

- (b) Each wheel assembly of the car is mounted on a suspension spring. In a garage test, one wheel assembly is suspended off the ground by its spring with the damper disconnected. Fig. 3.3 shows a graph of the vertical motion of the wheel assembly against time when it is given a small displacement and released.

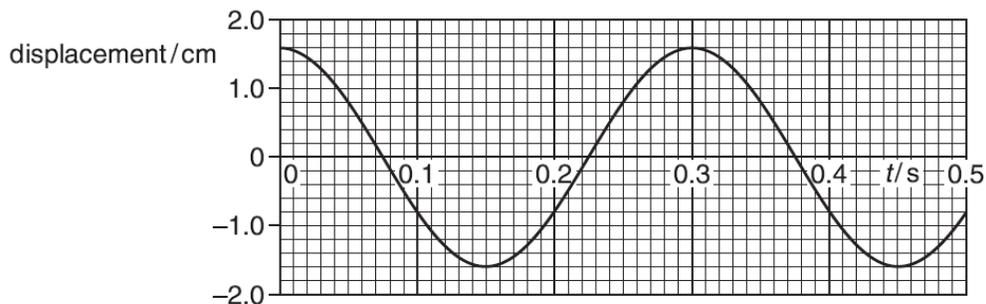


Fig. 3.3

- (i) Use the graph to find the natural frequency f_0 of oscillation of the wheel.

$$f_0 = \dots\dots\dots \text{ Hz [2]}$$

- (ii) When the car is travelling along a ridged concrete road at a speed of 20 m s^{-1} the driver notices that the car bounces significantly. The ridges in the road are equally spaced 6.2 m apart.

- 1 Calculate the frequency f of the bounce.

$$f = \dots\dots\dots \text{ Hz [1]}$$

- 2 State and explain the phenomenon which is occurring.

.....

 [3]

2.

A lead ball of mass 0.25 kg is swung round on the end of a string so that the ball moves in a horizontal circle of radius 1.5 m. The ball travels at a constant speed of 8.6 m s^{-1} .

(a) (i) Calculate the angle, in degrees, through which the string turns in 0.40 s.

[3 marks]

angle degree

(a) (ii) Calculate the tension in the string.
You may assume that the string is horizontal.

[2 marks]

tension N

(b) The string will break when the tension exceeds 60 N.
Calculate the number of revolutions that the ball makes in one second when the tension is 60 N.

[2 marks]

number of revolutions

(c) Discuss the motion of the ball in terms of the forces that act on it. In your answer you should:

- explain how Newton's three laws of motion apply to its motion in a circle
- explain why, in practice, the string will not be horizontal.

You may wish to draw a diagram to clarify your answer.

The quality of your written communication will be assessed in your answer.

[6 marks]

3.

(a) An object is oscillating with simple harmonic motion. Place a tick (✓) in the box against each true statement that applies to the acceleration of the object.

The acceleration ...

... is in the opposite direction to the displacement.

... is directly proportional to the amplitude squared.

... increases as the displacement decreases.

... increases as the speed of the object decreases.

[2]

(b) The graph in Fig. 3.1 shows the variation of the velocity v of the object with time t .

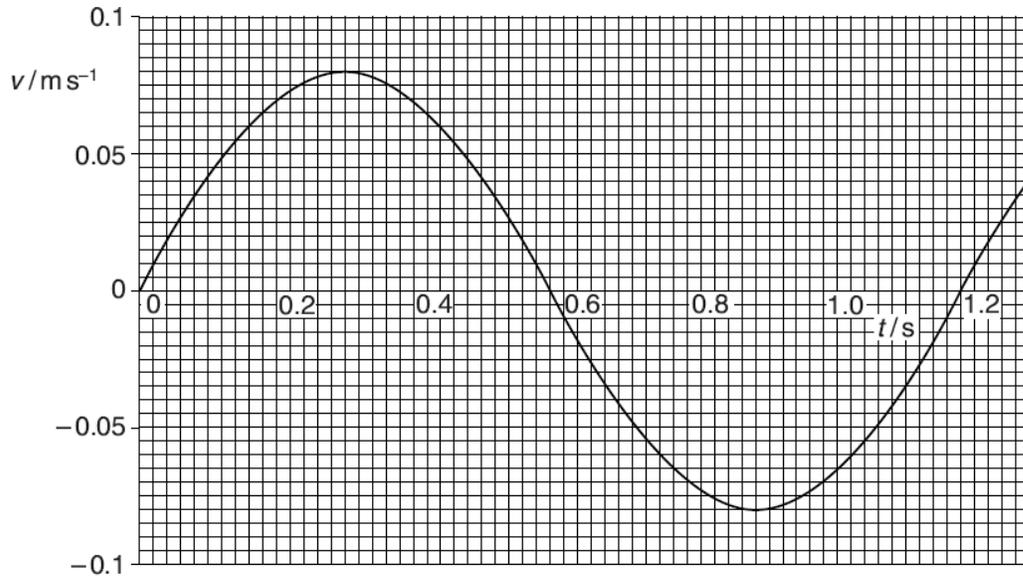


Fig. 3.1

Using the graph, determine

(i) the frequency of the motion

frequency = Hz [1]

