Solutions

2.1

- $A_1 = \pi(0.030)^2 = 2.827 \times 10^{-3}$ m^2; $V_1 = Q/A_1 = 0.008/(2.827 \times 10^{-3}) = \mathbf{2.8}$ m/s.
- $A_2 = \pi(0.0125)^2 = 4.909 \times 10^{-4}$ m^2; $V_2 = Q/A_2 = \mathbf{16.30}$ m/s.

2.2

- All the jet's momentum normal to the plate is destroyed: $F = \rho Q V_2 = 998 \times 0.008 \times 16.30 = \mathbf{130}$ N.

2.3

- Bernoulli, $p_2 = 0$ gauge: $p_1 = \tfrac{1}{2}\rho(V_2^2 - V_1^2) = 0.5 \times 998 \times (16.30^2 - 2.83^2) = \mathbf{128.5}$ kPa.
- Momentum: $p_1 A_1 + F = \rho Q(V_2 - V_1)$, with $p_1 A_1 = 363.4$ N and $\rho Q(V_2 - V_1) = 107.5$ N.
- $F = 107.5 - 363.4 = -255.9$ N on the fluid, so the fluid pushes the nozzle downstream: the bolts carry **256** N in **tension**.

3.1

- Each end: $pA + \rho Q V = 200\,000 \times 2.827 \times 10^{-3} + 998 \times 0.008 \times 2.83 = 565.5 + 22.6 = \mathbf{588.1}$ N.
- The two are at right angles: $R = \sqrt{2} \times 588.1 = \mathbf{832}$ N, at 45° into the outside of the bend.
- Pressure is 96% of each term, so even slow, high-pressure lines need thrust blocks at bends.

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