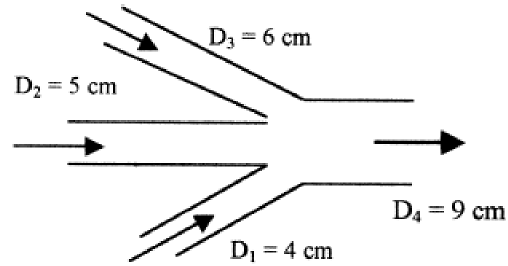
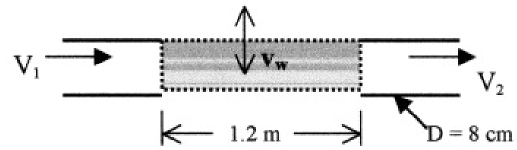
# CE 371 HOMEWORK 6

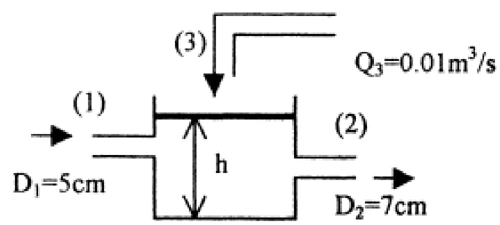
**1)** Three pipes steadily deliver water at 20°C to a large exit pipe as shown in the figure. The velocity $V_2 = 5$ m/s, and the exit flow rate $Q_4 = 120\ m^3/h$. Find **(a)** $V_1$; **(b)** $V_3$; and **(c)** $V_4$
if it is known that increasing $Q_3$ by 20% would increase $Q_4$ by 10%




**2)** Water flowing through an 8-cm-diameter pipe enters a porous section, as shown in the figure, which allows a uniform radial velocity $v_w$ through the wall surfaces for a distance of 1.2 m. If the entrance average velocity $V_1$ is 12 m/s, find the exit velocity $V_2$ if **(a)** $v_w = 15$ cm/s out of the pipe walls; **(b)** $v_w = 10$ cm/s into the pipe. **(c)** What value of $v_w$ will make $V_2 = 9$ m/s?



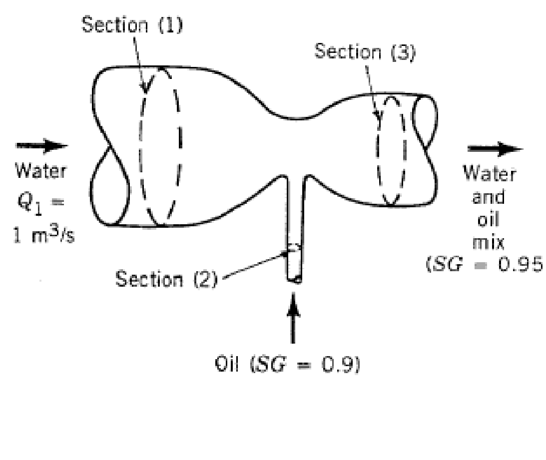

**3)** The open tank in the figure contains Water. If h is constant, determine $V_2$ for the given data if $V_1 = 3$ m/s and $Q_3 = 0.01\ m^3/s$.



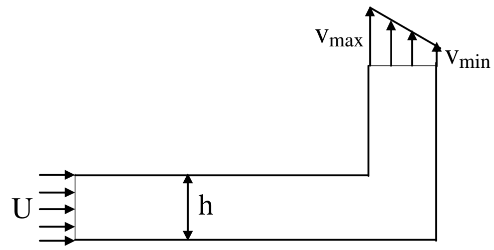

**4)** Viscous liquid from a circular tank, D = 300 mm in diameter, drains through a long circular tube of radius R = 50 mm. The velocity profile at the tube discharge is

$u = u_{max}\left[1-\left(\frac{r}{R}\right)^2\right]$ .Show that the average speed of flow in the drain tube is $V_{ave} = \frac{1}{2}u_{max}$.

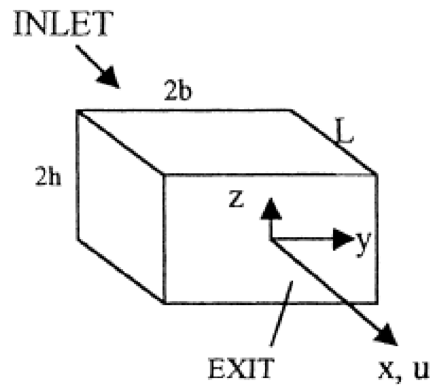
**5)** Oil having a specific gravity 0.9 is pumped as illustrated in the figure with a water jet pump. The water volume flowrate is 1 $m^3/s$. The water and oil mixture has an average specific gravity of 0.95. Calculate the rate, in $m^3/s$, at which the pump moves oil.



