

- 5 A cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

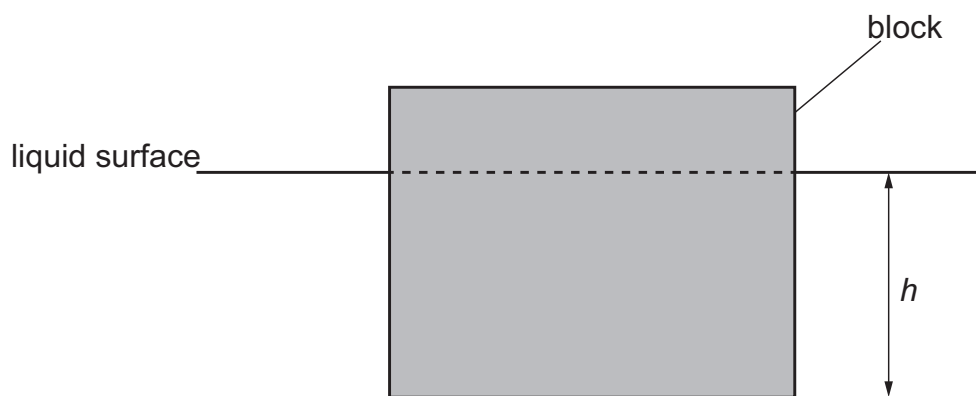


Fig. 5.1

The base of the block is at a depth h below the surface of the liquid.

The block is displaced downwards by a small distance and then released so that it oscillates.

Fig. 5.2 shows the variation with h of the acceleration a of the block.

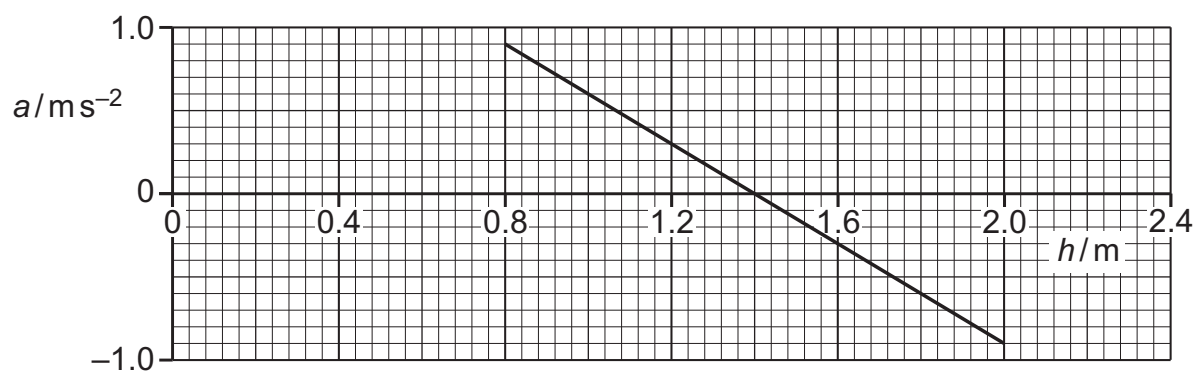


Fig. 5.2

Fig. 5.3 shows the variation with h of the kinetic energy E_K of the block.

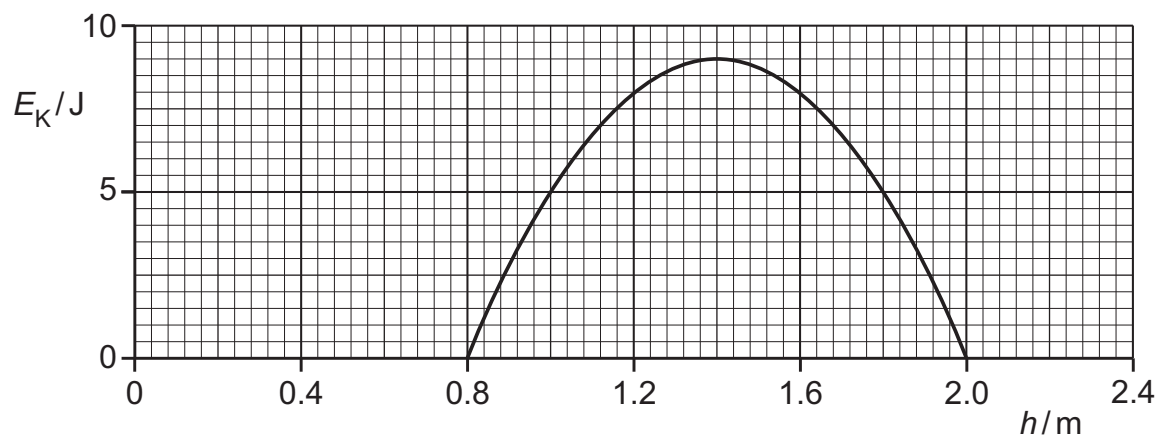


Fig. 5.3

(a) (i) Determine the amplitude of the oscillations.

amplitude = m [1]

(ii) State what the line in Fig. 5.2 shows about the nature of the oscillations.

