Oscillations

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Oscillations
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **63 minutes**

Score: **/52**

Percentage: **/100**

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

1 A student investigates the energy changes of a mass oscillating on a vertical spring, as shown in Fig. 4.1.

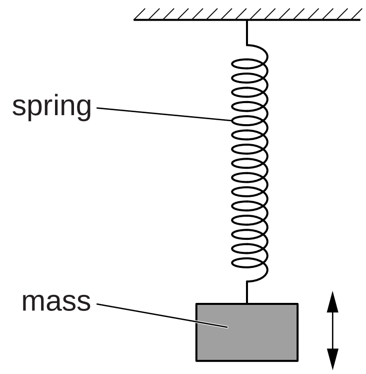

Fig. 4.1

The student draws a graph of the variation with displacement x of energy E of the oscillation, as shown in Fig. 4.2.

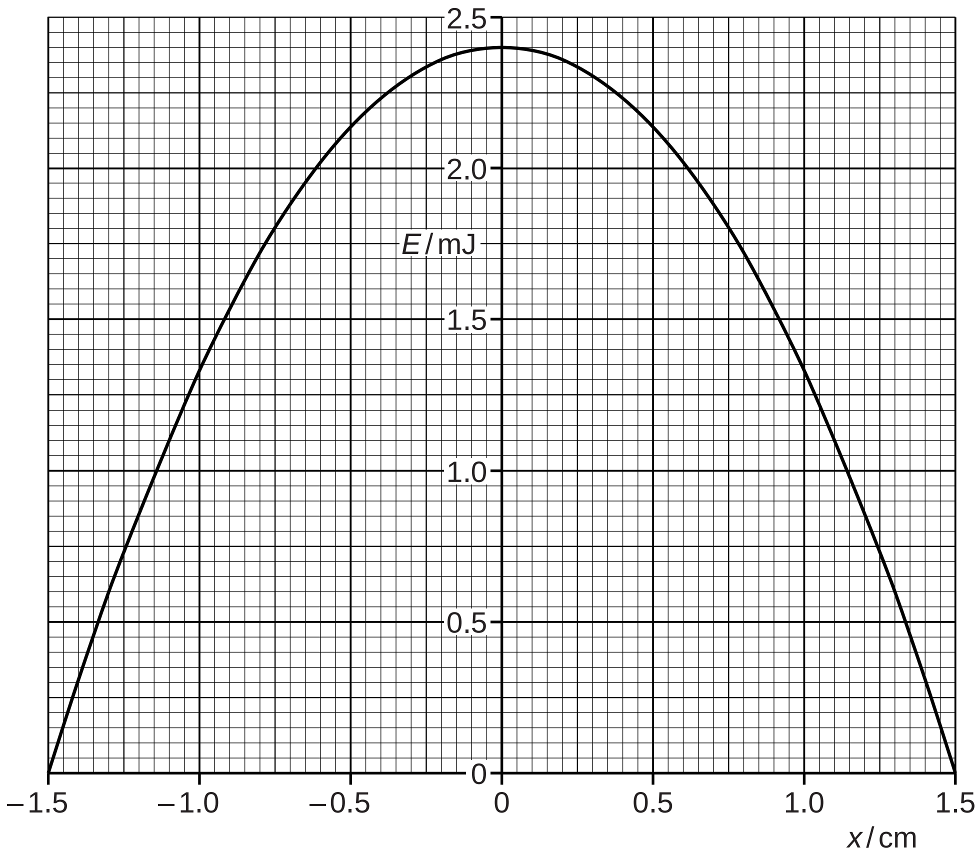

Fig. 4.2

(a) State whether the energy E represents the total energy, the potential energy or the kinetic energy of the oscillations.

.... [1]

(b) The student repeats the investigation but with a smaller amplitude. The maximum value of *E* is now found to be 1.8 mJ.

