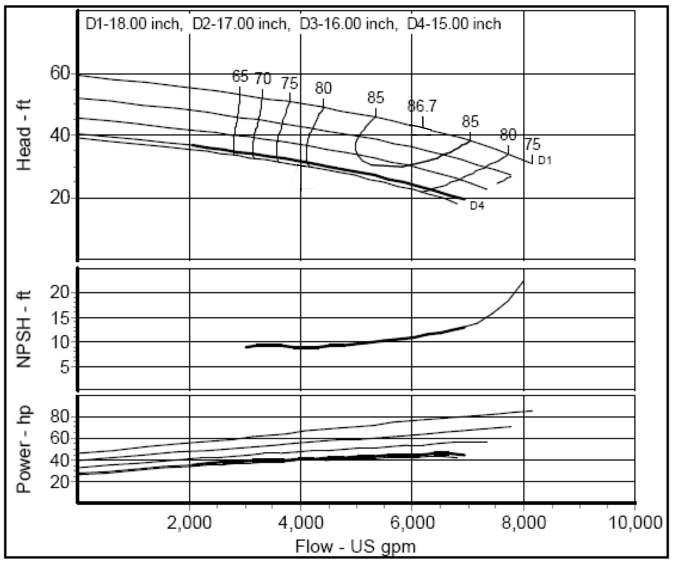
A Peerless Model 16A 18B pump is proposed as the supply unit for the Purdue Engineering Mall fountain. The following requirements have been provided by the architectural firm:

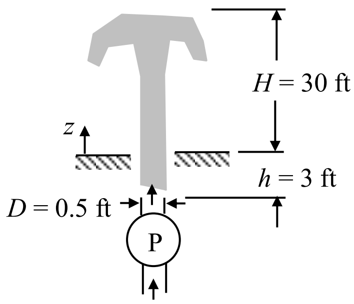
- The pump outlet is to be located 3 feet below ground level.
- The water flow is to reach a peak height of 30 feet above ground level.
- The discharge from the pump is 6 inches in diameter.

The pump characteristics are given in the following plot.



a. What head must be supplied by the pump? Report your answer in ft.
b. What flow rate must be supplied by the pump? Report your answer in gal/min (gpm).
c. What pump impeller diameter should be used? (either 15.00, 16.00, 17.00, or 18.00 inch diameter)
d. What is the pump efficiency? Report your answer in terms of a percentage.
e. What power is required to drive the pump? Report your answer in horsepower (hp).
f. What range of NPSH is acceptable at the pump inlet? Report your answer in ft.

SOLUTION:



The head that must be supplied by the pump is:

$$H_S = H + h \quad \Rightarrow \quad \boxed{H_S = 33 \text{ ft}} \tag{1}$$

The flow rate may be found using the pump outlet diameter and the velocity required to achieve the desired height. Apply Bernoulli's Equation from point 1 to point 2.

$$\left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_2 = \left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_1 \tag{2}$$

where

$p_1 = p_2 = p_{atm}$

$V_1 = 0$

$z_1 = -h$

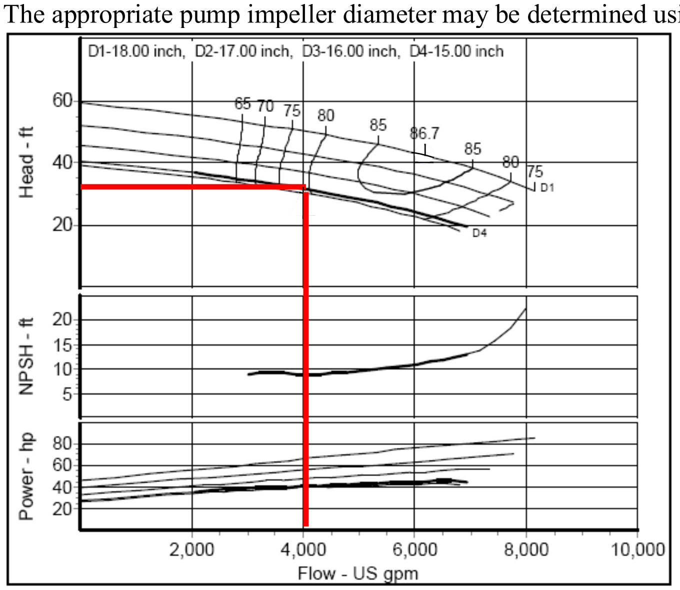
$z_2 = H$

$$\frac{V_1^2}{2g} = z_2 - z_1 \quad \Rightarrow \quad V_1 = \sqrt{2g\left(z_2 - z_1\right)} \quad \text{(using the given data: } \underline{V_1 = 46.1 \text{ ft/s}}\text{)} \tag{3}$$

The flow rate is thus:

$$Q = V_1 \tfrac{\pi}{4} D^2 \quad \text{(using the given data: } \boxed{Q = 9.05 \text{ ft}^3/\text{s} = 4060 \text{ gpm}}\text{)} \tag{4}$$

The appropriate pump impeller diameter may be determined using the given pump characteristics plot.



The nearest impeller diameter is the $\boxed{\text{15.00 inch}}$.

The pump efficiency may also be found from the pump characteristic plot and is $\boxed{\sim 80\%}$.

The power required to drive the pump is:

$$W_{\substack{\text{input into}\\ \text{pump}}} = \frac{\rho Q g H}{\eta} = \frac{1}{0.80}\left(62.4\ \frac{\text{lb}_\text{m}}{\text{ft}^3}\right)\left(9.05\ \frac{\text{ft}^3}{\text{s}}\right)\left(32.2\ \frac{\text{ft}}{\text{s}^2}\right)(33\ \text{ft})\left(\frac{\text{lb}_\text{f}}{32.2\,\dfrac{\text{lb}_\text{m}\cdot\text{ft}}{\text{s}^2}}\right)\left(\frac{\text{hp}}{550\ \dfrac{\text{ft}\cdot\text{lb}_\text{f}}{\text{s}}}\right) \tag{5}$$

$$\boxed{\therefore W_{\substack{\text{input into}\\ \text{pump}}} = 42.4\ \text{hp}}$$

The required NPSH to avoid cavitation at this flow rate is (from the pump plot) ~9 ft so the range of acceptable NPSH is $\boxed{> \sim 9\ \text{ft}}$.