Unit 3 · Fluid Mechanics

HARDER PRACTICE QUESTIONS

Full marks 32

Write your answers on separate paper. Show your working. Take g = 9.8 m/s^2 and the density of water as 1000 kg/m^3.

1 Spot the error [3]

Find the mistake in the working and correct it.

A soap film fills a wire frame with a sliding wire 5.0 cm long. The soap solution's surface tension is 0.030 N/m. Anjali finds the force with which the film pulls on the wire:
"F = TL = $0.030 \times 0.050 = \mathbf{1.5 \times 10^{-3}\ N}$."

2 A real setting [3]

The numbers are made up. Ignore friction in the pipes.

The water surface in a tank on a tall building is 12 m above a tap on the ground floor.

i. Find the gauge pressure at the tap while it is closed.
ii. Find the speed with which water leaves the tap when it is opened fully.

3 Predict, then explain [3]

Write your prediction first, then explain it.

An ice cube floats in a glass of water filled exactly to the brim. Predict whether the water overflows as the ice melts, then show why, using the law of flotation. (Density of ice 920 kg/m^3.)

4 Show that [3]

Using $h = \dfrac{2T\cos\theta}{r\rho g}$, show that the mass of water held up in a capillary tube is proportional to the tube's radius. So does a wide tube or a narrow one hold up more water?

5 Check the claim [4]

Answer from the data.

Glass beads of density 2500 kg/m^3 are dropped into a syrup of density 1300 kg/m^3. Bishal times their terminal velocities:

Radius (mm)	1.0	2.0	3.0	4.0
Terminal velocity (mm/s)	1.09	4.36	9.80	17.4

i. Bishal claims: "Doubling the radius doubles the terminal velocity." Is he right? Show from the data.
ii. What does the data show instead?
iii. Find the viscosity of the syrup.

6 Estimate it [3]

The ratio of the areas is made up, but of the right size.

The aorta is about 2.5 cm across, and blood moves through it at about 30 cm/s. Suppose all the body's capillaries together have a cross-section 700 times the aorta's. Estimate how fast blood moves through the capillaries, and say why that speed is useful.

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Smriti wrote: “A cone that widens upwards, filled with water, has a greater pressure on its base than a narrow tube of the same height, because it holds more water. Heating air makes it less viscous, just like heating honey. A wing gets lift because the air over the top has farther to go and must speed up to meet the air below at the back edge.”

8 What if? [2]

A small artery narrows so that its radius is 16% smaller, the pressure difference across it staying the same. By what factor does the flow through it change, according to Poiseuille’s formula?

9 Design it [4]

Describe how you would measure the viscosity of honey by the falling-sphere method. Say what you would measure, why the timing must start some way below the surface, and why the jar should be tall and wide.

10 Think [2]

Two boats moving fast side by side, close together, tend to drift towards each other. Explain why.

11 Make your own [2]

Design a hydraulic jack with which a force of 300 N on the small piston can lift a car of mass 1500 kg. Give the areas of the two pistons.