**6)** Water enters a two dimensional square channel of constant width h = 75.5 mm, with uniform velocity U. The channel makes a 90° bend that distorts the flow to produce the linear velocity profile as shown at the exit, with $v_{max} = 2v_{min}$ . Evaluate the $v_{min}$, if U = 7.5 m/s.




**7)** An incompressible fluid flows steadily through the rectangular duct in the figure. The exit velocity profile is given by $u = u_{max}(1 - y^2/b^2)(1 - z^2/h^2)$. **(a)** Does this profile satisfy the correct boundary conditions for viscous fluid flow? **(b)** Find an analytical expression for the volume flow Q at the exit. **(c)** If the inlet flow is 0.1416 $m^3/s$, estimate $u_{max}$ in m/s. (b = h = 10 cm)




**ANSWERS**

**1) a)** $V_1 = 5.45$ m/s ; **b)** $V_3 = 5.89$ m/s ; **c)** $V_4 = 5.24$ m/s

**2) a)** $V_2 = 3$ m/s; **b)** $V_2 = 18$ m/s; **c)** $v_w = 0.05$ m/s (out).

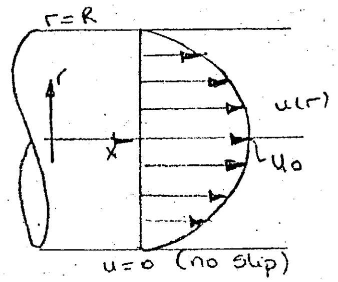
**3) a)** $\frac{dh}{dt} = \frac{Q_1 + Q_3 - Q_2}{(\pi d^2/4)}$ ; **b)** $V_2 = 4.13$ m/s

**5)** $Q_2 = 1\ m^3/s$

**6)** $v_{min} = 5.0$ m/s

**7) a)** Yes; **b)** $Q = \frac{16bhu_{max}}{9}$ **c)** $u_{max} = 7.96$ m/s

Q1) For steady viscous flow through a circular tube, the axial velocity profile is given by $u = U_0(1-\frac{r}{R})^m$ as shown in the figure. For laminar flow $m \approx 1/2$ while for turbulent flow $m \approx 1/7$. (a) Compute the average velocity if the density is constant (b) Suppose the density also varies according to the formula $\rho = \frac{1}{2}\rho_0\left[1+(1-\frac{r}{R})^n\right]$. i.e. It increases from $0.5\rho_0$ at the walls to $\rho_0$ at the centreline. This simulates high speed gas flow through a tube with hot walls. Compute the average density and the average product of density and velocity, and compare. (For laminar flow $n \approx 1/2$ and for turbulent flow $n \approx 1/7$)



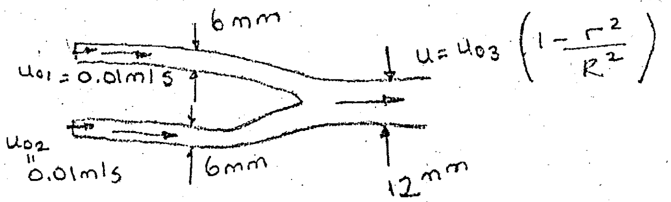

a) Laminar → $V_{av} \cong 0.53\, u_0$ ; Turbulent → $V_{av} \cong 0.82\, u_0$

b) Laminar → $\rho_{av} \cong 0.77\rho_0$ ; Turbulent → $\rho_{av} \cong 0.91\rho_0$

c) $(\rho V)_{av} \cong 1.06\, \rho_{av} V_{av}$ (laminar) ; $(\rho V)_{av} \cong 1.01\, \rho_{av} V_{av}$ (Turbulent)

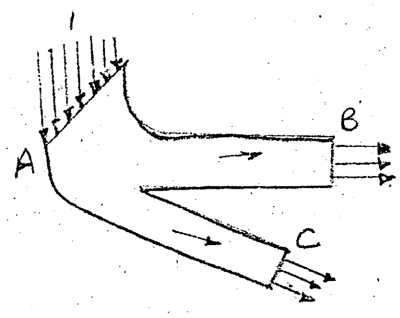
Q2) Consider a device used to mix and deliver two liquids with roughly the same density 1050 kg/m³, as shown in the figure. For the conditions shown in the figure, find the maximum velocity after the two liquid streams mix. ($u_{03}$ = maximum velocity)
The flow is assumed to be steady and incompressible.

