

- 1 Fig. 3.1 shows a metal plate attached to the end of a spiral spring. The end **A** of the spring is fixed to a rigid clamp. The plate is pulled down by a small amount and released. The plate performs simple harmonic motion in a vertical plane at a natural frequency of 8 Hz and the spring remains in tension at all times.

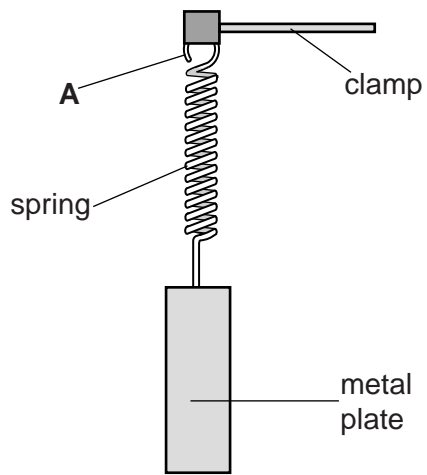


Fig. 3.1

- (a) (i) On Fig. 3.2 sketch an acceleration a against displacement x graph for the motion of the metal plate. You are not required to give values on the axes.

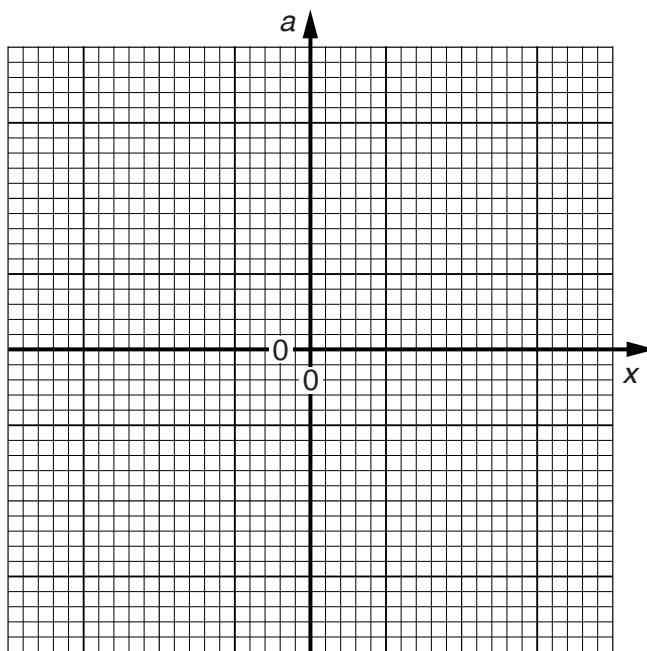


Fig. 3.2

[2]

(ii) Explain how your graph could be used to determine the frequency of oscillation of the metal plate.

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..... [2]

(b) Fig. 3.3 shows the variation of the vertical velocity v of the plate with time t at a frequency of 8 Hz.

