

Oscillations

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Oscillations
Sub Topic	
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: 58 minutes

Score: /48

Percentage: /100

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 A ball of mass 37 g is held between two fixed points A and B by two stretched helical springs, as shown in Fig. 2.1.

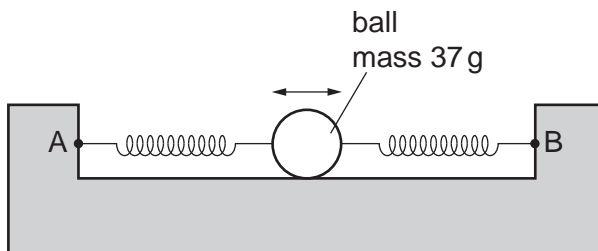


Fig. 2.1

The ball oscillates along the line AB with simple harmonic motion of frequency 3.5 Hz and amplitude 2.8 cm.

- (a) Show that the total energy of the oscillations is 7.0 mJ.

[2]

- (b) At two points in the oscillation of the ball, its kinetic energy is equal to the potential energy stored in the springs.
Calculate the magnitude of the displacement at which this occurs.

displacement = cm [3]

(c) On the axes of Fig. 2.2 and using your answers in (a) and (b), sketch a graph to show the variation with displacement x of

(i) the total energy of the system (label this line T), [1]

(ii) the kinetic energy of the ball (label this line K), [2]

(iii) the potential energy stored in the springs (label this line P). [2]

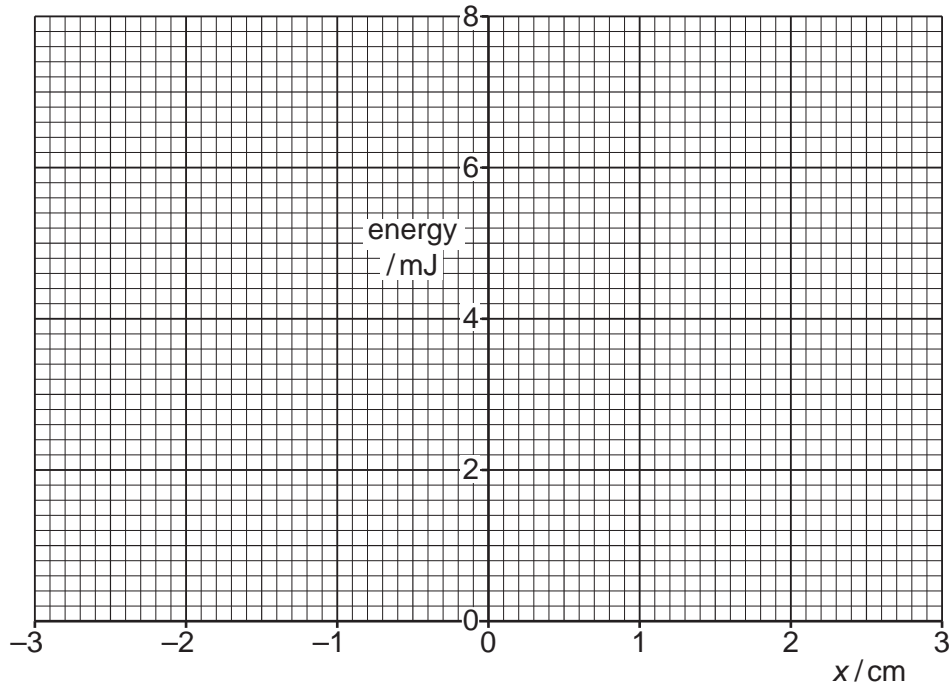


Fig. 2.2

(d) The arrangement in Fig. 2.1 is now rotated through 90° so that the line AB is vertical and the ball oscillates in a vertical plane.

Suggest one form of energy, other than those in (c), that must be taken into consideration when plotting new graphs to show energy changes with displacement.

.....[1]

- 2 A bar magnet is suspended from the free end of a helical spring, as illustrated in Fig. 3.1.

