

9.71

9.71 A 0.30-m-diameter cork ball ($SG = 0.21$) is tied to an object on the bottom of a river as is shown in Fig. P9.61. Estimate the speed of the river current. Neglect the weight of the cable and the drag on it.

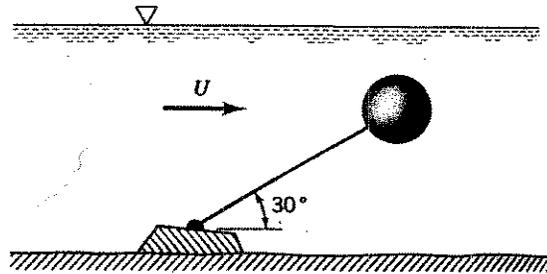
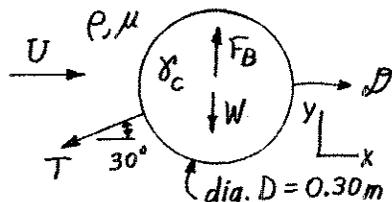


FIGURE P9.71



For the ball to remain stationary

$$\sum F_x = 0 \text{ and } \sum F_y = 0$$

Thus, $D = T \cos 30^\circ$ or $T = \frac{D}{\cos 30^\circ}$
and $F_B = W + T \sin 30^\circ$

Hence, $F_B = W + D \tan 30^\circ$, where $F_B = \rho g V = (9.80 \frac{kN}{m^3}) (\frac{4\pi}{3} (\frac{0.30}{2})^3)$
 $= 0.1385 \text{ kN}$

and

$$W = \gamma_c V = (\frac{\gamma_c}{\gamma}) \gamma V = (SG) F_B$$

$$= 0.21 (0.1385 \text{ kN})$$

$$= 0.0291 \text{ kN}$$

Thus,

$$0.1385 \text{ kN} = 0.0291 \text{ kN} + D \tan 30^\circ$$

or $D = 0.189 \text{ kN}$, where $D = C_D \frac{1}{2} \rho U^2 A = C_D U^2 (\frac{1}{2}) (999 \frac{kg}{m^3}) (\frac{\pi}{4} (0.3m)^2)$
 $= 35.3 C_D U^2 \text{ N, where } U \sim \frac{m}{s}$

Hence

$$35.3 C_D U^2 = 189 \text{ or } C_D U^2 = 5.35 \tag{1}$$

Also, $Re = \frac{UD}{\nu} = \frac{(0.3m) U}{1.12 \times 10^{-6} \frac{m^2}{s}} = 2.68 \times 10^5 U$ (2)

and from Fig. 9.21 C_D vs Re graph (3)

Trial and error solution for U : Assume C_D ; calculate U from Eq.(1) and Re from Eq.(2); check C_D from Eq.(3), the graph.

Assume $C_D = 0.5 \rightarrow U = 3.27 \frac{m}{s} \rightarrow Re = 8.76 \times 10^5 \rightarrow C_D = 0.15 \neq 0.5$

Assume $C_D = 0.15 \rightarrow U = 5.97 \frac{m}{s} \rightarrow Re = 1.60 \times 10^6 \rightarrow C_D = 0.20 \neq 0.15$

Assume $C_D = 0.19 \rightarrow U = 5.31 \frac{m}{s} \rightarrow Re = 1.42 \times 10^6 \rightarrow C_D = 0.19$ (checks)

Thus, $U = \underline{\underline{5.31 \frac{m}{s}}}$