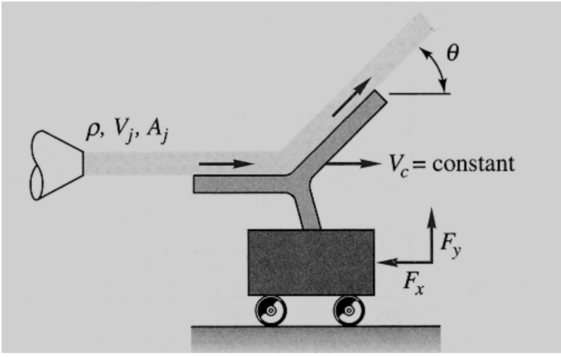
HW #8 SP 07

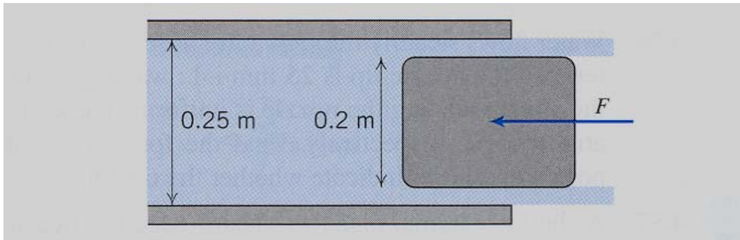
#1.

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.



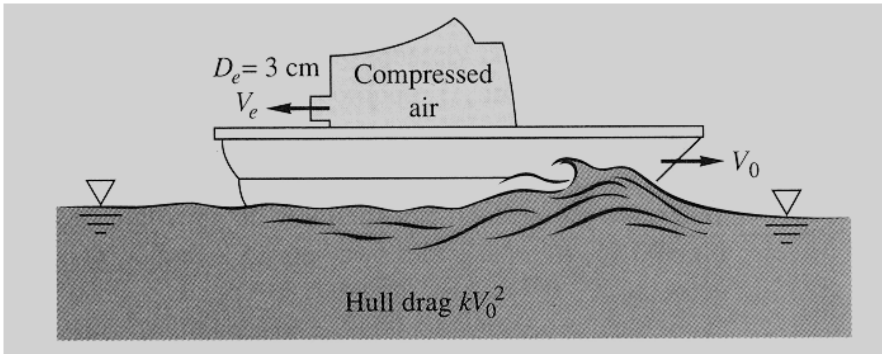
#2.

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*.



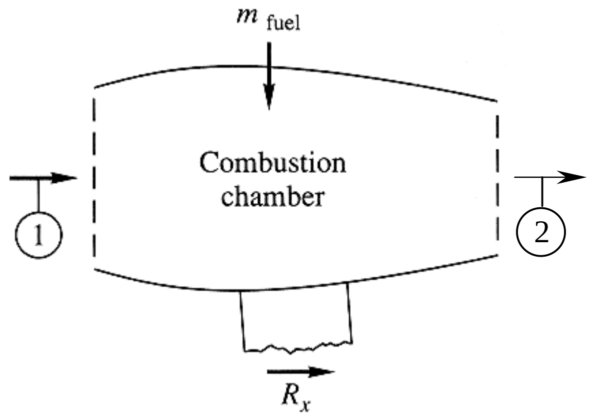
#3.

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°C. Air drag is negligible, and the hull drag is kV_0^2, where k ≈ 19 $N.s^2/m^2$. Estimate the boat speed V_0 in m/s.



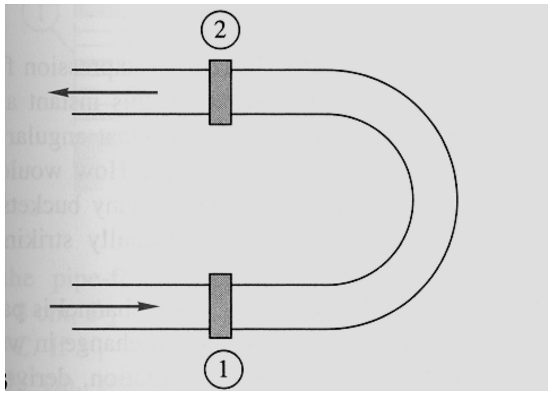
#4.

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 $V_1 = 250$ m/s. The fuel to air ratio is 1:30. The air leaves section 2 at atmospheric pressure and higher temperature, where $V_2 = 900$ 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.

