Oscillations

Question paper 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Oscillations
Sub Topic	
Paper Type	Theory
Booklet	Question paper 4

Time Allowed: **56 minutes**

Score: **/46**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 A cylinder and piston, used in a car engine, are illustrated in Fig. 3.1.

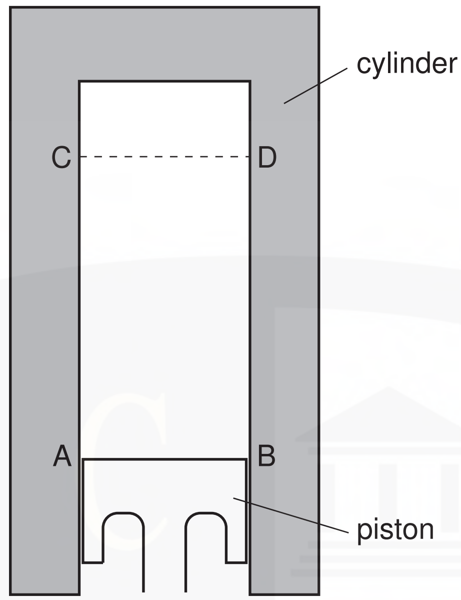

Fig. 3.1

The vertical motion of the piston in the cylinder is assumed to be simple harmonic.
The top surface of the piston is at AB when it is at its lowest position; it is at CD when at its highest position, as marked in Fig. 3.1.

(a) The displacement $\boldsymbol{d}$ of the piston may be represented by the equation

$$\boldsymbol{d} = -4.0 \cos(220\boldsymbol{t})$$

where $\boldsymbol{d}$ is measured in centimetres.

(i) State the distance between the lowest position AB and the highest position CD of the top surface of the piston.

distance = ... cm [1]

(ii) Determine the number of oscillations made per second by the piston.

number = ... [2]

(iii) On Fig. 3.1, draw a line to represent the top surface of the piston in the position where the speed of the piston is maximum. [1]

(iv) Calculate the maximum speed of the piston.

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

(b) The engine of a car has several cylinders. Three of these cylinders are shown in Fig. 3.2.

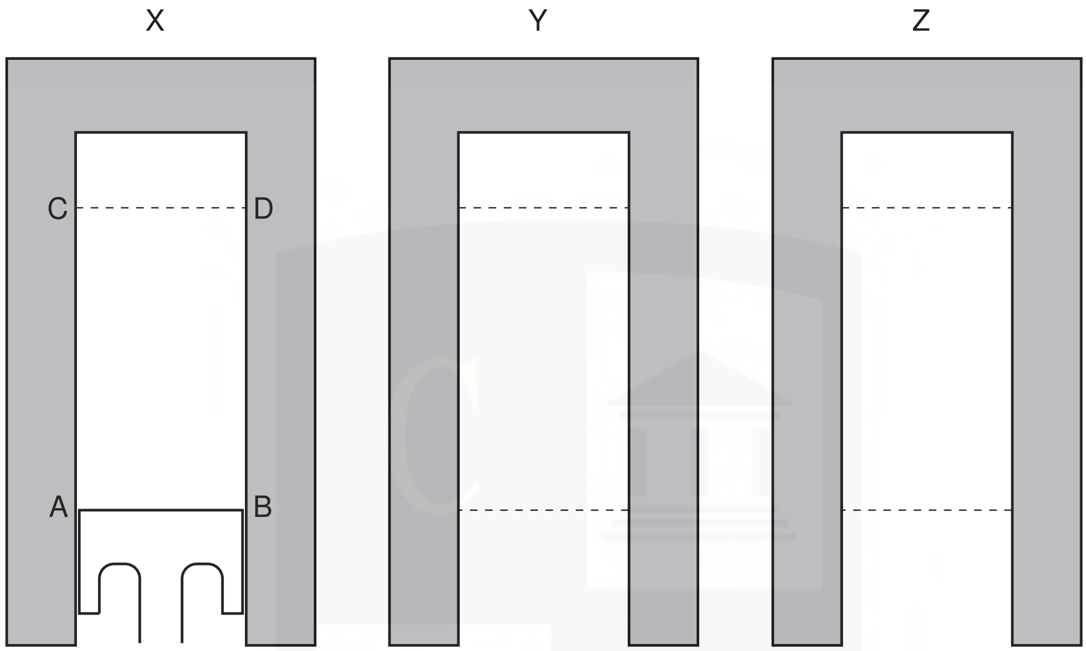

Fig. 3.2

X is the same cylinder and piston as in Fig. 3.1.
Y and Z are two further cylinders, with the lowest and the highest positions of the top surface of each piston indicated.
The pistons in the cylinders each have the same frequency of oscillation, but they are not in phase.
At a particular instant in time, the position of the top of the piston in cylinder X is as shown.

