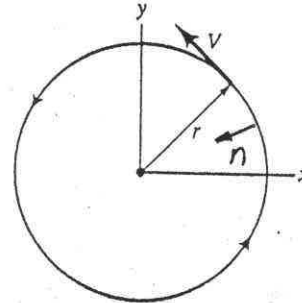


3.14

3.14 Water in a container and air in a tornado flow in horizontal circular streamlines of radius  $r$  and speed  $V$  as shown in Video V3.6 and Fig. P3.14. Determine the radial pressure gradient,  $\partial p/\partial r$ , needed for the following situations: (a) The fluid is water with  $r = 3$  in. and  $V = 0.8$  ft/s. (b) The fluid is air with  $r = 300$  ft and  $V = 200$  mph.



■ FIGURE P3.14

For curved streamlines,

$$-\frac{dp}{dn} = \frac{\rho V^2}{R} + \gamma \frac{dz}{dn}, \text{ or with } \frac{dz}{dn} = 0 \text{ (horizontal streamlines), } R=r,$$

and  $\frac{d}{dn} = -\frac{d}{dr}$  this becomes

$$\frac{dp}{dr} = \frac{\rho V^2}{r}$$

a) With  $r = \frac{3}{12}$  ft and  $V = 0.8 \frac{\text{ft}}{\text{s}}$  and water ( $\rho = 1.94 \frac{\text{slugs}}{\text{ft}^3}$ ),

$$\frac{dp}{dr} = \frac{1.94 \frac{\text{slugs}}{\text{ft}^3} (0.8 \frac{\text{ft}}{\text{s}})^2}{(\frac{3}{12} \text{ ft})} = 4.97 \frac{\text{slugs}}{\text{ft}^2 \cdot \text{s}^2} = \underline{\underline{4.97 \frac{\text{lb}}{\text{ft}^3}}}$$

(b) With  $r = 300$  ft and  $V = 200 \text{ mph} \left( \frac{88 \frac{\text{ft}}{\text{s}}}{60 \text{ mph}} \right) = 293 \frac{\text{ft}}{\text{s}}$

and air ( $\rho = 0.00238 \frac{\text{slugs}}{\text{ft}^3}$ ),

$$\frac{dp}{dr} = \frac{0.00238 \frac{\text{slugs}}{\text{ft}^3} (293 \frac{\text{ft}}{\text{s}})^2}{300 \text{ ft}} = 0.681 \frac{\text{slugs}}{\text{ft}^2 \cdot \text{s}^2} = \underline{\underline{0.681 \frac{\text{lb}}{\text{ft}^3}}}$$