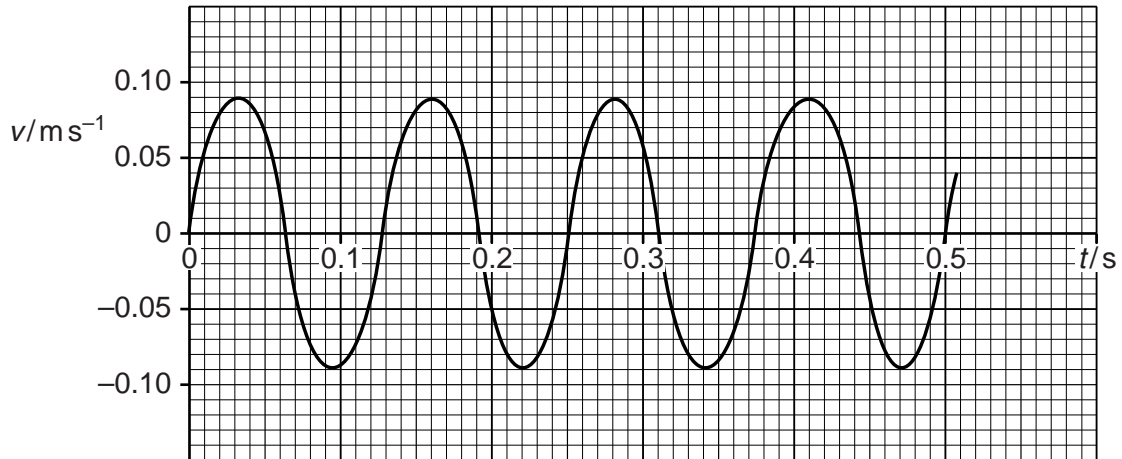


Fig. 3.3

Use the graph to determine

(i) the amplitude of the motion

amplitude = m [2]

(ii) the maximum vertical acceleration of the plate.

acceleration = ms^{-2} [2]

- (c) The metal plate is now immersed in light oil which provides a constant frictional force to the plate. On Fig. 3.4 draw carefully the graph you would expect to obtain for the variation of the vertical velocity v with time t . As a guide a copy of the graph in Fig. 3.3 is drawn for you.

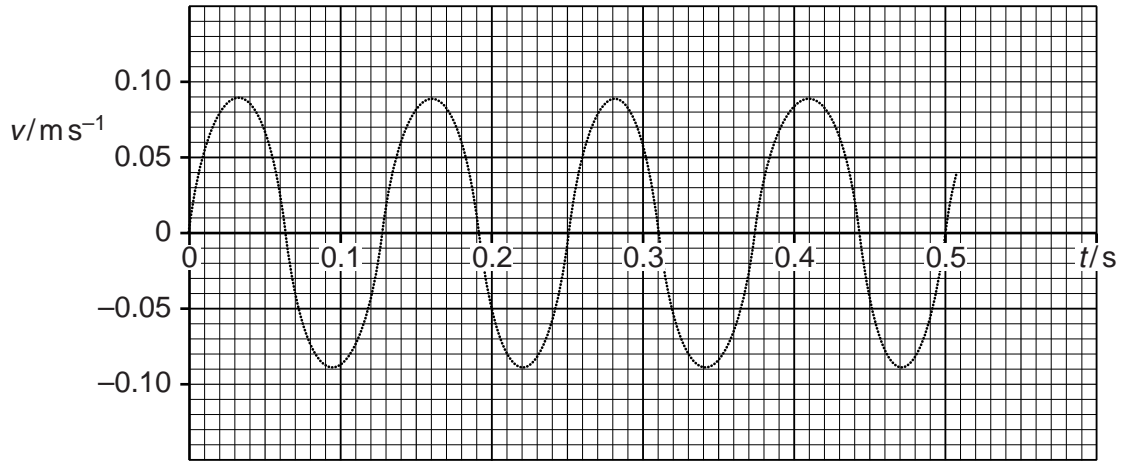


Fig. 3.4

[2]

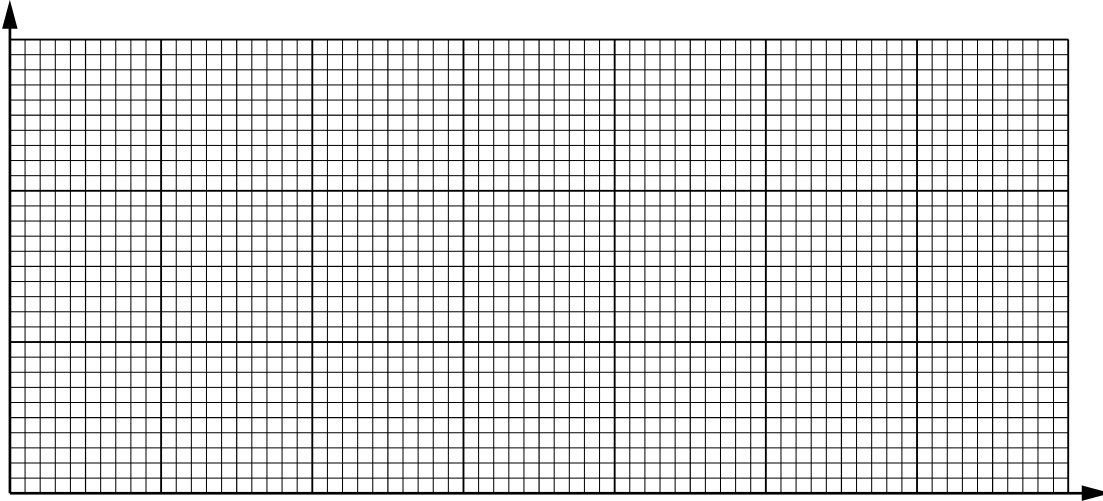
- (d) The plate is now removed from the oil and the point **A** on the spring connected to an oscillator that vibrates vertically with constant amplitude. The frequency of the oscillator is increased slowly from 0 Hz to 12 Hz.

Describe and explain the motion of the metal plate during this procedure.

Sketch a labelled graph to help with your explanation.



In your answer, you should use appropriate technical terms spelled correctly.



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..... [3]

- 2 (a) Fig. 3.1 shows a simple pendulum consisting of a steel sphere suspended by a light string from a rigid support. The sphere is displaced 50 mm from its vertical equilibrium position and released at time $t = 0$.

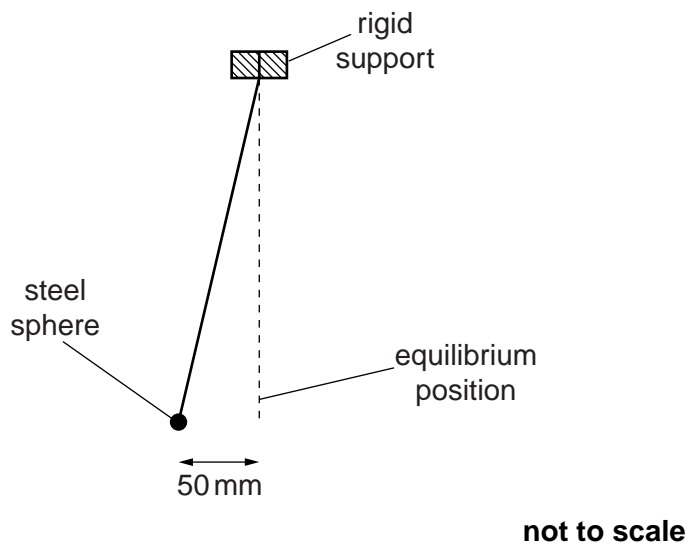


Fig. 3.1

Fig. 3.2 shows the graph of displacement x of the sphere against time t .