(i) In cylinder Y, the oscillations of the piston lead those of the piston in cylinder X by a phase angle of 120° ($\frac{2}{3}\pi$ rad).
Complete the diagram of cylinder Y, for this instant, by drawing

1. a line to show the top surface of the piston, [1]

2. an arrow to show the direction of movement of the piston. [1]

(ii) In cylinder Z, the oscillations of the piston lead those of the piston in cylinder X by a phase angle of 240° ($\frac{4}{3}\pi$ rad).

Complete the diagram of cylinder Z, for this instant, by drawing

1. a line to show the top surface of the piston, [1]

2. an arrow to show the direction of movement of the piston. [1]

(iii) For the piston in cylinder Y, calculate its speed for this instant.

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

2 **(a)** State what is meant by

(i) ***oscillations***,

....

....[1]

(ii) ***free*** oscillations,

....

....[1]

(iii) ***simple harmonic motion***.

....

....

....[2]

(b) Two inclined planes RA and LA each have the same constant gradient. They meet at their lower edges, as shown in Fig. 3.1.

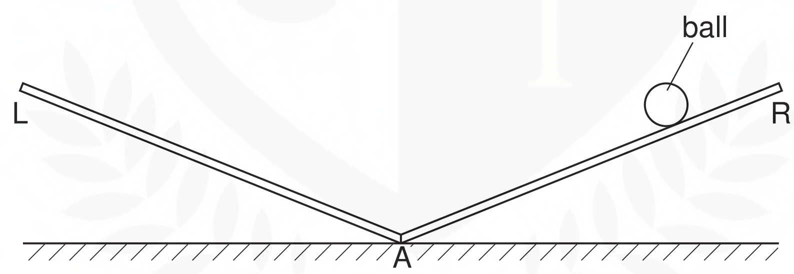

Fig. 3.1

A small ball moves from rest down plane RA and then rises up plane LA. It then moves down plane LA and rises up plane RA to its original height. The motion repeats itself.

State and explain whether the motion of the ball is simple harmonic.

....

....

....[2]

3 A long strip of springy steel is clamped at one end so that the strip is vertical. A mass of 65 g is attached to the free end of the strip, as shown in Fig. 2.1.

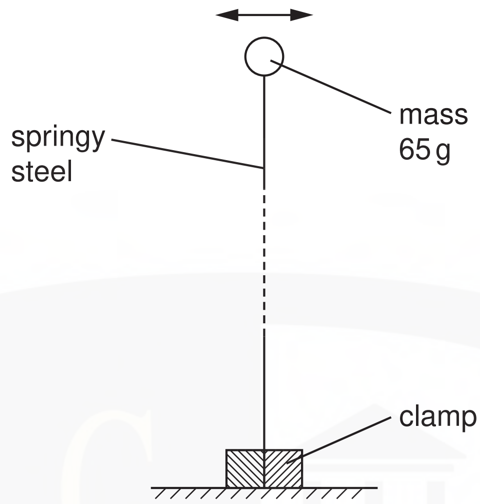

Fig. 2.1

The mass is pulled to one side and then released. The variation with time ***t*** of the horizontal displacement of the mass is shown in Fig. 2.2.

