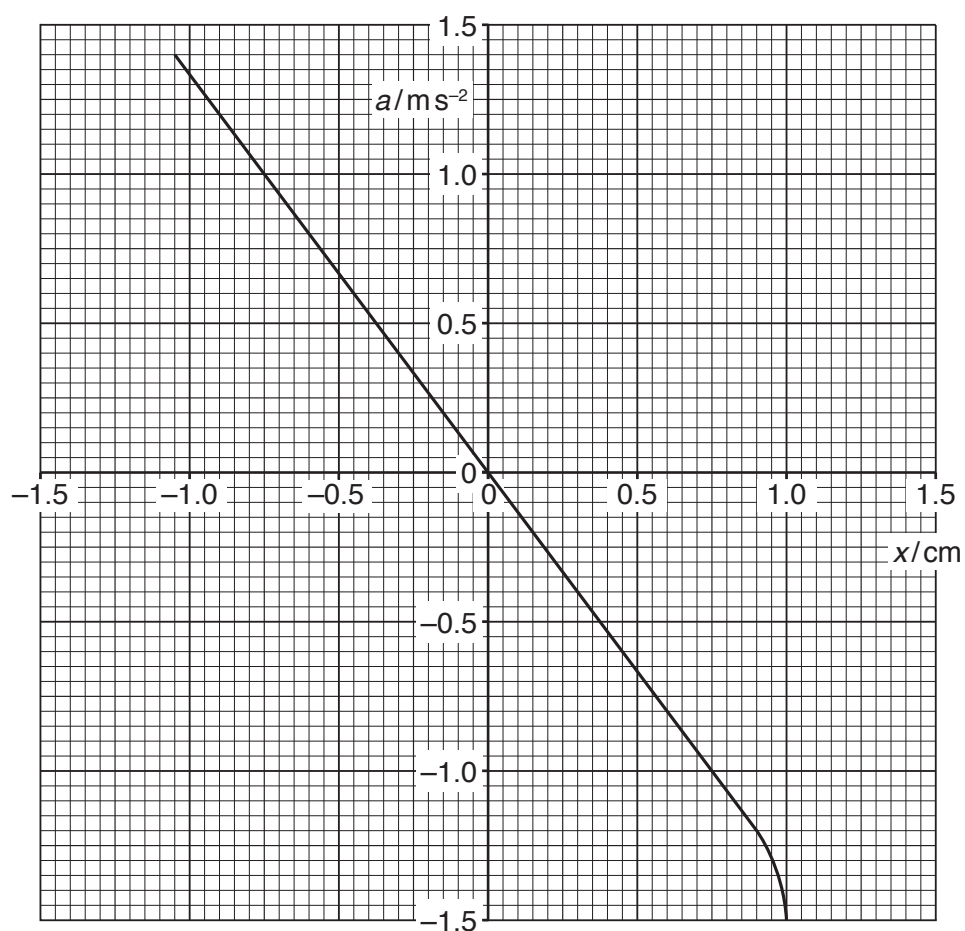


Fig. 4.2

- (a) (i) State what is meant by the *displacement* of the mass on the spring.

.....
 [1]

(ii) Suggest how Fig. 4.2 shows that the mass is not performing simple harmonic motion.

.....

..... [1]

(b) (i) The amplitude of oscillation of the mass may be changed.

State the maximum amplitude x_0 for which the oscillations are simple harmonic.

$x_0 =$ cm [1]

(ii) For the simple harmonic oscillations of the mass, use Fig. 4.2 to determine the frequency of the oscillations.

frequency = ... Hz [3]

(c) The maximum speed of the mass when oscillating with simple harmonic motion of amplitude x_0 is v_0 .

On Fig. 4.3, show the variation with displacement x of the velocity v of the mass for displacements from $+x_0$ to $-x_0$.

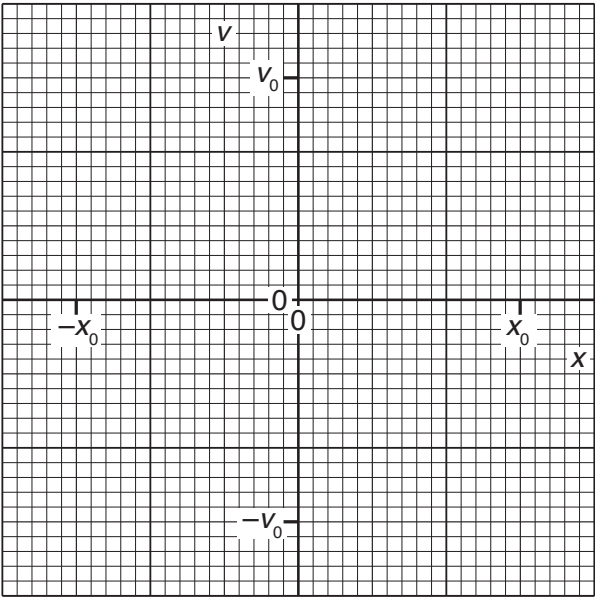


Fig. 4.3

[2]

[Total: 8]

- 3 (a) A body undergoes simple harmonic motion.

The variation with displacement x of its velocity v is shown in Fig. 3.1.

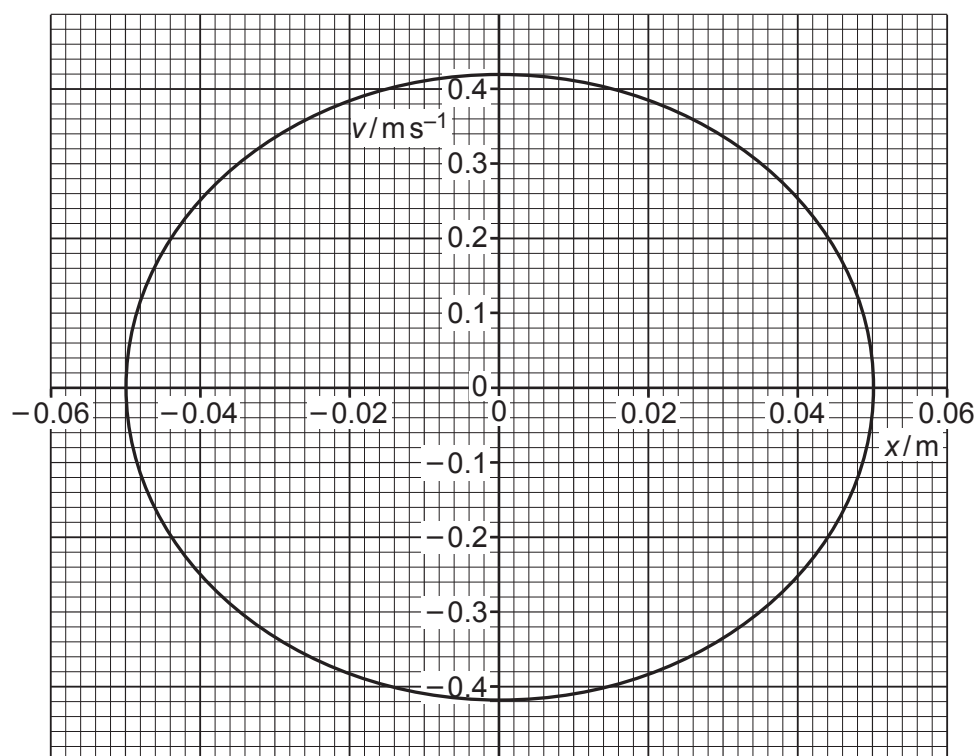


Fig. 3.1

- (i) State the amplitude x_0 of the oscillations.

$x_0 = \dots\dots\dots$ m [1]

- (ii) Calculate the period T of the oscillations.

$T = \dots\dots\dots$ s [3]

- (iii) On Fig. 3.1, label with a P a point where the body has **maximum** potential energy. [1]

- (b) A bar magnet is suspended from the free end of a spring, as shown in Fig. 3.2.

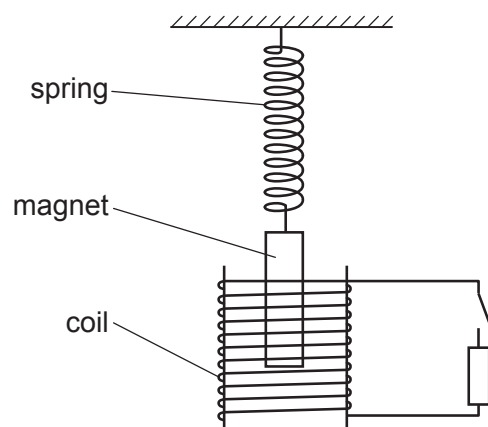


Fig. 3.2

One pole of the magnet is situated in a coil of wire. The coil is connected in series with a switch and a resistor. The switch is open.

The magnet is displaced vertically and then released. The magnet oscillates with simple harmonic motion.

- (i) State Faraday's law of electromagnetic induction.

.....

.....

.....

..... [2]

- (ii) The switch is now closed. Explain why the oscillations of the magnet are damped.

.....

.....

.....

.....

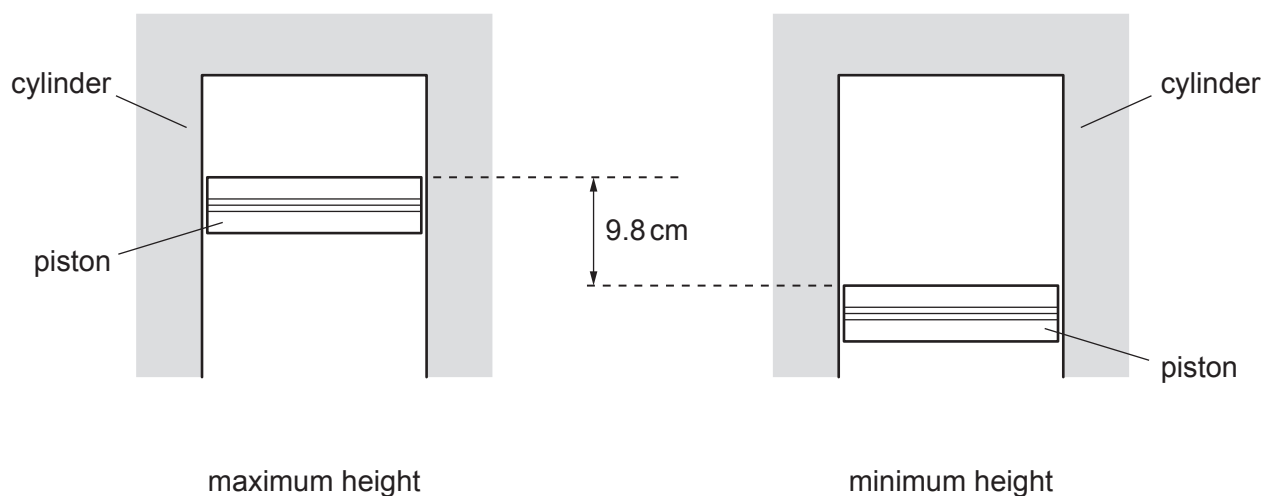
.....

..... [3]

[Total: 10]

30. Question part 1/2 | 9702 May-June 2020 P4 V1 Q3

- 3 The piston in the cylinder of a car engine moves in the cylinder with simple harmonic motion. The piston moves between a position of maximum height in the cylinder to a position of minimum height, as illustrated in Fig. 3.1.

**Fig. 3.1**

The distance moved by the piston between the positions shown in Fig. 3.1 is 9.8 cm.

The mass of the piston is 640 g.

At one particular speed of the engine, the piston completes 2700 oscillations in 1.0 minute.

(a) For the oscillations of the piston in the cylinder, determine:

(i) the amplitude

amplitude = ... cm [1]

(ii) the frequency

frequency = ... Hz [1]

(iii) the maximum speed

maximum speed = ... ms^{-1} [2]

(iv) the speed when the top of the piston is 2.3 cm below its maximum height.

speed = ... ms^{-1} [2]

(b) The acceleration of the piston varies.

Determine the resultant force on the piston that gives rise to its maximum acceleration.

force = ... N [3]

[Total: 9]

31. Question part 1/2 | 9702 May-June 2020 P4 V2 Q4

- 4 A dish is made from a section of a hollow glass sphere.

The dish, fixed to a horizontal table, contains a small solid ball of mass 45 g, as shown in Fig. 4.1.

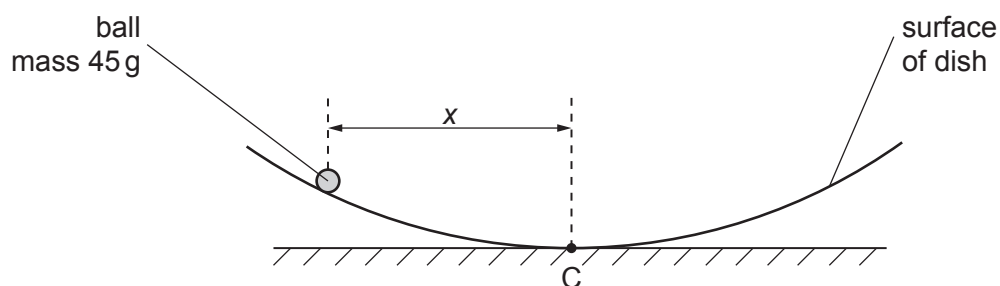


Fig. 4.1

The horizontal displacement of the ball from the centre C of the dish is x .

Initially, the ball is held at rest with distance $x = 3.0$ cm.

The ball is then released. The variation with time t of the horizontal displacement x of the ball from point C is shown in Fig. 4.2.

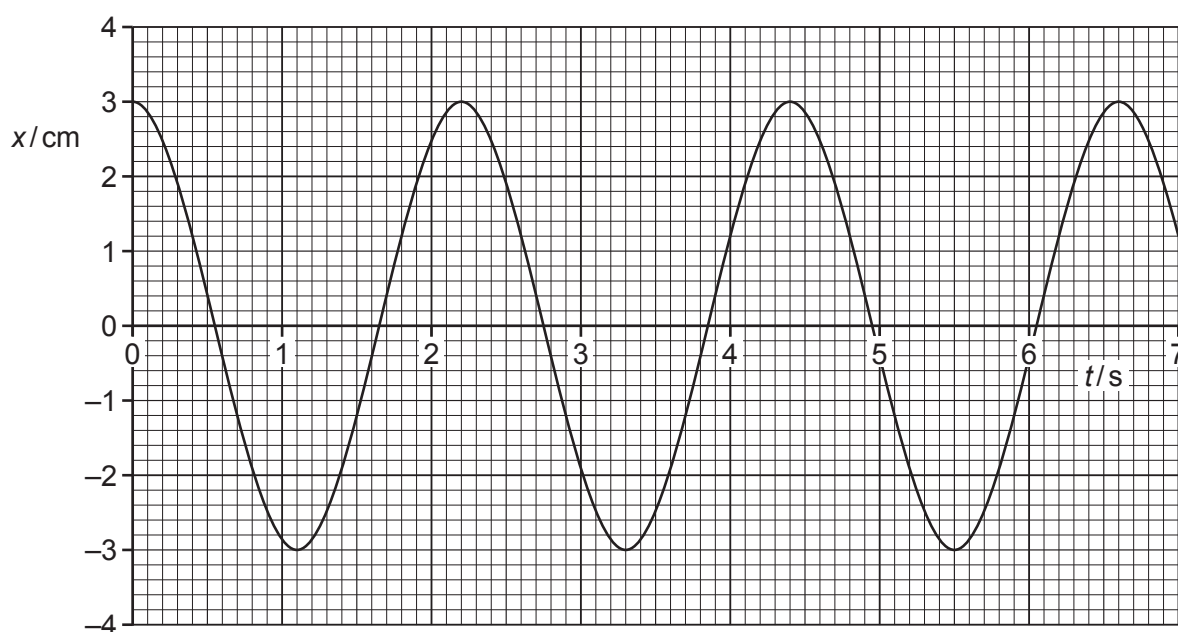


Fig. 4.2

The motion of the ball in the dish is simple harmonic with its acceleration a given by the expression

$$a = -\left(\frac{g}{R}\right)x$$

where g is the acceleration of free fall and R is a constant that depends on the dimensions of the dish and the ball.

31. Question part 2/2 | 9702 May-June 2020 P4 V2 Q4

- (a) Use Fig. 4.2 to show that the angular frequency ω of oscillation of the ball in the dish is 2.9rad s^{-1} .

[1]

- (b) Use the information in (a) to:

- (i) determine R

 $R = \dots\dots\dots \text{ m [2]}$

- (ii) calculate the speed of the ball as it passes over the centre C of the dish.

speed = $\dots\dots\dots \text{ ms}^{-1}$ [2]

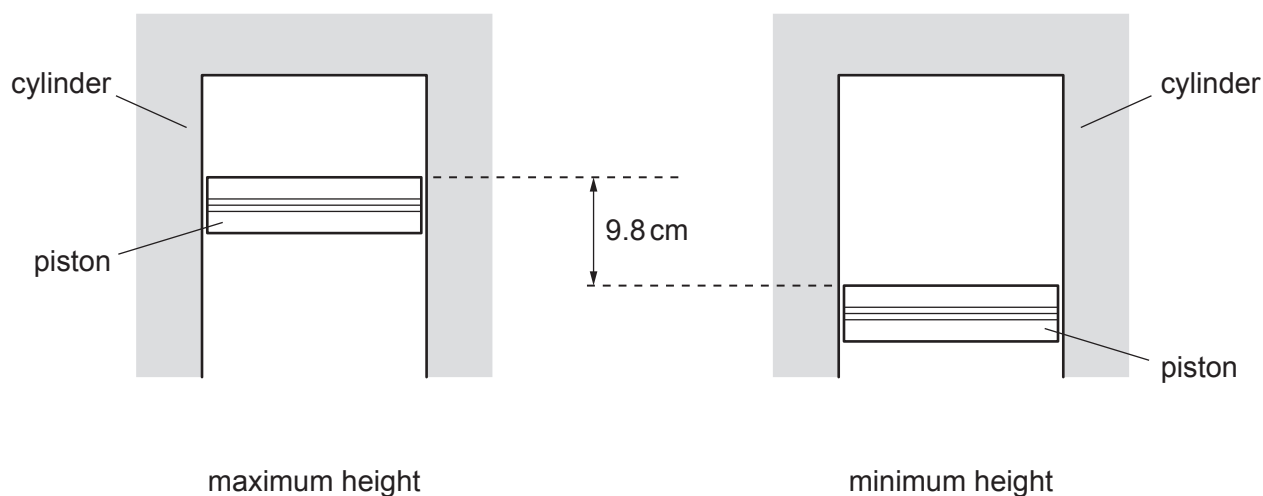
- (c) Some moisture collects on the surface of the dish so that the motion of the ball becomes lightly damped.

On the axes of Fig. 4.2, draw a line to show the lightly damped motion of the ball for the first 5.0 s after the release of the ball. [3]

[Total: 8]

32. Question part 1/2 | 9702 May-June 2020 P4 V3 Q3

- 3 The piston in the cylinder of a car engine moves in the cylinder with simple harmonic motion. The piston moves between a position of maximum height in the cylinder to a position of minimum height, as illustrated in Fig. 3.1.

**Fig. 3.1**

The distance moved by the piston between the positions shown in Fig. 3.1 is 9.8 cm.

The mass of the piston is 640 g.

At one particular speed of the engine, the piston completes 2700 oscillations in 1.0 minute.

(a) For the oscillations of the piston in the cylinder, determine:

(i) the amplitude

amplitude = ... cm [1]

(ii) the frequency

frequency = ... Hz [1]

(iii) the maximum speed

maximum speed = ... ms^{-1} [2]

(iv) the speed when the top of the piston is 2.3 cm below its maximum height.

speed = ... ms^{-1} [2]

(b) The acceleration of the piston varies.

Determine the resultant force on the piston that gives rise to its maximum acceleration.

force = ... N [3]

[Total: 9]

33. Question part 1/3 | 9702 Oct-Nov 2020 P4 V1 Q3

- 3 A pendulum consists of a metal sphere P suspended from a fixed point by means of a thread, as illustrated in Fig. 3.1.

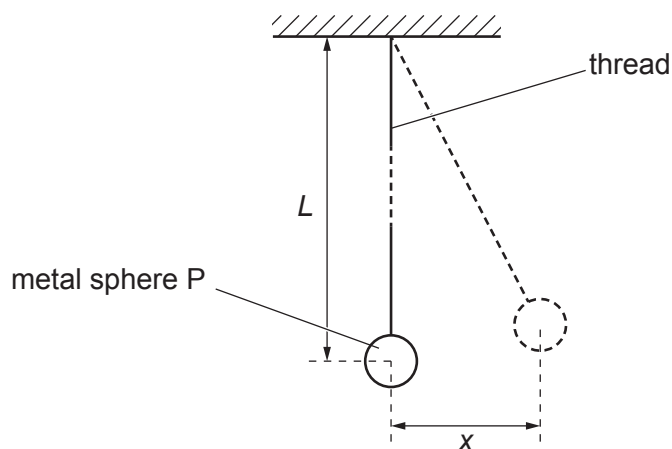


Fig. 3.1

The centre of gravity of sphere P is a distance L from the fixed point.

The sphere is pulled to one side and then released so that it oscillates. The sphere may be assumed to oscillate with simple harmonic motion.

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

.....

 [2]

- (b) The variation of the velocity v of sphere P with the displacement x from its mean position is shown in Fig. 3.2.

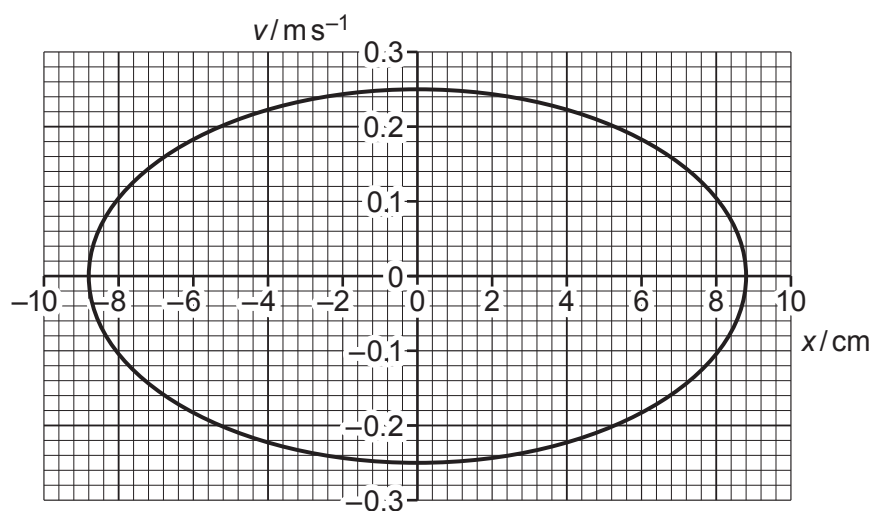


Fig. 3.2

Use Fig. 3.2 to determine the frequency f of the oscillations of sphere P.

$$f = \dots\dots\dots \text{ Hz [3]}$$

- (c) The period T of the oscillations of sphere P is given by the expression

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

where g is the acceleration of free fall.