Use Fig. 4.2 to determine the change in the amplitude. Explain your working.

change in amplitude = ... cm [3]

2 A metal ball is suspended from a fixed point by means of a string, as illustrated in Fig. 3.1.

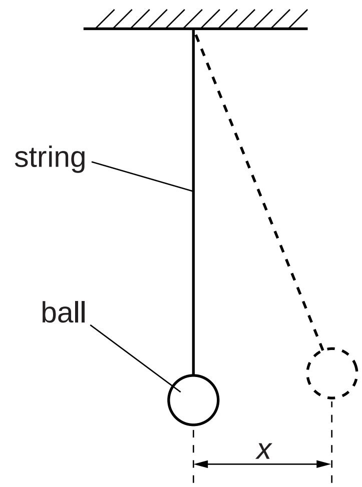

Fig. 3.1

The ball is given a small displacement and then released. The variation with time *t* of the displacement *x* of the ball is shown in Fig. 3.2.

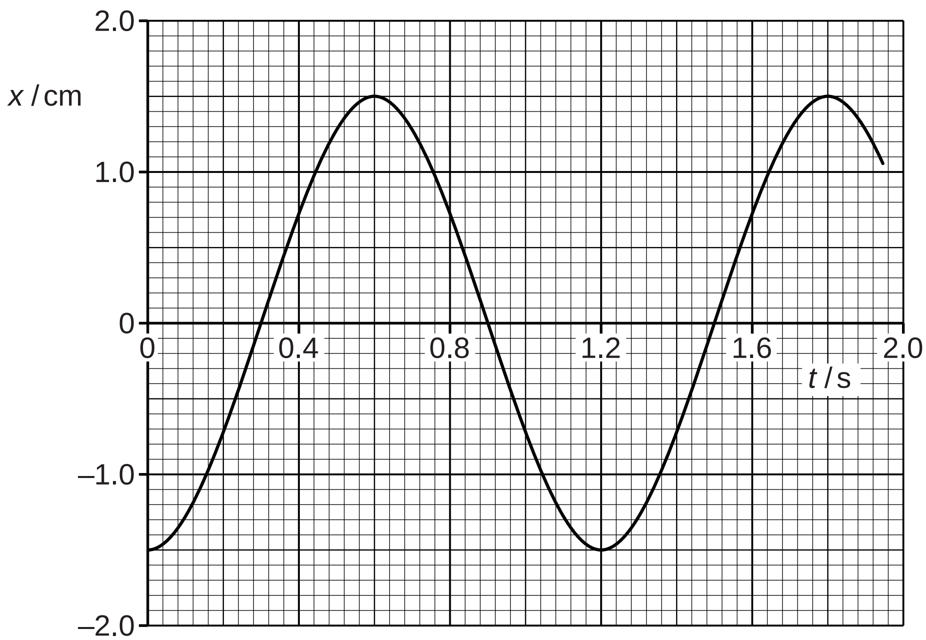

Fig. 3.2

(a) **(i)** State two times at which the speed of the ball is a maximum.

time = ... s and time = ... s [1]

(ii) Show that the maximum speed of the ball is approximately $0.08\,m\,s^{-1}$.

[2]

(b) The variation with displacement x of the potential energy E_P of the oscillations of the ball is shown in Fig. 3.3.