..... [1]

(b) State **three** other quantitative conclusions that can be drawn from Fig. 5.2 and Fig. 5.3 about the block and its oscillations. Use the space for any working.

- 1
-
- 2
-
- 3
-
- [3]

(c) On Fig. 5.4, sketch the variation with h of the potential energy E_P of the oscillations.

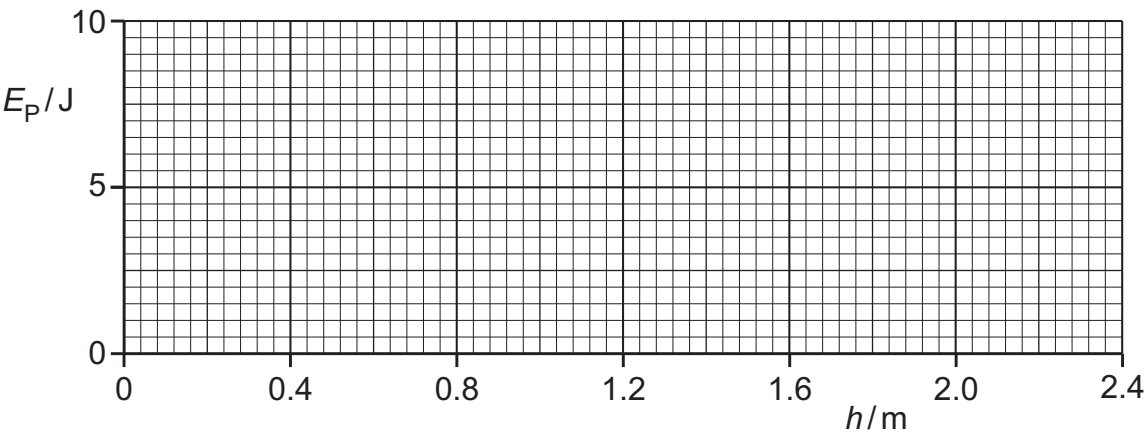


Fig. 5.4

[3]

[Total: 8]

- 4 A small crystal is made to vibrate with simple harmonic motion. The variation with time t of the displacement x of one surface of the crystal from its equilibrium position is shown in Fig. 4.1.

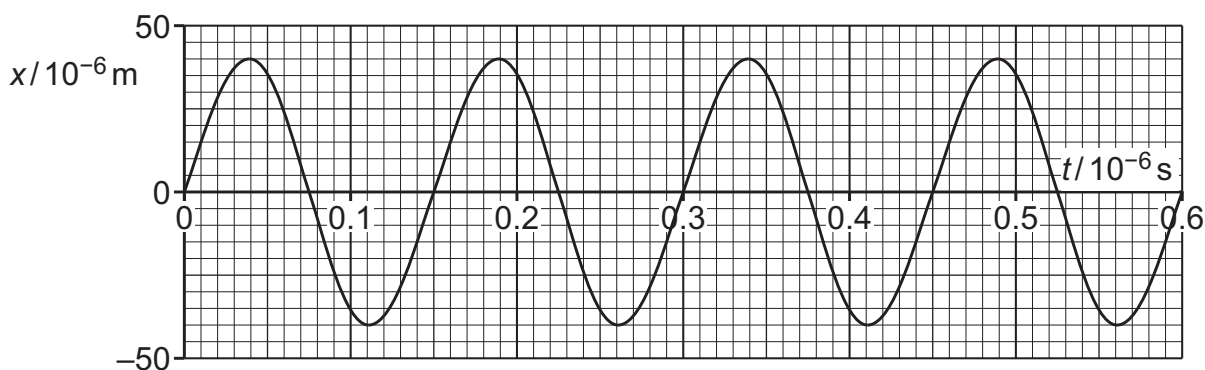


Fig. 4.1

- (a) Show that the angular frequency of the vibration of the surface is $4.2 \times 10^7 \text{ rad s}^{-1}$.