Use your answer in (b) to determine the length L .

$$L = \dots\dots\dots \text{ m [2]}$$

- (d) Another pendulum consists of a sphere Q suspended by a thread. Spheres P and Q are identical. The thread attached to sphere Q is longer than the thread attached to sphere P.

Sphere Q is displaced and then released. The oscillations of sphere Q have the same amplitude as the oscillations of sphere P.

On Fig. 3.2, sketch the variation of the velocity v with displacement x for sphere Q. [2]

[Total: 9]

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34. Question part 1/2 | 9702 Oct-Nov 2020 P4 V2 Q3

- 3 A simple pendulum consists of a metal sphere suspended from a fixed point by means of a thread, as illustrated in Fig. 3.1.

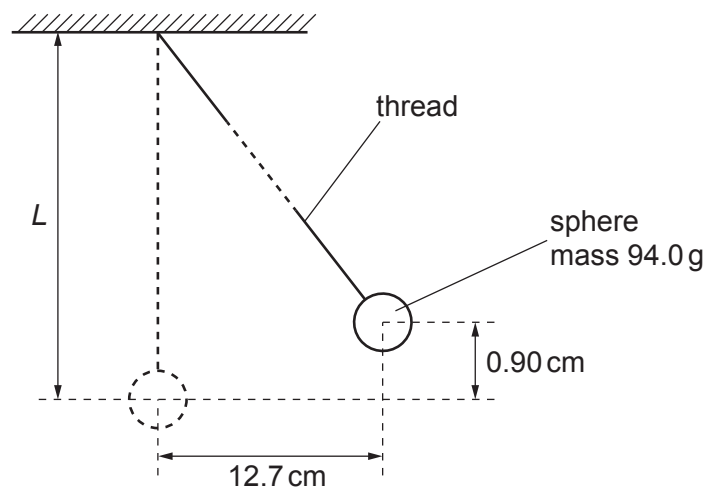


Fig. 3.1 (not to scale)

The sphere of mass 94.0 g is displaced to one side through a horizontal distance of 12.7 cm. The centre of gravity of the sphere rises vertically by 0.90 cm.

The sphere is released so that it oscillates. The sphere may be assumed to oscillate with simple harmonic motion.

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

.....

 [2]

- (b) (i) State the kinetic energy of the sphere when the sphere returns to the displaced position shown in Fig. 3.1.

kinetic energy = ... J [1]

- (ii) Calculate the total energy E_T of the oscillations.

$E_T =$ J [2]

34. Question part 2/2 | 9702 Oct-Nov 2020 P4 V2 Q3

- (iii) Use your answer in (ii) to show that the angular frequency ω of the oscillations of the pendulum is 3.3 rad s^{-1} .

[2]

- (c) The period T of oscillation of the pendulum is given by the expression

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

where g is the acceleration of free fall and L is the length of the pendulum.

Use data from (b) to determine L .

$L = \dots\dots\dots \text{m}$ [3]

[Total: 10]

35. Question part 1/3 | 9702 Oct-Nov 2020 P4 V3 Q3

- 3 A pendulum consists of a metal sphere P suspended from a fixed point by means of a thread, as illustrated in Fig. 3.1.

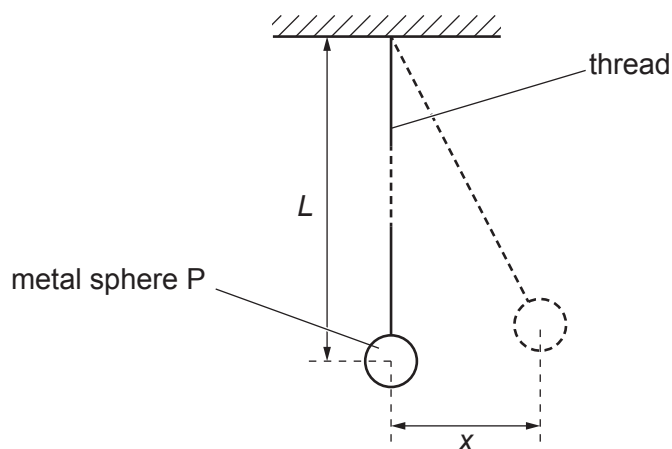


Fig. 3.1

The centre of gravity of sphere P is a distance L from the fixed point.

The sphere is pulled to one side and then released so that it oscillates. The sphere may be assumed to oscillate with simple harmonic motion.

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

.....

 [2]

- (b) The variation of the velocity v of sphere P with the displacement x from its mean position is shown in Fig. 3.2.

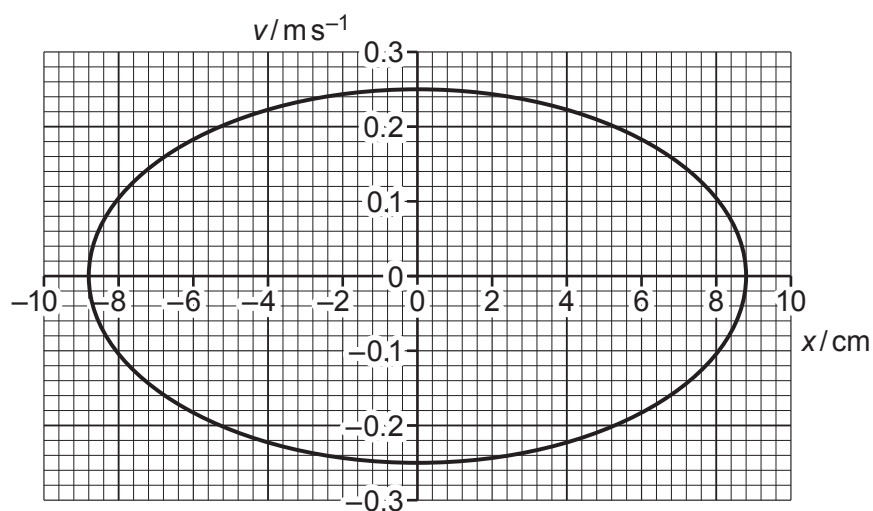


Fig. 3.2

Use Fig. 3.2 to determine the frequency f of the oscillations of sphere P.

$$f = \dots\dots\dots \text{ Hz [3]}$$

- (c) The period T of the oscillations of sphere P is given by the expression

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

where g is the acceleration of free fall.

Use your answer in (b) to determine the length L .

$$L = \dots\dots\dots \text{ m [2]}$$

- (d) Another pendulum consists of a sphere Q suspended by a thread. Spheres P and Q are identical. The thread attached to sphere Q is longer than the thread attached to sphere P.

Sphere Q is displaced and then released. The oscillations of sphere Q have the same amplitude as the oscillations of sphere P.

On Fig. 3.2, sketch the variation of the velocity v with displacement x for sphere Q. [2]

[Total: 9]

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- 4 (a) The defining equation of simple harmonic motion is

$$a = -\omega^2 x.$$

State the significance of the minus (–) sign in the equation.

.....
 [1]

- (b) A trolley rests on a bench. Two identical stretched springs are attached to the trolley as shown in Fig. 4.1. The other end of each spring is attached to a fixed support.

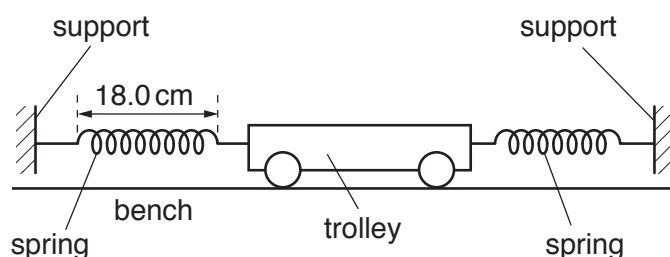


Fig. 4.1

The unstretched length of each spring is 12.0 cm. The spring constant of each spring is 8.0 N m^{-1} . When the trolley is in equilibrium the length of each spring is 18.0 cm.

The trolley is displaced 4.8 cm to one side and then released. Assume that resistive forces on the trolley are negligible.

- (i) Show that the resultant force on the trolley at the moment of release is 0.77 N.

[2]

- (ii) The mass of the trolley is 250 g.

Calculate the maximum acceleration a of the trolley.

$$a = \dots\dots\dots \text{ms}^{-2} \quad [1]$$

- (iii) Use your answer in (ii) to determine the period T of the subsequent oscillation.

$$T = \dots\dots\dots \text{s} \quad [3]$$

- (iv) The experiment is repeated with an initial displacement of the trolley of 2.4 cm.

State and explain the effect, if any, this change has on the period of the oscillation of the trolley.

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

[Total: 9]

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

.....

.....

..... [2]

(b) A trolley of mass m is held on a horizontal surface by means of two springs. One spring is attached to a fixed point P. The other spring is connected to an oscillator, as shown in Fig. 3.1.

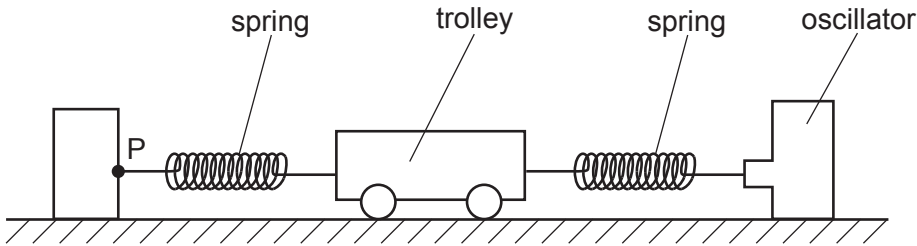


Fig. 3.1

The springs, each having spring constant k of 130 N m^{-1} , are always extended.

The oscillator is switched off. The trolley is displaced along the line of the springs and then released. The resulting oscillations of the trolley are simple harmonic.

The acceleration a of the trolley is given by the expression

$$a = -\left(\frac{2k}{m}\right)x$$

where x is the displacement of the trolley from its equilibrium position.

The mass of the trolley is 840 g .

Calculate the frequency f of oscillation of the trolley.

$f =$ Hz [3]

- (c) The oscillator in (b) is switched on. The frequency of oscillation of the oscillator is varied, keeping its amplitude of oscillation constant.

The amplitude of oscillation of the trolley is seen to vary. The amplitude is a maximum at the frequency calculated in (b).

- (i) State the name of the effect giving rise to this maximum.

..... [1]

- (ii) At any given frequency, the amplitude of oscillation of the trolley is constant.

Explain how this indicates that there are resistive forces opposing the motion of the trolley.

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

[Total: 8]

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38. Question part 1/2 | 9702 May-June 2021 P4 V2 Q3

- 3 A U-shaped tube contains some liquid. The liquid column in each half of the tube has length L , as shown in Fig. 3.1.

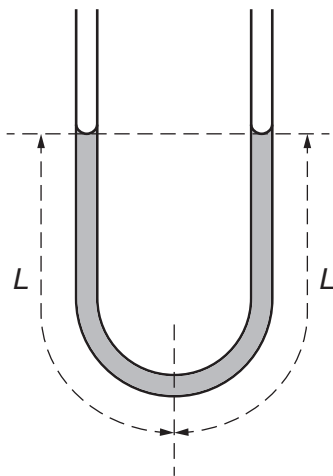


Fig. 3.1

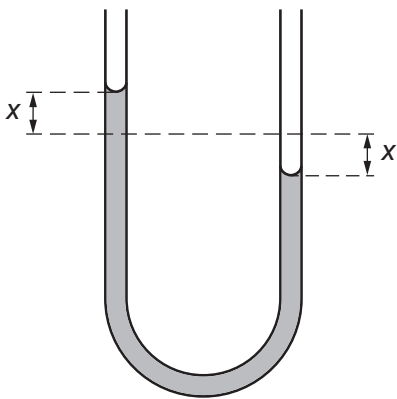


Fig. 3.2

The liquid columns are displaced vertically. The liquid then oscillates in the tube. The liquid levels are displaced from the equilibrium positions as shown in Fig. 3.2.

The acceleration a of the liquid in the tube is related to the displacement x by the expression

$$a = - \left(\frac{g}{L} \right) x$$

where g is the acceleration of free fall.

- (a) Explain how the expression shows that the liquid in the tube is undergoing simple harmonic motion.

.....

.....

.....

.....

..... [3]

- (b) The length L of each liquid column is 18 cm.

Determine the period T of the oscillations.

$T =$ s [3]

9702 Physics Paper 4 - Oscillations

Topical questions | 70 questions

38. Question part 2/2 | 9702 May-June 2021 P4 V2 Q3

- (c) The oscillations of the liquid in the tube are damped.
In any one complete cycle of the oscillations, the amplitude decreases by 6.0% of its value at the beginning of the oscillation.

Determine the ratio

$$\frac{\text{energy of oscillations after 3 cycles}}{\text{initial energy of oscillations}} .$$

ratio = ... [3]

[Total: 9]

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

.....

.....

..... [2]

(b) A trolley of mass m is held on a horizontal surface by means of two springs. One spring is attached to a fixed point P. The other spring is connected to an oscillator, as shown in Fig. 3.1.

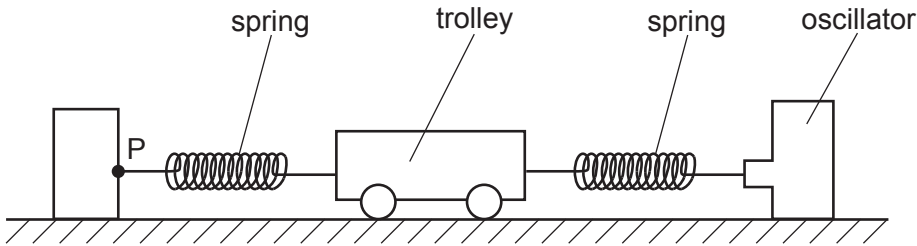


Fig. 3.1

The springs, each having spring constant k of 130 N m^{-1} , are always extended.

The oscillator is switched off. The trolley is displaced along the line of the springs and then released. The resulting oscillations of the trolley are simple harmonic.

The acceleration a of the trolley is given by the expression

$$a = -\left(\frac{2k}{m}\right)x$$

where x is the displacement of the trolley from its equilibrium position.

The mass of the trolley is 840 g .

Calculate the frequency f of oscillation of the trolley.

$f =$ Hz [3]

- (c) The oscillator in (b) is switched on. The frequency of oscillation of the oscillator is varied, keeping its amplitude of oscillation constant.

The amplitude of oscillation of the trolley is seen to vary. The amplitude is a maximum at the frequency calculated in (b).

- (i) State the name of the effect giving rise to this maximum.

..... [1]

- (ii) At any given frequency, the amplitude of oscillation of the trolley is constant.

Explain how this indicates that there are resistive forces opposing the motion of the trolley.

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

[Total: 8]

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40. Question part 1/3 | 9702 Oct-Nov 2021 P4 V1 Q4

- 4 A trolley on a track is attached by springs to fixed blocks X and Y, as shown in Fig. 4.1. The track contains many small holes through which air is blown vertically upwards. This results in the trolley resting on a cushion of air rather than being in direct contact with the track.

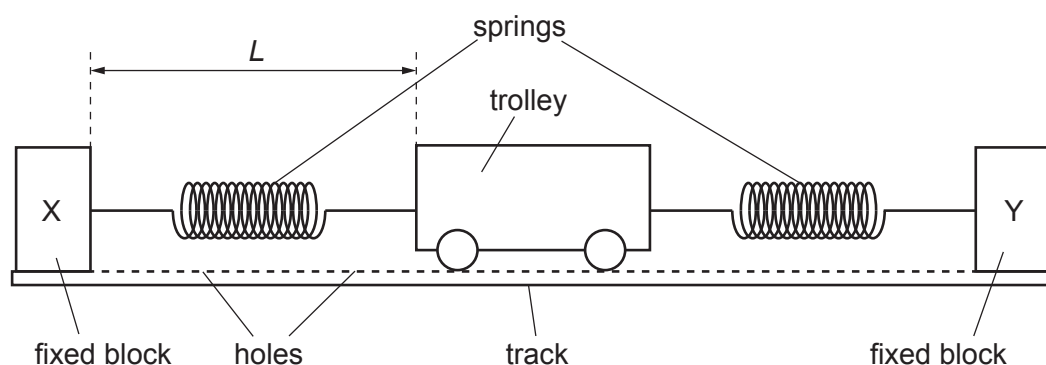


Fig. 4.1

The trolley is pulled to one side of its equilibrium position and then released so that it oscillates initially with simple harmonic motion. After a short time, the air blower is switched off. The variation with time t of the distance L of the trolley from block X is shown in Fig. 4.2.

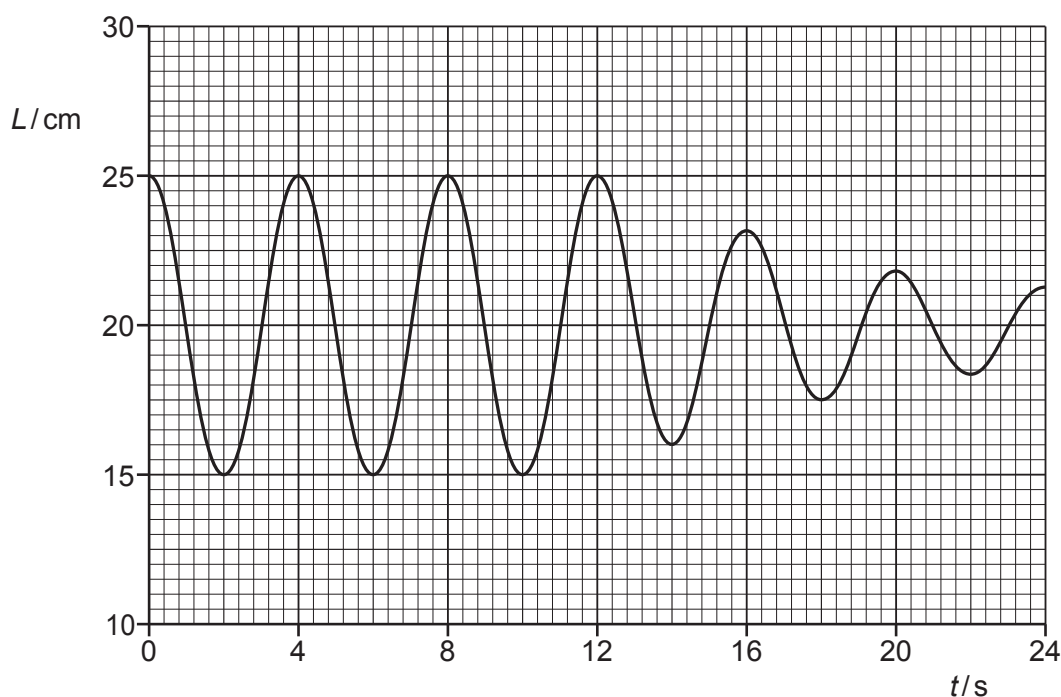


Fig. 4.2

(a) Use Fig. 4.2 to determine:

- (i) the initial amplitude of the oscillations

amplitude = ... cm [1]

- (ii) the angular frequency ω of the oscillations

$$\omega = \dots\dots\dots \text{ rad s}^{-1} \quad [2]$$

- (iii) the maximum speed v_0 , in cm s^{-1} , of the oscillating trolley.

$$v_0 = \dots\dots\dots \text{ cm s}^{-1} \quad [2]$$

- (b) Apart from the quantities in (a), describe what may be deduced from Fig. 4.2 about the motion of the trolley between time $t = 0$ and time $t = 24$ s. No calculations are required.

.....

.....

.....

.....

..... [3]

- (c) On Fig. 4.3, sketch the variation with L of the velocity v of the trolley for its first complete oscillation.

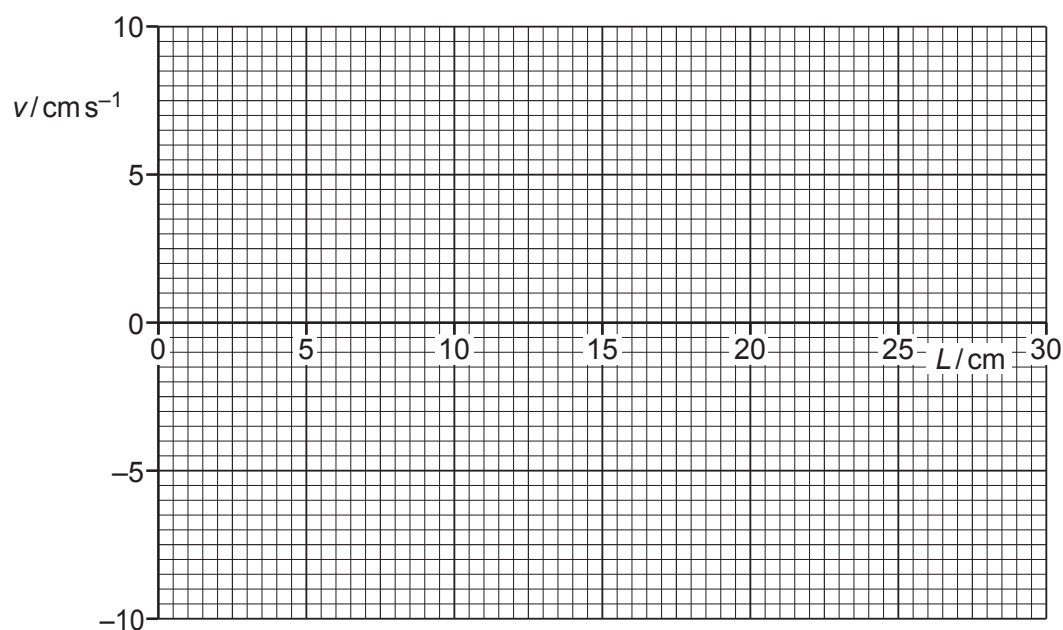


Fig. 4.3

[3]

[Total: 11]

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41. Question part 1/2 | 9702 Oct-Nov 2021 P4 V2 Q4

- 4 A trolley on a smooth surface is attached by springs to fixed blocks as shown in Fig. 4.1.