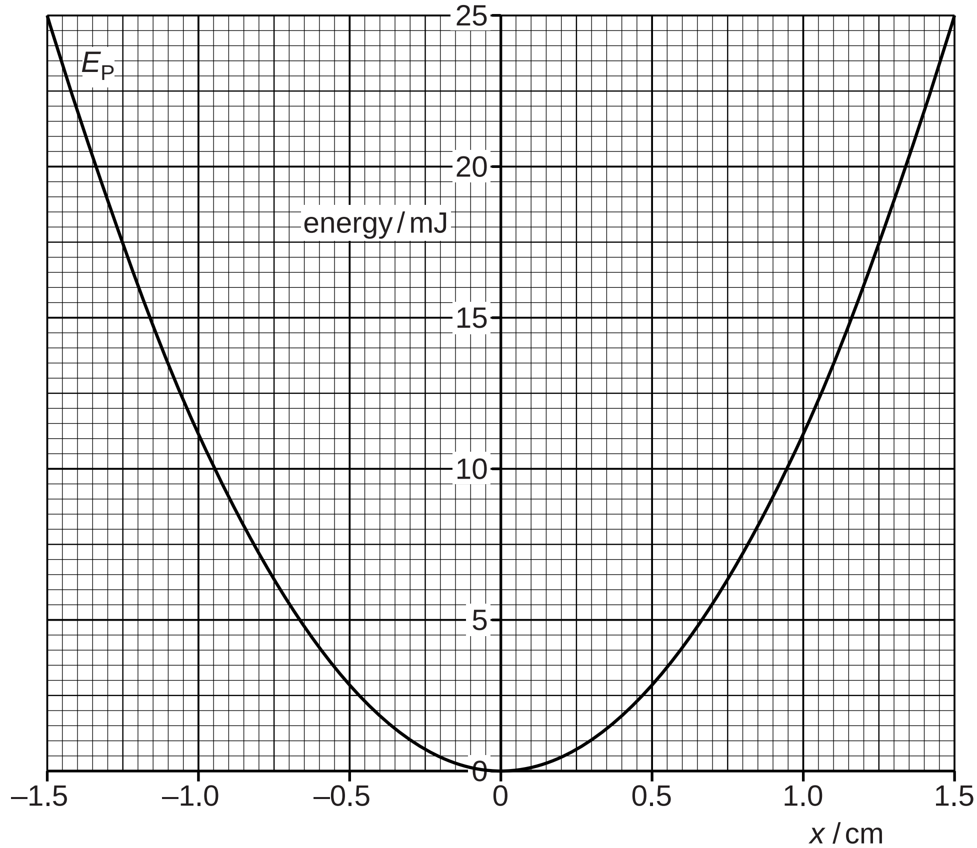

Fig. 3.3

(i) On the axes of Fig. 3.3, sketch a graph to show the variation with displacement x of the kinetic energy of the ball. [2]

(ii) The amplitude of the oscillations reduces over a long period of time.
After many oscillations, the amplitude of the oscillations is 0.60 cm.

Use Fig. 3.3 to determine the total energy of the oscillations of the ball for oscillations of amplitude 0.60 cm. Explain your working.

energy = ... J [2]

3 A ball is held between two fixed points A and B by means of two stretched springs, as shown in Fig. 3.1.

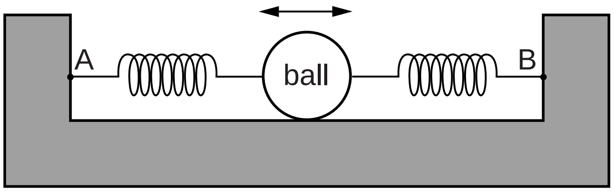

Fig. 3.1

The ball is free to oscillate along the straight line AB. The springs remain stretched and the motion of the ball is simple harmonic.

The variation with time t of the displacement x of the ball from its equilibrium position is shown in Fig. 3.2.

