For Examiner's Use

**3** A cylindrical tube, containing some sand, floats upright in a liquid of density $\rho$ with its base at a depth of $h$ below the liquid surface as shown in Fig. 3.1.

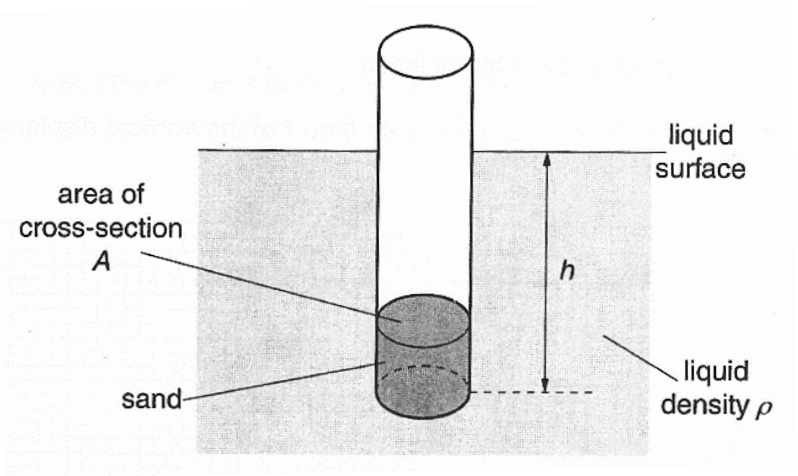


**Fig. 3.1**

The tube has a cross-sectional $A$ and the total mass of the tube and the sand is $M$.

**(a)** By considering forces acting on the tube, explain why the tube is able to float.

……..

……..

……..

……..... [2]

**[Turn over**

For Examiner's Use

**(b)** The tube is displaced vertically downwards and then released.

Show that the acceleration $a$ of the tube is given by

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

where $x$ is the displacement from the depth $h$ and $g$ is the acceleration due to free fall. Explain your working.

[3]

**(c)** Explain why the expression in **(b)** suggests that the motion of the tube is simple harmonic.

……..

……..

……..

……..…….. [2]

For Examiner's Use

**(d)** The mass $M$ is 120 g and the cross-section $A$ of the tube is 5.5 $cm^2$.

Calculate the frequency of oscillation of the tube when it is in a liquid of density $1.2 \times 10^3$ kg $m^{-3}$.

frequency = …… Hz [3]

**(e)** **(i)** On Fig. 6.2, sketch a graph to show the variation with displacement $x$ of the velocity $v$ of the tube.

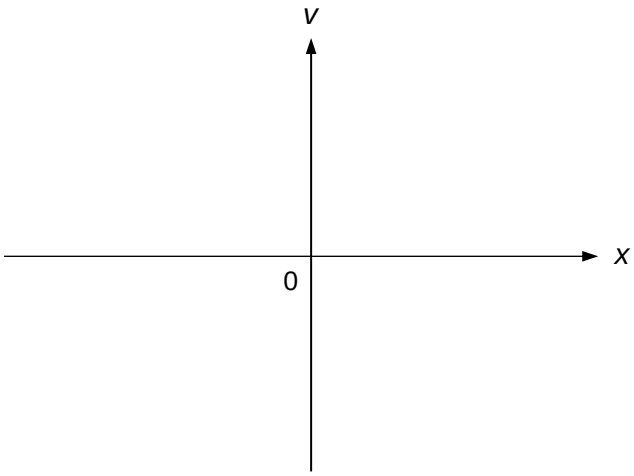


**Fig. 6.2**

[1]

**(ii)** If the viscosity of the fluid cannot be neglected, on Fig. 6.2, draw the variation with displacement $x$ of the velocity $v$ of the tube. [1]

[Total: 12]

**[Turn over**