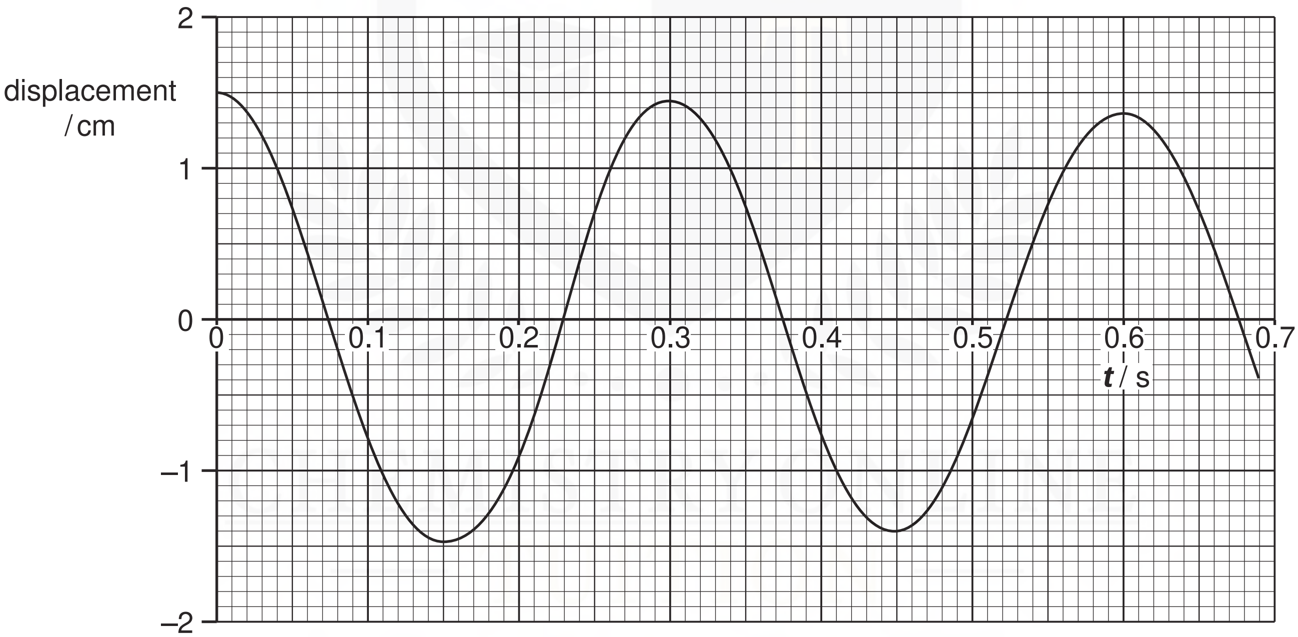

Fig. 2.2

The mass undergoes damped simple harmonic motion.

(a) **(i)** Explain what is meant by ***damping***.

....

....

.... [2]

(ii) Suggest, with a reason, whether the damping is light, critical or heavy.

....

....

.... [2]

(b) **(i)** Use Fig. 2.2 to determine the frequency of vibration of the mass.

frequency = ... Hz [1]

(ii) Hence show that the initial energy stored in the steel strip before the mass is released is approximately 3.2 mJ.

[2]

(c) After eight complete oscillations of the mass, the amplitude of vibration is reduced from 1.5 cm to 1.1 cm. State and explain whether, after a further eight complete oscillations, the amplitude will be 0.7 cm.

....

....

.... [2]

4 The variation with time ***t*** of the displacement ***x*** of the cone of a loudspeaker is shown in Fig. 4.1.

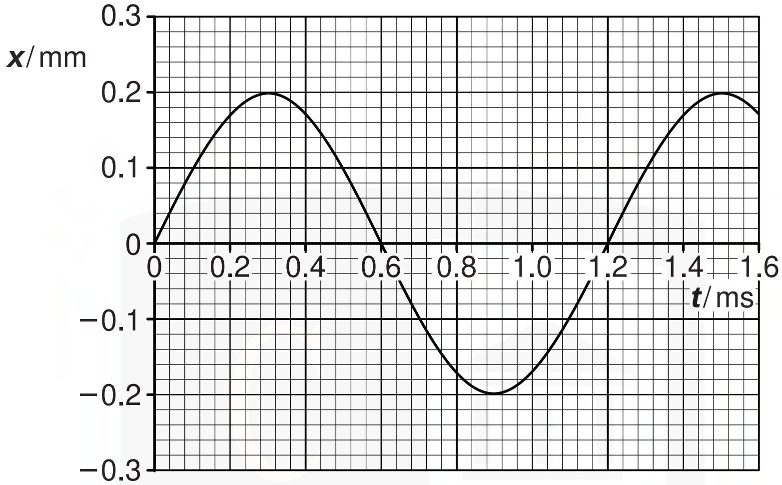

Fig. 4.1

(a) Use Fig. 4.1 to determine, for these oscillations,

(i) the amplitude,

amplitude = ... mm [1]

(ii) the frequency.

frequency = ... Hz [2]

(b) State two times at which

(i) the speed of the cone is maximum,

time .... ms and time .... ms [1]

(ii) the acceleration of the cone is maximum.

time .... ms and time .... ms [1]

(c) The effective mass of the cone is 2.5 g.