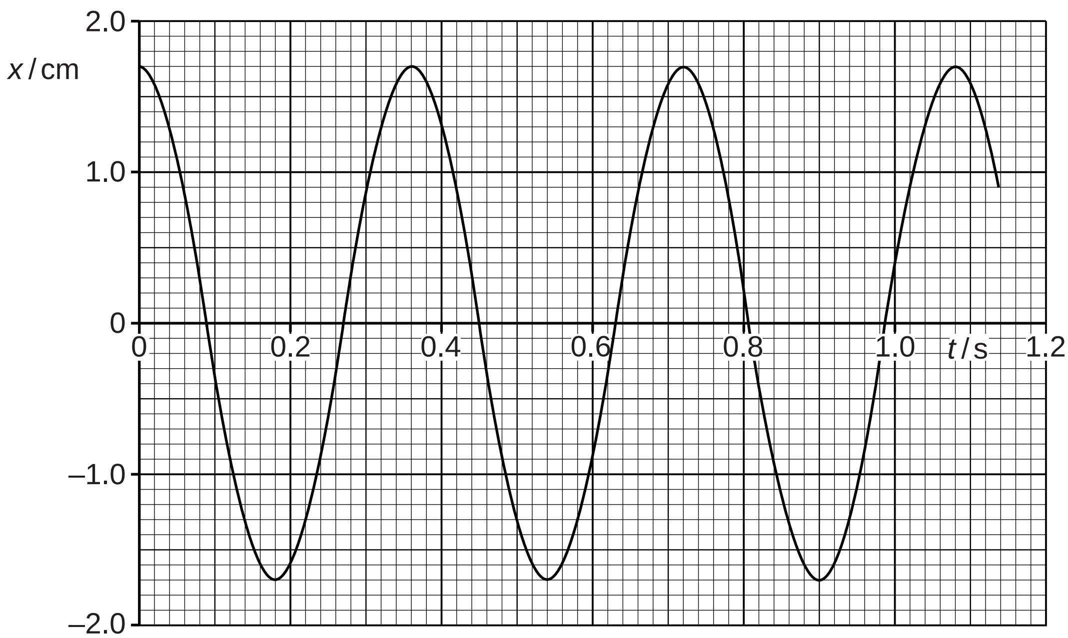

Fig. 3.2

(a) **(i)** Use Fig. 3.2 to determine, for the oscillations of the ball,

1. the amplitude,

amplitude = ... cm [1]

2. the frequency.

frequency = ... Hz [2]

(ii) Show that the maximum acceleration of the ball is 5.2 m s^{-2}.

[2]

(b) Use your answers in **(a)** to plot, on the axes of Fig. 3.3, the variation with displacement *x* of the acceleration *a* of the ball.

