For Examiner's Use

4 A ball of mass m is hung on a spring of spring constant k as shown in Fig. 4.1 below. The ball is in equilibrium and the spring is extended by a length of d.

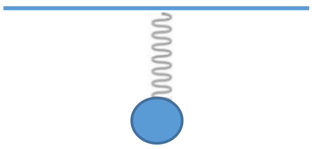

Fig. 4.1

The ball is displaced vertically downwards from its equilibrium position and then released. The acceleration of the ball is a and the vertical displacement of the ball from its equilibrium position is x.

(a) **(i)** By considering the resultant force acting on the ball, show that $a = -\frac{k}{m}x$.

[2]

(ii) Explain why the expression in **(a)(i)** leads to the conclusion that the ball is performing simple harmonic motion.

…………………………………………………………………………………………..

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……………………………………………………………………………………… [2]

For Examiner's Use

(iii) The spring and ball system is now attached to an oscillator. The mass of the ball is 50 g and the spring constant is 1.2 N m^{-1}.

With reference to the expression in **(a)(i)**, determine the natural frequency of the system.

frequency = ……………………… Hz [2]

(iv) On Fig. 4.2, sketch a graph showing the variation with frequency *f* of the oscillator of the amplitude *A* of the ball. Air resistance is not negligible.

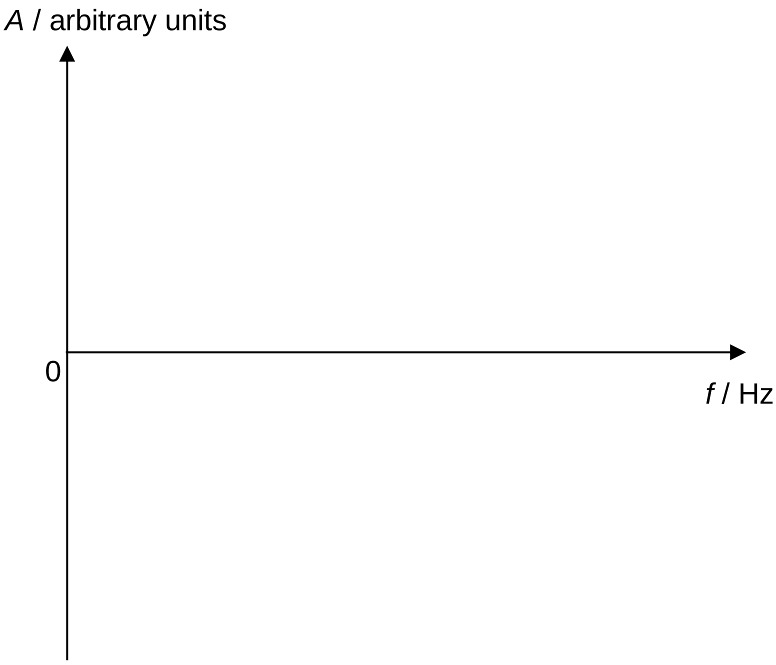

Fig. 4.2

[2]

(b) The spring is now cut into two equal segments.

(i) Determine the natural frequency of the system if only one segment of the spring is used to support the ball.

frequency = ……………………… Hz [2]

(ii) A piece of cardboard with negligible mass is then attached to the ball and the ball is made to oscillate with an initial displacement x_o.

On Fig. 4.3, sketch a graph showing the variation with time t of the displacement x of the ball.

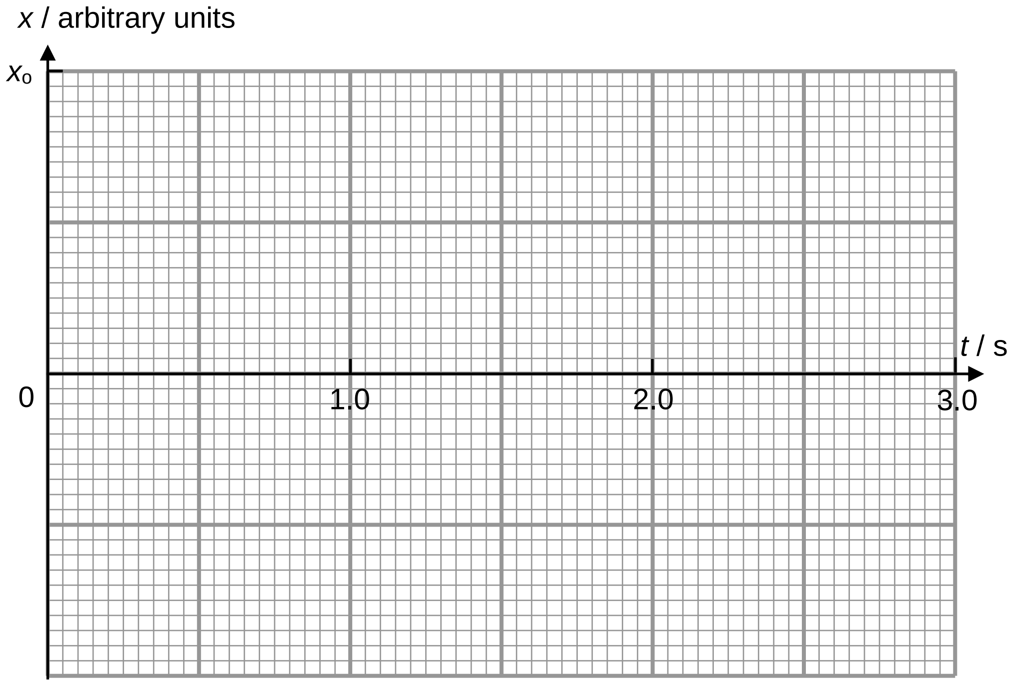

Fig. 4.3

[2]

[Total: 12]