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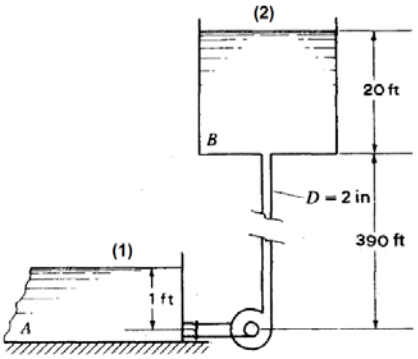
NAME

Quiz 12. The pump moves 120 gal/min (1 gal = 0.133681 ft^3) of water from tank A to tank B as shown in the figure. The pipes are steel (ε = 0.00015 ft). Water is at 60 °F (ρ = 1.938 slugs/ft^3 and μ = 2.344 × 10^{-5} lb·s/ft^2). Neglecting the minor losses, find the (a) the average water velocity V, (b) Reynolds number Re = $\rho VD/\mu$, and (c) friction factor f through the 2-in pipe and (d) the required pump power $\dot{W}_p = \rho g Q h_p$ (1 hp = 550 ft-lb/s and g = 32.2 ft^2/s). Assume the flow is turbulent and use the following energy and friction factor equations,



$$\frac{p_1}{\gamma}+\frac{V_1}{2g}+z_1+h_p=\frac{p_2}{\gamma}+\frac{V_2}{2g}+z_2+f\frac{L}{D}\frac{V^2}{2g}$$

$$\frac{1}{\sqrt{f}}=-1.8\log\left[\left(\frac{\varepsilon/D}{3.7}\right)^{1.1}+\frac{6.9}{Re}\right]$$

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

Solution

(a) $V=\frac{Q}{A}=\frac{(120)(0.133681)/(60)}{(\pi)(2/12)^2/(4)}=\mathbf{12.25\ ft/s}$ **(+1)**

(b) $Re=(1.938)(12.25)\left(\frac{2}{12}\right)/(2.344\times10^{-5})=\mathbf{1.688\times10^5}$ **(+1)**

(c) $\frac{1}{\sqrt{f}}=-1.8\log\left[\left(\frac{0.00015/(2/12)}{3.7}\right)^{1.1}+\frac{6.9}{1.688\times10^5}\right]\Rightarrow f=\mathbf{0.021}$ **(+1)**

(d) Energy equation:

Since $p_1 = p_2 = 0$, $V_1 = V_2 = 0$, z_1 = 1 ft, and z_2 = 390 ft + 20 ft,

$$h_p=(z_2-z_1)+f\frac{L}{D}\frac{V^2}{2g}\ \textbf{(+2)}$$

$$h_p=(390+20-1)+(0.021)\frac{(390)}{(2/12)}\frac{(12.25)^2}{(2)(32.2)}$$

$$h_p=\mathbf{523.5\ ft}\ \textbf{(+1)}$$

$$\therefore W_p=\rho g Q h_p=\frac{(1.938)(32.2)\left[\frac{(120)(0.133681)}{60}\right](523.5)}{550}=\mathbf{16\ hp}\ \textbf{(+1)}$$