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7.87 TEXTBOOK

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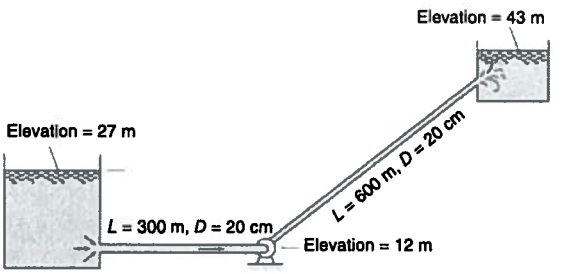
## 7.86: PROBLEM DEFINITION

Situation:

Water is pumped from a lower reservoir to an upper one.
$z_1 = 27\,\text{m}$, $z_2 = 43\,\text{m}$.
$L_1 = 300\,\text{m}$, $L_2 = 600\,\text{m}$.
$D_1 = 20\,\text{cm}$, $D_2 = 20\,\text{cm}$.
$Q = 0.1\,\text{m}^3/\text{s}$, $h_L = 0.018\frac{L}{D}\frac{V^2}{2g}$.

TEXTBOOK IS U.S. CUSTOMARY

METHOD IS SAME




Find:

(a) Power supplied to the pump (kW).
(b) Sketch the HGL and EGL.

Properties:

Water (20 °C), Table A.5: $\gamma = 9810\,\text{N/m}^3$.

## PLAN

Apply the flow rate equation to find the velocity. Then calculate head loss. Next apply the energy equation from water surface to water surface to find the head the pump provides. Finally, apply the power equation.

## SOLUTION

Flow rate equation

$$\begin{aligned} V &= \frac{Q}{A} \\ &= \frac{0.1\,\text{m}^3/\text{s}}{(\pi/4)\times(0.2\,\text{m})^2} \\ &= 3.2\,\text{m/s} \end{aligned}$$

Head loss

$$\begin{aligned} h_L &= \left(0.018\frac{L}{D}\frac{V^2}{2g}\right) + \left(\frac{V^2}{2g}\right) \\ &= 0.018\left(\frac{900\,\text{m}}{0.2\,\text{m}}\right)\frac{(3.2\,\text{m/s})^2}{2\,(9.81\,\text{m/s}^2)} + \frac{(3.2\,\text{m/s})^2}{2\,(9.81\,\text{m/s}^2)} \\ &= 42.64\,\text{m} \end{aligned}$$

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Energy equation

$$\begin{aligned} \frac{p_1}{\gamma} + \alpha_1 \frac{V_1^2}{2g} + z_1 + h_p &= \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^2}{2g} + z_2 + h_L \\ 0 + 0 + 27 + h_p &= 0 + 0 + 43 + 42.64 \\ h_p &= 58.64 \text{ m} \end{aligned}$$

U.S. CUSTOMARY IN FEET HEAD

Power equation

$$\begin{aligned} P &= Q\gamma h_p \\ &= 0.1\,\text{m}^3/\text{s} \times 9810\,\text{N/m}^3 \times 58.64\,\text{m} \\ &= 57,526\,\text{N-m/s} \end{aligned}$$

$$\boxed{P = 58\,\text{kW}}$$

U.S. CUSTOMARY WOULD REPORT lbf-ft/sec OR HP