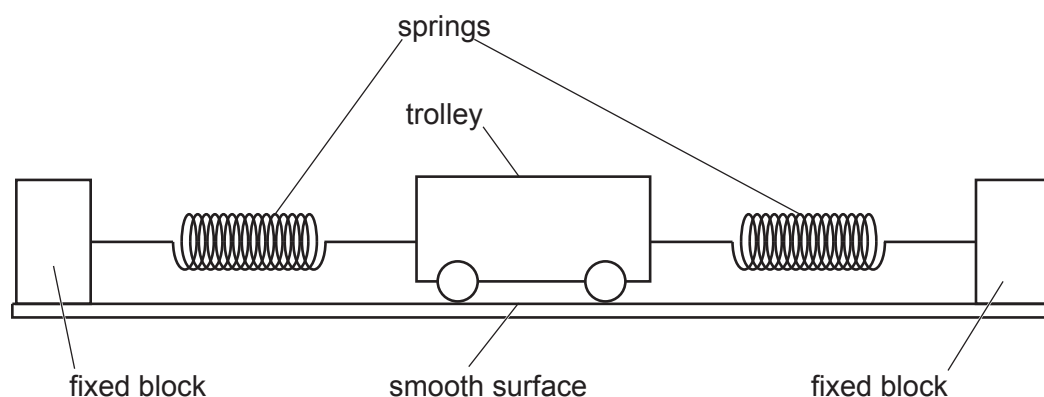


Fig. 4.1

The trolley oscillates horizontally about its equilibrium position with an amplitude of 12 cm. Fig. 4.2 shows the variation of the acceleration a of the trolley with displacement x from its equilibrium position. Friction between the trolley and the surface can be assumed to be negligible.

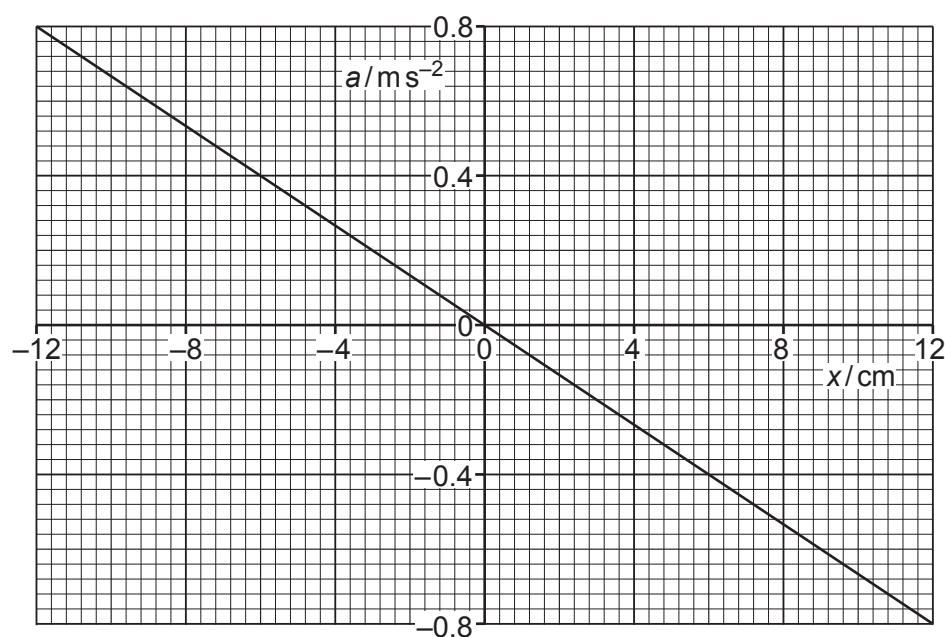


Fig. 4.2

- (a) Describe the features of the line in Fig. 4.2 that demonstrate that the motion of the trolley is simple harmonic.

.....

.....

..... [2]

(b) Use Fig. 4.2 to determine the period T of the oscillations of the trolley.

$T = \dots\dots\dots$ s [3]

(c) (i) On the line of the graph of Fig. 4.2, label with the letter P one point where the kinetic energy of the trolley is zero. [1]

(ii) On the line of the graph of Fig. 4.2, label with the letter Q an approximate position of one point where the kinetic energy of the trolley is equal to the potential energy stored in the springs. [1]

[Total: 7]

42. Question part 1/3 | 9702 Oct-Nov 2021 P4 V3 Q4

- 4 A trolley on a track is attached by springs to fixed blocks X and Y, as shown in Fig. 4.1. The track contains many small holes through which air is blown vertically upwards. This results in the trolley resting on a cushion of air rather than being in direct contact with the track.

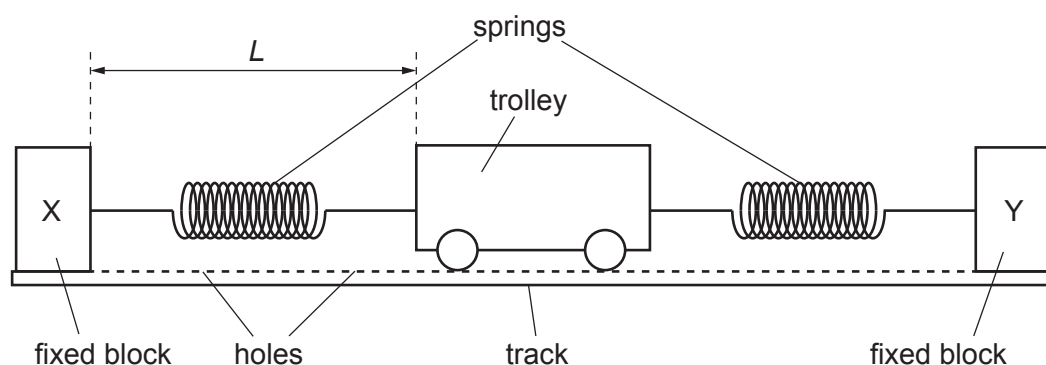


Fig. 4.1

The trolley is pulled to one side of its equilibrium position and then released so that it oscillates initially with simple harmonic motion. After a short time, the air blower is switched off. The variation with time t of the distance L of the trolley from block X is shown in Fig. 4.2.

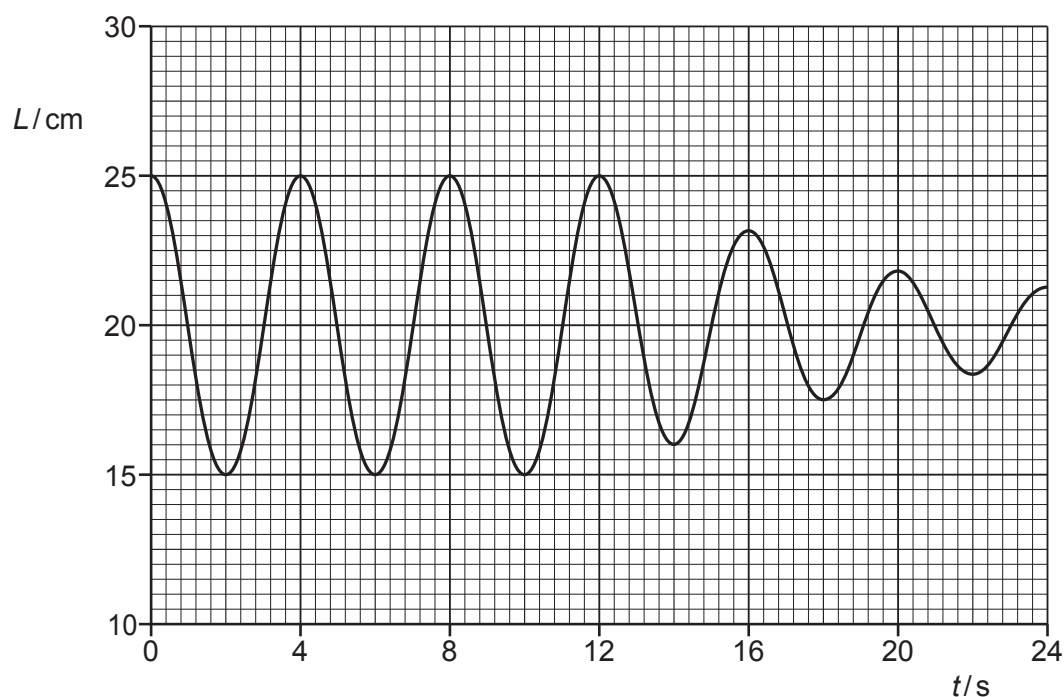


Fig. 4.2

(a) Use Fig. 4.2 to determine:

- (i) the initial amplitude of the oscillations

amplitude = ... cm [1]

- (ii) the angular frequency ω of the oscillations

$$\omega = \dots\dots\dots \text{ rad s}^{-1} \quad [2]$$

- (iii) the maximum speed v_0 , in cm s^{-1} , of the oscillating trolley.

$$v_0 = \dots\dots\dots \text{ cm s}^{-1} \quad [2]$$

- (b) Apart from the quantities in (a), describe what may be deduced from Fig. 4.2 about the motion of the trolley between time $t = 0$ and time $t = 24$ s. No calculations are required.

.....

.....

.....

.....

..... [3]

- (c) On Fig. 4.3, sketch the variation with L of the velocity v of the trolley for its first complete oscillation.

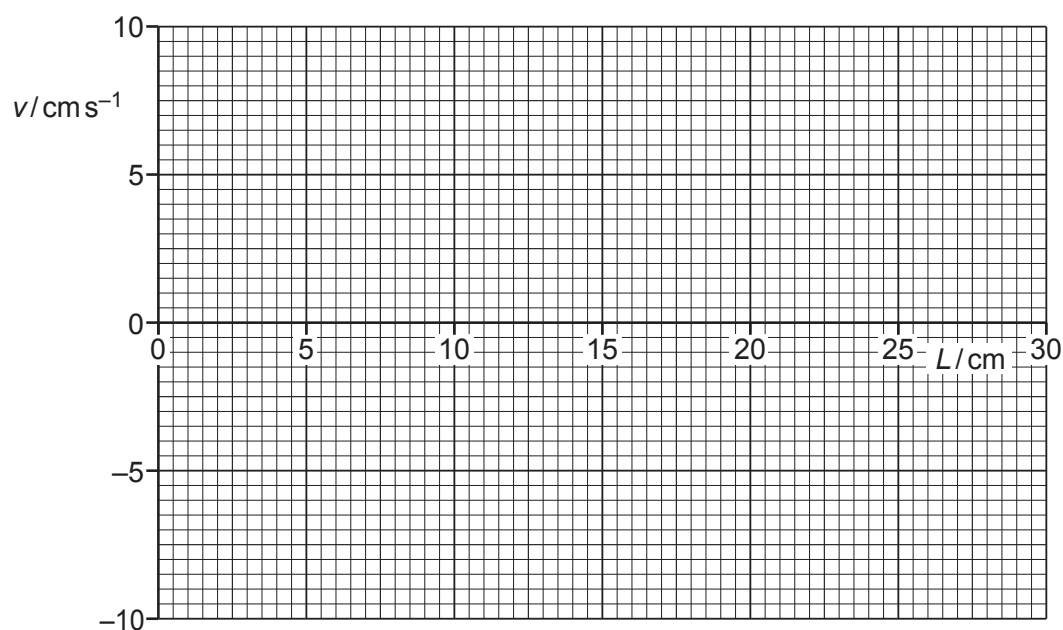


Fig. 4.3

[3]

[Total: 11]

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43. Question part 1/3 | 9702 Feb-March 2022 P4 V2 Q3

- 3 A small wooden block (cuboid) of mass m floats in water, as shown in Fig. 3.1.

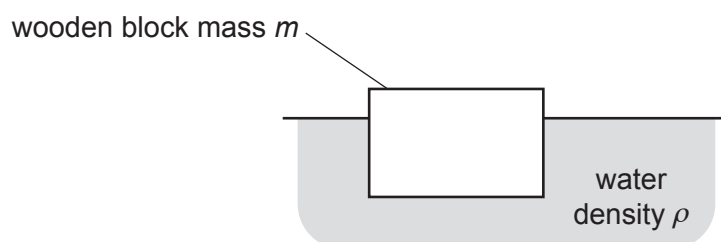


Fig. 3.1

The top face of the block is horizontal and has area A . The density of the water is ρ .

- (a) State the names of the two forces acting on the block when it is stationary.

..... [1]

- (b) The block is now displaced downwards as shown in Fig. 3.2 so that the surface of the water is higher up the block.

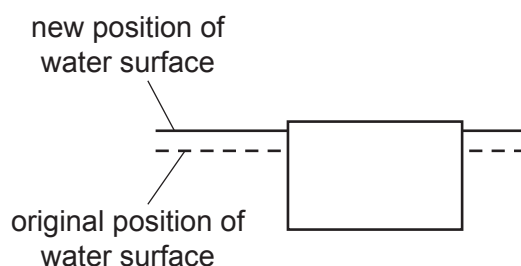


Fig. 3.2

State and explain the direction of the resultant force acting on the wooden block in this position.

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

(c) The block in (b) is now released so that it oscillates vertically.

The resultant force F acting on the block is given by

$$F = -Ag\rho x$$

where g is the gravitational field strength and x is the vertical displacement of the block from the equilibrium position.

(i) Explain why the oscillations of the block are simple harmonic.

.....

.....

..... [2]

(ii) Show that the angular frequency ω of the oscillations is given by

$$\omega = \sqrt{\frac{A\rho g}{m}}.$$

- (d) The block is now placed in a liquid with a greater density. The block is displaced and released so that it oscillates vertically. The variation with displacement x of the acceleration a of the block is measured for the first half oscillation, as shown in Fig. 3.3.

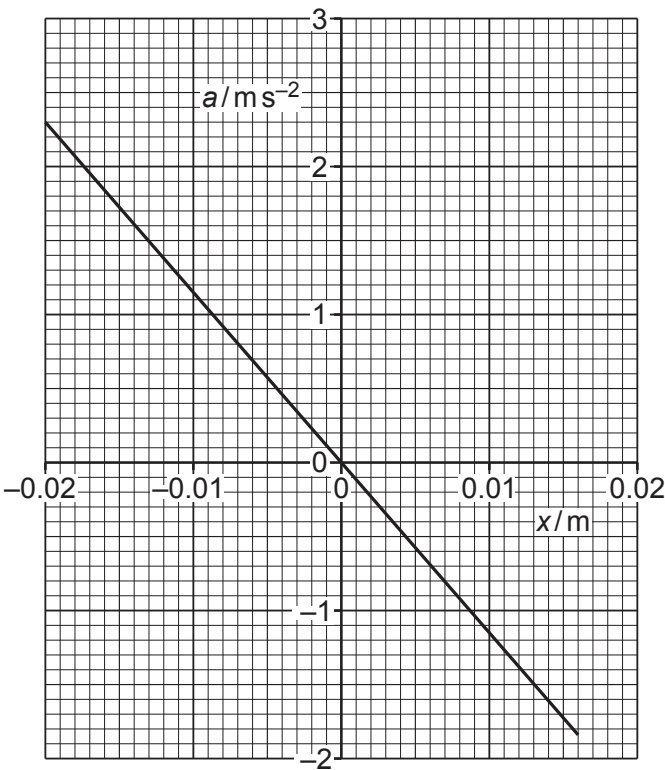


Fig. 3.3

- (i) Explain why the maximum negative displacement of the block is not equal to its maximum positive displacement.

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

- (ii) The mass of the block is 0.57 kg.

Use Fig. 3.3 to determine the decrease ΔE in energy of the oscillation for the first half oscillation.

$E =$ J [3]

[Total: 10]

44. Question part 1/2 | 9702 May-June 2022 P4 V1 Q4

- 4 A pendulum consists of a bob (small metal sphere) attached to the end of a piece of string. The other end of the string is attached to a fixed point. The bob oscillates with small oscillations about its equilibrium position, as shown in Fig. 4.1.

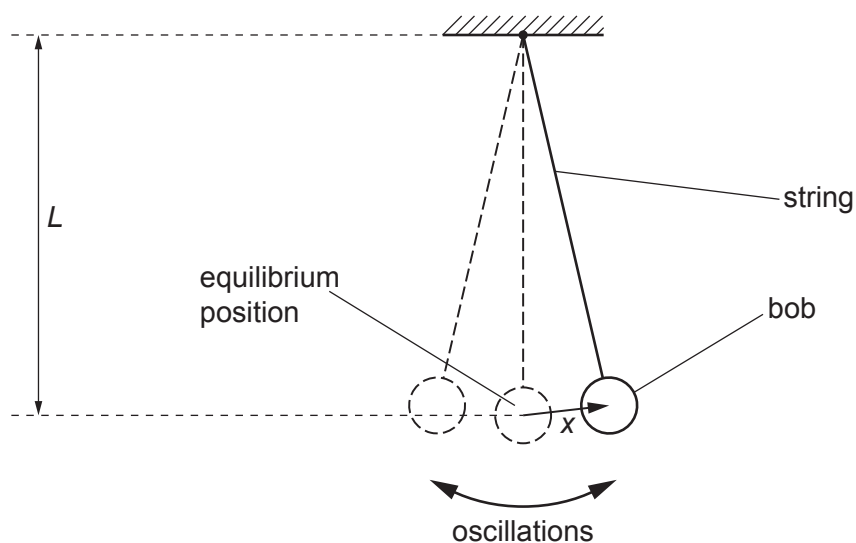


Fig. 4.1 (not to scale)

The length L of the pendulum, measured from the fixed point to the centre of the bob, is 1.24 m.

The acceleration a of the bob varies with its displacement x from the equilibrium position as shown in Fig. 4.2.

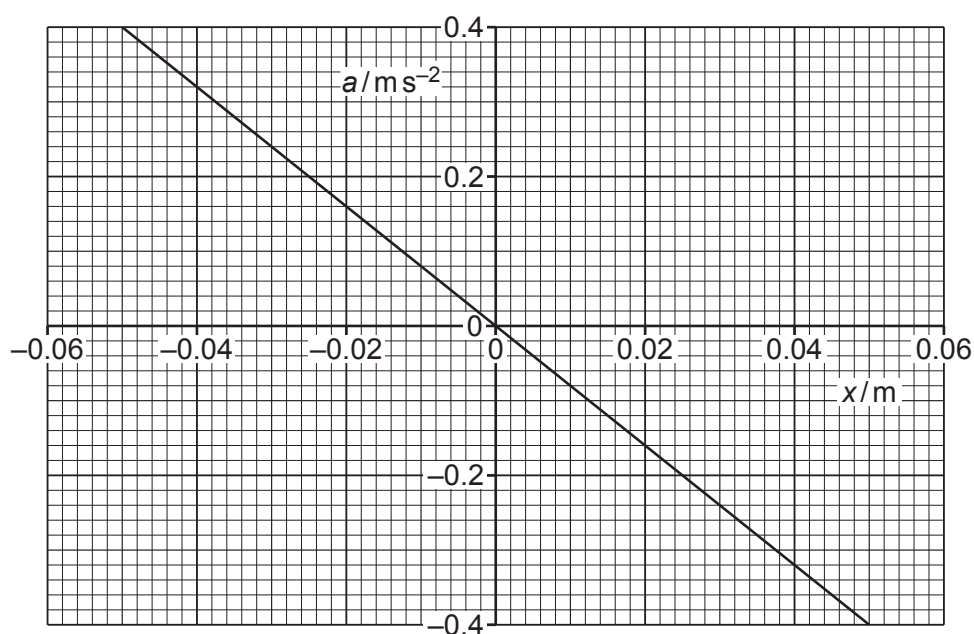


Fig. 4.2

(a) State how Fig. 4.2 shows that the motion of the pendulum is simple harmonic.

.....

.....

..... [2]

(b) (i) Use Fig. 4.2 to determine the angular frequency ω of the oscillations.

$\omega =$ rad s^{-1} [2]

(ii) The angular frequency ω is related to the length L of the pendulum by

$$\omega = \sqrt{\frac{k}{L}}$$

where k is a constant.

Use your answer in (b)(i) to determine k . Give a unit with your answer.

$k =$ unit [2]

(c) While the pendulum is oscillating, the length of the string is increased in such a way that the total energy of the oscillations remains constant.

Suggest and explain the qualitative effect of this change on the amplitude of the oscillations.

.....

.....

..... [2]

- 4 (a) State what is meant by resonance.

.....

.....

..... [2]

- (b) Fig. 4.1 shows a heavy pendulum and a light pendulum, both suspended from the same piece of string. This string is secured at each end to fixed points.

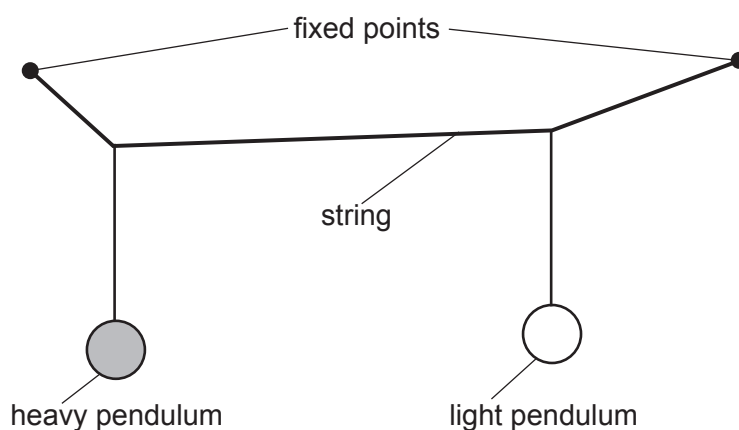


Fig. 4.1

Both pendulums have the same natural frequency.

The heavy pendulum is set oscillating perpendicular to the plane of the diagram. As it oscillates, it causes the light pendulum to oscillate.

Fig. 4.2 shows the variation with time t of the displacements of the two pendulums for three oscillations.

