Question 10. 11. Can Bernoulli's equation be used to describe the flow of water through a rapid motion in a river? Explain.
Answer: Bernoulli's theorem is applicable only for there it ideal fluids in streamlined motion. Since the flow of water in a river is rapid, way cannot be treated as streamlined motion, the theorem cannot be used.

Question 10. 12. Does it matter if one uses gauge instead of absolute pressures in applying Bernoulli's equation? Explain.
Answer: No, it does not matter if one uses gauge instead of absolute pressures in applying Bernoulli's equation, provided the atmospheric pressure at the two points where Bernoulli's equation is applied are significantly different.

Question 10. 13. Glycerine flows steadily through a horizontal tube of length 1.5 m and radius 1.0 cm. If the amount of glycerine collected per second at one end is 4.0 x 10^{-3} kg s^{-1}, what is the pressure difference between the two ends of the tube? (Density of glycerine = 1.3 x 10^{3} kg m^{-3} and viscosity of glycerine = 0.83 Pa s). [You may also like to check if the assumption of laminar flow in the tube is correct],
Answer:

$$l = 1.5 \text{ m}, \quad r = 1 \times 10^{-2}\text{m},$$

Volume/s,
$$V = \frac{\text{Mass / s}}{\text{Density}} = \frac{4 \times 10^{-3}}{1.3 \times 10^{3}} \text{m}^3 \text{ s}^{-1}$$
$$= \frac{4}{1.3} \times 10^{-6} \text{m}^3 \text{s}^{-1}$$
$$\eta = 0.83 \text{ Pa s}$$

Now,
$$V = \frac{\pi p r^4}{8 \eta l},$$

where p is the pressure difference across the capillary.

or
$$p = \frac{8 V \eta l}{\pi r^4}$$

Substituting values,
$$p = 8 \times \frac{4}{1.3} \times 10^{-6} \times 0.83 \times 1.5 \times \frac{7}{22} \times \frac{1}{10^{-8}} Pa$$
$$= \mathbf{9.75 \times 10^2 \text{ Pa}}$$

The Reynolds number is 0.3. So, the flow is **laminar.**

Question 10. 14.
In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are 70 ms^{-1} and 63 ms^{-1} respectively. What is the lift on the wing if its area is 2.5 m^2? Take the density of air to be 1.3 kg m^{-3}.

Answer:
Let v_1, v_2 be the speeds on the upper and lower surfaces of the wing of aeroplane, and P_1 and P_2 be the pressures on upper and lower surfaces of the wing respectively.
Then v_1 = 70 ms^{-1}; v_2 = 63 ms^{-1}; ρ = 1.3 kg m^{-3}.
From Bernoulli's theorem

$$\frac{P_1}{\rho} + gh + \frac{1}{2}v_1^2 = \frac{P_2}{\rho} + gh + \frac{1}{2}v_2^2$$

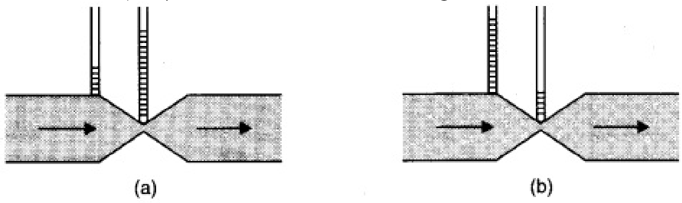
$$\therefore \quad \frac{P_1}{\rho} - \frac{P_2}{\rho} = \frac{1}{2}(v_2^2 - v_1^2)$$

or $$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2) = \frac{1}{2}\times 1.3[(70)^2-(63)^2] \text{ Pa} = 605.15 \text{ Pa}.$$

This difference of pressure provides the lift to the aeroplane. So, lift on the aeroplane = pressure difference × area of wings

$$= 605.15 \times 2.5 \text{ N} = 1512.875 \text{ N}$$
$$= 1.51 \times 10^3 \text{ N}.$$

Question 10. 15. Figures (a) and (b) refer to the steady flow of a (non-viscous) liquid. Which of the two figures in incorrect? Why?



Answer: Figure (a) is incorrect. It is because of the fact that at the kink, the velocity of flow of liquid is large and hence using the Bernoulli's theorem the pressure is less. As a result, the water should not rise higher in the tube where there is a kink (i.e., where the area of cross-section is small).

Question 10. 16. The cylindrical tube of a spare pump has a cross-section of 8.0 cm^2 one end of which has 40 fine holes each of diameter 1.0 mm. If the liquid flow inside the tube is 1.5 m min^{-1}, what is the speed of ejection of the liquid through the holes?

