#1.
In figure the jet strikes a vane that moves to the right at constant velocity $V_c$ on a frictionless cart. Compute (a) the force $F_x$ required to restrain the cart and (b) the power $P$ delivered to the cart. Also find the cart velocity for which (c) the force $F_x$ is a maximum and (d) the power $P$ is a maximum.
#2.
Find the force required to hold the plug in place at the exit of the water pipe. The flow rate is 1.5 \( m^3/s \), and the upstream pressure is 3.5 MPa.
#3.
The small boat in the figure is driven at a steady speed $V_0$ by a jet of compressed air issuing from a 3-cm-diameter hole at $V_e = 343$ m/s. Jet exit conditions are $p_e = 1$ atm and $T_e = 30^\circ$C. Air drag is negligible, and the hull drag is $k V_0^2$, where $k \approx 19$ N.s$^2$/m$^2$. Estimate the boat speed $V_0$ in m/s.
#4.
The jet engine on a test stand in figure admits at 20°C and 1 atm at section 1, where $A_1 = 0.5 \text{ m}^2$ and $V_1 = 250 \text{ m/s}$. The fuel to air ratio is 1:30. The air leaves section 2 at atmospheric pressure and higher temperature, where $V_2 = 900 \text{ m/s}$ and $A_2 = 0.4 \text{ m}^2$. Compute the horizontal test stand reaction $R_x$ needed to hold this engine fixed.
#5.
Water at 20°C flows through a 5-cm-diameter pipe that has a 180° vertical bend, as in figure. The total length of pipe between flanges 1 and 2 is 75 cm. When the weight flow rate is 230 N/s, $p_1 = 165$ kPa and $p_2 = 134$ kPa. Neglecting pipe weight, determine the total force that the flanges must withstand for this flow.
#6.
Consider incompressible flow in the entrance of a circular tube, as in the figure. The inlet flow is uniform, \( u_1 = U_0 \). The flow at section 2 is developed pipe flow. Find the wall drag force \( F \) as a function of \( (p_1, p_2, \rho, U_0, R) \) if the flow at section 2 is

(a) Laminar: \( u_2 = u_{\text{max}} \left(1 - \frac{r^2}{R^2}\right) \)

(b) Turbulent: \( u_2 \approx u_{\text{max}} \left(1 - \frac{r}{R}\right)^{1/7} \)
#7.
A 20°C water jet strikes a vane mounted on a tank with frictionless wheels, as in the figure. The jet turns and falls into the tank without spilling out. If $\theta = 30^\circ$, evaluate the horizontal force $F$ required to hold the tank stationary.
#8.
Water flows through a duct in the figure, which is 50 cm wide and 1 m deep into the paper. Gate BC completely closes the duct when $\beta = 90^\circ$. Assuming one-dimensional flow, for what angle $\beta$ will the force of the exit jet on the plate be 3 kN?
#9.
Suppose that a deflector is deployed at the exit of the jet engine of problem #4 as shown in the figure. What will the reaction $R_x$ on the test stand be now? Is this reaction sufficient to serve as a braking force during airplane landing?
#10.
Water flows steadily through the nozzle shown, discharging to atmosphere. Calculate the horizontal component of force in the flanged joint. Indicate whether the joint is in tension or compression.
#11.
Air at standard conditions flows along a flat plate. The undisturbed freestream speed is $U_0 = 10 \text{ m/s}$. At $L = 145 \text{ mm}$ downstream from the leading edge of the plate, the boundary-layer thickness is $\delta = 2.3 \text{ mm}$. The velocity profile at this location is

$$\frac{u}{U_0} = \frac{3y}{2\delta} - \frac{1}{2} \left[ \frac{y^3}{\delta} \right]$$

Calculate the horizontal component of force per unit width required to hold the plate stationary.