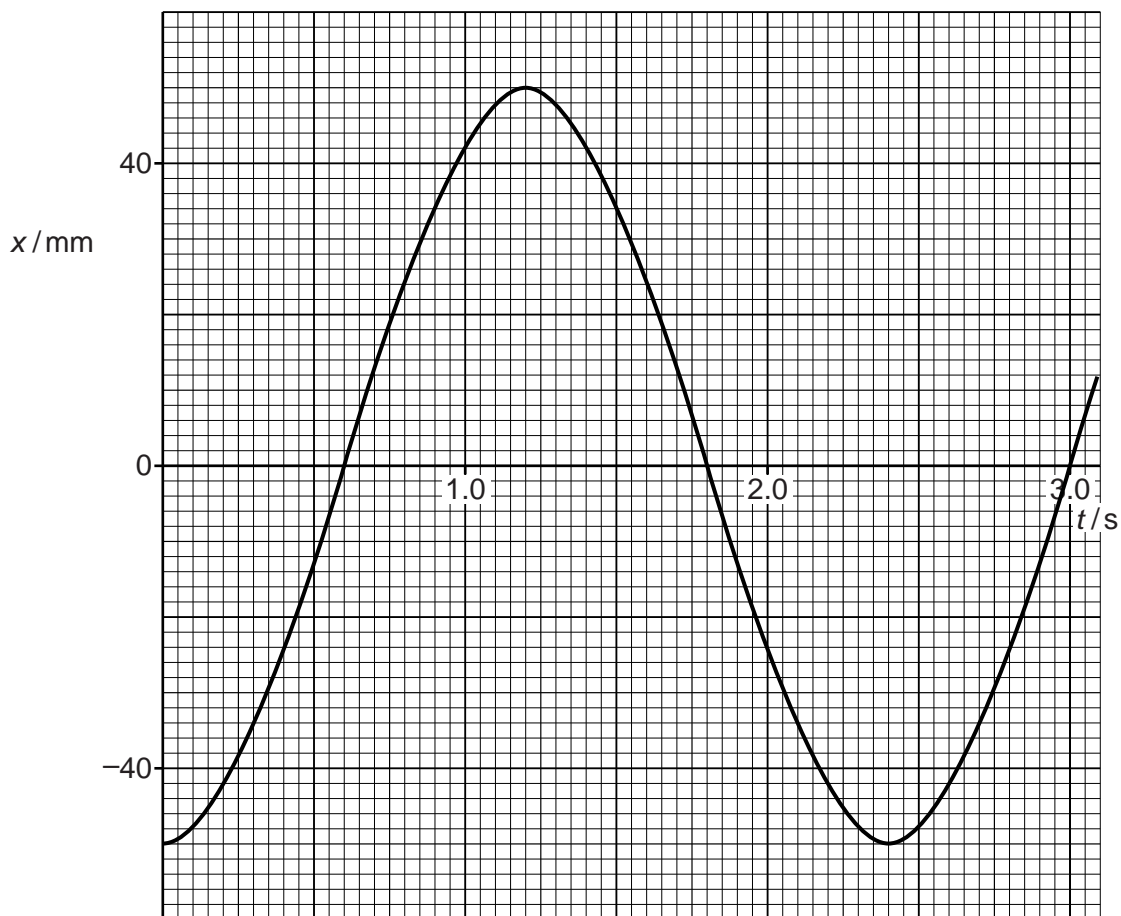


Fig. 3.2

(i) Use Fig. 3.2 to determine the frequency of oscillation of the pendulum.

frequency = Hz [1]

(ii) Use Fig. 3.2, or otherwise, to determine the maximum speed of the sphere.
Show your method clearly.

speed = ms^{-1} [2]

(b) The sphere is now released from rest with a displacement $x = 25 \text{ mm}$.
State with a reason, the change if any in

(i) the frequency of the oscillations

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..... [1]

(ii) the maximum kinetic energy of the sphere.

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..... [2]

- (c) In turbulent air the wingtip of an aircraft can vibrate vertically. To investigate this effect, the acceleration and the vertical displacement of the wingtip are measured. Fig. 3.3 shows how the acceleration of the wingtip varies with displacement.

