ENG243 - TUTORIAL EXERCISES - Set 8

The tutorials for this unit will come from two sources. There are problems taken directly from the text book. The reference MYO 03.53 would mean problem 3.53 from chapter 3 of the set textbook. The information given in the textbook is reprinted in the tutorials for your convenience. Other problems will give full details.

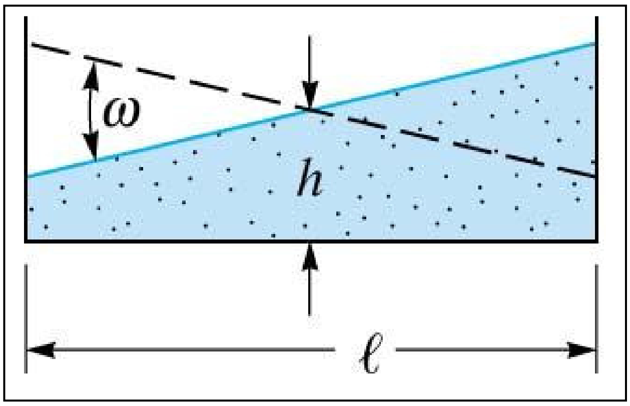
Some problems are given in BG units. I recommend you convert all numbers into SI units, and then solve the problem in SI units. You can then convert the answer back to BG units if necessary.

1. (MYO 07.10) The drag force, *D* on a washer-shaped plate placed normal to a stream of fluid can be expressed as

$$D = f\left(d_1, d_2, V, \mu, \rho\right)$$

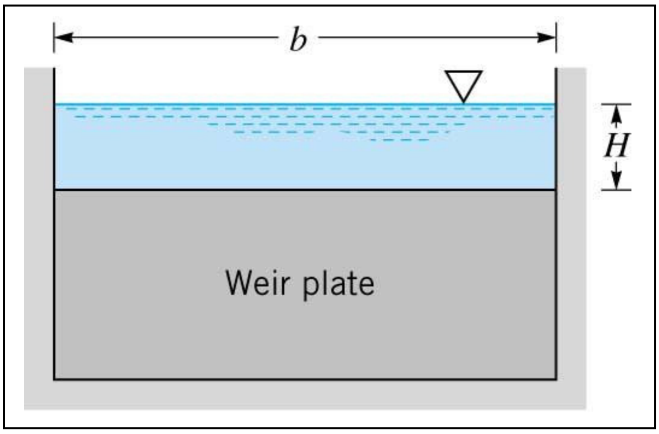
where d_1 is the outer diameter, d_2 the inner diameter, *V* the fluid velocity, μ the fluid viscosity and ρ the fluid density. Some experiments are to be performed in a wind tunnel to determine the drag. What dimensionless parameters would you use to organize these data?

2. (MYO 07.06) Water sloshes back and forth in a tank as shown in the figure (Fig. P7.6). The frequency of the sloshing *ω,* is assumed to be a function of the acceleration of gravity, *g*, the average depth of the water, *h*, and the length of the tank, *l*. Develop a suitable set of dimensionless parameters for this problem using g and l as repeating variables.



3. (MYO 7.18) The pressure drop Δp, along a straight pipe of diameter D has been experimentally studied, and it is observed that for laminar flow of a given fluid in the pipe, the pressure drop varies directly with the distance, *L*, between pressure taps. Assume that Δp is a function of *D* and *L*, the velocity, *V*, and the fluid viscosity, μ. Use dimensional analysis to deduce how the pressure drop varies with pipe diameter.

4. (MYO 07.30) The water flowrate, Q, in an open rectangular channel can be measured by placing a plate across the channel as shown in the figure (Fig. P7.30). This type of device is called a weir. The height of the water, H, above the weir crest is referred to as the head and can be used to determine the flowrate through the channel. Assume that Q is a function of the head, H, the channel width, b, and the acceleration of gravity, g. Determine a suitable set of dimensionless variables for this problem.

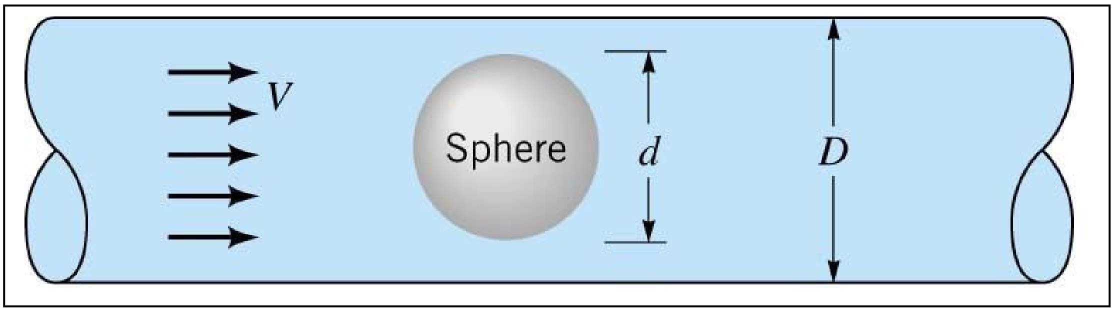


5. The drag, F_D, on a sphere located in a pipe though which a fluid is flowing is to be determined experimentally – see the figure. Assume that the drag is a function of the sphere diameter, d, the pipe diameter, D, the fluid velocity, V, and the fluid density ρ.

(a) What dimensionless parameters would you use for this problem?

(b) Some experiments using water indicate that for d = 0.20 m, D = 0.50 m, and V = 2.0 m/s, the drag is 1.5 N. If possible, estimate the drag on a sphere located in a 2.0-m-diameter pipe through which water is flowing with a velocity of 6.0 m/s, assuming that the general relationship: $F_D = aV^2$, can be applied. The sphere diameter is such that geometric similarity is maintained. If it is not possible, explain why not.

(c) Using the data contained in question (b), determine the diameter of the sphere used.



ANSWERS

1. $\dfrac{D}{d_1^2 V^2 \rho} \quad \dfrac{d_2}{d_1} \quad \dfrac{\mu}{\rho V d_1}$

2. $\omega\sqrt{\dfrac{l}{g}} = \phi\left(\dfrac{h}{l}\right)$

3. $\Delta p \propto \dfrac{1}{D^2}$

4. $\dfrac{Q}{\sqrt{H^5 g}} = \phi\left(\dfrac{h}{d}\right)$

5. (a) $\Pi_1 = F_D/(\rho V^2 D^2)$ $\Pi_2 = d/D$ (b) 216 N (c) 0.80 m