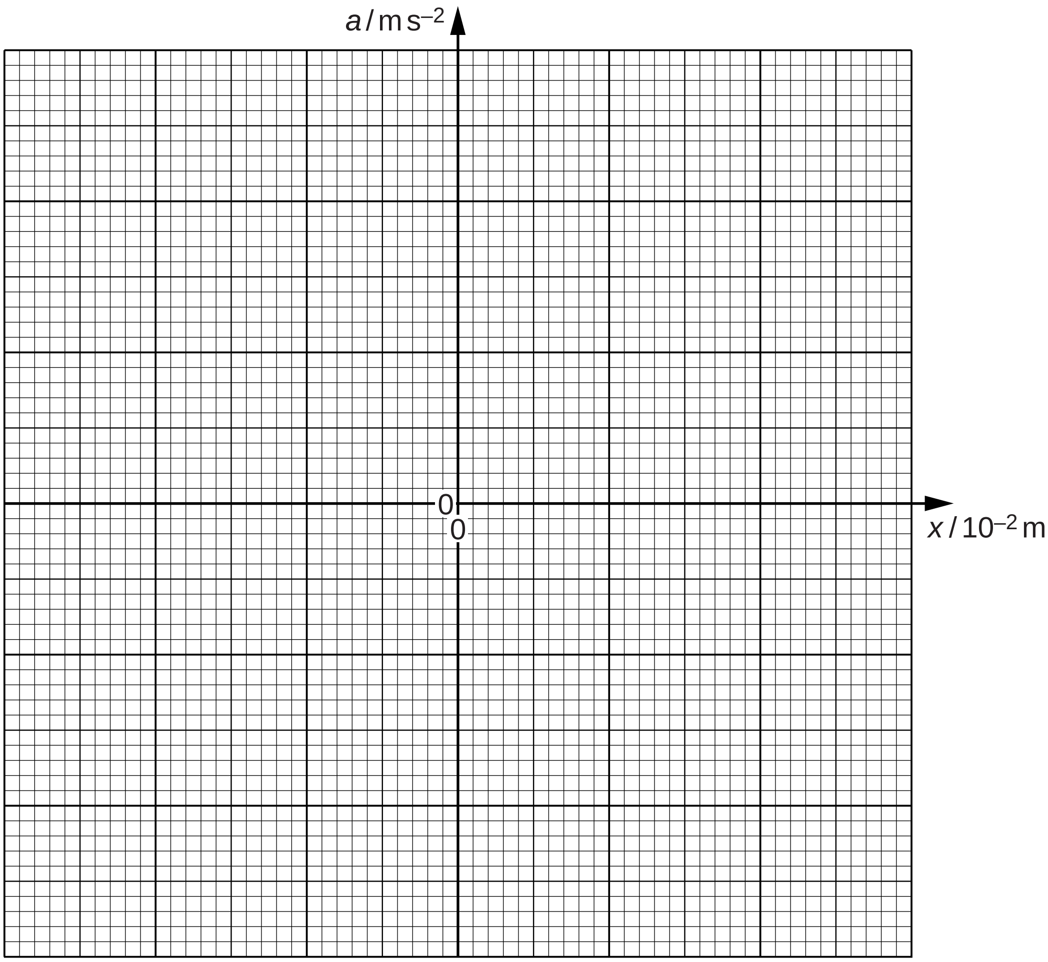

Fig. 3.3

[2]

(c) Calculate the displacement of the ball at which its kinetic energy is equal to one half of the maximum kinetic energy.

displacement = ... cm [3]

4 A mass of 78 g is suspended from a fixed point by means of a spring, as illustrated in Fig. 3.1.

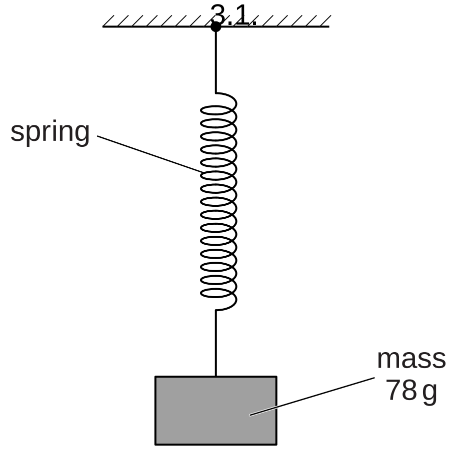

Fig. 3.1

The stationary mass is pulled vertically downwards through a distance of 2.1 cm and then released.
The mass is observed to perform simple harmonic motion with a period of 0.69 s.

(a) The mass is released at time *t* = 0.

For the oscillations of the mass,

(i) calculate the angular frequency ω,

ω = ... rad s^{-1} [2]

(ii) determine numerical equations for the variation with time *t* of

1. the displacement *x* in cm,

....

.... [2]

2. the speed *v* in m s^{-1}.

....

.... [2]

(b) Calculate the total energy of oscillation of the mass.

energy = ... J [2]

5 A ball is held between two fixed points A and B by means of two stretched springs, as shown in Fig. 4.1.

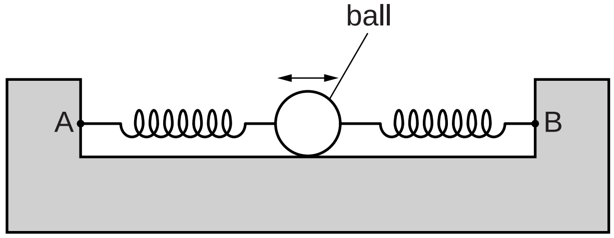

Fig. 4.1

The ball is free to oscillate horizontally along the line AB. During the oscillations, the springs remain stretched and do not exceed their limits of proportionality.

The variation of the acceleration *a* of the ball with its displacement *x* from its equilibrium position is shown in Fig. 4.2.

