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NAME

Fluids-ID

Quiz 14. A smooth 0.10-m-diameter cork ball (SG = 0.21) is tied to an object on the bottom of a river as is shown in Figure 2. The flow speed *U* is 1.12 m/s. Neglect the string drag. Determine (a) buoyancy force *B,* (b) weight *W*, and (c) drag force on cork ball $D_f$ (Hint: $D_f = \frac{1}{2}\rho U^2 A C_D$ ). (d) Calculate angle θ (Hint: Use $\sum F_x = 0$ and $\sum F_y = 0$).

($\rho_{water}$ = 998 kg/m$^3$, $\nu_{water}$ = 1.12 × 10$^{-6}$ m$^2$/s, $\forall_{sphere} = \frac{4}{3}\pi R^3$)

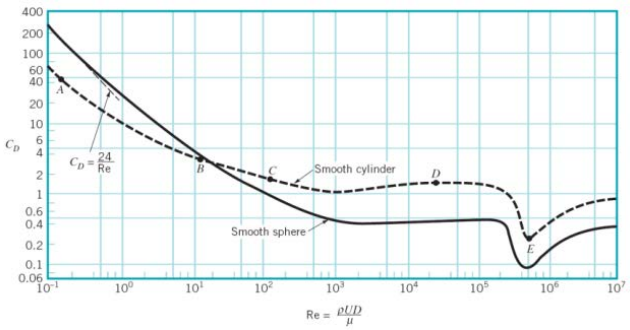


*Figure 1 - Drag coefficient $C_D$ as a function of Reynolds number Re*

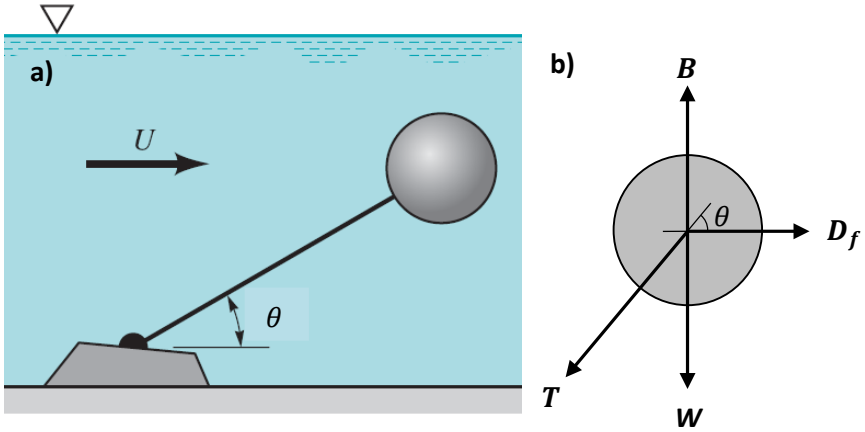


*Figure 2 - (a) Schematic and (b) free body diagram for crock ball*

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

**Solution:**

a) Buoyancy force

$$B = \gamma \forall = \gamma \frac{4}{3}\pi R^3 = (998\,\text{kg/m}^3)(9.81\,\text{m/s}^2)\left(\frac{4\pi}{3}\right)\left(\frac{0.1\text{m}}{2}\right)^3 = 5.126\,\text{N}$$

(+1 point)

b) Weight

$$W = \gamma_{cork} \forall = \left(\frac{\gamma_{cork}}{\gamma}\right)\gamma \forall = SG \cdot B = 0.21 \times 5.126\,\text{N} = 1.077\,\text{N}$$

(+1 point)

c) Calculating drag force

$$Re = \frac{UD}{\nu} = \frac{(1.12\,\text{m/s})(0.1\,\text{m})}{1.12 \times 10^{-6}\,\text{m}^2/\text{s}} = 1 \times 10^5$$

(+1 points)

From figure 7, $C_D = 0.5$ at $Re_D = 10^5$

(+1 points)

$$D_f = \frac{1}{2}\rho U^2 A C_D$$

$$D_f = \frac{1}{2}(998\,\text{kg/m}^3)(1.12\,\text{m/s})^2\left(\frac{\pi}{4}\right)(0.1\,\text{m})^2(0.5) = 2.458\,\text{N}$$

(+2 point)

d) Calculating angle $\theta$

$$\sum F_x = 0 : T\cos\theta = D \text{ (1)}$$

$$\sum F_y = 0 : T\sin\theta = B - W \text{(2)}$$

Dividing equation (2) by equation (1)

$$\tan\theta = \frac{B - W}{D}$$

$$\theta = \tan^{-1}\frac{B - W}{D} = \tan^{-1}\frac{5.126\,\text{N} - 1.077\,\text{N}}{2.458\,\text{N}} = \mathbf{58.7}^\circ$$

(+1 point)