NAME

Quiz 11. Flow characteristics for a 30-ft-diameter prototype parachute are to be determined by tests of a 1-ft-diameter model parachute in a water tunnel. Some data collected with the model parachute indicate a drag of 17 lb when the water velocity is 4 ft/s. (a) Use the dimensional analysis and find a suitable pi parameter for this problem. (b) Use the model data to predict the drag on the prototype parachute falling through the air at 10 ft/s. Assume the drag to be a function of the velocity, V, the fluid density, ρ, and the parachute diameter, d. (ρ_{water} = 1.94 slugs/ft^3 and ρ_{air} = 2.38 $\times 10^{-3}$ slugs/ft^3)

Note: Attendance (+2 points), format (+1 point)

Solution:

(a) Pi parameter

$$D = f(V, \rho, d)$$

Where, $D \doteq F$, $V \doteq LT^{-1}$, $\rho \doteq FL^{-4}T^2$, $d = L$, and 4 – 3 = 1 pi parameter.

Thus,

$$\Pi = DV^a\rho^b d^c = (F)(LT^{-1})^a(FL^{-4}T^2)^b(L)^c = F^0L^0T^0$$

or

$$\Pi = \frac{D}{\rho V^2 d^2}$$ (+4 points)

(b) For similarity between model and prototype,

$$\frac{D}{\rho V^2 d^2} = \frac{D_m}{\rho_m V_m^2 d_m^2}$$ (+2 points)

So that

$$D = \left(\frac{\rho}{\rho_m}\right)\left(\frac{V}{V_m}\right)^2\left(\frac{d}{d_m}\right)^2 D_m$$

$$= \left(\frac{2.38 \times 10^{-3}\,\frac{slugs}{ft^3}}{1.94\,\frac{slugs}{ft^3}}\right)\left(\frac{10\,\frac{ft}{s}}{4\,\frac{ft}{s}}\right)^2\left(\frac{30\,ft}{1\,ft}\right)^2(17\,lb) = 117\,lb$$ (+1 points)