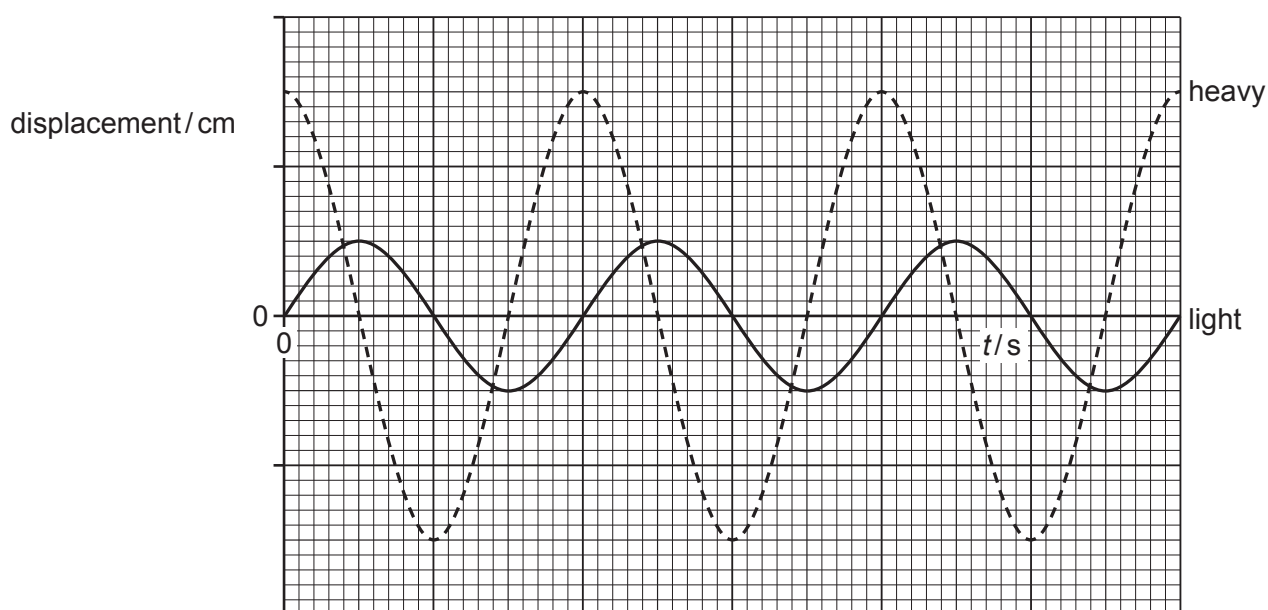


Fig. 4.2

The variation with t of the displacement x of the light pendulum is given by

$$x = 0.25 \sin 5.0\pi t$$

where x is in centimetres and t is in seconds.

- (i) Calculate the period T of the oscillations.

$$T = \dots\dots\dots \text{ s [2]}$$

- (ii) On Fig. 4.2, label both of the axes with the correct scales. Use the space below for any additional working that you need.

[2]

- (iii) Determine the magnitude of the phase difference ϕ between the oscillations of the light and heavy pendulums. Give a unit with your answer.

$$\phi = \dots\dots\dots \text{ unit } \dots\dots\dots \text{ [2]}$$

[Total: 8]

46. Question part 1/2 | 9702 May-June 2022 P4 V3 Q4

- 4 A pendulum consists of a bob (small metal sphere) attached to the end of a piece of string. The other end of the string is attached to a fixed point. The bob oscillates with small oscillations about its equilibrium position, as shown in Fig. 4.1.

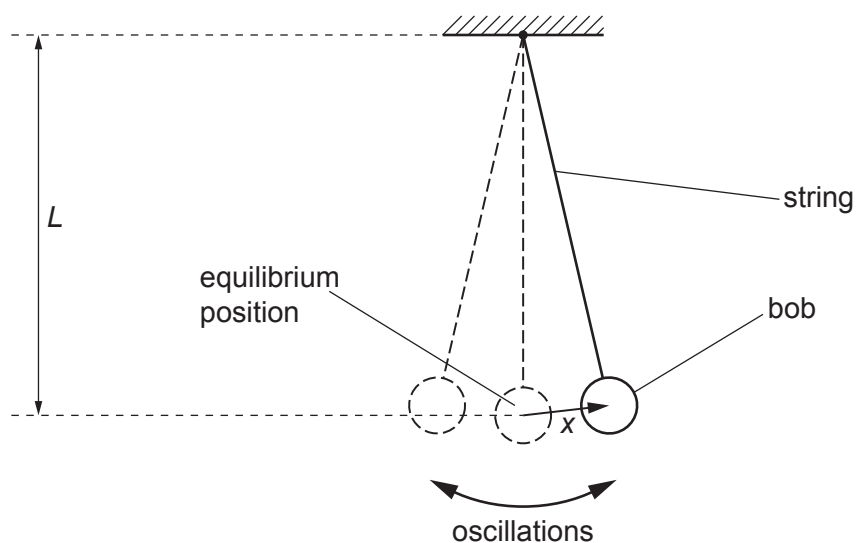


Fig. 4.1 (not to scale)

The length L of the pendulum, measured from the fixed point to the centre of the bob, is 1.24 m.

The acceleration a of the bob varies with its displacement x from the equilibrium position as shown in Fig. 4.2.

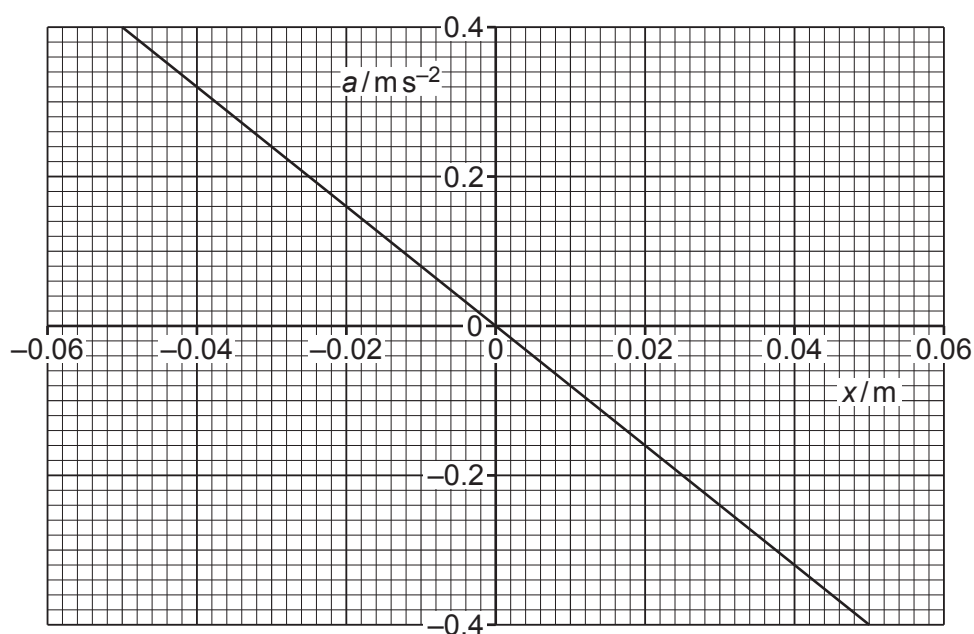


Fig. 4.2

(a) State how Fig. 4.2 shows that the motion of the pendulum is simple harmonic.

.....

.....

..... [2]

(b) (i) Use Fig. 4.2 to determine the angular frequency ω of the oscillations.

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

(ii) The angular frequency ω is related to the length L of the pendulum by

$$\omega = \sqrt{\frac{k}{L}}$$

where k is a constant.

Use your answer in (b)(i) to determine k . Give a unit with your answer.

$k = \dots\dots\dots \text{unit } \dots\dots\dots$ [2]

(c) While the pendulum is oscillating, the length of the string is increased in such a way that the total energy of the oscillations remains constant.

Suggest and explain the qualitative effect of this change on the amplitude of the oscillations.

.....

.....

..... [2]

- 3 An object is suspended from a spring that is attached to a fixed point as shown in Fig. 3.1.

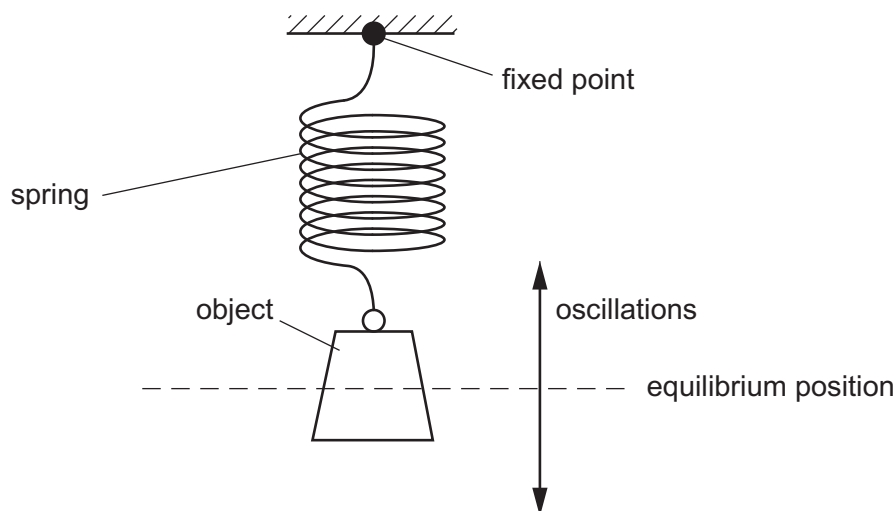


Fig. 3.1

The object oscillates vertically with simple harmonic motion about its equilibrium position.

- (a) State the defining equation for simple harmonic motion. Identify the meaning of each of the symbols used to represent physical quantities.

.....

 [2]

- (b) The variation with displacement x from the equilibrium position of the velocity v of the object is shown in Fig. 3.2.

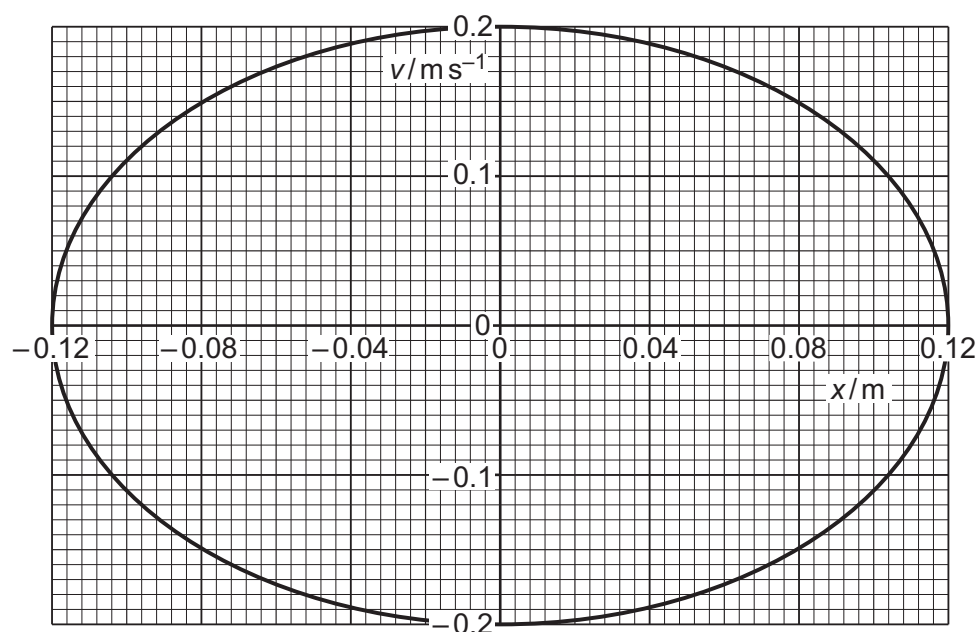


Fig. 3.2

The variation with x of the potential energy E_p of the oscillations of the object is shown in Fig. 3.3.

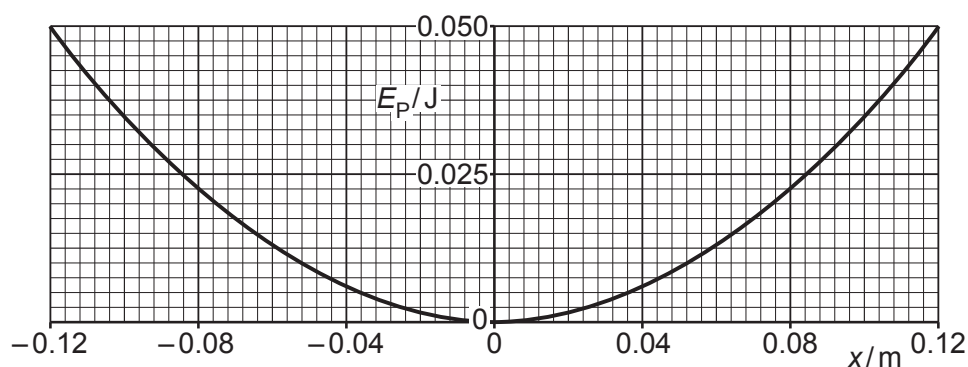


Fig. 3.3

Use Fig. 3.2 and Fig. 3.3 to:

- (i) determine the amplitude x_0 of the oscillations

$$x_0 = \dots\dots\dots \text{ m [1]}$$

- (ii) show that the angular frequency of the oscillations is 1.7 rad s^{-1}

[2]

- (iii) determine the mass M of the object.

$$M = \dots\dots\dots \text{ kg [2]}$$

(c) The oscillations of the object are now lightly damped.

(i) State what is meant by damping.

.....

.....

..... [2]

(ii) Assume that the damping does not change the angular frequency of the oscillations.

On Fig. 3.2, sketch the variation with x of v when the amplitude of the oscillations is 0.060 m. [2]

[Total: 11]

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- 4 Fig. 4.1 shows the variation with time t of the height h above the ground of an object of mass 36 kg that is undergoing vertical simple harmonic motion.

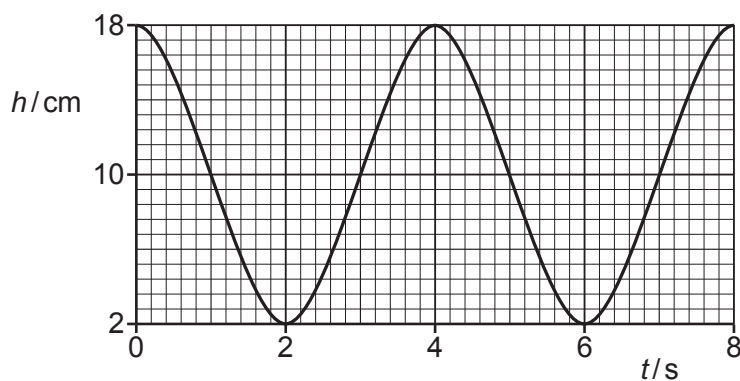


Fig. 4.1

(a) For the oscillations of the object:

- (i) determine the amplitude x_0 , in cm

$$x_0 = \dots\dots\dots \text{ cm [1]}$$

- (ii) show that the angular frequency ω is 1.6 rad s^{-1}

[2]

- (iii) determine the total energy E .

$$E = \dots\dots\dots \text{ J [3]}$$

(b) On Fig. 4.2, sketch the variation with h of the kinetic energy E_K of the object.

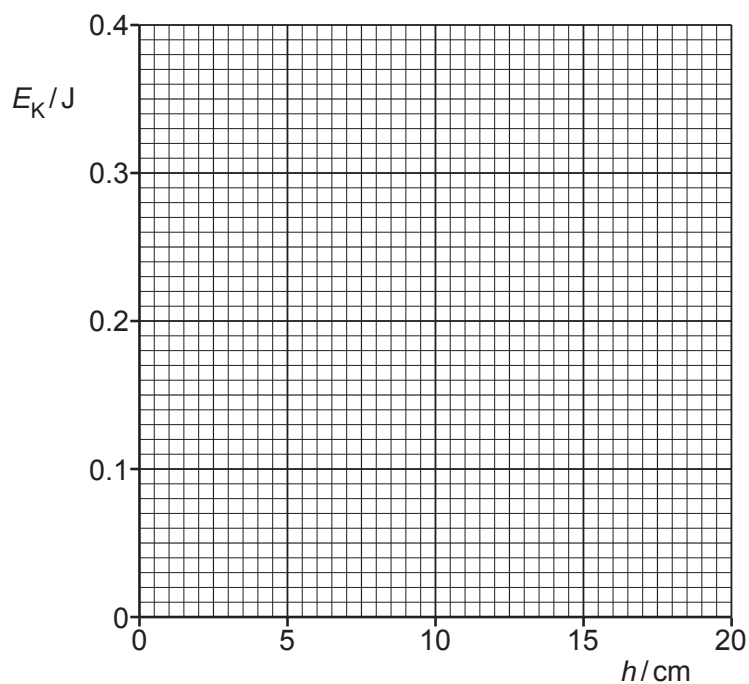


Fig. 4.2

[4]

[Total: 10]

- 3 An object is suspended from a spring that is attached to a fixed point as shown in Fig. 3.1.

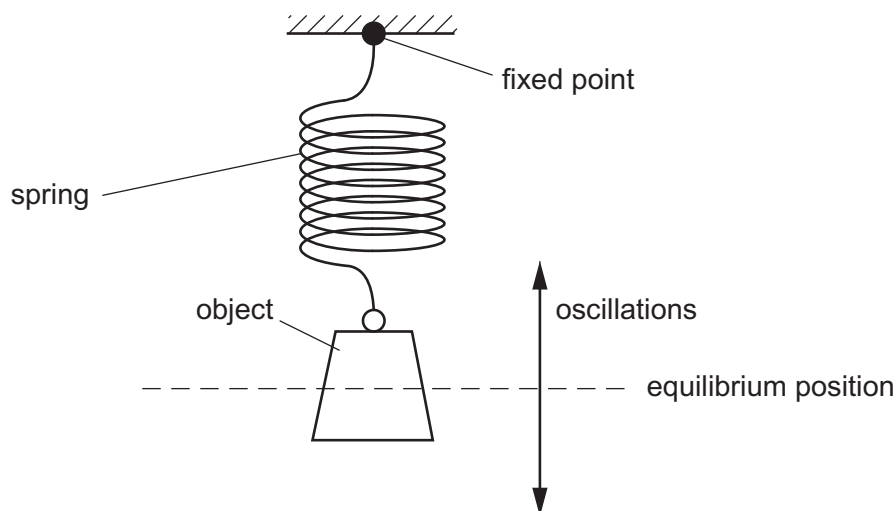


Fig. 3.1

The object oscillates vertically with simple harmonic motion about its equilibrium position.

- (a) State the defining equation for simple harmonic motion. Identify the meaning of each of the symbols used to represent physical quantities.

.....

.....

..... [2]

- (b) The variation with displacement x from the equilibrium position of the velocity v of the object is shown in Fig. 3.2.

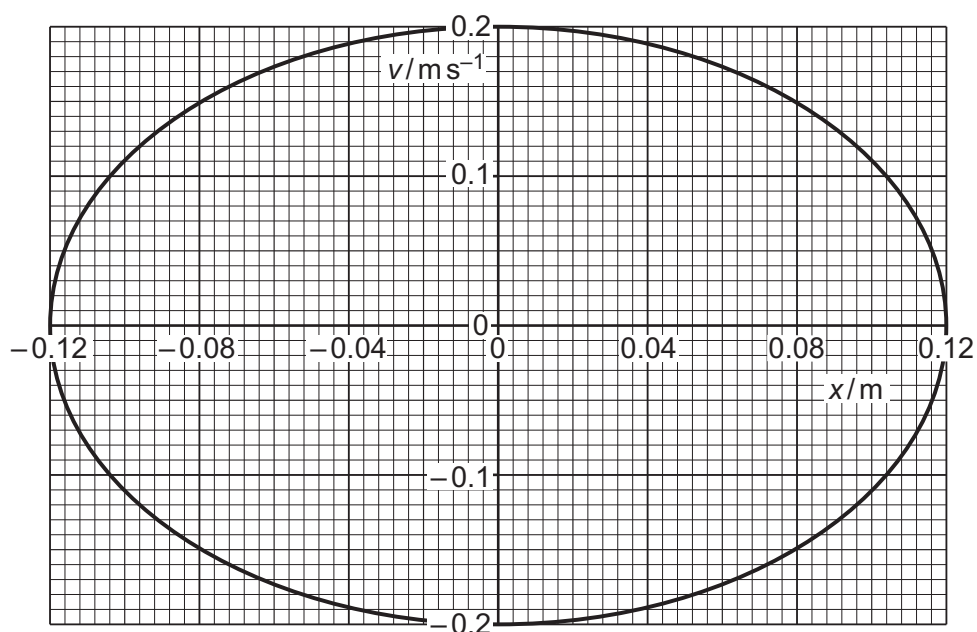


Fig. 3.2

The variation with x of the potential energy E_p of the oscillations of the object is shown in Fig. 3.3.

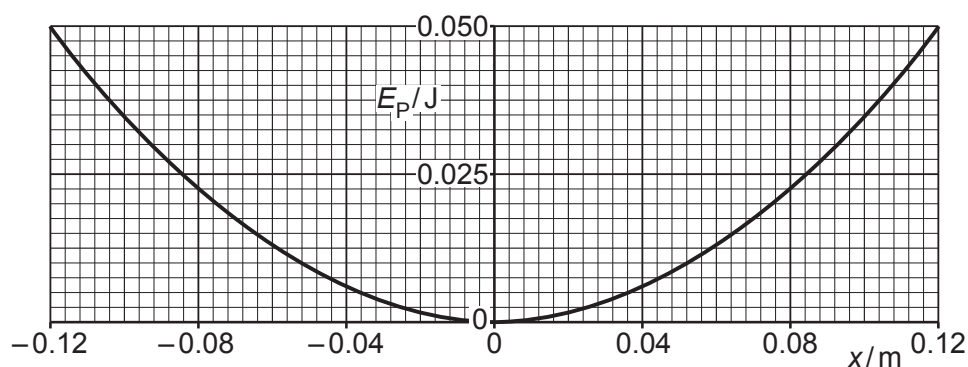


Fig. 3.3

Use Fig. 3.2 and Fig. 3.3 to:

- (i) determine the amplitude x_0 of the oscillations

$$x_0 = \dots\dots\dots \text{ m [1]}$$

- (ii) show that the angular frequency of the oscillations is 1.7 rad s^{-1}

[2]

- (iii) determine the mass M of the object.

$$M = \dots\dots\dots \text{ kg [2]}$$

(c) The oscillations of the object are now lightly damped.