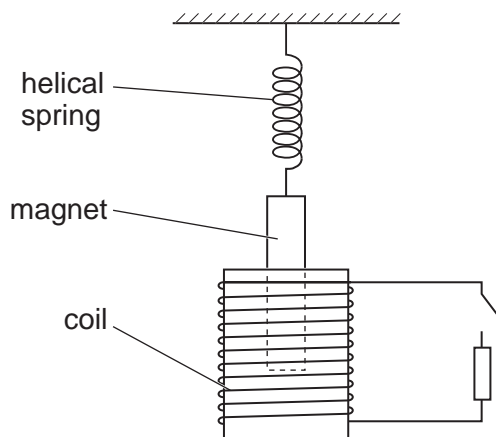


Fig. 3.1

One pole of the magnet is situated in a coil of wire. The coil is connected in series with a switch and a resistor. The switch is open.

The magnet is displaced vertically and then released. As the magnet passes through its rest position, a timer is started. The variation with time t of the vertical displacement y of the magnet from its rest position is shown in Fig. 3.2.

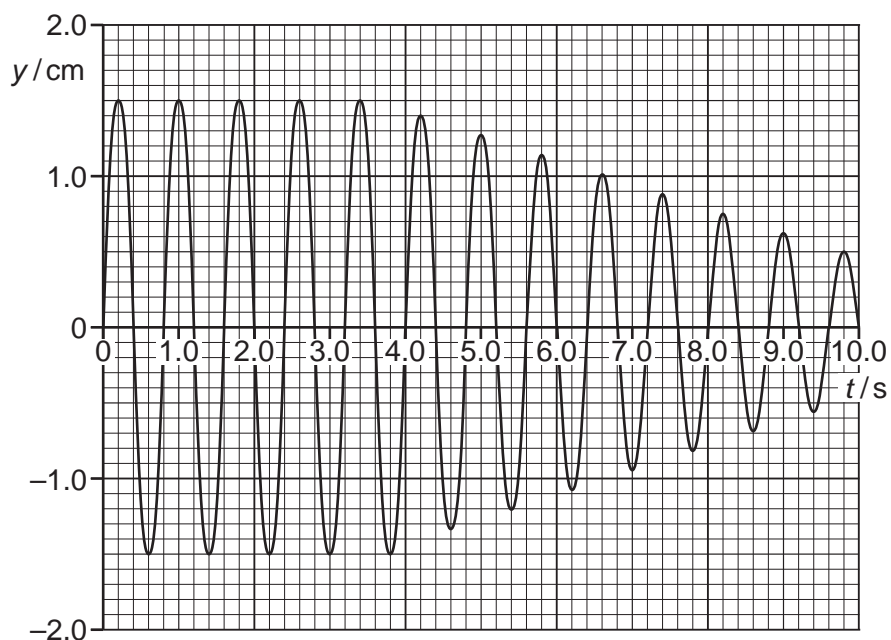


Fig. 3.2

At time $t = 4.0$ s, the switch is closed.

(a) Use Fig. 3.2 to

(i) state the evidence for the magnet to be undergoing free oscillations during the period $t = 0$ to $t = 4.0$ s,

.....
.....[1]

(ii) state, with a reason, whether the damping after time $t = 4.0$ s is light, critical or heavy,

.....
.....
.....[2]

(iii) determine the natural frequency of vibration of the magnet on the spring.

frequency = Hz [2]

(b) (i) State Faraday’s law of electromagnetic induction.

.....
.....
.....[2]

(ii) Explain why, after time $t = 4.0$ s, the amplitude of vibration of the magnet is seen to decrease.

.....
.....
.....
.....
.....
.....[4]

3 (a) Define *simple harmonic motion*.

.....
.....
..... [2]

(b) A horizontal plate is vibrating vertically, as shown in Fig. 3.1.

