4 A tube, closed at one end, has a constant area of cross-section A. Some lead shot is placed in the tube so that the tube floats vertically in a liquid of density ρ, as shown in Fig. 4.1.

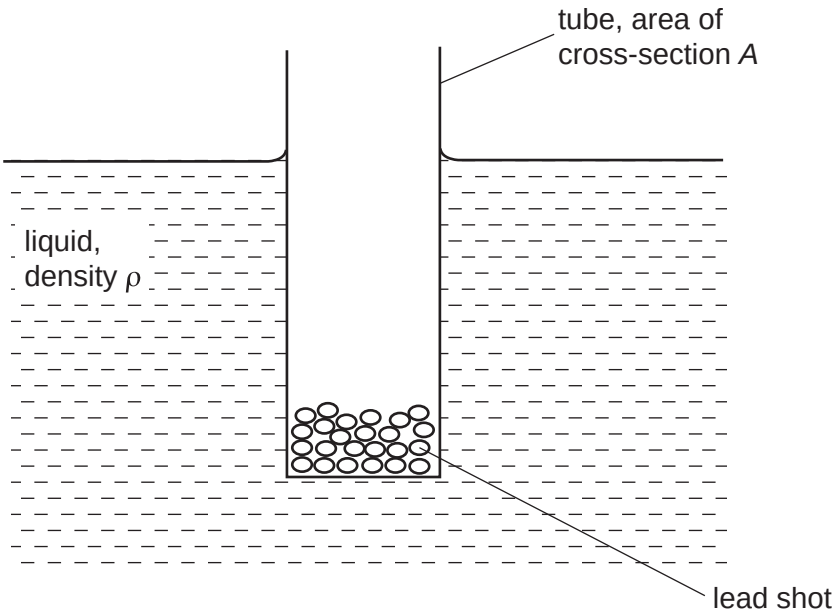

Fig. 4.1

The total mass of the tube and its contents is M.
When the tube is given a small vertical displacement and then released, the vertical acceleration a of the tube is related to its vertical displacement y by the expression

$$a = -\frac{A\rho g}{M} y,$$

where g is the acceleration of free fall.

(a) Define *simple harmonic motion*.

.....

.....

.....[2]

(b) Show that the tube is performing simple harmonic motion with a frequency f given by

$$f = \frac{1}{2\pi}\sqrt{\frac{A\rho g}{M}}.$$

[3]

(c) Fig. 4.2 shows the variation with time t of the vertical displacement y of the tube in another liquid.

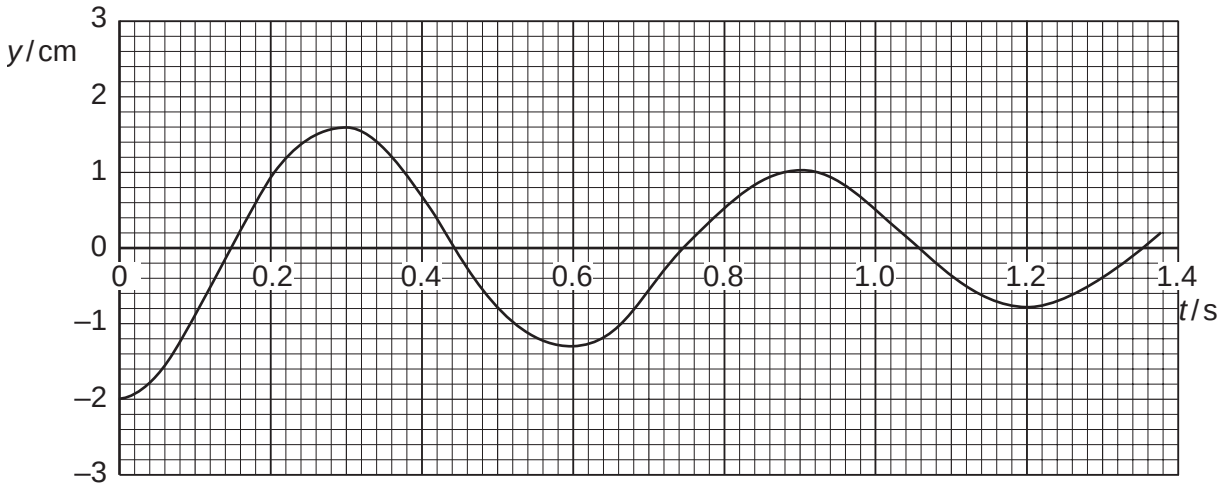

Fig. 4.2

(i) The tube has an external diameter of 2.4 cm and is floating in a liquid of density 950 kg m^{-3}. Assuming the equation in **(b)**, calculate the mass of the tube and its contents.

mass = ... kg [3]

(ii) State what feature of Fig. 4.2 indicates that the oscillations are damped.

.....

.....[1]