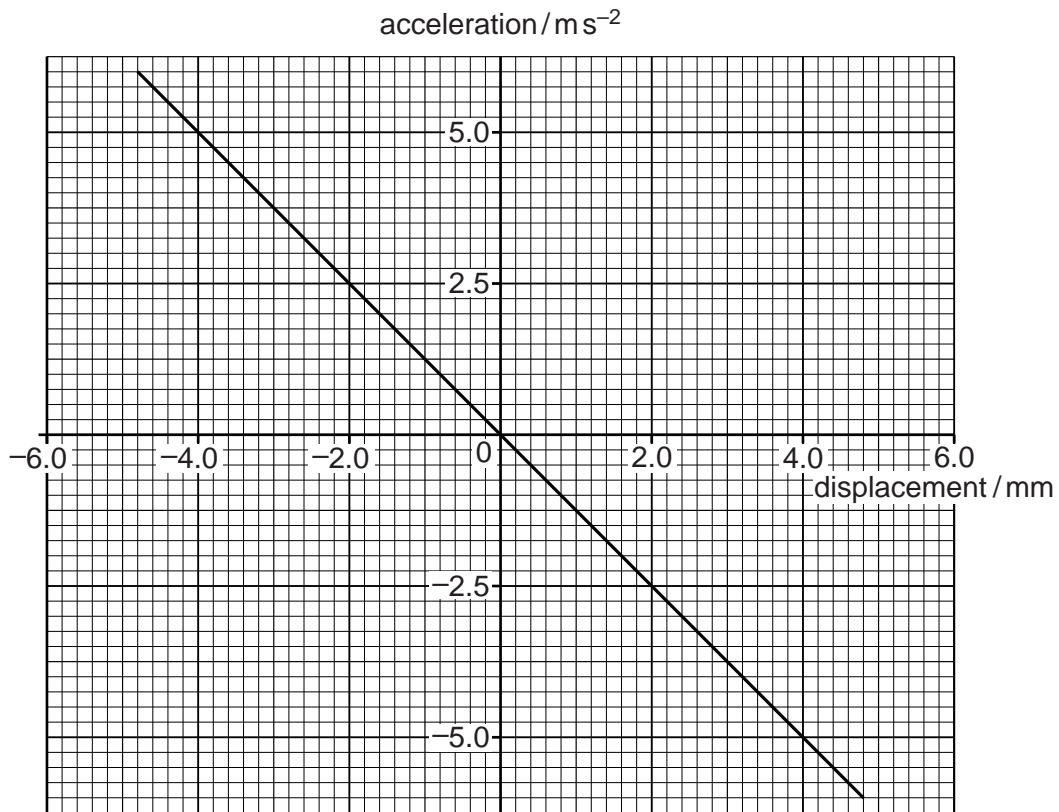


Fig. 3.3

- (i) Explain how Fig. 3.3 suggests that the wingtip undergoes simple harmonic motion under the test conditions.

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 [2]

- (ii) Use Fig. 3.3 to determine the frequency of the vibration.

frequency = Hz [2]

- 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 .