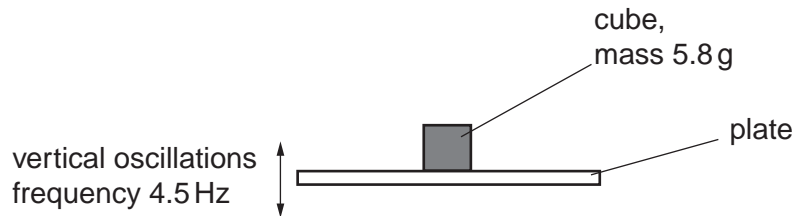


Fig. 3.1

The plate undergoes simple harmonic motion with a frequency of 4.5 Hz and amplitude 3.0 mm.

A metal cube of mass 5.8 g rests on the plate.

Calculate, for the cube, the energy of oscillation.

energy = J [3]

(c) The amplitude of oscillation of the plate in (b) is gradually increased. The frequency remains constant.

At one particular amplitude, the cube just loses contact momentarily with the plate.

(i) State the position of the plate in its oscillation at the point when the cube loses contact.

.....
.....
..... [2]

(ii) Calculate this amplitude of oscillation.

amplitude = m [2]

4 (a) Define *simple harmonic motion*.

.....

.....

..... [2]

(b) A tube, sealed at one end, has a total mass m and a uniform area of cross-section A . The tube floats upright in a liquid of density ρ with length L submerged, as shown in Fig. 3.1a.

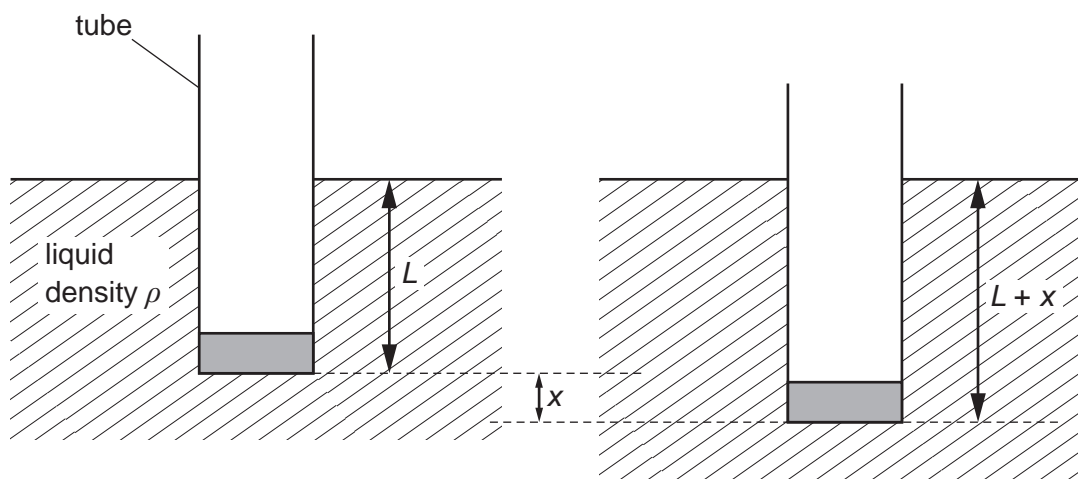


Fig. 3.1a

Fig. 3.1b

The tube is displaced vertically and then released. The tube oscillates vertically in the liquid.

At one time, the displacement is x , as shown in Fig. 3.1b.

Theory shows that the acceleration a of the tube is given by the expression

$$a = -\frac{A\rho g}{m}x.$$

- (i) Explain how it can be deduced from the expression that the tube is moving with simple harmonic motion.

.....
.....
.....[2]

- (ii) The tube, of area of cross-section 4.5cm^2 , is floating in water of density $1.0 \times 10^3\text{kg m}^{-3}$.

Calculate the mass of the tube that would give rise to oscillations of frequency 1.5 Hz.

mass = g [4]

- 5 A student sets up the apparatus illustrated in Fig. 3.1 in order to investigate the oscillations of a metal cube suspended on a spring.

