6

A cylindrical tube, seated at one end, has cross-sectional area A and contains some sand. The total mass of the tube and the sand is M.

The tube floats upright in a liquid of density ρ, as illustrated in Fig. 6.1.

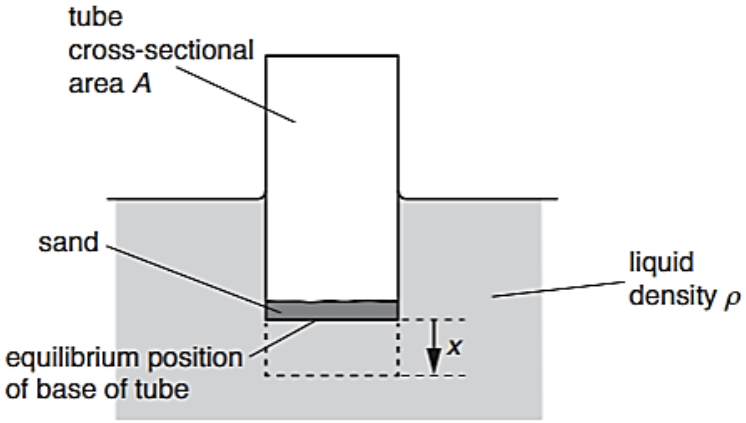

Fig. 6.1

The tube is pushed downwards by a distance of 3.0 cm into the liquid and then released.

(a)

(i)

State the two forces that act on the tube immediately after its release.

……...

……

[1]

(ii)

State and explain the direction of the resultant force acting on the tube immediately after its release.

……...

……...

……

[2]

(b)

The acceleration *a* of the tube is given by the expression

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

where x is the vertical displacement of the tube from its equilibrium position.

Use the expression to explain why the tube undergoes simple harmonic oscillations in the liquid.

…….....

…….....

……..

[2]

(c)

The tube has a cross-sectional area A of 4.5 cm^2 and a total mass M of 0.17 kg.

The variation with time t of the vertical displacement x of the tube from its equilibrium position is shown in Fig. 6.2.

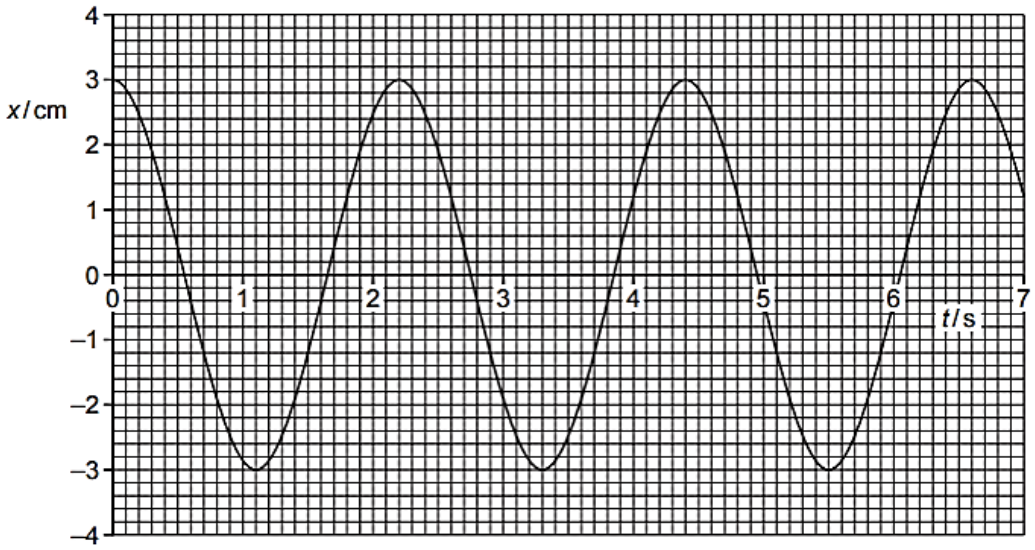

Fig. 6.2

(i)

Use Fig. 6.2 to show that the angular frequency ω of oscillation of the tube is 2.9 rad s^{-1}.

[1]

(ii)

Determine the density ρ of the liquid in which the tube is floating.

ρ = …….. kg m^{-3}

[2]

(iii)

Determine the speed of the tube as it passes through its equilibrium position.

speed = …… m s^{-1}

[2]

[Total: 10]