Solutions

2.1

- $Re = VD/\nu = 0.6 \times 0.025/(1.2 \times 10^{-4}) = \mathbf{125}$: laminar, so $f = 64/Re = \mathbf{0.512}$.
- $h_f = f(L/D)V^2/2g = 0.512 \times (15/0.025) \times 0.6^2/(2 \times 9.81) = \mathbf{5.64}$ m of oil.
- $\Delta p = \rho g h_f = 880 \times 9.81 \times 5.64 = \mathbf{48.7}$ kPa.

2.2

- $V^2/2g = 2.0^2/(2 \times 9.81) = 0.204$ m.
- $h_f = f(L/D)V^2/2g = 0.020 \times 600 \times 0.204 = \mathbf{2.45}$ m.
- $h_m = \sum K\, V^2/2g = 3.5 \times 0.204 = \mathbf{0.71}$ m.

2.3

- $Q = VA = 2.0 \times \pi(0.05)^2 = \mathbf{15.71}$ L/s.
- $H = \Delta z + h_f + h_m = 5 + 2.45 + 0.71 = \mathbf{8.16}$ m.
- $P = \rho g Q H/\eta = 998 \times 9.81 \times 0.01571 \times 8.16/0.75 = \mathbf{1673}$ W.

3.1

- At the crossing: $25 - 40\,000Q^2 = 5 + 25\,000Q^2$, so $Q = \sqrt{20/65\,000} = \mathbf{17.5}$ L/s.
- $H = 25 - 40\,000 \times 0.01754^2 = \mathbf{12.7}$ m.
- $P = \rho g Q H/\eta = 998 \times 9.81 \times 0.01754 \times 12.69/0.70 = \mathbf{3114}$ W.
- The pump delivers 12% too much: throttle a valve, which burns the extra head as loss, or slow the pump with a drive, which saves the power.

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