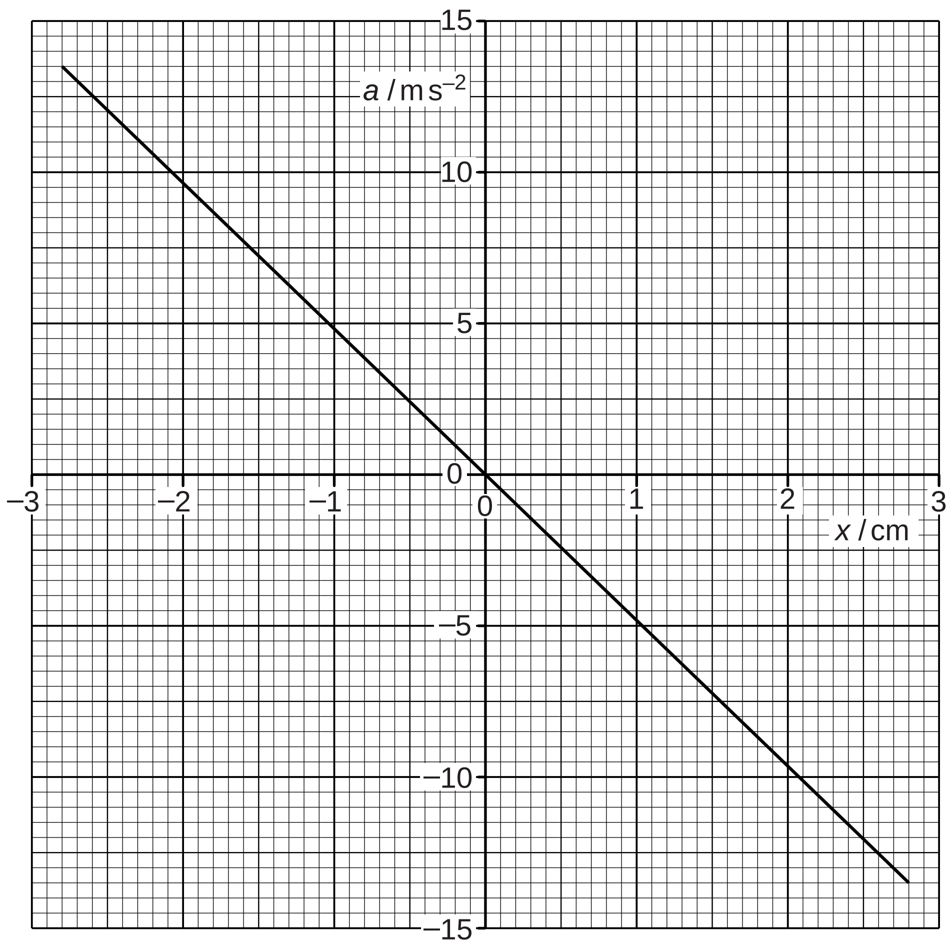

Fig. 4.2

(a) State and explain the features of Fig. 4.2 that indicate that the motion of the ball is simple harmonic.

....

....

....

....

.... [4]

(b) Use Fig. 4.2 to determine, for the oscillations of the ball,

(i) the amplitude,

amplitude = ... cm [1]

(ii) the frequency.

frequency = ... Hz [3]

(c) The arrangement in Fig. 4.1 is now rotated through 90° so that the line AB is vertical. The ball now oscillates in a vertical plane.

Suggest one reason why the oscillations may no longer be simple harmonic.

....

.... [1]

6 A small frictionless trolley is attached to a fixed point A by means of a spring. A second spring is used to attach the trolley to a variable frequency oscillator, as shown in Fig. 2.1.

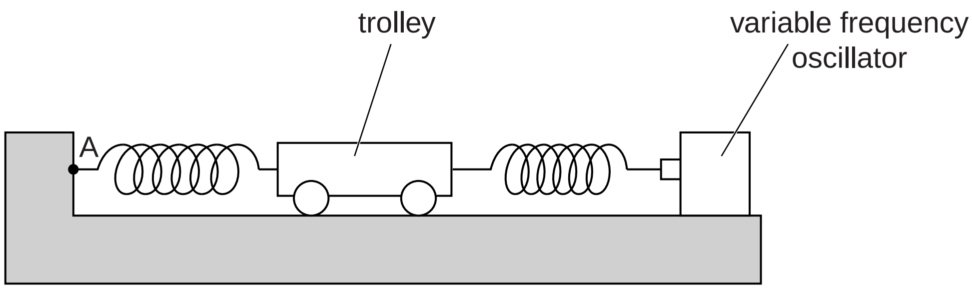

Fig. 2.1

Both springs remain extended within the limit of proportionality.
Initially, the oscillator is switched off. The trolley is displaced horizontally along the line joining the two springs and is then released.
The variation with time *t* of the velocity *v* of the trolley is shown in Fig. 2.2.

