**7** **(a)** A cylindrical tube, containing some sand, floats upright in a liquid of density $\rho$, as shown in Fig. 7.1.

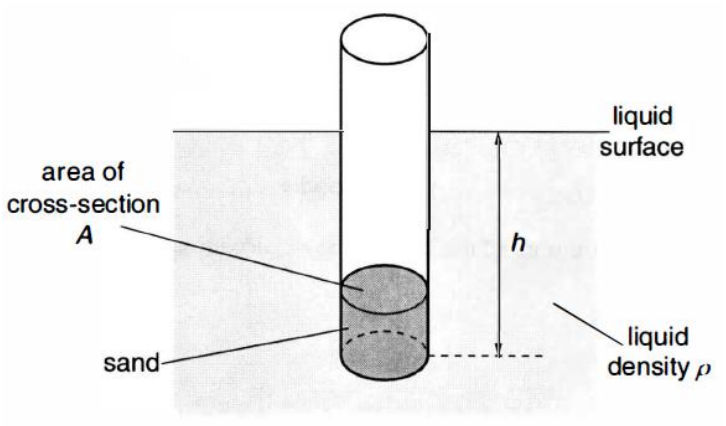


**Fig. 7.1**

The tube has cross-sectional area *A*. The total mass of the tube and sand is *M*.
The tube floats in equilibrium with its base a distance *h* below the surface of the liquid.

**(i)** By considering the pressure due to a fluid, show that $M = \rho h A$.
Explain your working.

[2]

**(ii)** The tube is now held stationary below the equilibrium floating position of the tube.

Show that, when released, the acceleration *a* of the tube is related to its displacement *x* from the equilibrium position by the equation:

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

where *g* is the acceleration of free fall.
Explain your working.

[3]

**[Turn over**

**(iii)** Explain whether the tube is performing simple harmonic motion.

……

……

……

…… [2]

**(iv)** The mass $M$ of the tube and sand is 130 g. The area of cross-section $A$ of the tube is 5.3 $cm^2$. The tube, floating in a liquid of density $1.2 \times 10^3$ kg $m^{-3}$, is held stationary 1.3 cm below its equilibrium position and then released.

Calculate

**1.** the frequency of oscillation of the tube,

frequency = …… Hz [3]

**2.** the total energy of oscillation of the tube.

energy = …… J [2]

**(b)** A dipper oscillates at a frequency of 2.0 Hz in a ripple tank. Surface water waves ripple circularly out from the dipper with wavelength 1.0 cm as shown in Fig. 7.3.

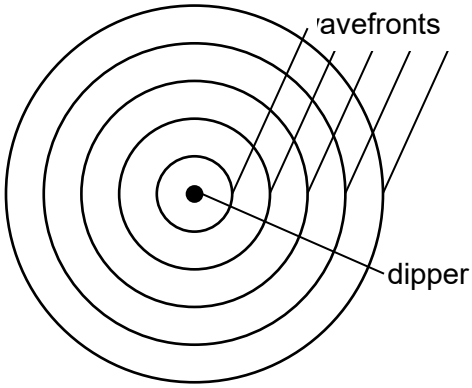


**Fig. 7.3**

**(i)** Explain why the amplitude of the wave decreases with distance from the dipper.

……

……

……

…… [2]

**(ii)** Show that the dipper and the water at a point 2.0 cm away from the dipper oscillate in phase.

[2]

**(iii)** At a particular instance in time, the dipper is at its maximum negative displacement.
X on Fig. 7.4 shows the variation with distance of the amplitude of the water wave.

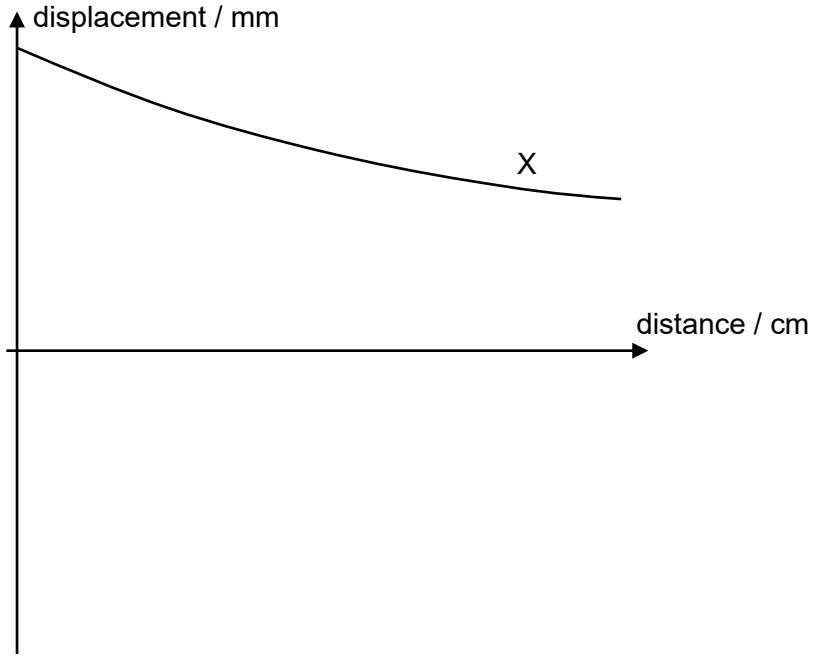


**Fig. 7.4**

On Fig. 7.4, sketch the displacement-distance graph of the water wave at this instance. [2]

**(iv)** The dipper is at its maximum negative displacement when time = 0 s.
On Fig. 7.5, sketch the displacement-time graph of the water at a point 3.0 cm away from the dipper.

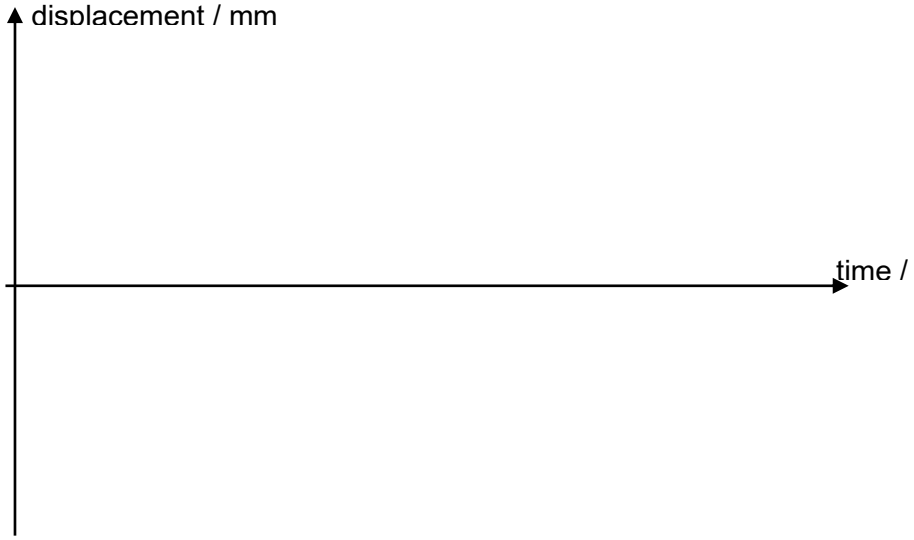


**Fig. 7.5**

[2]

[Total: 20]