Solutions

2.1

- Bernoulli from the still surface to the jet, both at atmospheric pressure: $V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0} = \mathbf{6.26}$ m/s.
- $Q = C_d A V = 0.61 \times \pi (0.010)^2 \times 6.26 = \mathbf{1.20}$ L/s.

2.2

- Stagnation at the tip: $\Delta p = \tfrac{1}{2}\rho V^2$, so $V = \sqrt{2\Delta p/\rho} = \sqrt{2 \times 300/1.204} = \mathbf{22.3}$ m/s.

2.3

- $A_2 = \pi (0.025)^2 = 1.963 \times 10^{-3}$ m^2; $1 - \beta^4 = 0.9375$.
- $Q_i = A_2 \sqrt{2\Delta p/(\rho(1-\beta^4))} = 1.963 \times 10^{-3} \sqrt{2 \times 20\,000/(998 \times 0.9375)} = \mathbf{12.84}$ L/s.
- $Q = 0.98 \times 12.84 = \mathbf{12.58}$ L/s.

3.1

- $Q = C_d Q_i = 0.61 \times 12.84 = \mathbf{7.83}$ L/s.
- The jet contracts after the sharp plate (the vena contracta) and loses energy in eddies, so less flow gives the same pressure drop.
- An orifice is cheap, short and easy to change; the venturi's gentle cone recovers pressure but costs length and money.

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