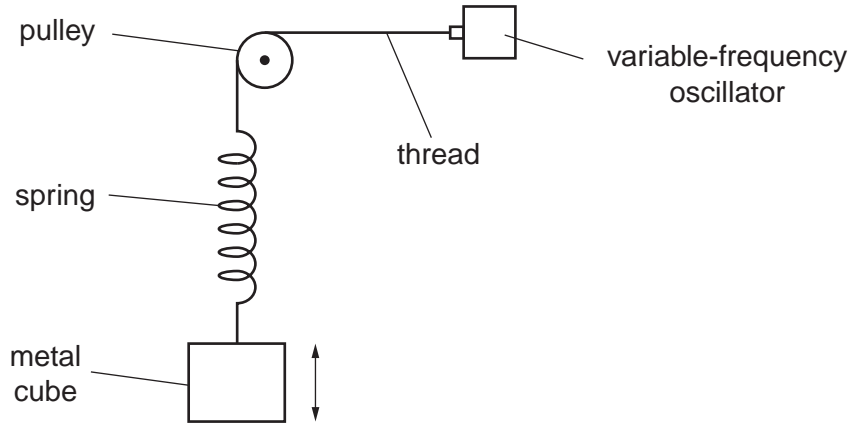


Fig. 3.1

The amplitude of the vibrations produced by the oscillator is constant. The variation with frequency of the amplitude of the oscillations of the metal cube is shown in Fig. 3.2.

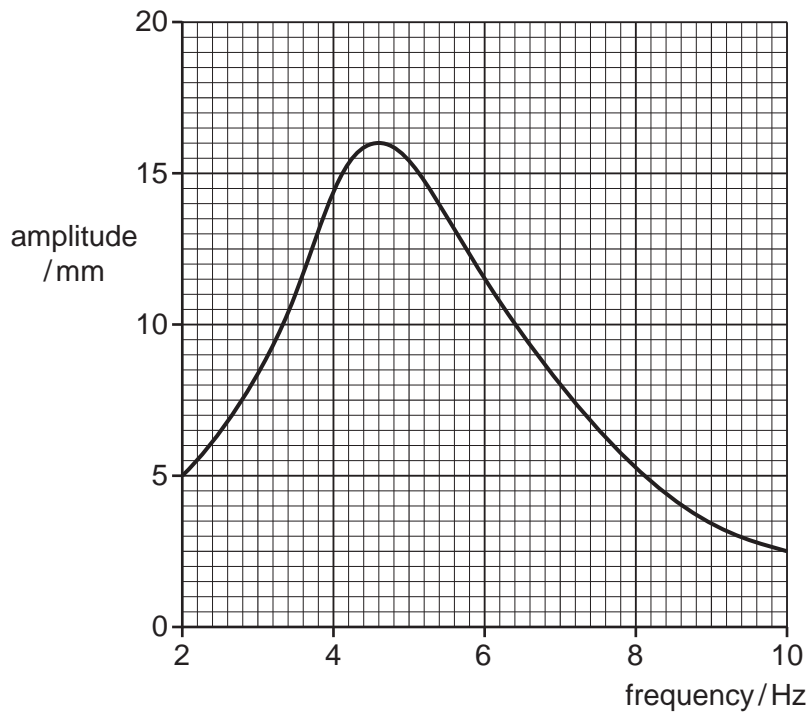


Fig. 3.2

- (a) (i) State the phenomenon illustrated in Fig. 3.2.

..... [1]

- (ii) For the maximum amplitude of vibration, state the magnitudes of the amplitude and the frequency.

amplitude = mm

frequency = Hz

[1]

(b) The oscillations of the metal cube of mass 150g may be assumed to be simple harmonic.

Use your answers in **(a)(ii)** to determine, for the metal cube,

(i) its maximum acceleration,

acceleration = ms^{-2} [3]

(ii) the maximum resultant force on the cube.

force = N [2]

(c) Some very light feathers are attached to the top surface of the cube so that the feathers extend outwards, beyond the vertical sides of the cube.

The investigation is now repeated.

On Fig. 3.2, draw a line to show the new variation with frequency of the amplitude of vibration for frequencies between 2Hz and 10Hz. [2]