(i) State what is meant by damping.

.....

.....

..... [2]

(ii) Assume that the damping does not change the angular frequency of the oscillations.

On Fig. 3.2, sketch the variation with x of v when the amplitude of the oscillations is 0.060 m. [2]

[Total: 11]

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- 3** A bar magnet of mass 250 g is suspended from the free end of a spring, as illustrated in Fig. 3.1.

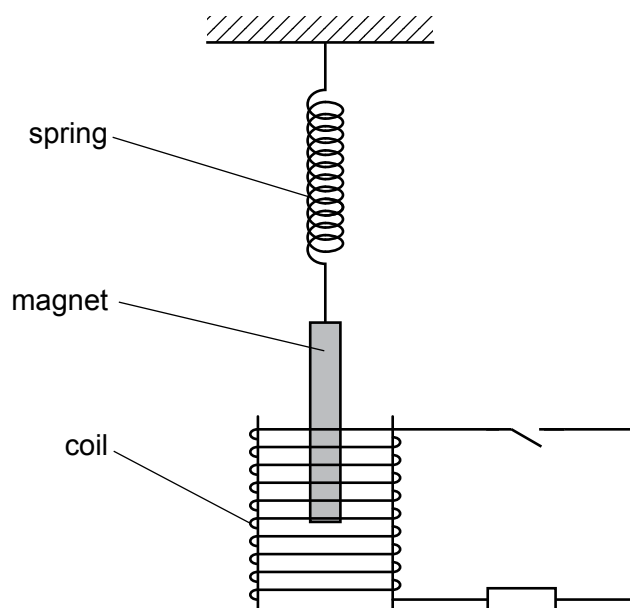


Fig. 3.1

The magnet hangs so that one pole is near the centre of a coil of wire.
The coil is connected in series with a resistor and a switch. The switch is open.

The magnet is displaced vertically and then allowed to oscillate.

At time $t = 0$, the magnet is oscillating freely. At time $t = 6.0$ s, the switch in the circuit is closed.

The variation with time t of the vertical displacement y of the magnet is shown in Fig. 3.2.

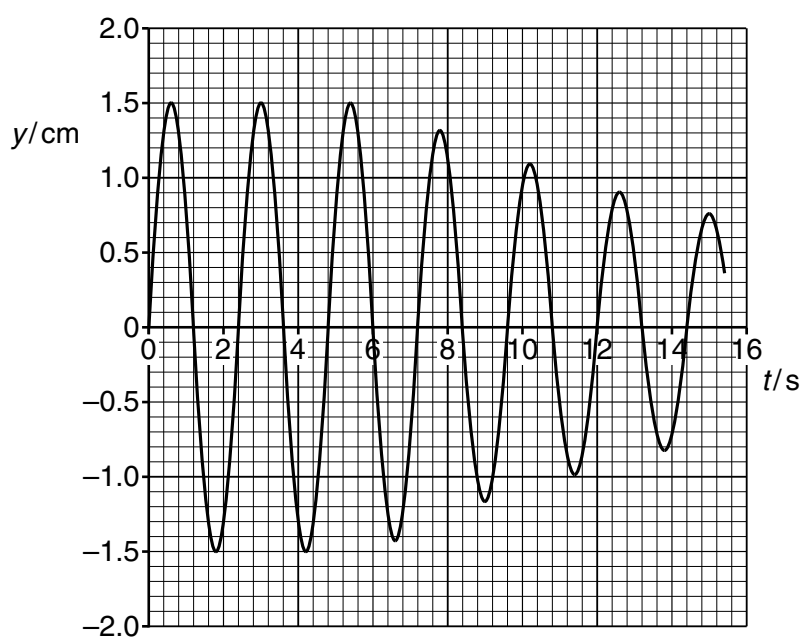


Fig. 3.2

- (a) For the oscillating magnet, use data from Fig. 3.2 to determine, to two significant figures:
- (i) the frequency f

$f = \dots\dots\dots$ Hz [2]

- (ii) the energy of the oscillations during the time interval $t = 0$ to $t = 6.0$ s.

energy = $\dots\dots\dots$ J [3]

- (b) When the switch is closed, the oscillations are damped.

Explain, with reference to Fig. 3.2, whether this damping is light, critical or heavy.

.....

.....

..... [1]

[Total: 6]

- 3 An object is suspended from a vertical spring as shown in Fig. 3.1.

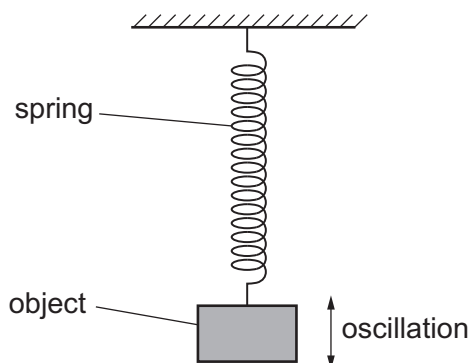


Fig. 3.1

The object is displaced vertically and then released so that it oscillates, undergoing simple harmonic motion.

Fig. 3.2 shows the variation with displacement x of the energy E of the oscillations.

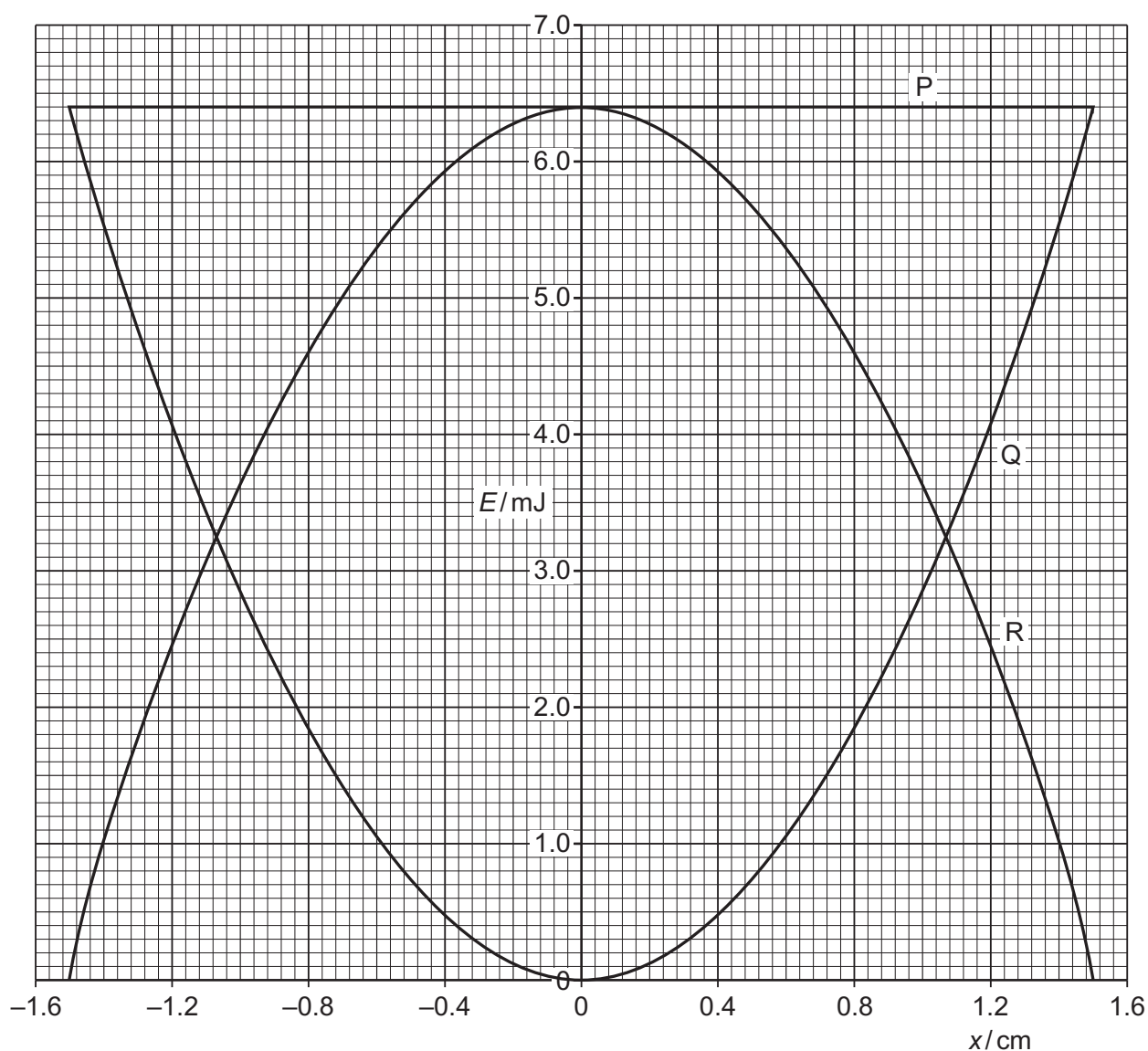


Fig. 3.2

The kinetic energy, the potential energy and the total energy of the oscillations are each represented by one of the lines P, Q and R.

(a) State the energy that is represented by each of the lines P, Q and R.

P
Q
R
[2]

(b) The object has a mass of 130 g.
Determine the period of the oscillations.

period = ... s [4]

(c) (i) State the cause of damping.

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

(ii) A light card is attached to the object. The object is displaced with the same initial amplitude and then released. During each complete oscillation the total energy of the system decreases by 8.0% of the total energy at the start of that oscillation.

Determine the decrease in total energy, in mJ, of the system by the end of the first 6 complete oscillations.

energy lost = ... mJ [2]

(iii) State, with a reason, the type of damping that the card introduces into the system.

.....

.....

..... [1]

[Total: 10]

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- 4 A small steel sphere is oscillating vertically on the end of a spring, as shown in Fig. 4.1.

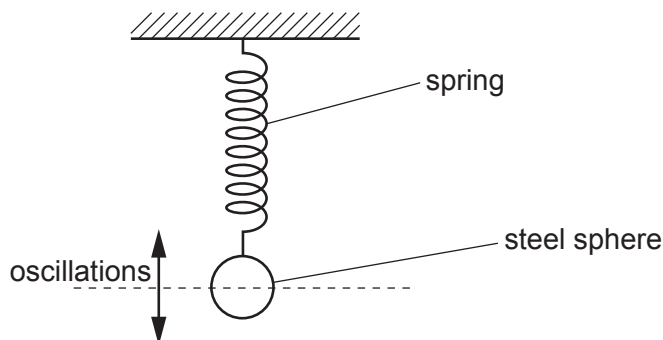


Fig. 4.1

The velocity v of the sphere varies with displacement x from its equilibrium position according to

$$v = \pm 9.7 \sqrt{(11.6 - x^2)}$$

where v is in cm s^{-1} and x is in cm.

- (a) (i) Calculate the frequency of the oscillations.

frequency = ... Hz [2]

- (ii) Show that the amplitude of the oscillations is 3.4 cm.

[1]

- (iii) Calculate the maximum acceleration a_0 of the sphere.

$a_0 = \dots \text{ms}^{-2}$ [2]

(b) On Fig. 4.2, sketch the variation with x of the acceleration a of the sphere.

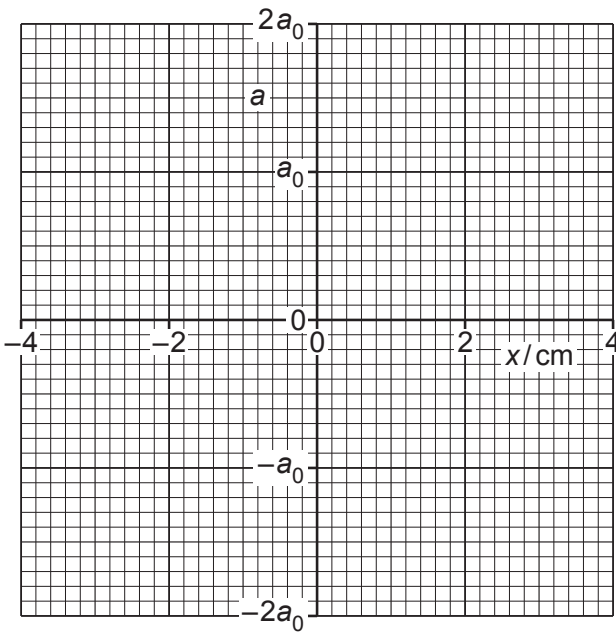


Fig. 4.2

[3]

(c) Describe, without calculation, the interchange between the potential energy and the kinetic energy of the oscillations.

.....

.....

.....

.....

..... [3]

[Total: 11]

- 4 A heavy metal sphere of mass 0.81 kg is suspended from a string. The sphere is undergoing small oscillations from side to side, as shown in Fig. 4.1.

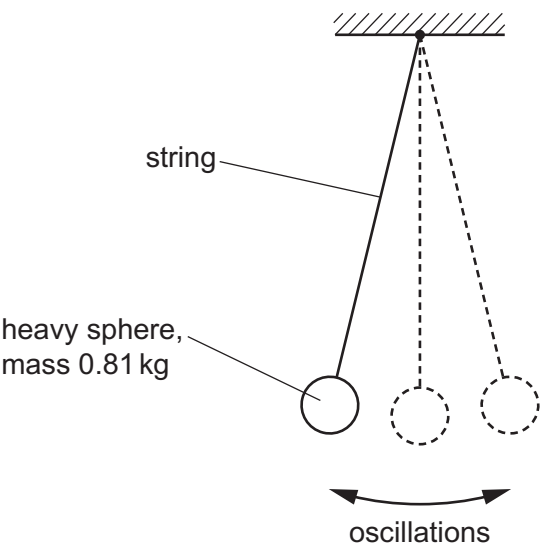


Fig. 4.1

The oscillations of the sphere may be considered to be simple harmonic with amplitude 0.036 m and period 3.0 s.

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

.....

.....

..... [2]

- (b) Calculate:

- (i) the angular frequency of the oscillations

angular frequency = ... rad s^{-1} [2]

(ii) the total energy of the oscillations.

total energy = ... J [2]

(c) The suspended sphere is now lowered into water. The sphere is given a sideways displacement of +0.036 m from its equilibrium position and is then released at time $t = 0$. The water causes the motion of the sphere to be critically damped.

On Fig. 4.2, sketch the variation of the displacement x of the sphere from its equilibrium position with t from $t = 0$ to $t = 6.0$ s.

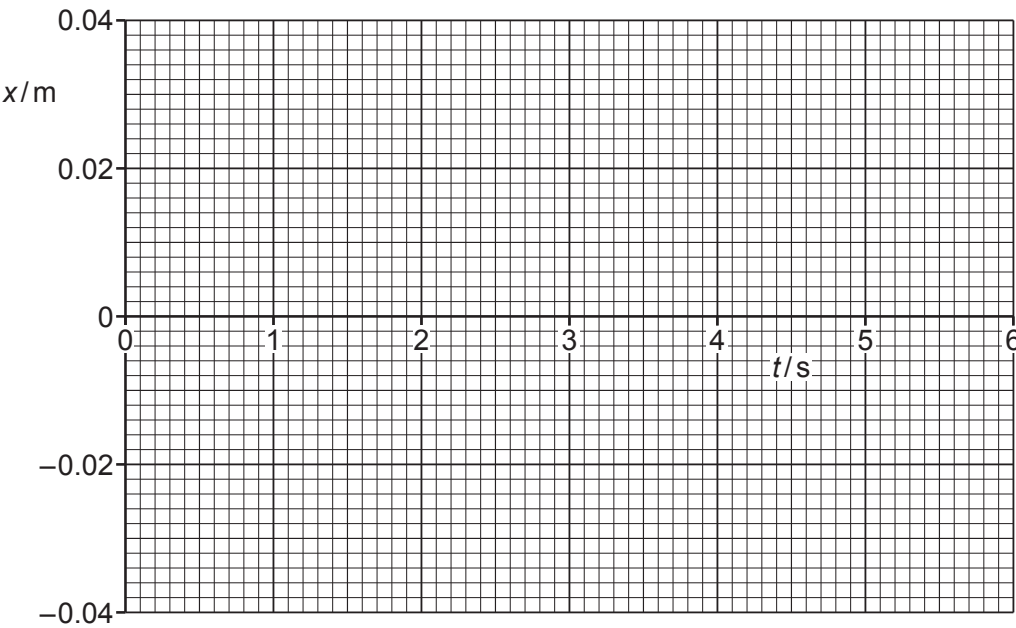


Fig. 4.2

[3]

[Total: 9]

54. Question part 1/2 | 9702 Oct-Nov 2023 P4 V2 Q4

- 4 An electron in a metal rod moves randomly about a mean position. When an alternating voltage is applied to the ends of the rod, the mean position can be considered to oscillate with simple harmonic motion along the axis of the rod. Fig. 4.1 shows the variation with time t of the displacement x of the mean position from a fixed point on the axis of the rod.

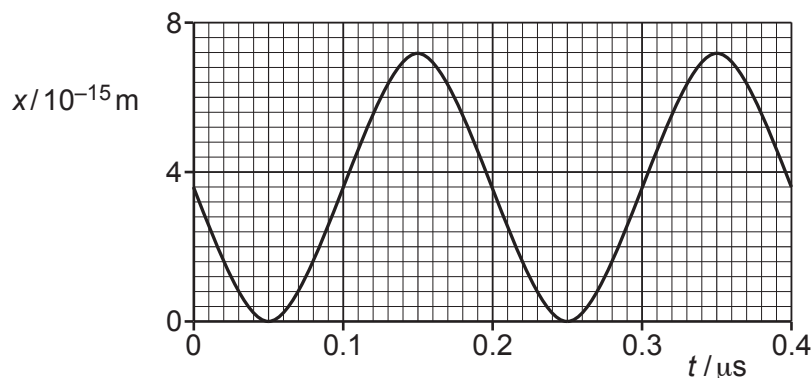


Fig. 4.1

- (a) (i) Determine the amplitude of the oscillations.

amplitude = ... m [1]

- (ii) Determine the angular frequency of the oscillations.

angular frequency = ... rad s^{-1} [1]

- (iii) Use your answers in (a)(i) and (a)(ii) to show that the maximum drift speed v_0 of the electron is $1.1 \times 10^{-7} \text{ m s}^{-1}$.

[2]

- (b) The rod has a cross-sectional area of 4.3 cm^2 and contains a number density of conduction electrons (charge carriers) of $8.5 \times 10^{28}\text{ m}^{-3}$.

All of the conduction electrons in the rod may be assumed to be oscillating in phase with, and with the same amplitude as, the oscillation shown in Fig. 4.1.

- (i) Use the information in (a)(iii) to calculate the magnitude I_0 of the maximum current in the rod.

$I_0 = \dots\dots\dots\text{A}$ [2]

- (ii) On Fig. 4.2, sketch the variation of the current I in the rod with time t between $t = 0$ and $t = 0.40\text{ }\mu\text{s}$.

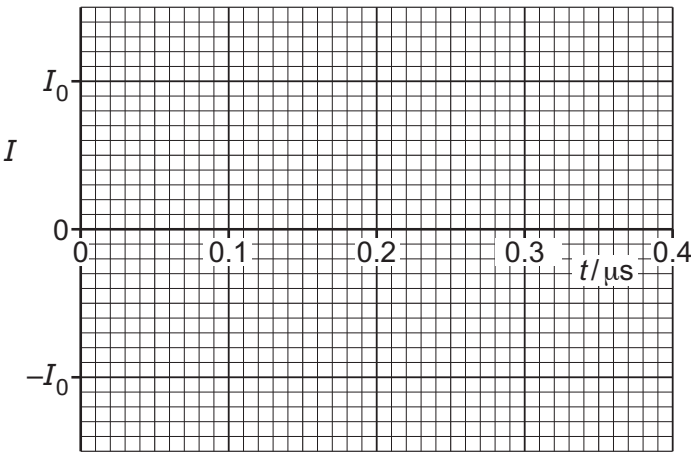


Fig. 4.2 [2]

- (iii) Use your answers in (a)(ii) and (b)(i) to determine an expression for I in terms of t , where I is in A and t is in s.

$I = \dots\dots\dots$ [2]

- (iv) Determine the root-mean-square (r.m.s.) current in the rod.

r.m.s. current = $\dots\dots\dots\text{A}$ [1]

- 4 A heavy metal sphere of mass 0.81 kg is suspended from a string. The sphere is undergoing small oscillations from side to side, as shown in Fig. 4.1.

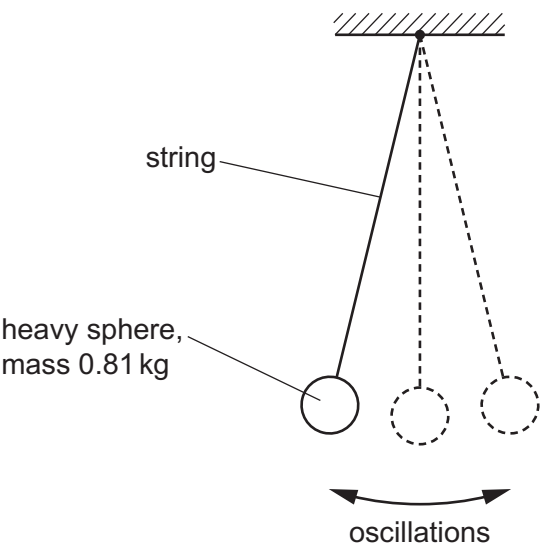


Fig. 4.1

The oscillations of the sphere may be considered to be simple harmonic with amplitude 0.036 m and period 3.0 s.

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

.....

.....

..... [2]

- (b) Calculate:

- (i) the angular frequency of the oscillations

angular frequency = ... rad s^{-1} [2]

(ii) the total energy of the oscillations.

total energy = ... J [2]

(c) The suspended sphere is now lowered into water. The sphere is given a sideways displacement of +0.036 m from its equilibrium position and is then released at time $t = 0$. The water causes the motion of the sphere to be critically damped.

On Fig. 4.2, sketch the variation of the displacement x of the sphere from its equilibrium position with t from $t = 0$ to $t = 6.0$ s.