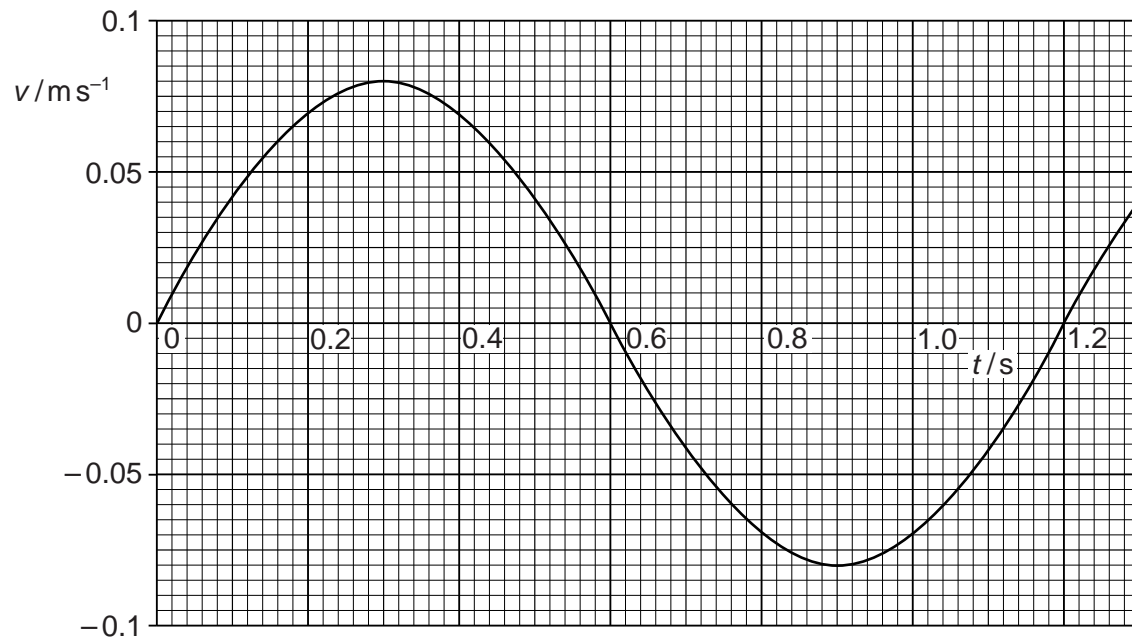


Fig. 3.1

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]**

4 (a) A body moves with simple harmonic motion. Define, in words, *simple harmonic*



motion. In your answer, you should use appropriate technical terms, spelled correctly.

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..... [2]

(b) A horizontal metal plate connected to a vibration generator is oscillating vertically with simple harmonic motion of period 0.080 s and amplitude 1.2 mm. There are dry grains of sand on the plate. Fig. 2.1 shows the arrangement.

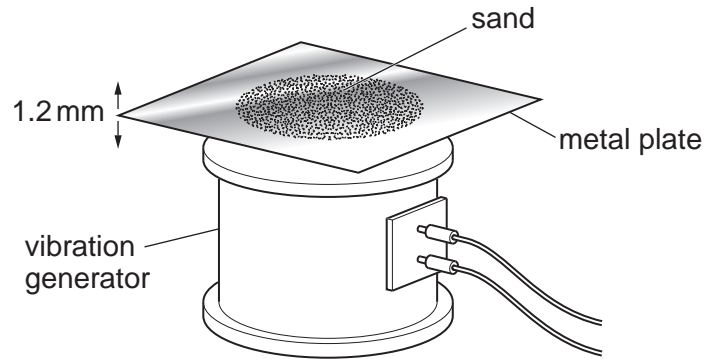


Fig. 2.1

(i) Calculate the maximum speed of the oscillating plate.

maximum speed = m s^{-1} [2]

(ii) The frequency of the vibrating plate is kept constant and its amplitude is slowly increased from zero. The grains of sand start to lose contact with the plate when the amplitude is A_0 . State and explain the necessary conditions when the grains of sand first lose contact with the plate. Hence calculate the value of A_0 .

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- (c) The casing of a poorly designed washing machine vibrates violently when the drum rotates during the spin cycle. Fig. 2.2 shows how the amplitude of vibration of the casing varies with the frequency of rotation of the drum.

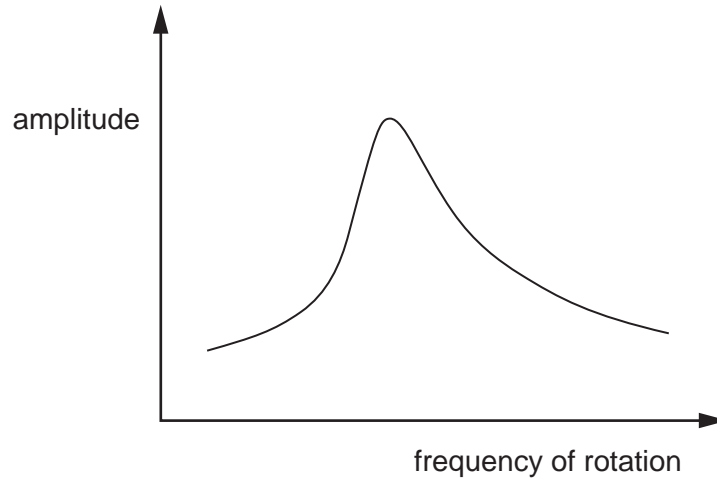


Fig. 2.2

- (i) State the name of this effect and describe the conditions under which it occurs.

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..... [2]

- (ii) The design of the washing machine is improved to reduce the effect by adding a damping mechanism to the inside of the machine. Sketch on Fig. 2.2 the new graph of amplitude against frequency of rotation expected for this improved design. [2]

[Total: 12]