$u_{03} = 0.01\, m/s$



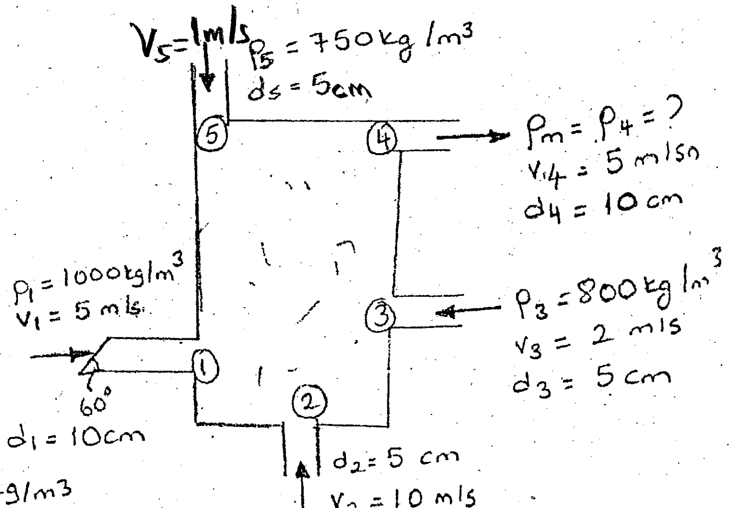

Q3) A two-dimensional water flow divider is shown in the figure. The flow in through opening A varies linearly from 3 m/s to 6 m/s and is inclined with an angle $\alpha$=45° to the opening itself. The area of the A opening is 0.4 m²/m, that of B is 0.2 m²/m and that of C is 0.15 m²/m. The flow at B, normal to the opening, varies linearly from 3 m/s to 5 m/s, and the flow at C, normal to the opening, is approximately constant. Find $q_C$. Note that the flow is incompressible.

$q_c = 3.153\, m/s$



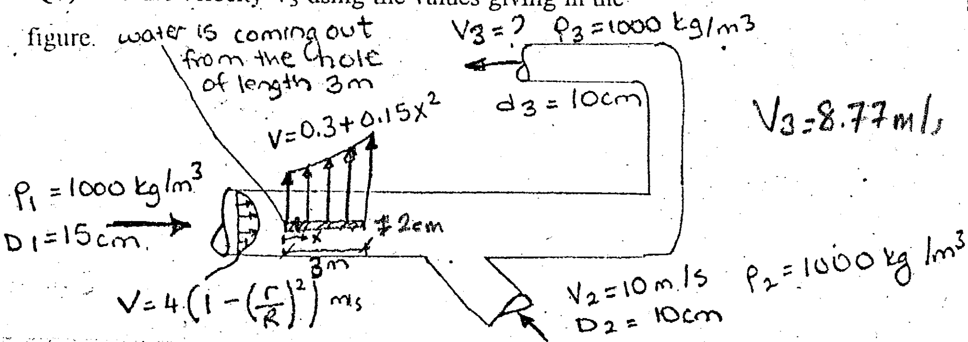

Q4) Assuming that the flow is incompressible and steady, find the density of the mixture $\rho_m$ coming out of the tank using the values shown in the figure.

$\rho_m = 1118\ kg/m^3$




Q5) Find the velocity $V_3$ using the values giving in the figure. water is coming out from the hole of length 3m

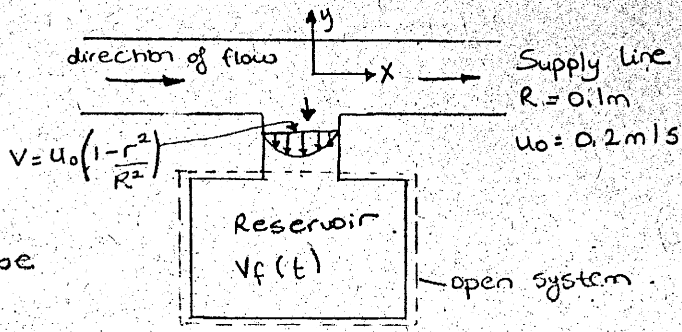
$V_3 = 8.77\, m/s$



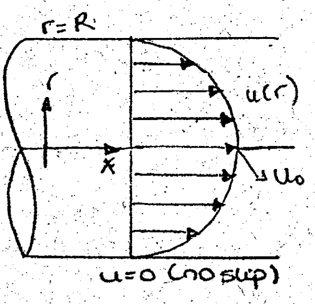
# CE 371 HOMEWORK 6.3

Q1) