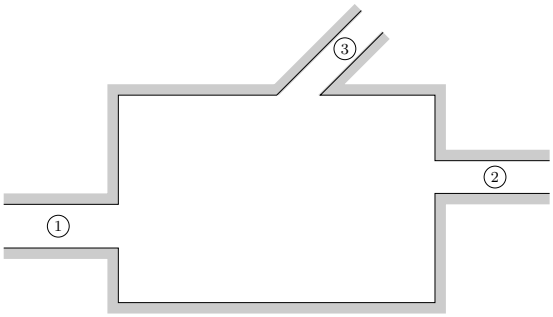
Forces, drag and lift

1. Consider steady, incompressible flow through the device shown. Determine the magnitude and direction of the weight flow rate through port 3 if sea water enters port 1 with a volume flow rate of 2 ft^3/s and exits port 2 with a velocity of 72 ft/s. Take the areas of the ports to be $A_1 = 2$ in^2, $A_2 = 1$ in^2, and $A_3 = 0.75$ in^2.



2. What force is required to hold a flat plate in equilibrium perpendicular to the flow of a 1 cm diameter jet of water having a velocity of 3 m/s? Report your result in Newtons.

3. In this problem we will estimate the force from an 80 mph wind gust on a highway sign that is 12 ft wide by 3 ft high. Assume the wind is flowing perpendicular to the face of the sign. Take the air temperature to be $-20°\text{F}$ where $\rho = 2.68 \times 10^{-3}$ slug/ft^3.

   First compute the force on the sign using the Force Equation $F = \rho Q \Delta v$. Assume the air leaves parallel to the face of the sign.

   Next compute the drag force using a drag coefficient $C_D = 1.16$.

   These should agree within a factor of two. Do you trust one calculation more than the other?

4. Compute the force required to hold a 90° standard elbow in place when attached to DN 100 Schedule 40 pipes carrying water at 0.125 m^3/s and 500 kPa. Neglect energy loss in the elbow.

5. A ball is thrown without spin at a velocity of 80 mph. If the ball has a circumference of 9 inches, calculate the drag force on the ball. Take the density of air to be $\rho = 2.37 \times 10^{-3}$ slugs/ft^3 and the kinematic viscosity $\nu = 1.58 \times 10^{-4}$ ft^2/s.

6. For the airfoil polar diagram of a Boeing 737 shown below determine the lift and drag at an angle of attack of 5°. Assume the airfoil has a chord length of 7.88 m and a span of 17 m. Perform the calculation at a speed of 240 km/h and in the standard atmosphere at 200 m and 10,000 m.