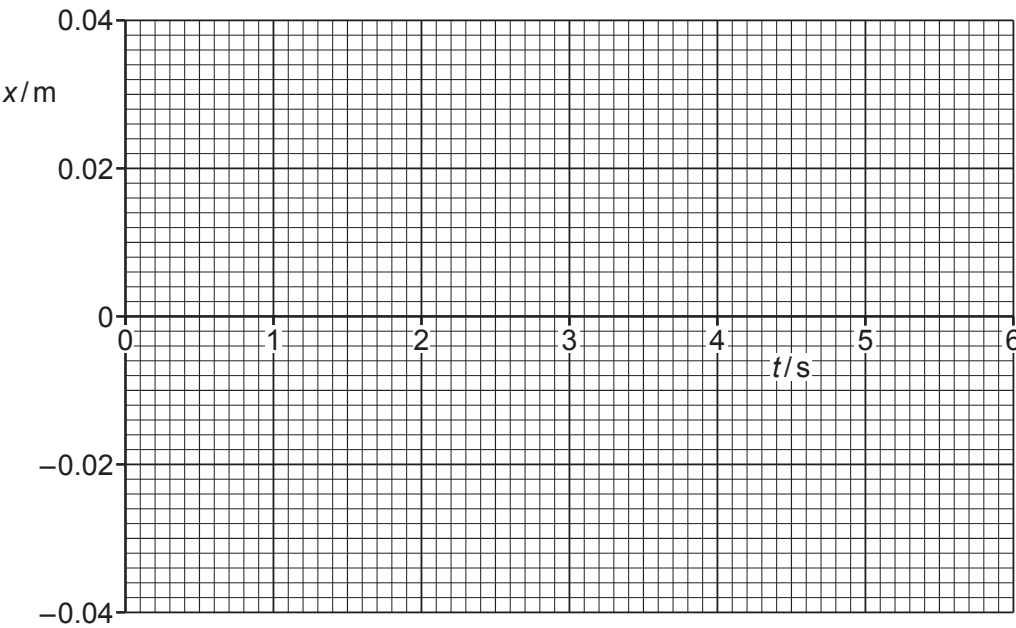


Fig. 4.2

[3]

[Total: 9]

56. Question part 1/2 | 9702 Feb-March 2024 P4 V2 Q3

- 3** A small object of mass 24 g rests on a platform. The platform is attached to an oscillator, as shown in Fig. 3.1.

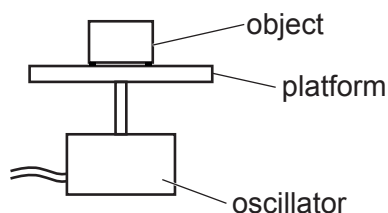


Fig. 3.1

The oscillator moves the platform up and down.

- (a)** The total energy of the oscillations of the object is 2.2×10^{-4} J.
In one oscillation the object travels a total distance of 14 mm.

Calculate the angular frequency ω of the oscillations.

$$\omega = \dots\dots\dots \text{rad s}^{-1} \quad [3]$$

- (b)** The frequency of the oscillator is fixed, and the amplitude of the oscillations is gradually increased.

- (i)** Calculate the maximum amplitude of the oscillations so the object does not lose contact with the platform.

$$\text{amplitude} = \dots\dots\dots \text{m} \quad [2]$$

(ii) The amplitude of the oscillations is increased so it is greater than the value in (b)(i).

State and explain the position in an oscillation where the object first loses contact with the platform.

.....

.....

.....

..... [2]

[Total: 7]

4 (a) State what is meant by resonance.

.....

.....

..... [2]

(b) A small ball is held in place using a stretched string. One end of the string is fixed to a wall and the other end is attached to a vibration generator, as shown in Fig. 4.1.

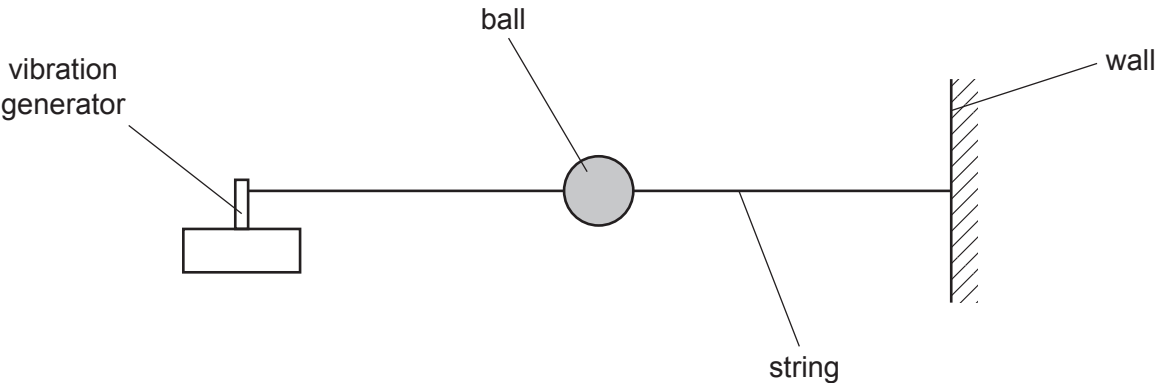


Fig. 4.1

Initially, the vibration generator is switched off.

A student displaces the ball vertically and then releases it. Fig. 4.2 shows the variation of the displacement of the ball with time after it is released.

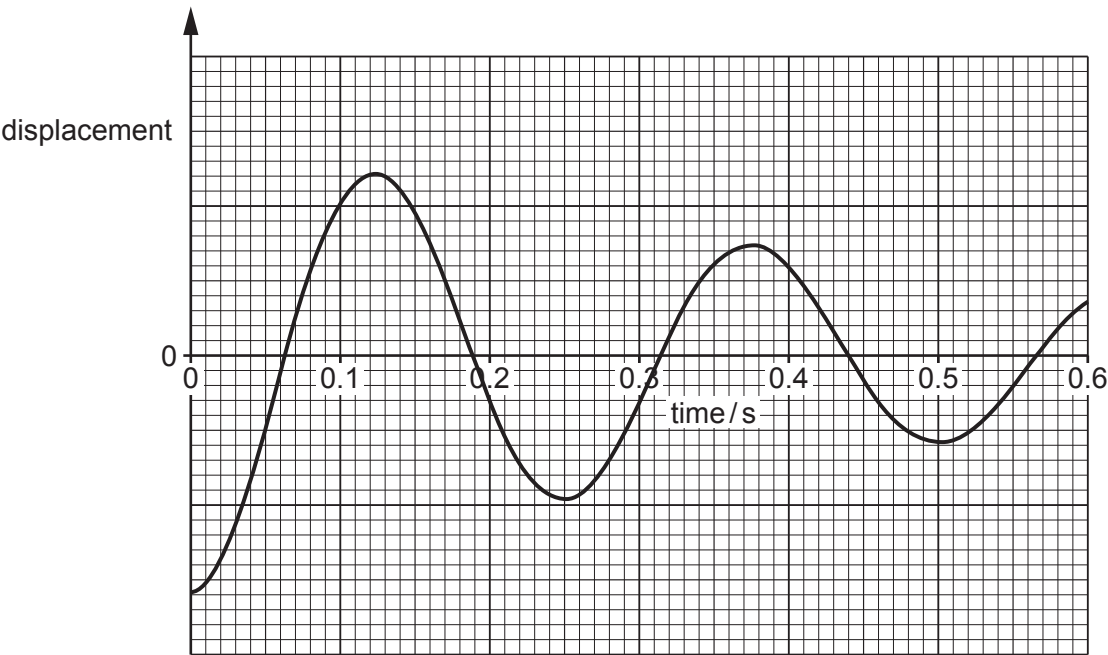


Fig. 4.2

(i) State the name of the phenomenon illustrated by the decrease in the amplitude of the oscillations in Fig. 4.2.

..... [1]

(ii) Explain the decrease with time of the amplitude of the oscillations of the ball.

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

(iii) Determine the frequency of the oscillations of the ball.

frequency = ... Hz [1]

(c) The vibration generator in (b) is switched on and its frequency f of vibration is gradually increased from 0 to 10 Hz.

On Fig. 4.3, sketch the variation with f of the amplitude of the oscillations of the ball.

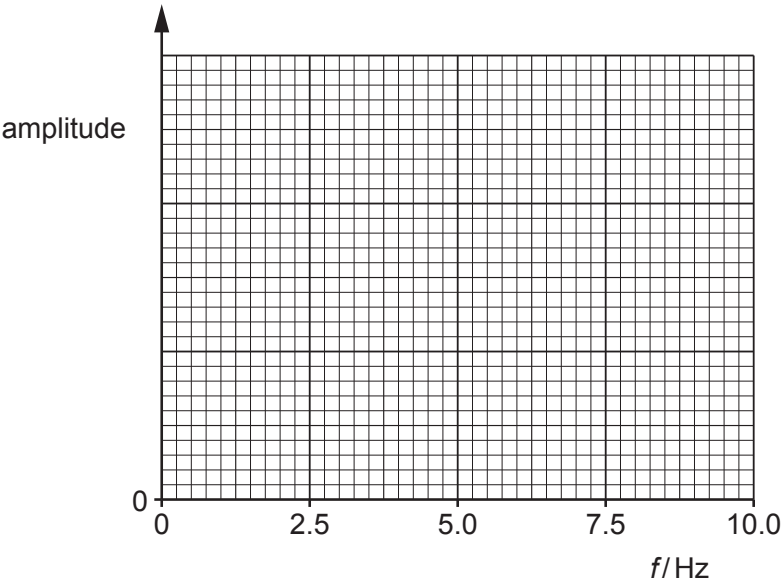


Fig. 4.3

[2]

[Total: 8]

58. Question part 1/2 | 9702 May-June 2024 P4 V2 Q4

- 4 A block of mass m oscillates vertically on a spring, as shown in Fig. 4.1.

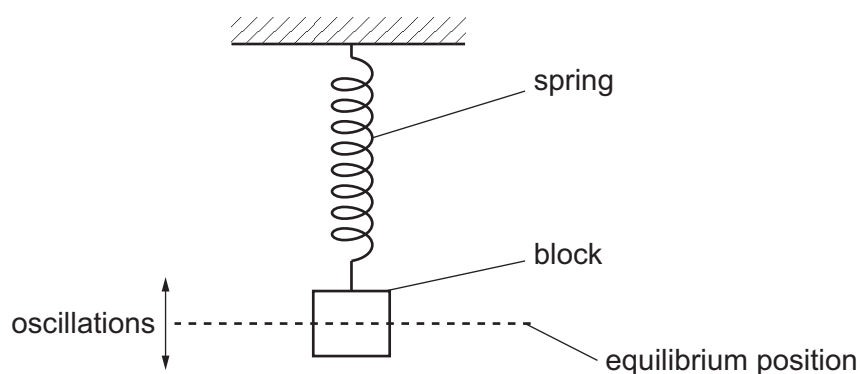


Fig. 4.1

The acceleration a of the block varies with displacement x from its equilibrium position, as shown in Fig. 4.2.

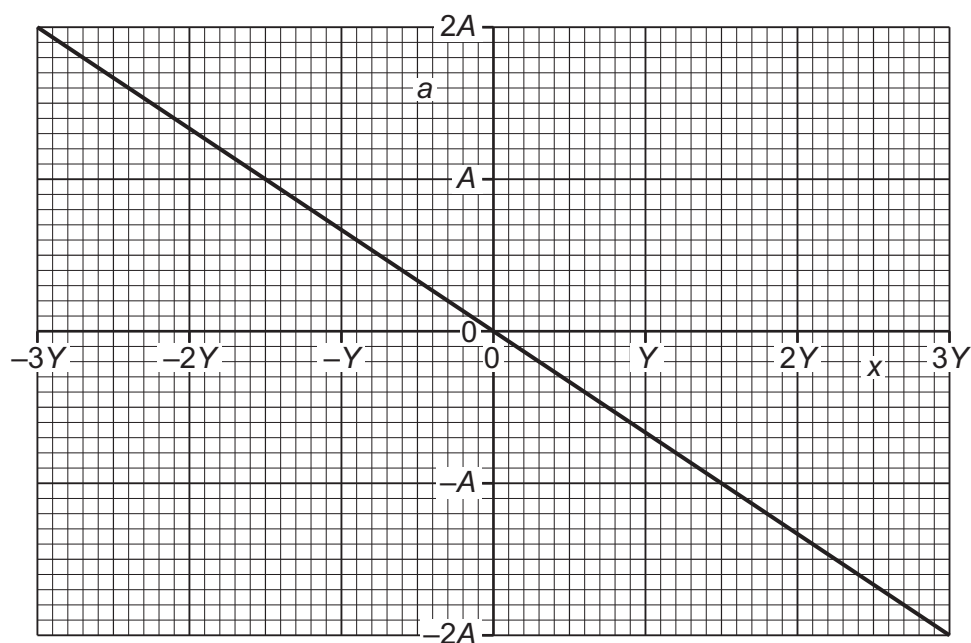


Fig. 4.2

The amplitude of the oscillations is $3Y$ and the maximum acceleration is $2A$.

- (a) Explain how Fig. 4.2 shows that the oscillations of the block are simple harmonic.

.....

.....

..... [2]



(b) Deduce expressions, in terms of some or all of m , A and Y , for:

(i) the angular frequency ω of the oscillations

$\omega = \dots\dots\dots$ [1]

(ii) the maximum speed v_0 of the oscillations

$v_0 = \dots\dots\dots$ [2]

(iii) the energy E of the oscillations.

$E = \dots\dots\dots$ [2]

(c) The period of the oscillations is 0.75 s and the value of $3Y$ is 1.8 cm.

Determine an expression for x in terms of time t , where x is in cm and t is in seconds.

$x = \dots\dots\dots$ [2]

[Total: 9]

4 (a) State what is meant by resonance.

.....

.....

..... [2]

(b) A small ball is held in place using a stretched string. One end of the string is fixed to a wall and the other end is attached to a vibration generator, as shown in Fig. 4.1.

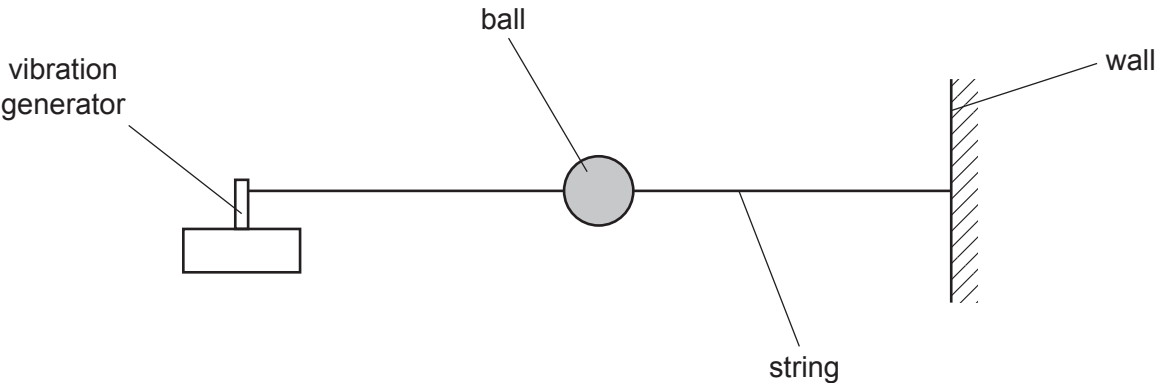


Fig. 4.1

Initially, the vibration generator is switched off.

A student displaces the ball vertically and then releases it. Fig. 4.2 shows the variation of the displacement of the ball with time after it is released.

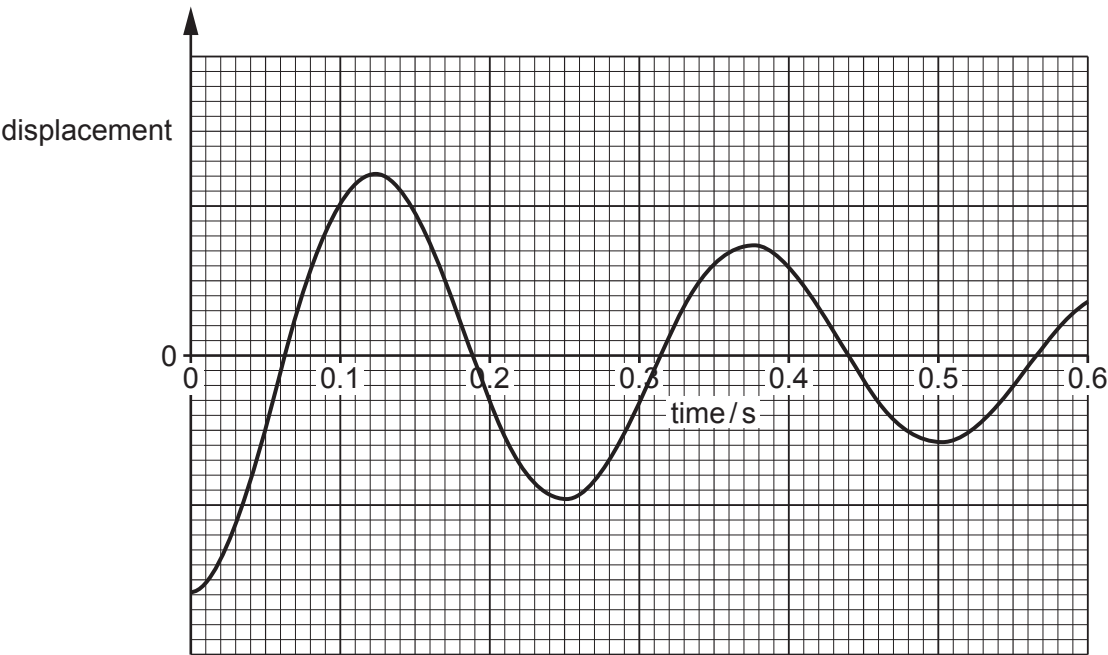


Fig. 4.2

(i) State the name of the phenomenon illustrated by the decrease in the amplitude of the oscillations in Fig. 4.2.

..... [1]

(ii) Explain the decrease with time of the amplitude of the oscillations of the ball.

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

(iii) Determine the frequency of the oscillations of the ball.

frequency = ... Hz [1]

(c) The vibration generator in (b) is switched on and its frequency f of vibration is gradually increased from 0 to 10 Hz.

On Fig. 4.3, sketch the variation with f of the amplitude of the oscillations of the ball.

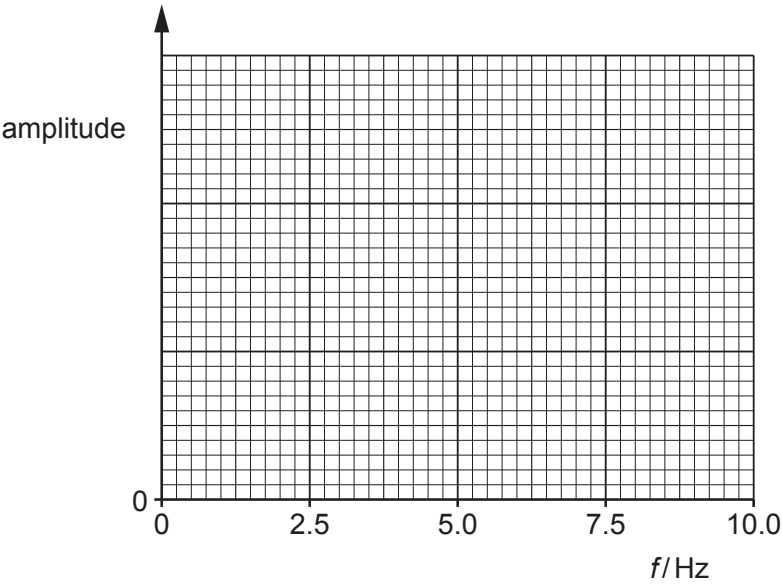


Fig. 4.3

[2]

[Total: 8]

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

.....

.....

..... [2]

(b) A block is suspended from a spring, as shown in Fig. 4.1.

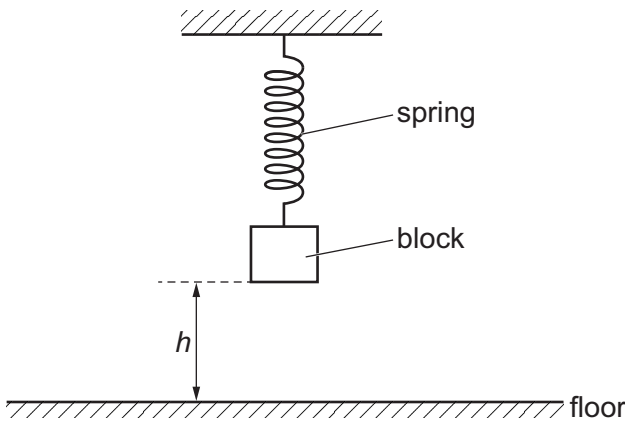


Fig. 4.1

The block is pulled down and released at time $t = 0$. It then oscillates vertically with simple harmonic motion.

Fig. 4.2 shows the variation of the velocity v of the block with height h of the base of the block above the floor.

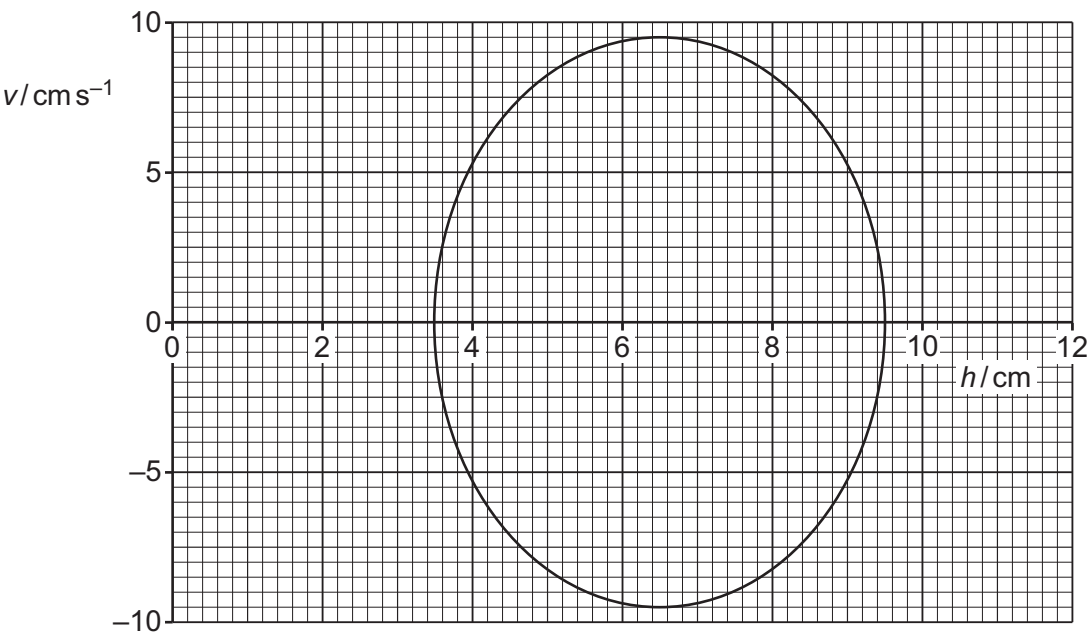


Fig. 4.2



(i) Determine the amplitude, in cm, of the oscillations.

amplitude = ... cm [1]

(ii) Show that the angular frequency of the oscillations is 3.2 rad s^{-1} .