Answer:

Total cross-sectional area of 40 holes, a_2

$$= 40 \times \frac{22}{7} \times \frac{(1\times 10^{-3})^2}{4} \text{m}^2$$
$$= \frac{22}{7} \times 10^{-5}\text{m}^2$$

Cross-sectional area of tube, $a_1 = 8 \times 10^{-4}$ m^2

Speed inside the tube, $v_1 = 1.5 \text{ m min}^{-1} = \frac{1.5}{60} \text{ms}^{-1}$;

Speed of ejection, $v_2 = ?$

Using $a_2v_2 = a_1v_1$,

we get

$$v_2 = \frac{a_1v_1}{a_2} = \frac{8\times 10^{-4}\times\frac{1.5}{60}\times 7}{22\times 10^{-5}} \text{ms}^{-1} = 0.64 \text{ ms}^{-1}.$$

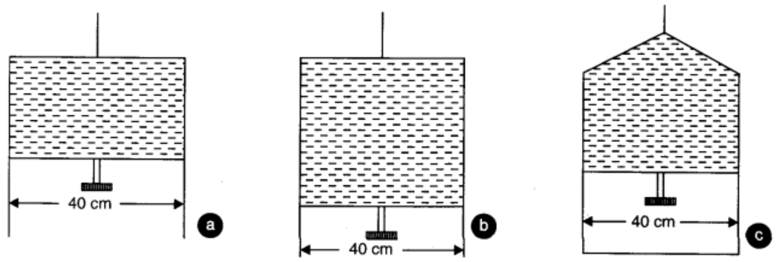
Question 10. 17. A U-shaped wire is dipped in a soap solution, and removed. A thin soap film formed between the wire and a light slider supports a weight of 1.5 x 10^{-2} N (which includes the small weight of the slider). The length of the slider is 30 cm. What is the surface tension of the film?

Answer: In present case force of surface tension is balancing the weight of 1.5 x 10^{-2} N, hence force of surface tension, F = 1.5 x 10^{-2} N.

Total length of liquid film, l = 2 x 30 cm = 60 cm = 0.6 m because the liquid film has two surfaces.

Surface tension, T = F/l =1.5 x 10^{-2} N/0.6m =2.5 x 10^{-2} Nm^{-1}

Question 10. 18. Figure (a) below shows a thin film supporting a small weight = 4.5 x 10^{-2} N. What is the weight supported by a film of the same liquid at the same temperature in Fig. (b) and (c) Explain your answer physically.



Ans. (a) Here, length of the film supporting the weight = 40 cm = 0.4 m. Total weight supported (or force) = 4.5×10^{-2} N.
Film has two free surfaces, Surface tension, S =$4.5 \times 10^{-2}/2 \times 0.4$ =5.625×10^{-2} Nm^{-1}
Since the liquid is same for all the cases (a), (b) and (c), and temperature is also same, therefore surface tension for cases (b) and (c) will also be the same = 5.625×10^{-2}. In Fig. 7(b), 38(b) and (c), the length of the film supporting the weight is also the saihe as that of (a), hence the total weight supported in each case is 4.5×10^{-2} N.

Question 10. 19. What is the pressure inside a drop of mercury of radius 3.0 mm at room temperature? Surface tension of mercury at that temperature (20°C) is 4.65×10^{-1} Nm^{-1}. The atmospheric pressure is 1.01×10^{5} Pa. Also give the excess pressure inside the drop.
Answer:

$$\text{Excess pressure} = \frac{2\sigma}{R} = \frac{2 \times 4.65 \times 10^{-1}}{3 \times 10^{-3}} = 310 \text{ Pa}$$

$$\text{Total pressure} = 1.01 \times 10^5 + \frac{2\sigma}{R}$$

$$= 1.01 \times 10^5 + 310 = 1.0131 \times 10^5 \text{ Pa}$$

Since data is correct up to three significant figures, we should write total pressure inside the drop as 1.01×10^{5} Pa.

Question 10. 20. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm, given that the surface tension of soap solution at the temperature (20 °C) is 2.50×10^{-2} Nm^{-1}? If an air bubble of the same dimension were formed at depth of 40.0 cm inside a container containing the soap solution (of relative density 1.20), what would be the pressure inside the bubble? (1 atmospheric pressure is 1.01×10^{5} Pa).
Answer: Here surface tension of soap solution at room temperature T = 2.50×10^{-2} Nm^{-1}, radius of soap bubble, r = 5.00 mm = 5.00×10^{-3} m.

$\therefore$ Excess pressure inside soap bubble, $P = P_i - P_0 = \frac{4T}{r}$

$$= \frac{4 \times 2.50 \times 10^{-2}}{5.00 \times 10^{-3}} = 20.0 \text{ Pa}$$

When an air bubble of radius $r = 5.00 \times 10^{-3}$ m is formed at a depth h = 40.0 cm = 0.4 m inside a container containing a soap solution of relative density 1.20 or density $\rho = 1.20 \times 10^3$ kg m^{-3}, then excess pressure

$$P = P_i - P_0 = \frac{2T}{r}$$

$$\therefore \quad P_i = P_0 + \frac{2T}{r} = (P_a + h\rho g) + \frac{2T}{r}$$

$$= \left[1.01 \times 10^5 + 0.4 \times 1.2 \times 10^3 \times 9.8 + \frac{2 \times 2.50 \times 10^{-2}}{5.00 \times 10^{-3}}\right] \text{Pa}$$

$$= (1.01 \times 10^5 + 4.7 \times 10^3 + 10.0) \text{ Pa}$$

$$\simeq 1.06 \times 10^5 \text{ Pa.}$$

*********** END **********