Oxford Cambridge and RSA

A Level Physics A

H556/01 Modelling physics

Question Set 6

1 A swimming pool designer investigates the depth *d* below a water surface reached by a diver when diving from a height *h* above the water surface. The designer models the diver as a uniform wooden cylinder. The experimental arrangement is shown in Fig. 18.1.

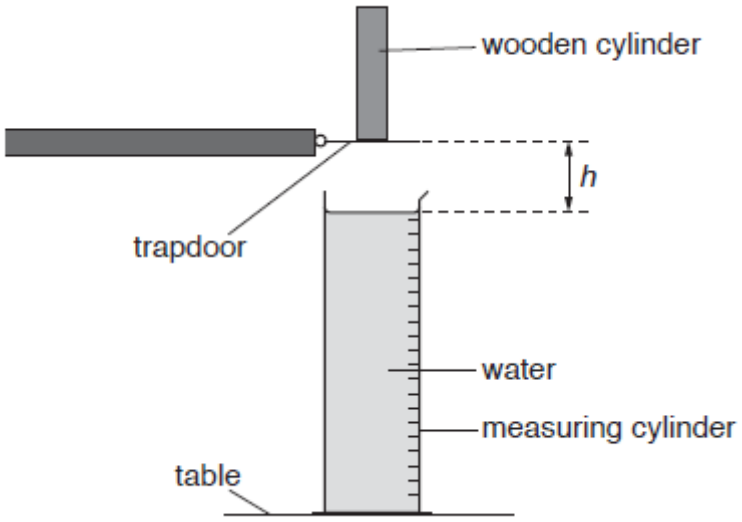

Fig. 18.1

(a) The wooden cylinder has mass 5.0×10^{-3} kg, diameter 1.0×10^{-2} m and length 7.0×10^{-2} m.

(i) Calculate the density of the wood.

Volume $= (0.5 \times 10^{-2})^2 \times 7.0 \times 10^{-2} \times \pi = 5.5 \times 10^{-6}\ m^3$

Density $= \frac{\text{mass}}{\text{volume}} = \frac{5.0 \times 10^{-3}}{5.5 \times 10^{-6}} = 910$

density = 910 kg m^{-3} **[2]**

(ii) Suggest why wood is an appropriate material to model the depth reached by a diver. **[2]**

- The wood is of a similar density to a human
- It is also less dense than water, so will float

(b) The cylinder is released from **rest** from a trapdoor. The base of the cylinder is at a height $h = 0.30$ m above the water surface.
Calculate the speed of the cylinder just before the base hits the water. Ignore air resistance.

$s = 0.3$
$u = 0$
$v = ?$
$a = 9.81$
$t = X$

$v^2 = u^2 + 2as$

$v^2 = 2as$

$v = \sqrt{2 \times 9.81 \times 0.3} = 2.4\ ms^{-1}$

speed = 2.4 m s^{-1} **[2]**

(c) Fig. 18.2 shows the cylinder fully submerged under the water surface before it has come to rest. The cylinder is moving vertically **down**.

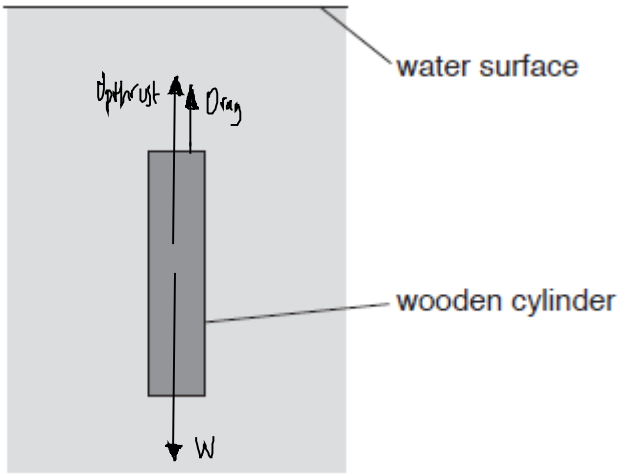

Fig. 18.2

(i) Add arrows to Fig. 18.2 to show the **three** forces acting on the wooden cylinder. Label the arrows. **[3]**

(ii) Describe and explain how the **resultant** force on the wooden cylinder varies from the moment the cylinder is fully submerged until it reaches its deepest point. **[3]**

Resultant force will decrease in this time period. This is because the upthrust and weight remain constant, but drag will decrease from a maximum when it is just fully submerged, to zero at the lowest point. The resultant force will always be pointing upwards.

(d) The graph of Fig. 18.3 shows the depth *d* reached for different initial drop height *h*.

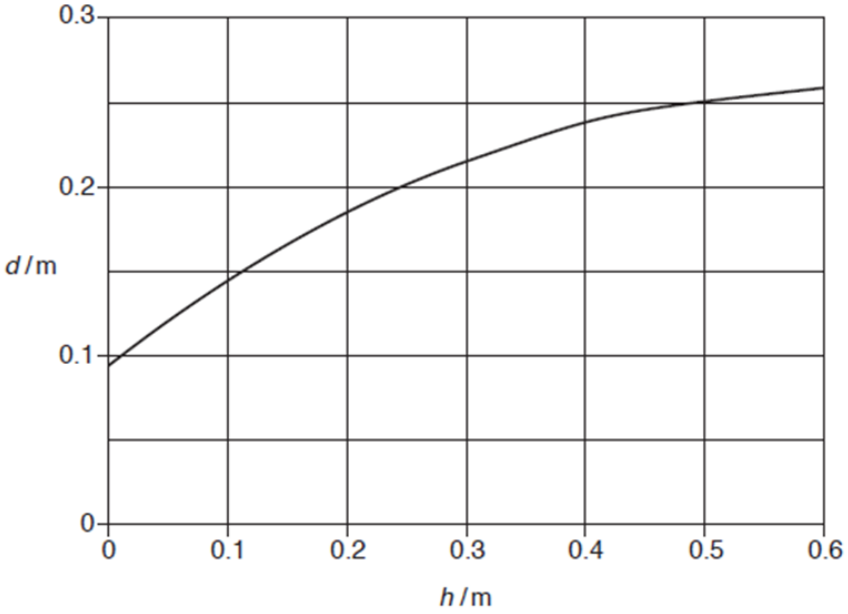

Fig. 18.3

The designer is required to double the height of a diving board for an existing swimming pool. He suggests that the depth of the pool also needs to be doubled. Use Fig. 18.3 to explain whether you agree with this suggestion. **[2]**

- Disagree → doubling the depth is too much
- This is because d is not directly proportional to h ; a fact made evident by the decreasing gradient of the line.

Total Marks for Question Set 6: 14