[2]

(iii) Calculate the period T of the oscillations.

$T = \dots\dots\dots$ s [2]

(iv) On Fig. 4.3, sketch the variation of h with time t from $t = 0$ to $t = 6.0\text{ s}$.

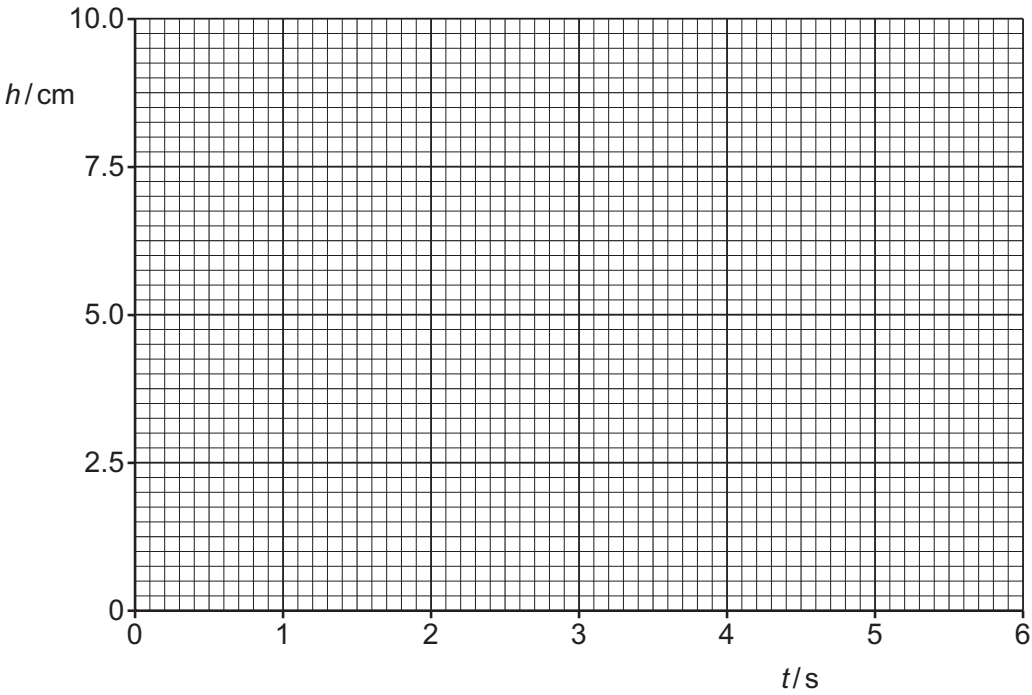


Fig. 4.3

[4]

- 5 Fig. 5.1 shows a pendulum consisting of a metal sphere suspended by a thin string.

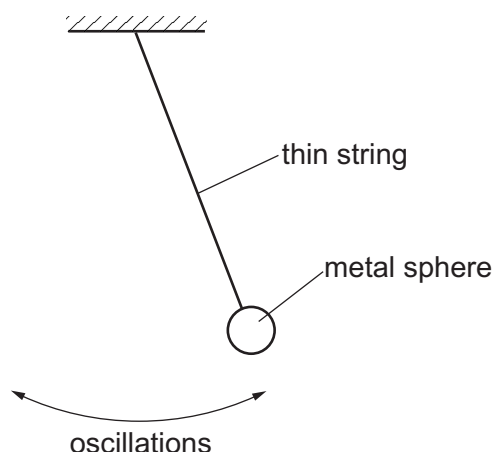


Fig. 5.1 (not to scale)

The sphere undergoes small oscillations about its equilibrium position. The oscillations may be considered to be simple harmonic.

Fig. 5.2 shows the variation with time t of the displacement x of the sphere from its equilibrium position.

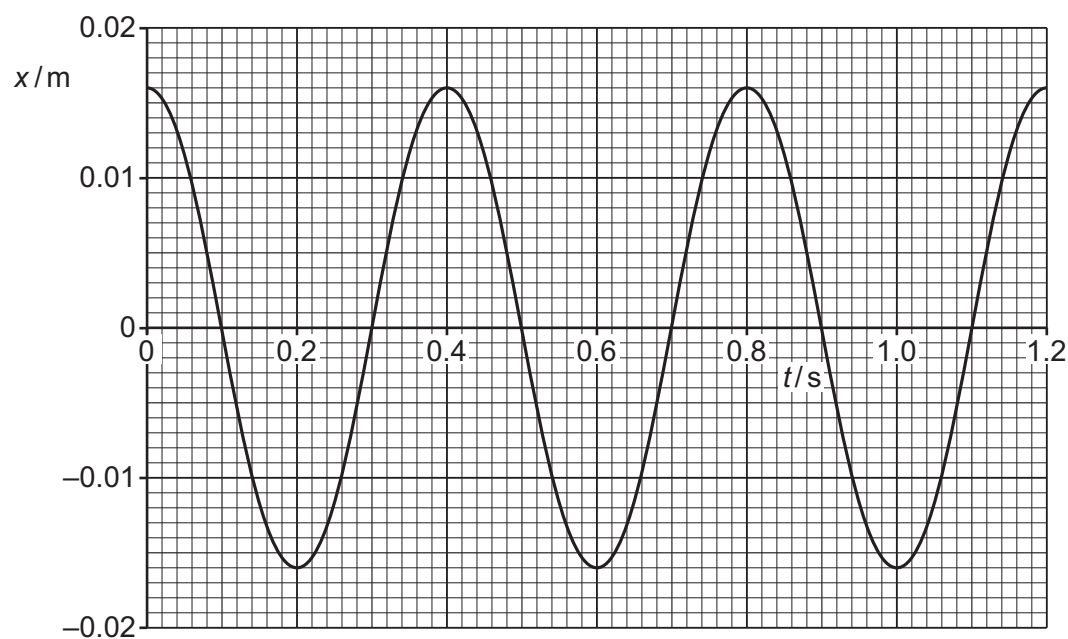


Fig. 5.2

- (a) On Fig. 5.1, draw an arrow, from the centre of the sphere, to represent the direction of the resultant force acting on the sphere when it is in the position shown. [1]

61. Question part 2/2 | 9702 Oct-Nov 2024 P4 V2 Q5



(b) The mass of the sphere is 0.15 kg.

(i) State the amplitude of the oscillations.

amplitude = ...m [1]

(ii) Determine the angular frequency of the oscillations.

angular frequency = ... rad s⁻¹ [2]

(iii) Calculate the total energy of the oscillations.

total energy = ... J [2]

(c) On Fig. 5.3, sketch the variation with x of the kinetic energy E_K of the sphere.

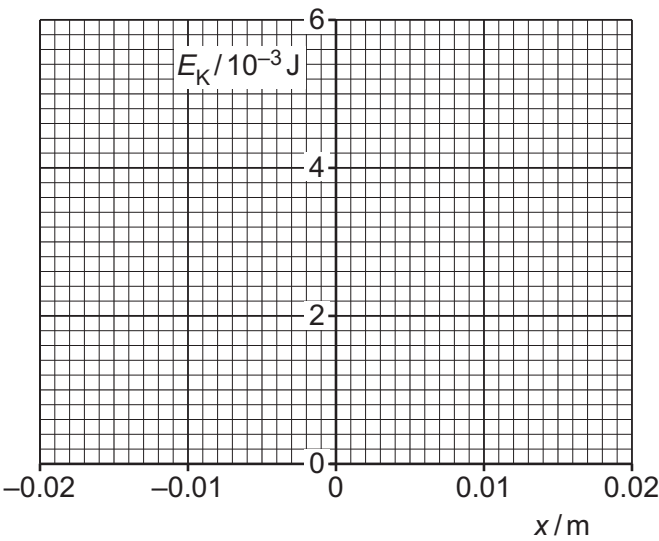


Fig. 5.3

[3]

[Total: 9]

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

.....

.....

..... [2]

(b) A block is suspended from a spring, as shown in Fig. 4.1.

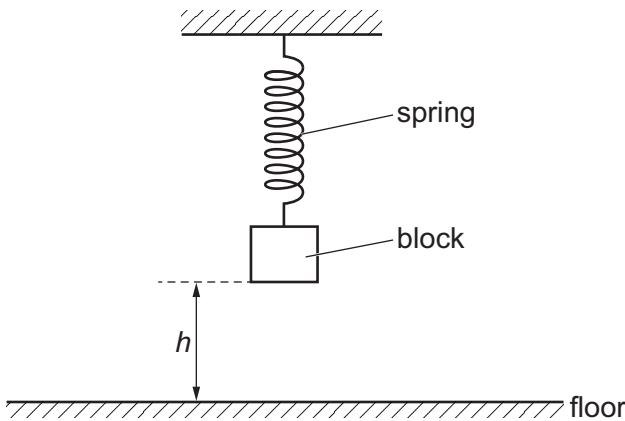


Fig. 4.1

The block is pulled down and released at time $t = 0$. It then oscillates vertically with simple harmonic motion.

Fig. 4.2 shows the variation of the velocity v of the block with height h of the base of the block above the floor.

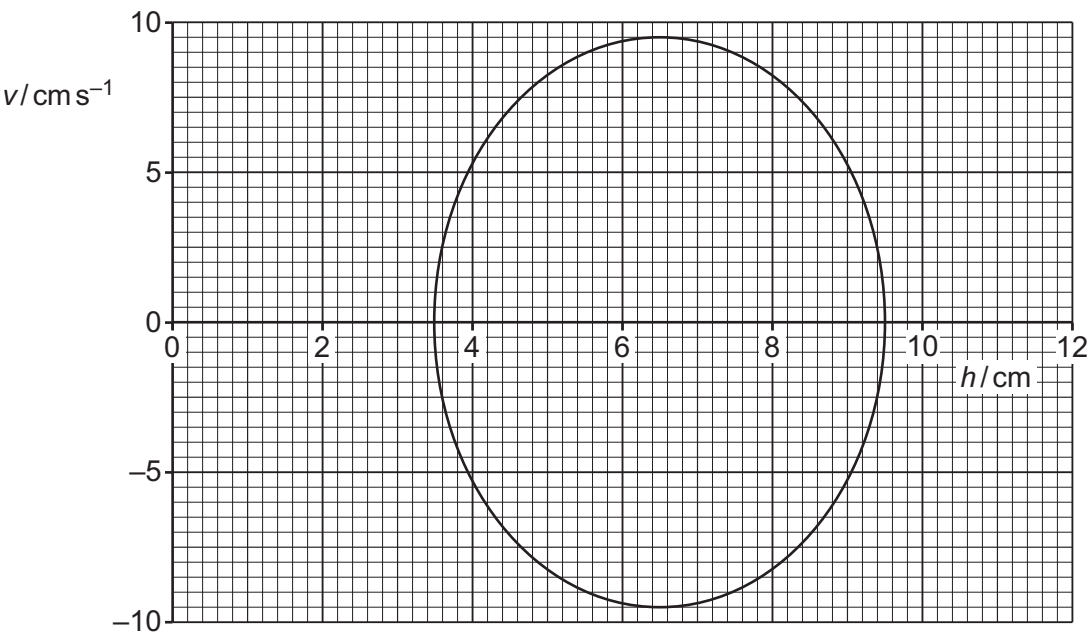


Fig. 4.2



(i) Determine the amplitude, in cm, of the oscillations.

amplitude = ... cm [1]

(ii) Show that the angular frequency of the oscillations is 3.2 rad s^{-1} .

[2]

(iii) Calculate the period T of the oscillations.

$T =$ s [2]

(iv) On Fig. 4.3, sketch the variation of h with time t from $t = 0$ to $t = 6.0\text{ s}$.

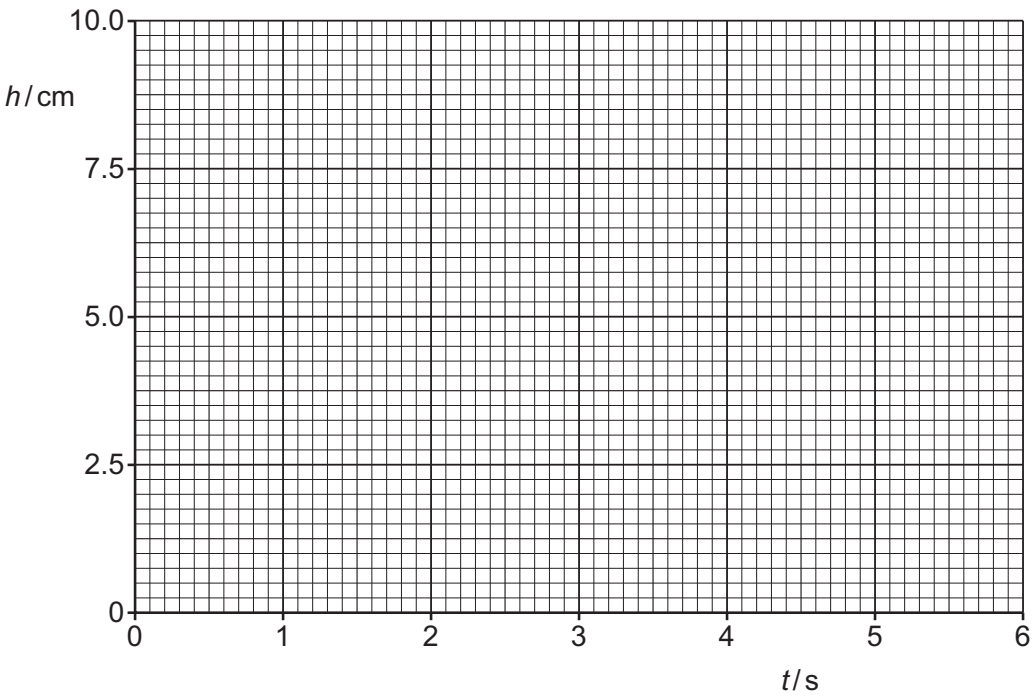


Fig. 4.3

[4]

63. Question part 1/2 | 9702 Feb-March 2025 P4 V2 Q4

- 4 A small crystal is made to vibrate with simple harmonic motion. The variation with time t of the displacement x of one surface of the crystal from its equilibrium position is shown in Fig. 4.1.

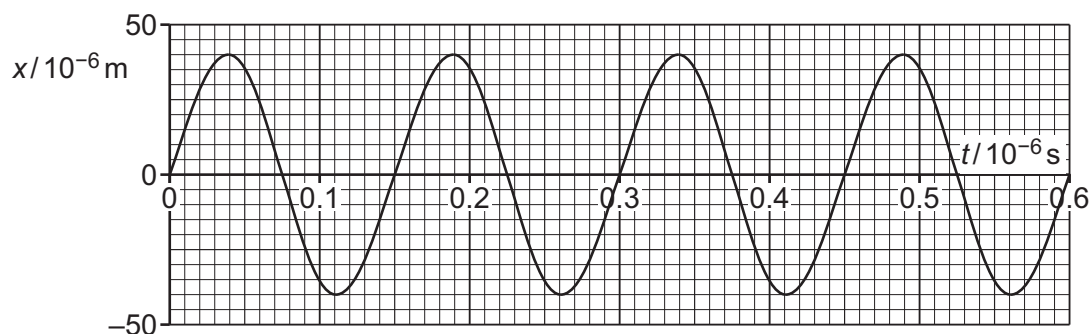


Fig. 4.1

- (a) Show that the angular frequency of the vibration of the surface is $4.2 \times 10^7 \text{ rad s}^{-1}$.

[2]

- (b) Determine the maximum acceleration a_0 of the vibration of the surface.

$$a_0 = \dots\dots\dots \text{ms}^{-2} \quad [2]$$

- (c) The crystal may be modelled as a single mass of $2.4 \times 10^{-4}\text{kg}$ that vibrates as shown in Fig. 4.1.

Calculate the total energy E of the vibrations.

$$E = \dots\dots\dots \text{J} \quad [3]$$

63. Question part 2/2 | 9702 Feb-March 2025 P4 V2 Q4



(d) The crystal generates ultrasound waves that are used to obtain diagnostic information about internal structures.

(i) The crystal is made from piezoelectric material.

Explain how the crystal is made to vibrate.

.....

.....

.....

..... [2]

(ii) A parallel beam of ultrasound waves is incident on a muscle-bone boundary. Data for muscle and bone are given in Table 4.1.

Table 4.1

material	density / kg m ⁻³	speed of sound / m s ⁻¹
muscle	1100	1600
bone	1900	4100

Calculate the percentage of the intensity of the ultrasound beam that is transmitted at this boundary.

percentage transmitted = ... % [3]

[Total: 12]

64. Question part 1/2 | 9702 May-June 2025 P4 V1 Q5

- 5 A cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

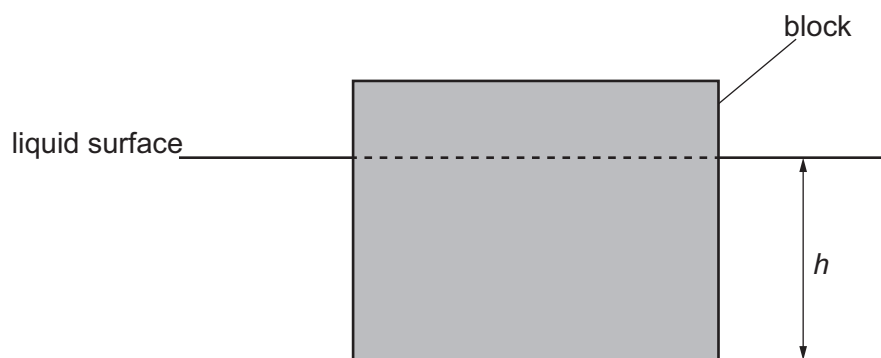


Fig. 5.1

The base of the block is at a depth h below the surface of the liquid.

The block is displaced downwards by a small distance and then released so that it oscillates.

Fig. 5.2 shows the variation with h of the acceleration a of the block.

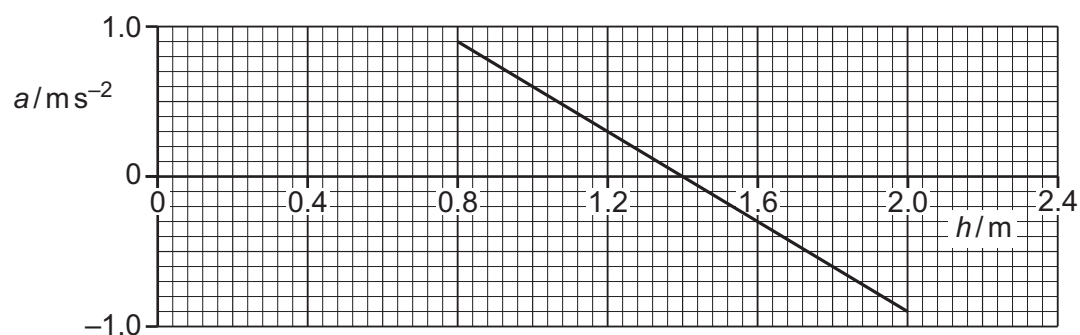


Fig. 5.2

Fig. 5.3 shows the variation with h of the kinetic energy E_K of the block.

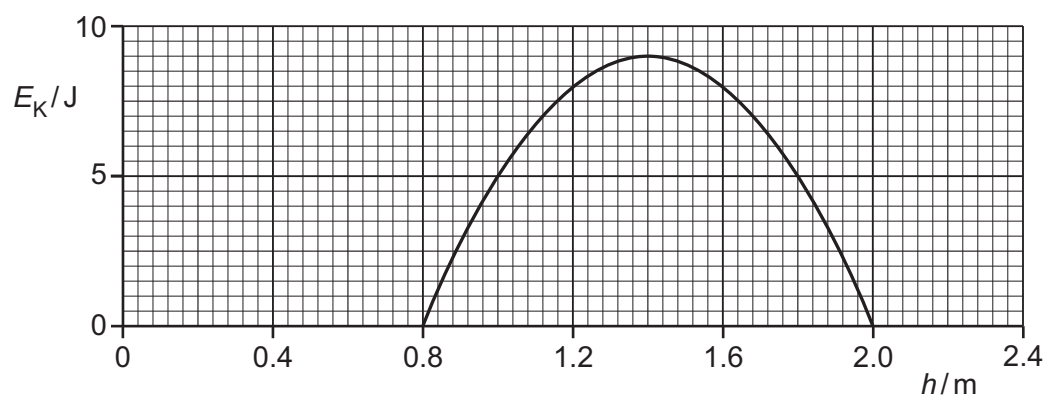


Fig. 5.3

64. Question part 2/2 | 9702 May-June 2025 P4 V1 Q5



(a) (i) Determine the amplitude of the oscillations.

amplitude = ... m [1]

(ii) State what the line in Fig. 5.2 shows about the nature of the oscillations.

..... [1]

(b) State **three** other quantitative conclusions that can be drawn from Fig. 5.2 and Fig. 5.3 about the block and its oscillations. Use the space for any working.

1

.....

2

.....

3

.....

[3]

(c) On Fig. 5.4, sketch the variation with h of the potential energy E_p of the oscillations.