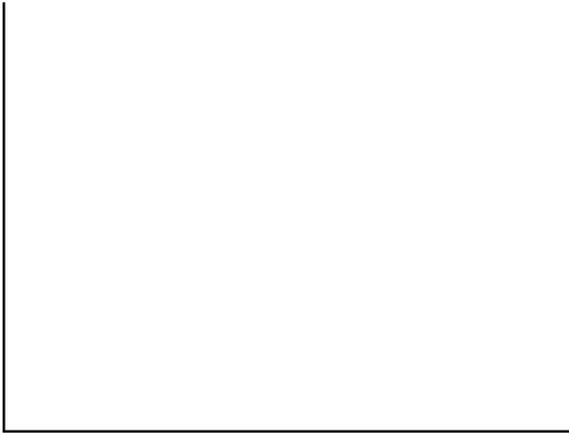
(ii) the amplitude of the motion

amplitude = m [2]

(iii) the maximum acceleration of the object.

acceleration = ms^{-2} [2]

(c) (i) With the help of a suitably labelled graph, explain what is meant by *resonance* of a mechanical system.



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..... [4]

(ii) State and explain an everyday example of resonance.

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..... [2]

4.

- (a) (i) Name the **two** types of potential energy involved when a mass–spring system performs vertical simple harmonic oscillations.

[1 mark]

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- (a) (ii) Describe the energy changes which take place during one complete oscillation of a vertical mass-spring system, starting when the mass is at its lowest point.

[2 marks]

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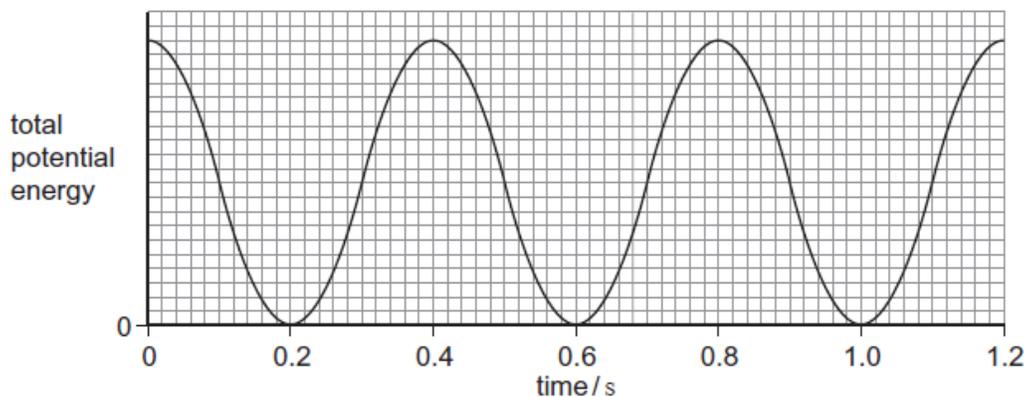
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- (b) **Figure 3** shows how the **total** potential energy due to the simple harmonic motion varies with time when a mass-spring system oscillates vertically.

Figure 3



- (b) (i) State the time period of the simple harmonic oscillations that produces the energy–time graph shown in **Figure 3**, explaining how you arrive at your answer.

[2 marks]

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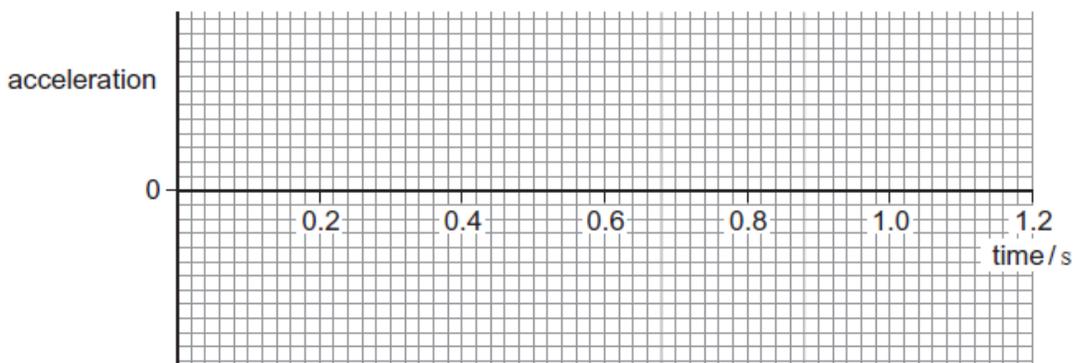
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- (b) (ii) Sketch a graph on **Figure 4** to show how the acceleration of the mass varies with time over a period of 1.2s, starting with the mass at the highest point of its oscillations. On your graph, upwards acceleration should be shown as positive and downwards acceleration as negative. Values are not required on the acceleration axis.

[2 marks]

Figure 4



Time period of a mass spring system is given by,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

- (c) (i) The mass of the object suspended from the spring in part (b) is 0.35kg. Calculate the spring constant of the spring used to obtain **Figure 3**. State an appropriate unit for your answer.

[3 marks]

spring constant unit

- (c) (ii) The maximum kinetic energy of the oscillating object is 2.0×10^{-2} J. Show that the amplitude of the oscillations of the object is about 40 mm.

[4 marks]