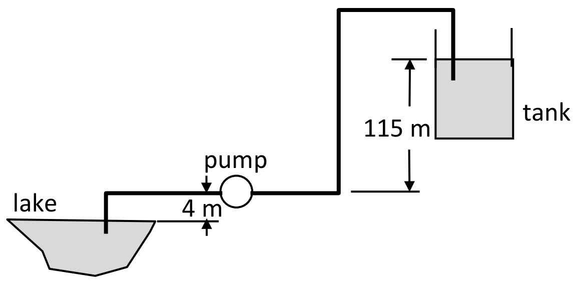
A pump station is used to fill a tank on a hill using water from a lake. The flow rate is 10.5 L/s and atmospheric pressure is 101 kPa (abs). The pump is located 4 m above the lake, and the tank surface level is 115 m above the pump. The suction and discharge lines are 10.2 cm diameter commercial steel pipe. The equivalent length of the inlet line between the lake and the pump is 100 m. The total equivalent length between the lake and the tank is 2300 m, including all fittings, bends, screens, and valves. The overall efficiency of the pump and motor set is 70%.



water density = 1000 kg/m^3
water dynamic viscosity = 1*10^{-3} Pa.s
water vapor pressure = 1820 Pa (abs)

What is the net positive suction head available for this pump?

SOLUTION:

Apply the Extended Bernoulli Equation between the lake surface (1) and the pump inlet (2).

$$\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_2=\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_1-H_L+H_S \quad (1)$$

where

ρ = 1000 kg/m^3

μ = 1*10^{-3} Pa.s

p_V = 1820 Pa (abs)

g = 9.81 m/s^2

p_1 = p_{atm} = 101 kPa (abs)

V_1 $\approx$ 0

$z_2 - z_1$ = 4 m

H_S = 0 (Point 2 is located upstream of the pump.)

D = 0.102 m

Q = 10.5 L/s = 0.0105 m^3/s

V_2 = $Q/(\pi/4D^2)$ = 1.28 m/s (2)

Re_D = $\rho V_2 D/\mu$ = 131,000 (3)

α_2 $\approx$ 1 (turbulent flow)

ε = 0.045*10^{-3} m (commercial steel)

H_L = $f\left(\frac{L_e}{D}\right)\frac{\bar{V}_2^2}{2g}$ = 1.61 m (4)

where Re_D = 131,000 and ε/D = 0.0004 $\Rightarrow$ f = 0.0195 (from the Moody chart) (5)
and L_e = 100 m

Re-arrange Eqn. (1) to solve for the NPSHA:

$$NPSHA=\left(\frac{p}{\rho g}+\frac{\bar{V}^2}{2g}\right)_S-\frac{p_V}{\rho g}=\frac{p_{atm}-p_V}{\rho g}+z_1-z_2-H_L \quad (6)$$

$\therefore$ **NPSHA = 4.5 m**