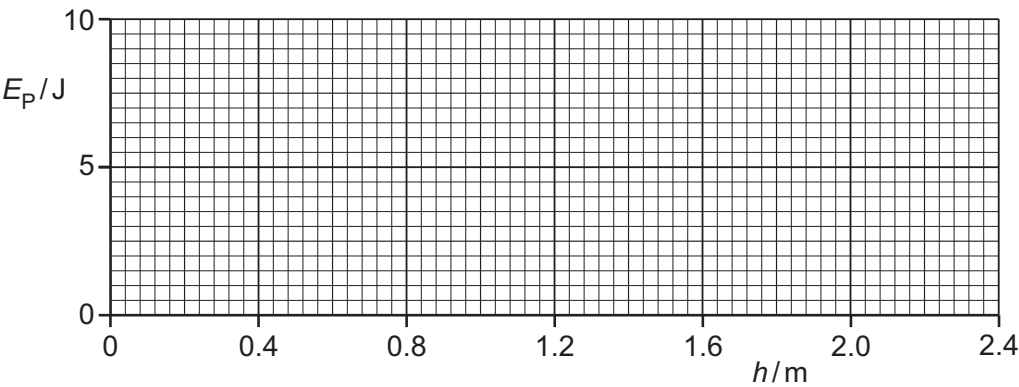


Fig. 5.4

[3]

[Total: 8]

65. Question part 1/2 | 9702 May-June 2025 P4 V2 Q5

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

.....

.....

..... [2]

(b) A block is suspended by a spring. The block oscillates vertically with simple harmonic motion.

The velocity v of the block varies with time t according to

$$v = 0.56 \cos 16t$$

where v is in ms^{-1} and t is in s.

(i) Calculate the period of the oscillation.

period = ... s [1]

(ii) Determine the amplitude x_0 of the oscillation.

$x_0 =$ m [2]

(iii) Use your answer in (b)(ii) to determine the equation for v in terms of the displacement x of the block, where v is in ms^{-1} and x is in m.

$v =$ [1]

65. Question part 2/2 | 9702 May-June 2025 P4 V2 Q5



(iv) On Fig. 5.1, sketch the variation of v with x .

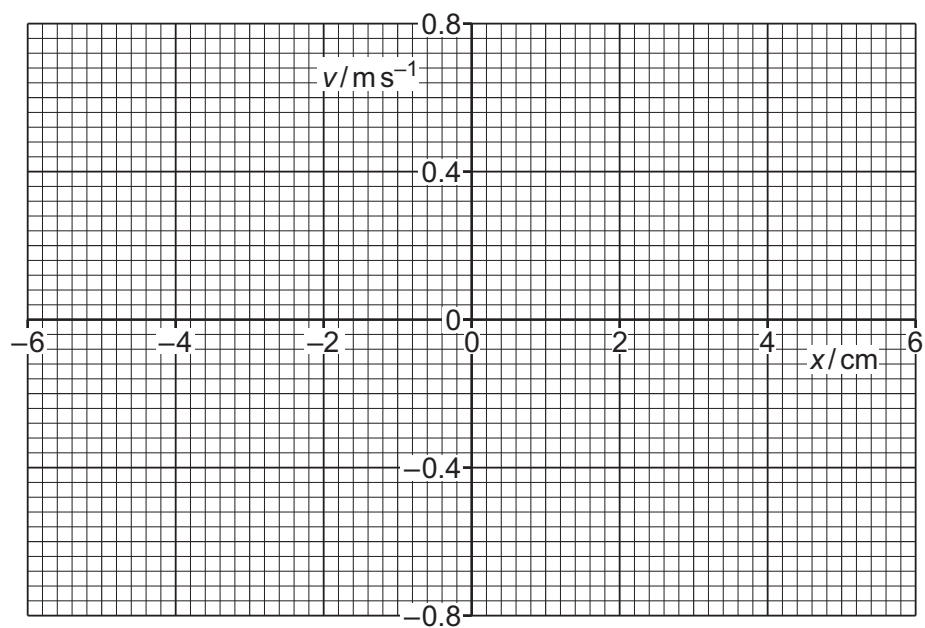


Fig. 5.1

[3]

[Total: 9]

66. Question part 1/2 | 9702 May-June 2025 P4 V3 Q5

- 5 A cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

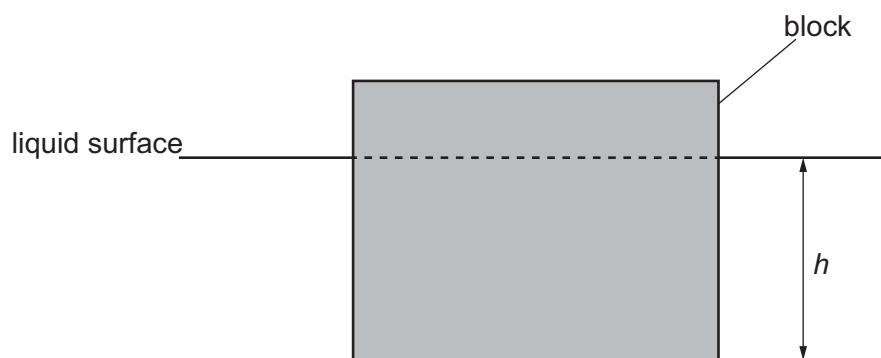


Fig. 5.1

The base of the block is at a depth h below the surface of the liquid.

The block is displaced downwards by a small distance and then released so that it oscillates.

Fig. 5.2 shows the variation with h of the acceleration a of the block.

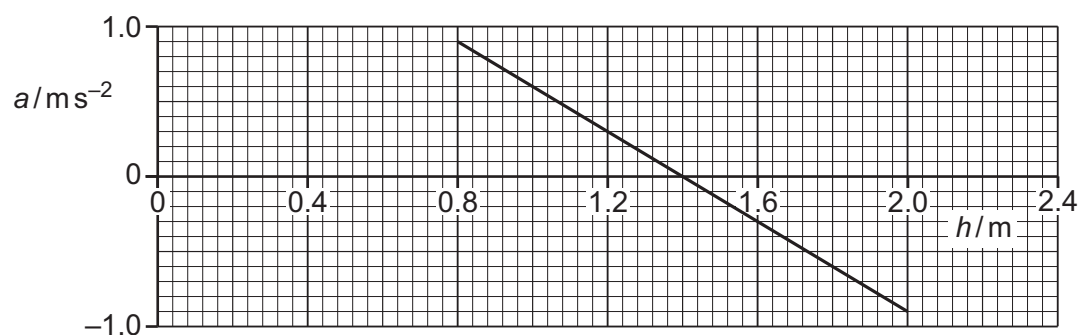


Fig. 5.2

Fig. 5.3 shows the variation with h of the kinetic energy E_K of the block.

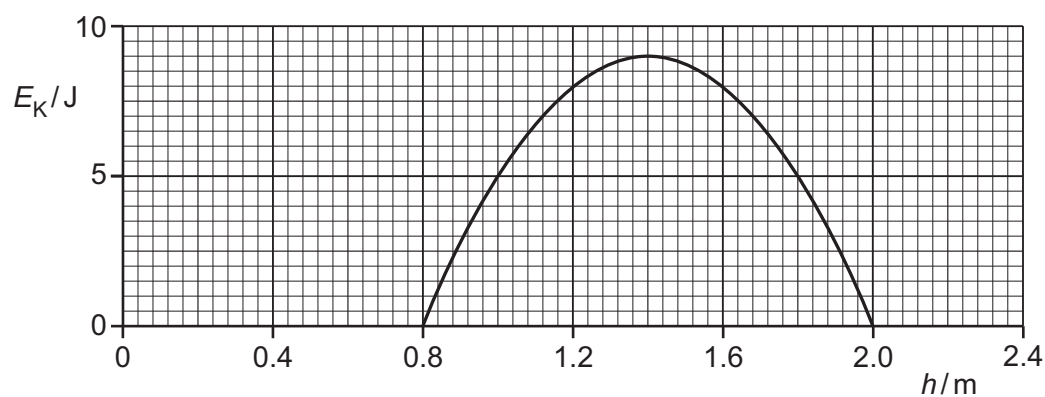


Fig. 5.3

66. Question part 2/2 | 9702 May-June 2025 P4 V3 Q5



(a) (i) Determine the amplitude of the oscillations.

amplitude = ... m [1]

(ii) State what the line in Fig. 5.2 shows about the nature of the oscillations.

..... [1]

(b) State **three** other quantitative conclusions that can be drawn from Fig. 5.2 and Fig. 5.3 about the block and its oscillations. Use the space for any working.

1

.....

2

.....

3

.....

[3]

(c) On Fig. 5.4, sketch the variation with h of the potential energy E_p of the oscillations.

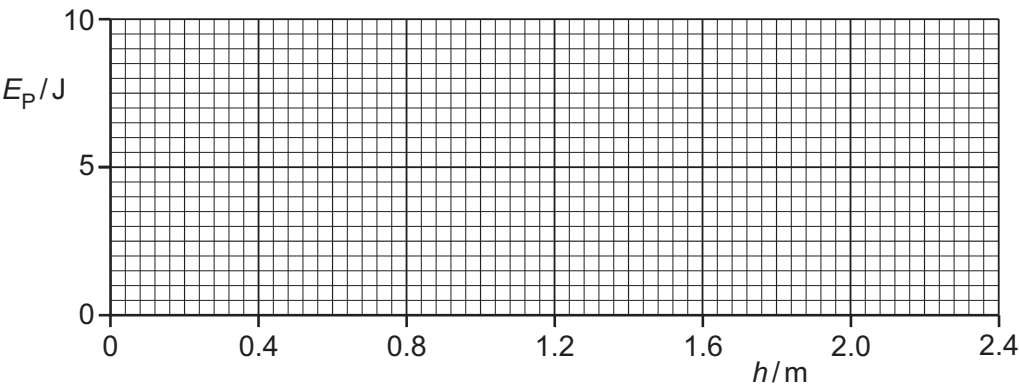


Fig. 5.4

[3]

[Total: 8]

67. Question part 1/2 | 9702 May-June 2025 P4 V4 Q4

- 4 (a) State what is meant by simple harmonic motion.

.....

.....

..... [2]

- (b) A small sphere is suspended from a fixed point P by a string of negligible mass, as shown in Fig. 4.1.

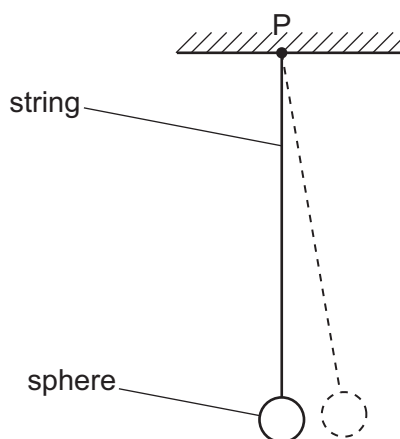


Fig. 4.1

The sphere is given a small horizontal displacement and is then released.

The variation with time of the horizontal velocity v of the sphere is shown in Fig. 4.2.

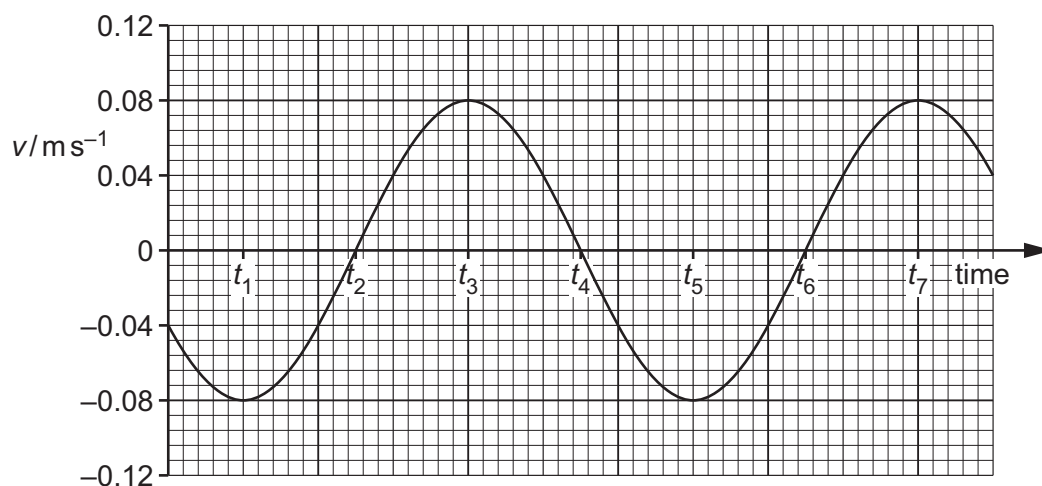


Fig. 4.2

67. Question part 2/2 | 9702 May-June 2025 P4 V4 Q4



(i) State two times at which the sphere is passing in the same direction through the equilibrium position.

time and time [1]

(ii) The time interval between t_1 and t_6 is 2.2s.

Calculate the frequency of oscillation of the sphere.

frequency = ... Hz [2]

(c) The sphere in (b) is undergoing simple harmonic motion.

Use your answer in (b)(ii) and data from Fig. 4.2 to determine the maximum displacement of the sphere from its equilibrium position.

maximum displacement = ... m [3]

[Total: 8]

68. Question part 1/2 | 9702 May-June 2025 P4 V4 Q7

- 7 A bar magnet is suspended from a spring. One pole of the magnet oscillates freely in a coil of wire, as shown in Fig. 7.1.

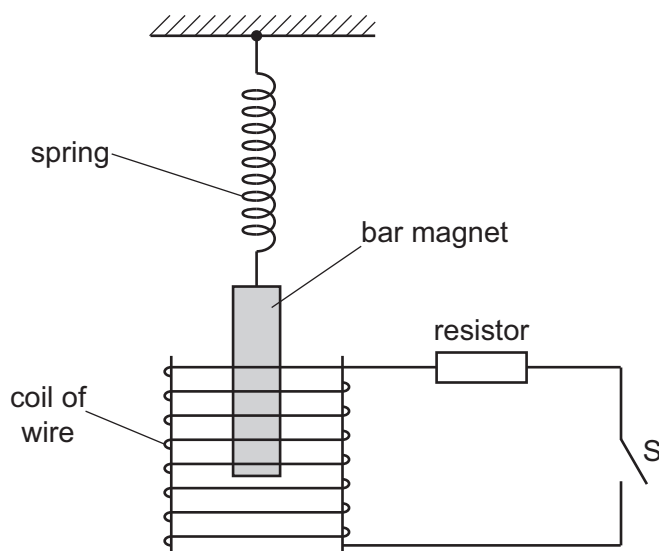


Fig. 7.1

The switch S is initially open.

- (a) The switch S is now closed. As a result, the oscillations of the magnet are lightly damped.

- (i) State what is meant by damping.

.....

 [2]

- (ii) Describe what is observed to indicate that the damping is light.

.....
 [1]

- (iii) By reference to electromagnetic induction and to conservation of energy, explain why the oscillations are damped.

.....

 [3]

68. Question part 2/2 | 9702 May-June 2025 P4 V4 Q7



(b) The procedure in **(a)** is repeated after replacing the resistor with one of greater resistance.

Suggest, with a reason, the effect of this change on the oscillations.

.....

.....

..... [2]

[Total: 8]

69. Question part 1/2 | 9702 Oct-Nov 2025 P4 V2 Q5

- 5 A steel ball on the end of a thin string oscillates with small oscillations, as shown in Fig. 5.1.

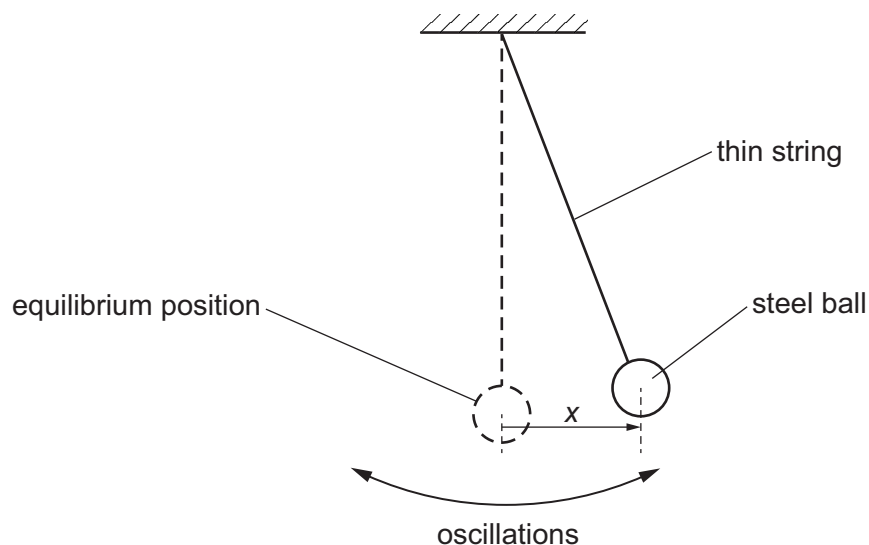


Fig. 5.1 (not to scale)

The displacement of the centre of the ball from its equilibrium position is x .

- (a) Fig. 5.2 shows the variation with x of the acceleration a of the ball.

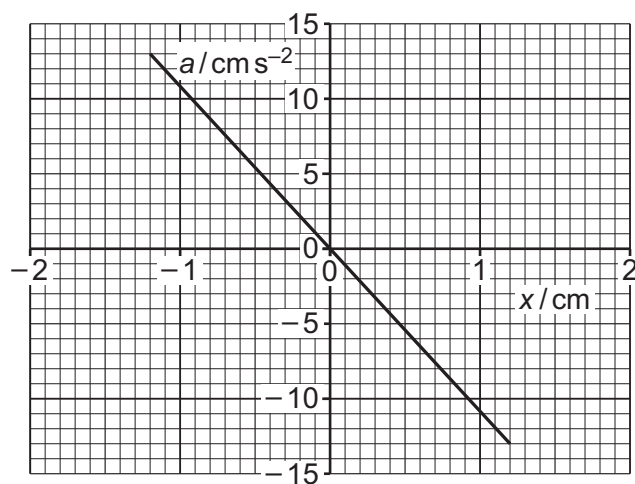


Fig. 5.2

- (i) Explain how Fig. 5.2 shows that the oscillations of the ball are simple harmonic.

.....

.....

..... [2]

69. Question part 2/2 | 9702 Oct-Nov 2025 P4 V2 Q5



(ii) Determine the period T of the oscillations.

$T = \dots\dots\dots$ s [3]

(b) At time $t = 0$, when the displacement of the ball has its maximum value, the ball is immersed in a trough containing thick oil so that the ball is just below the surface of the oil. This results in the subsequent motion of the ball being heavily damped.

(i) State what is meant by damping.

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

(ii) On Fig. 5.3, sketch a possible variation of the displacement x of the ball with t between $t = 0$ and $t = 2T$.

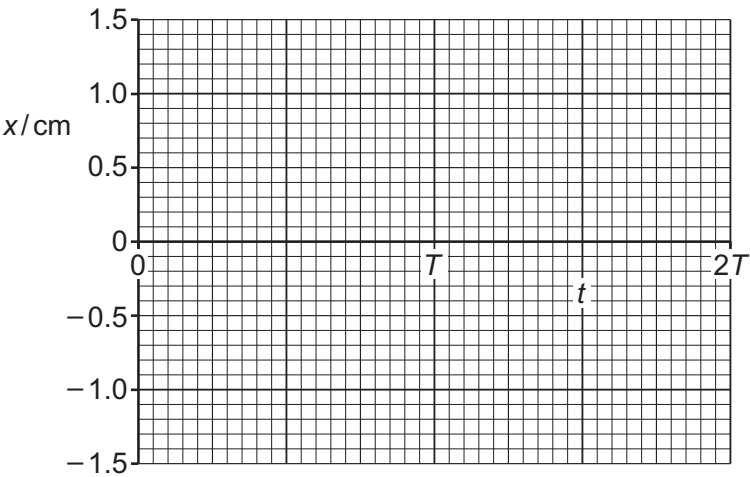


Fig. 5.3

[3]

[Total: 10]

4 (a) State what is meant by the frequency of the oscillations of an oscillating object.

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

(b) An object is oscillating.

Fig. 4.1 shows the variation of the acceleration a of the object with its displacement x from the equilibrium position.

Fig. 4.2 shows the variation of the kinetic energy E_K of the object with time t .

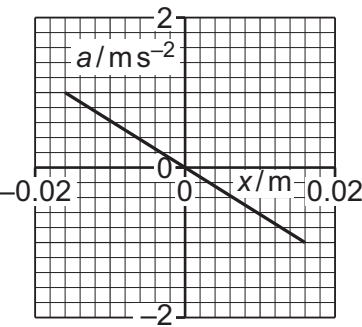


Fig. 4.1

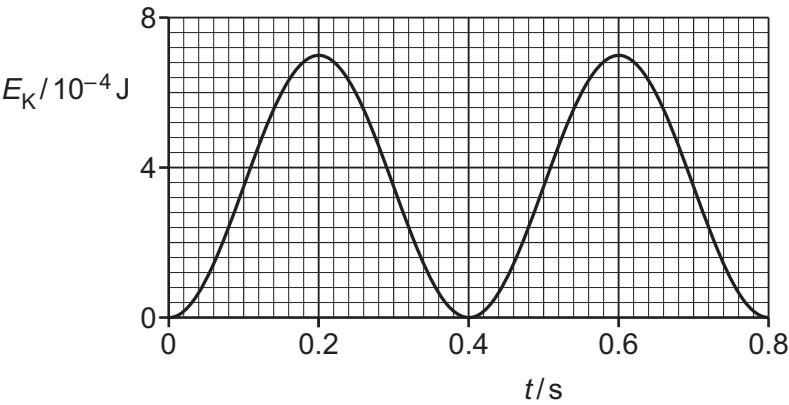


Fig. 4.2

(i) Explain how Fig. 4.2 shows that the period of the oscillations is 0.80 s.

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

(ii) Calculate the angular frequency ω of the oscillations.

$\omega =$ rad s^{-1} [2]

70. Question part 2/2 | 9702 Oct-Nov 2025 P4 V4 Q4



(iii) Apart from the period, frequency and angular frequency of the oscillations, determine **three** other conclusions about the object and its oscillations that may be drawn from Fig. 4.1 and Fig. 4.2. The conclusions may be qualitative or quantitative. Use the space below for any working.

1

.....

2

.....

3

.....

[3]

(iv) Describe the interchange between kinetic energy and potential energy during the oscillations. Numerical values are **not** required.

.....

.....

.....

.....

.....

[3]

[Total: 10]