[2]

- (b) Determine the maximum acceleration a_0 of the vibration of the surface.

$$a_0 = \dots \text{ ms}^{-2} \quad [2]$$

- (c) The crystal may be modelled as a single mass of $2.4 \times 10^{-4} \text{ kg}$ that vibrates as shown in Fig. 4.1.

Calculate the total energy E of the vibrations.

$$E = \dots \text{ J} \quad [3]$$

- (d) The crystal generates ultrasound waves that are used to obtain diagnostic information about internal structures.
- (i) The crystal is made from piezoelectric material.

Explain how the crystal is made to vibrate.

[2]

- (ii) A parallel beam of ultrasound waves is incident on a muscle-bone boundary. Data for muscle and bone are given in Table 4.1.

Table 4.1

material	density / kg m ⁻³	speed of sound / m s ⁻¹
muscle	1100	1600
bone	1900	4100

Calculate the percentage of the intensity of the ultrasound beam that is transmitted at this boundary.

percentage transmitted = % [3]

[Total: 12]

- 4 A small steel sphere is oscillating vertically on the end of a spring, as shown in Fig. 4.1.

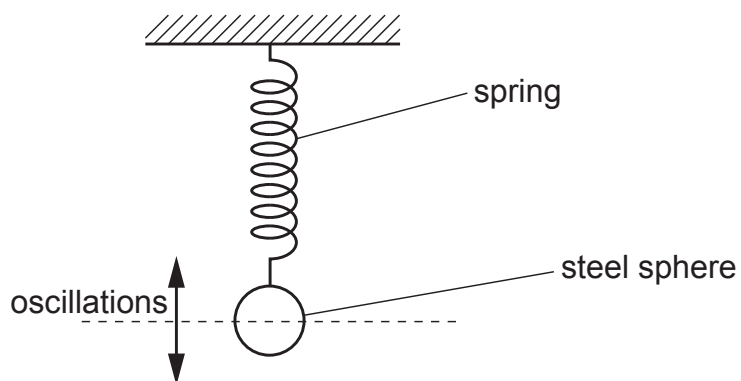


Fig. 4.1

The velocity v of the sphere varies with displacement x from its equilibrium position according to

$$v = \pm 9.7 \sqrt{(11.6 - x^2)}$$

where v is in cm s^{-1} and x is in cm.

- (a) (i) Calculate the frequency of the oscillations.

frequency = Hz [2]

- (ii) Show that the amplitude of the oscillations is 3.4 cm.

[1]

- (iii) Calculate the maximum acceleration a_0 of the sphere.

$a_0 = \dots \text{ms}^{-2}$ [2]

(b) On Fig. 4.2, sketch the variation with x of the acceleration a of the sphere.

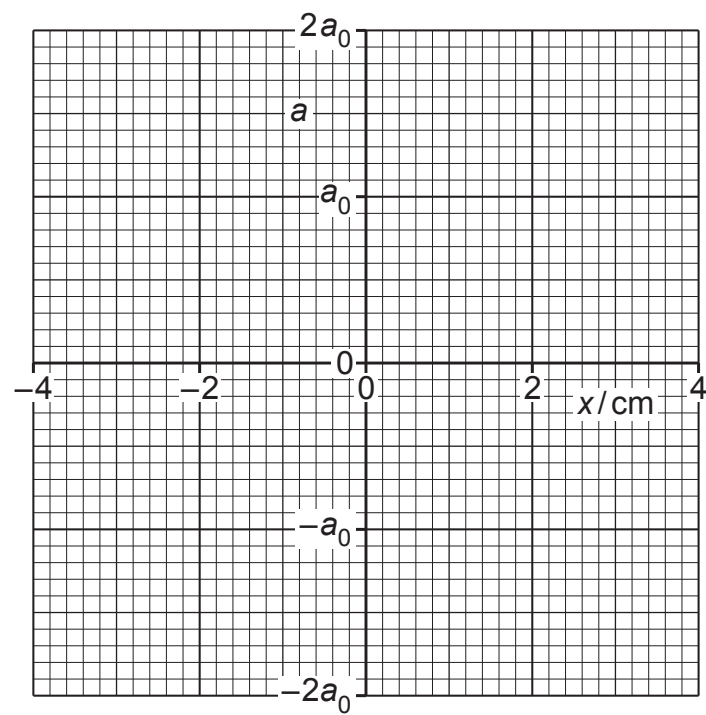


Fig. 4.2

[3]

(c) Describe, without calculation, the interchange between the potential energy and the kinetic energy of the oscillations.

[3]

[Total: 11]