4 A test-tube with a total mass M is able to float upright in water of density ρ, as shown in Fig. 4.1. Ignoring its rounded bottom, the test-tube may be regarded as a cylinder of a cross-sectional area A.

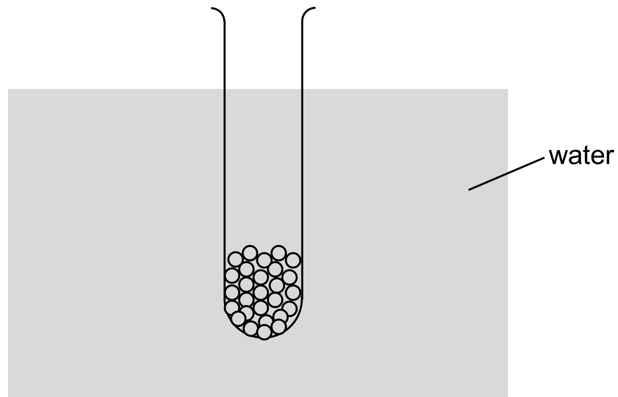

Fig. 4.1

The test-tube is displaced vertically by a small displacement y and then released.

The acceleration of the test-tube is given by

$$a = -\left(\frac{\rho A g}{M}\right)y$$

where g is the acceleration of free fall.

(a) Define simple harmonic motion.

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……..

[2]

(b) Given: $\rho = 1.00 \times 10^{3}\ \text{kg m}^{-3}$,

$A = 6.0 \times 10^{-4}\ \text{m}^{2}$,

$M = 0.037\ \text{kg}$,

show that the period of oscillation of the test-tube is 0.50 s.

[2]

(c) The test-tube is given a displacement of 1.0 cm and allowed to oscillate. The variation with time *t* of the vertical displacement *y* of the test-tube is shown in Fig. 4.2.

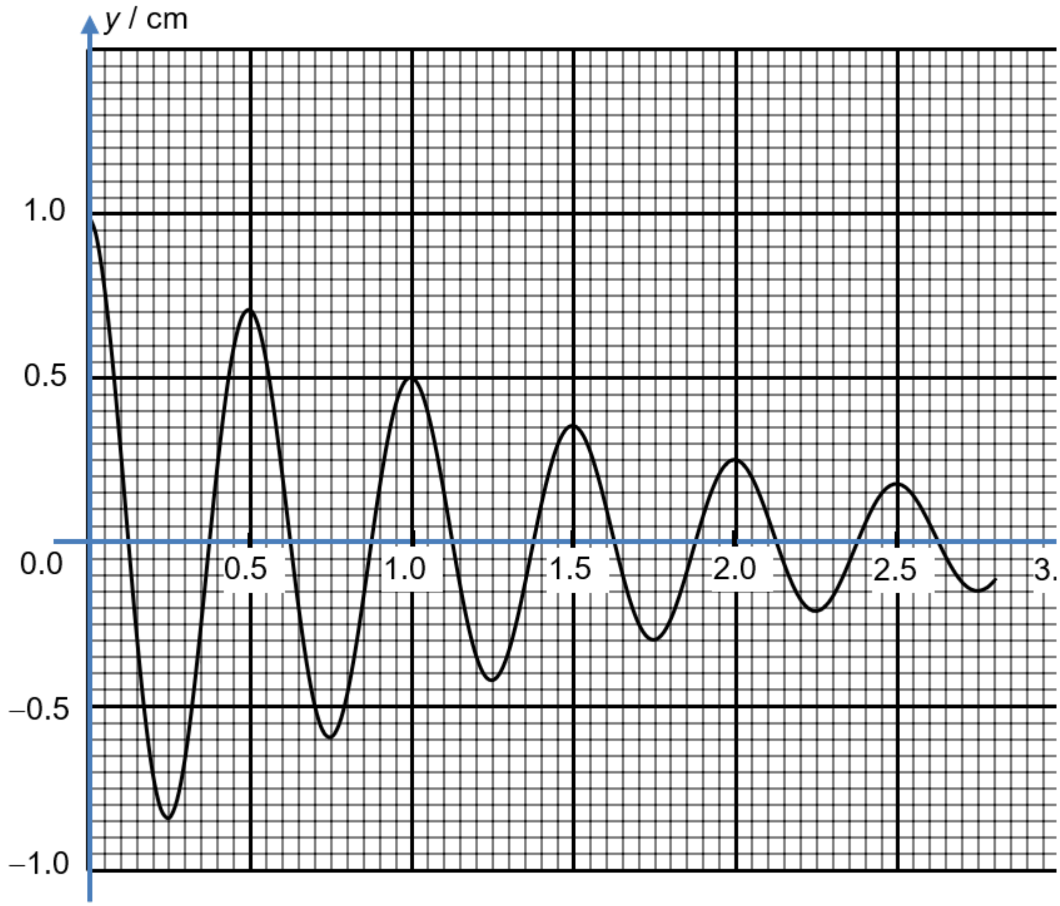

Fig. 4.2

(i) Estimate the time when the *energy of oscillation* has decreased by 75 % of its original value.

time = ... s [2]

(ii) To sustain the oscillations of the test-tube, low-amplitude water waves of frequency 1.0 Hz are generated on the surface of the water. It is observed that the amplitude of the vertical oscillations of this test-tube is rather small while oscillating at 1.0 Hz.

Using information from earlier in the question, explain this observation.

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[Total: 8]

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