Use your answers in **(a)** to determine the maximum kinetic energy of the cone.

kinetic energy = ... J [3]

(d) The loudspeaker must be designed so that resonance of the cone is avoided.

(i) State what is meant by ***resonance***.

....

....

.... [2]

(ii) State and briefly explain one other situation in which resonance should be avoided.

....

....

....

.... [2]

5 The variation with displacement ***x*** of the acceleration ***a*** of the centre of the cone of a loudspeaker is shown in Fig. 3.1.

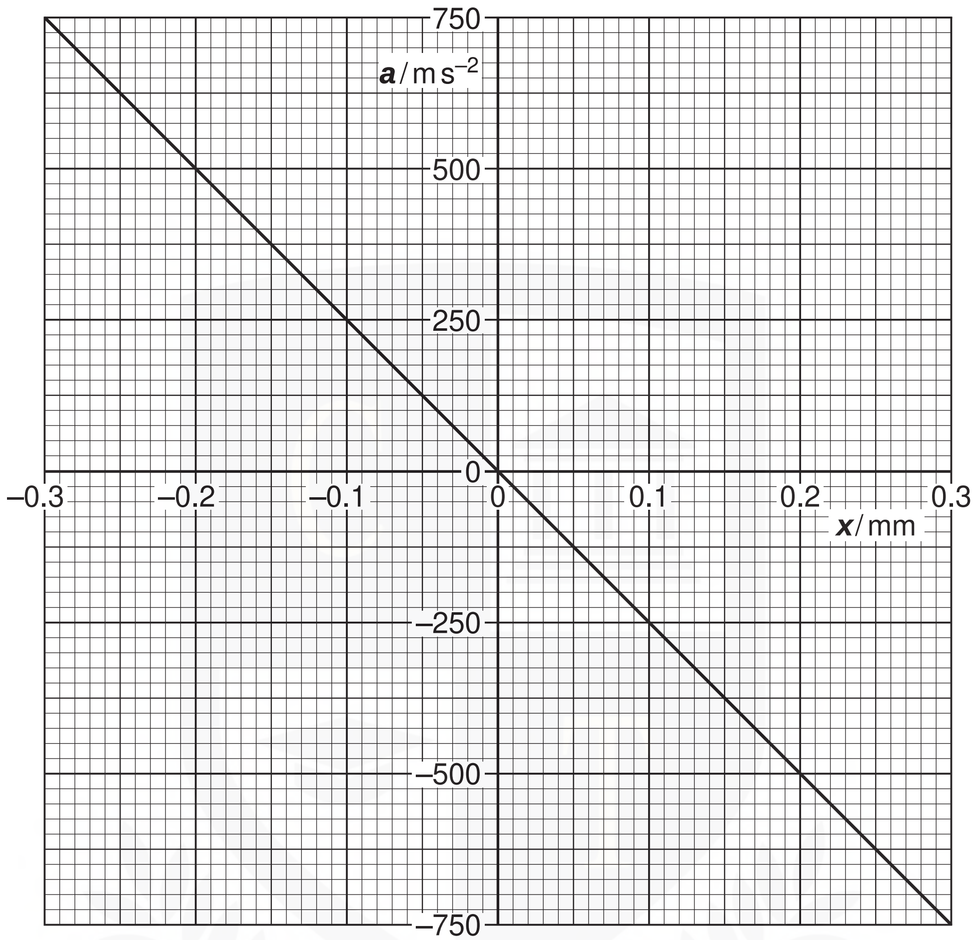

Fig. 3.1

(a) State the two features of Fig. 3.1 that show that the motion of the cone is simple harmonic.

1. ....

2. ....
[2]

(b) Use data from Fig. 3.1 to determine the frequency, in hertz, of vibration of the cone.

frequency = ... Hz [3]

(c) The frequency of vibration of the cone is now reduced to one half of that calculated in **(b)**.

The amplitude of vibration remains unchanged.

On the axes of Fig. 3.1, draw a line to represent the variation with displacement ***x*** of the acceleration ***a*** of the centre of the loudspeaker cone.

[2]