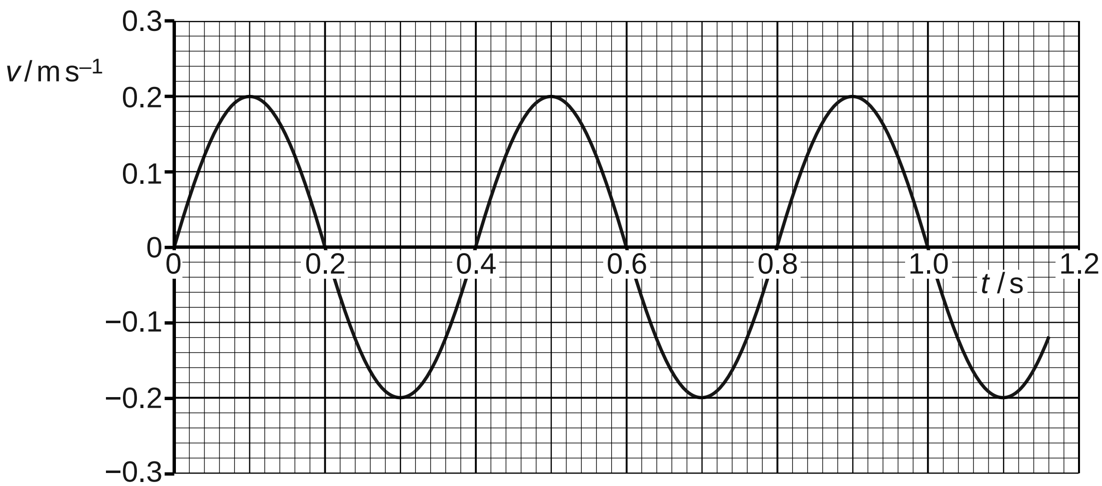

Fig. 2.2

(a) **(i)** Using Fig. 2.2, state two different times at which

1. the displacement of the trolley is zero,

time = ... s and time = ... s [1]

2. the acceleration in one direction is maximum.

time = ... s and time = ... s [1]

(ii) Determine the frequency of oscillation of the trolley.

frequency = ... Hz [2]

(iii) The variation with time of the displacement of the trolley is sinusoidal. The variation with time of the velocity of the trolley is also sinusoidal.

State the phase difference between the displacement and the velocity.

phase difference = ... [1]

(b) The oscillator is now switched on. The amplitude of vibration of the oscillator is constant.
The frequency f of vibration of the oscillator is varied.
The trolley is forced to oscillate by means of vibrations of the oscillator.
The variation with f of the amplitude a_0 of the oscillations of the trolley is shown in Fig. 2.3.

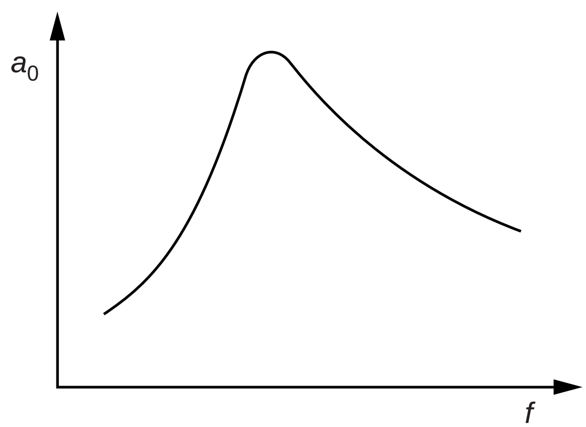

Fig. 2.3

By reference to your answer in **(a)**, state the approximate frequency at which the amplitude is maximum.

frequency = ... Hz [1]

(c) The amplitude of the oscillations in **(b)** may be reduced without changing significantly the frequency at which the amplitude is a maximum. State how this may be done and give a reason for your answer.
You may draw on Fig. 2.1 if you wish.

....

....

....

....

