33.13 A pump transfers $100gpm$ of water from an open reservoir at atmospheric pressure. The static suction lift is 5 feet, the static discharge head is 30 feet, and the working pressure at the outlet is $10psig$. The pump efficiency is 85% and the motor efficiency is 80%. Assuming losses are insignificant, what size motor is required?

A. $1.5hp$

B. $2hp$

C. $3hp$

D. $5hp$

Write the form of the Bernoulli Equation suited for pumping applications.

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{v_2^2 - v_1^2}{2g} + z_2 - z_1 + h_f$$

The working pressure at the outlet, P_2, is given. The static pressure in the open reservoir, P_1, is atmospheric pressure. Therefore, the gauge pressure at P_2 is the differential pressure. Use the rule of thumb conversion factor for water $2.31\frac{ft}{psi}$ for convenience converting between pressure units and feet of head.

$$\frac{P_2 - P_1}{\gamma} = \frac{(10psi + 1atm) - (1atm)}{\gamma} = \frac{10psi}{\gamma} \rightarrow (10psi)\left(2.31\frac{ft}{psi}\right) = 23.1ft$$

The velocity at the outlet, v_2, is greater than in the reservoir, $v_1 \approx 0; v_2 > v_1$. However, the velocity term remains negligible. Feel free to include and show this to be the case.

$$\frac{v_2^2 - v_1^2}{2g} \approx 0$$

The height differential is the sum of both the static suction lift and the discharge head.

$$\Delta z = z_2 - z_1 = 30ft + 5ft = 35ft$$

The problem states losses are insignificant.

$$h_f = 0$$

The head added by the pump is then:

$$h_A = 23.1ft + 35ft = 58.1ft$$

The motor sizing is based on the bhp; therefore, the motor efficiency is not needed. The Brake HP depends on the pump efficiency and hydraulic horsepower, whp, which is a function of volume flow rate and head added by the pump. Solve for bhp and select the smallest sufficient motor size.

$$bhp = \frac{whp}{\eta_p} = \frac{Q_{[gpm]}\Delta h_{[ft]}}{3960 \cdot \eta_p} = \frac{(100)(58.1)}{(3960)(0.85)} = 1.73hp$$

Answer B