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

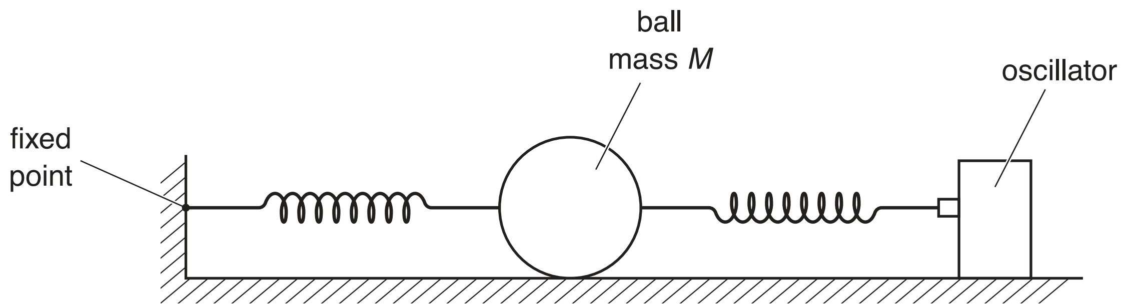

Fig. 4.1

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.

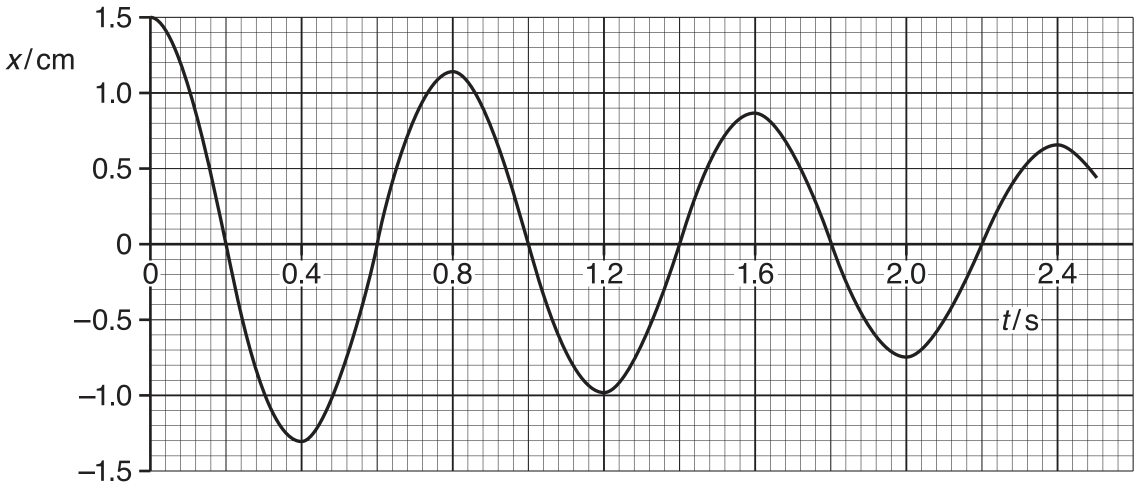

Fig. 4.2

(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.

ω = ... rad s^{-1} [2]

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

k = ... N m^{-1} [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.

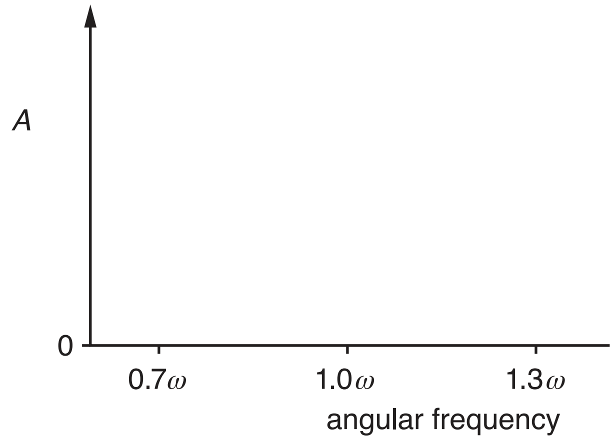

Fig. 4.3

[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]