

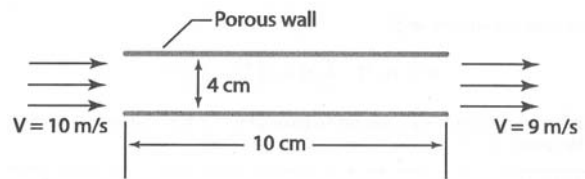
**10.303 & 14.301 Fluid Mechanics**  
**Homework Assignment #6 Fall 2006**

**More Problems Associated with the Continuity Equation**

1. A mechanical pump is used to pressurize a bicycle tire. The inflow to the pump is constant at 1 cfm (i.e. 1 ft<sup>3</sup>/min). The density of the air entering the pump is 0.075 lbm/ft<sup>3</sup>. The inflated volume of the bicycle tire is 0.04 ft<sup>3</sup> and the density of the air within the inflated tire is 0.4 lbm/ft<sup>3</sup>.

Under these conditions, how many seconds does it take to pressurize the tire if there is initially no air in the tire?

2. Water flows steadily through a 4 cm diameter pipe that is 10 cm long. The pipe wall is porous, leading to a small flow through the wall. The pipe inlet velocity is 10 m/s and the average exit velocity is 9 m/s.



Find the average velocity of the water that is passing through the porous surface.

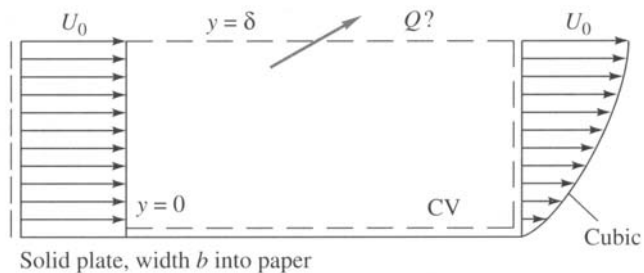
3. An incompressible fluid flows past an impermeable flat plate as shown. The inlet velocity profile is uniform,

$$u = u_0 \quad (\text{at inlet})$$

and it has a cubic polynomial exit profile,

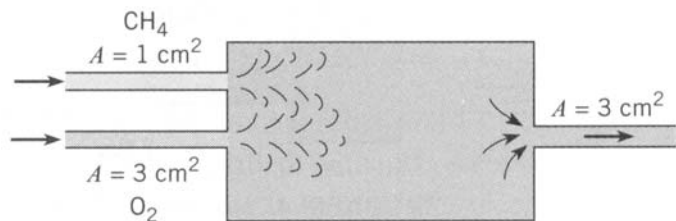
$$u(\eta) = u_0 \left( \frac{3\eta - \eta^3}{2} \right) \quad (\text{at exit})$$

with  $\eta = y/\delta$ .



For this situation, formally develop an expression for the volume flow rate,  $Q$ , across the top surface of the control volume (CV).

4. Oxygen and methane enter a mixing chamber at 200 kPa absolute pressure and 100 C as shown in the sketch below. The velocity of both gases into the mixer is 5 m/s. The density of the gas leaving the mixer is 2.2 kg/m<sup>3</sup>.



Determine the exit velocity of the gas.

5. Water is draining from a pressurized tank as shown. For constant pressure,  $P$ , the exit velocity is can be approximated by

$$V_e = \sqrt{\frac{2P}{\rho} + 2gh}$$

where  $\rho$  is the water density and  $h$  is the elevation of the water surface above the outlet.

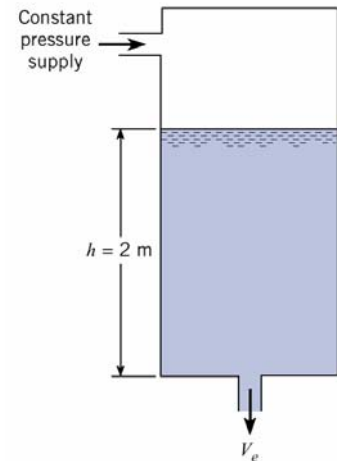
Data for the system are:

initial depth =  $h_0 = 2$  m

constant tank pressure =  $P$

tank area =  $A = 1$  m<sup>2</sup>

exit flow area =  $A_e = 10$  cm<sup>2</sup>



- If  $P = 10$  kPa, how long does it take to empty the tank?
- Compare the value in Part a with the drain time for an un-pressurized tank (top open to atmosphere).