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

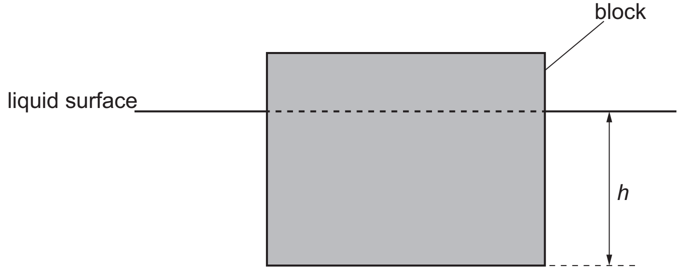

Fig. 5.1

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.

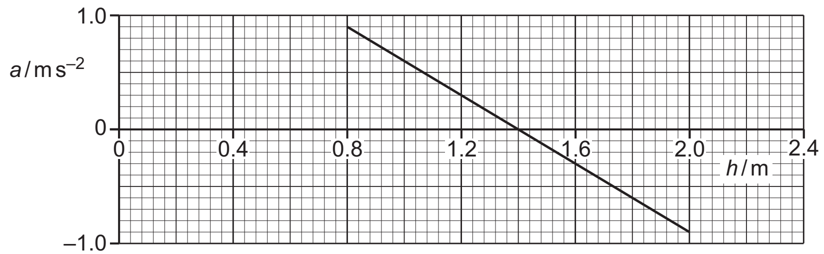

Fig. 5.2

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

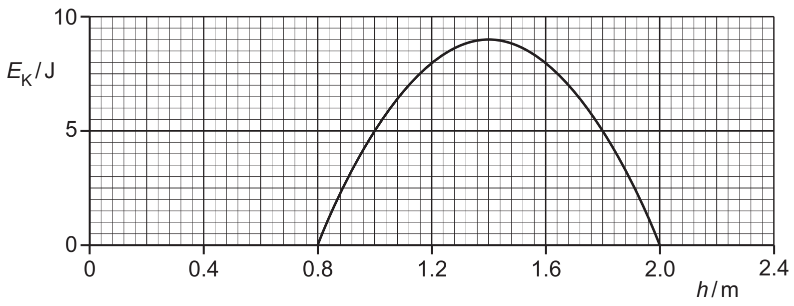

Fig. 5.3

(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.

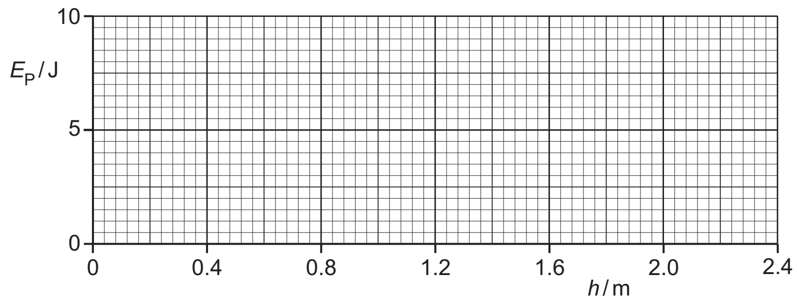

Fig. 5.4

[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.

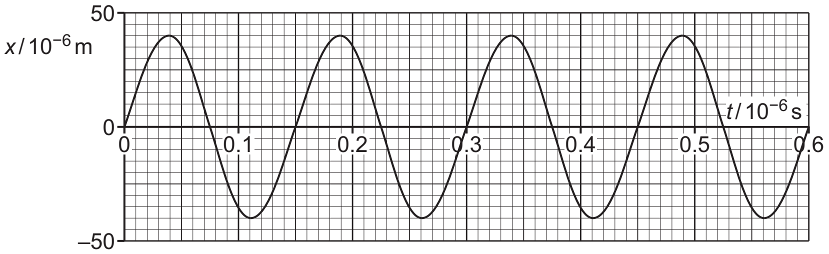

Fig. 4.1

(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 = ... m s^{-2} [2]

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

Calculate the total energy E of the vibrations.

E = ... J [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.

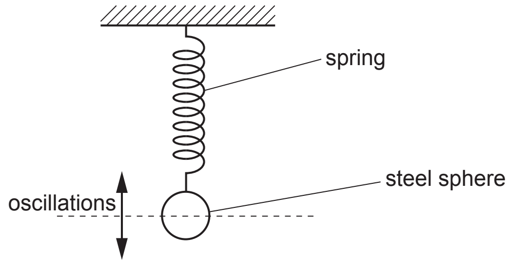

Fig. 4.1

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 = ... $m\,s^{-2}$ [2]

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

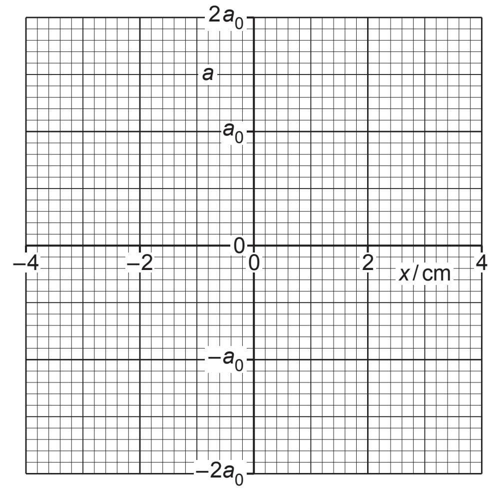

Fig. 4.2

[3]

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

....

....

....

....

.... [3]

[Total: 11]