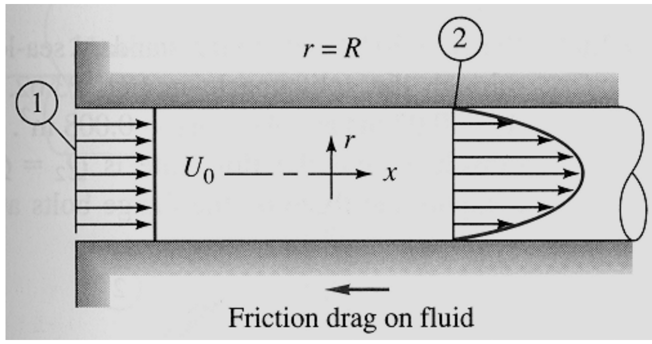


#6.

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, ρ, U_0, R) if the flow at section 2 is

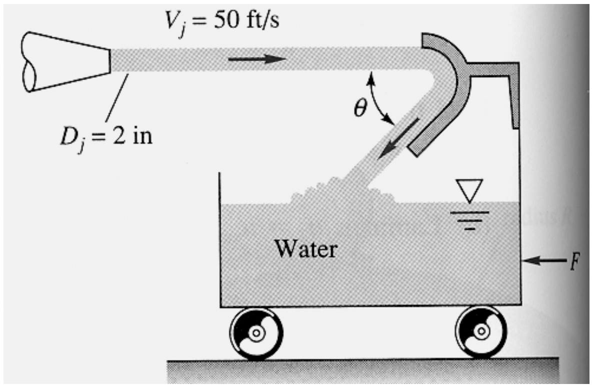
(a) Laminar: $u_2 = u_{\max}\left(1 - \frac{r^2}{R^2}\right)$

(b) Turbulent: $u_2 \approx u_{\max}\left(1 - \frac{r}{R}\right)^{1/7}$



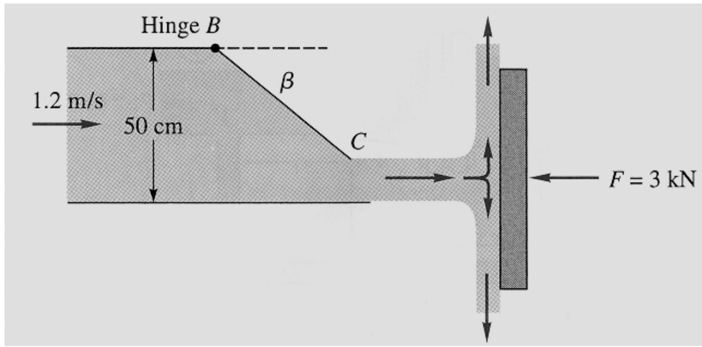
#7.

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 $\theta = 30°$, evaluate the horizontal force F required to hold the tank stationary.



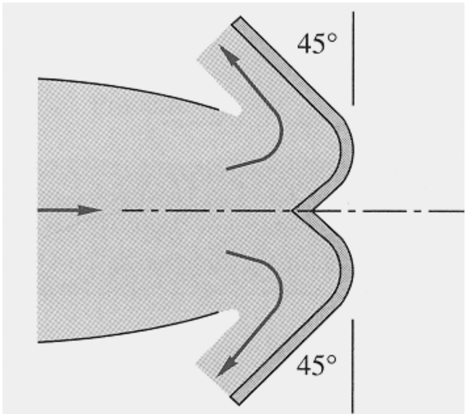
#8.

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 $\beta = 90°$. Assuming one-dimensional flow, for what angle β will the force of the exit jet on the plate be 3 kN?



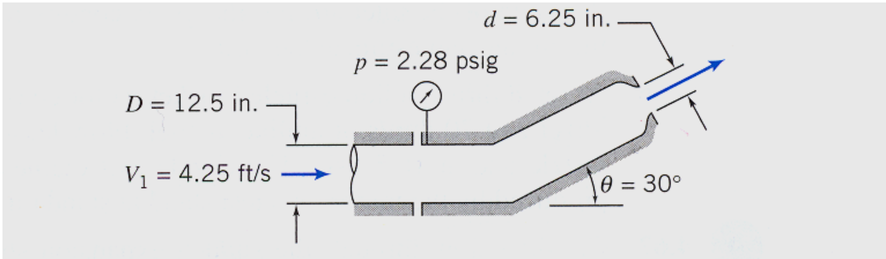
#9.

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 *m/s*. At L = 145 *mm* downstream from the leading edge of the plate, the boundary-layer thickness is δ = 2.3 *mm*. The velocity profile at this location is

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

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