33.31 **A 70% efficient pump driven by an 85% efficient motor transfers $50gpm$ of canola oil $\left(\rho = 57\frac{lb_m}{ft^3}\right)$ from an open tank to a sealed tank held at $10psig$ and located $20ft$ below. What is the power input to the motor?**

A. $80W$

B. $400W$

C. $700W$

D. $800W$

Write the modified Bernoulli Equation for head added by a pump, ignoring velocity terms and losses. Consider the open tank as State 1 and the sealed tank as State 2.

$$h_A = \frac{P_2 - P_1}{\gamma} + z_2 - z_1$$

The Specific Weight of the oil has the same magnitude as the density, however the units change from $\frac{lb_m}{ft^3}$ to $\frac{lb_f}{ft^3}$. This may be taken as a given, but the formal equation can also be used.

$$\gamma_{oil} = \rho_{oil}\frac{g}{g_c} = 57\frac{lb_m}{ft^3}\left(\frac{32.2\frac{ft}{s^2}}{32.2\frac{ft \cdot lb_m}{s^2 \cdot lb_f}}\right) = 57\frac{lb_f}{ft^3}$$

Calculate h_A. Be sure to convert $in^2$to ft^2 in the numerator of the pressure term to ensure the units align. There is no need to convert from $psig$ to $psia$ since the *change* in pressure is sought.

$$h_A = \frac{\left(10\frac{lb_f}{in^2} - 0\frac{lb_f}{in^2}\right)\left(144\frac{in^2}{ft^2}\right)}{57\frac{lb_f}{ft^3}} + (-20ft - 0ft) = 5.3ft$$

Determine the Specific Gravity of canola oil.

$$SG_{oil} = \frac{\rho_{oil}}{\rho_{water}} = \frac{57\frac{lb_m}{ft^3}}{62.4\frac{lb_m}{ft^3}} = 0.913$$

Calculate the input power to the pump motor by using the Brake HP equation and including the motor efficiency in the denominator to go from *bhp* to input power. Since the head added by the pump is in ft *of oil*, it is appropriate to include the specific gravity in the numerator, as the constant 3960 in the denominator implies the working fluid to expected to be water.

$$\dot{W} = \frac{QhSG}{3960\eta_p\eta_m}$$

$$\dot{W} = \frac{(50)\,(5.3)\,(0.913)}{(3960)\,(0.7)\,(0.85)} = 0.1hp$$

Convert units to W.

$$\dot{W} = 0.1hp\left(\frac{745.7W}{hp}\right) = 76W$$

Answer A