.... [2]

7 A small metal ball is suspended from a fixed point by means of a string, as shown in Fig. 4.1.

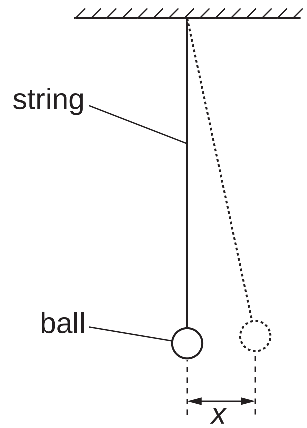

Fig. 4.1

The ball is pulled a small distance to one side and then released. The variation with time *t* of the horizontal displacement *x* of the ball is shown in Fig. 4.2.

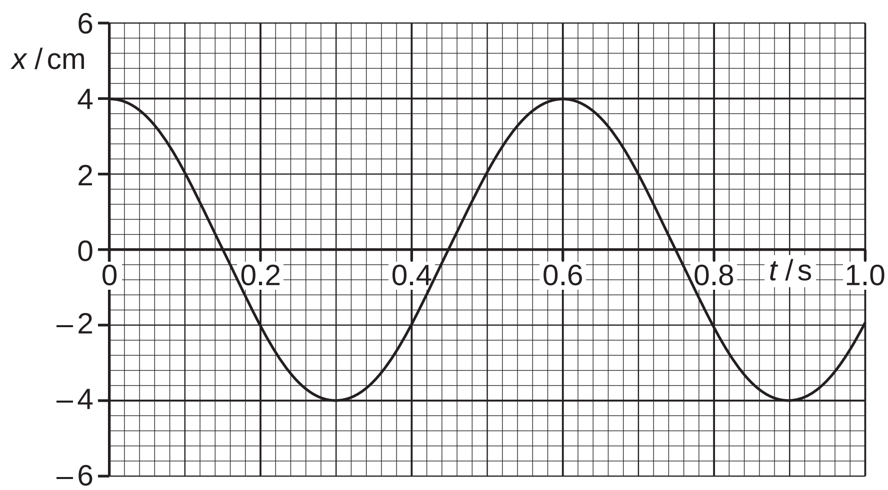

Fig. 4.2

The motion of the ball is simple harmonic.

(a) Use data from Fig. 4.2 to determine the horizontal acceleration of the ball for a displacement *x* of 2.0 cm.

acceleration = ... $m s^{-2}$ [3]

(b) The maximum kinetic energy of the ball is E_K.
On the axes of Fig. 4.3, sketch a graph to show the variation with time t of the kinetic energy of the ball for the first 1.0 s of its motion.

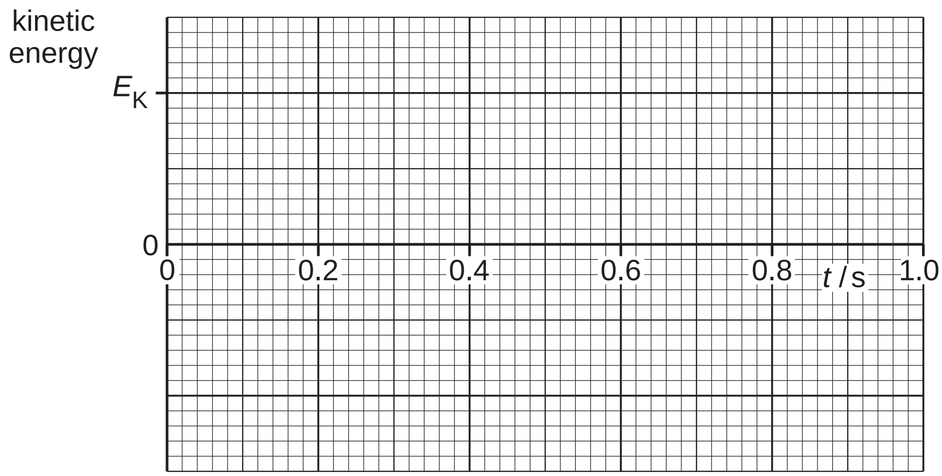

Fig. 4.3

[3]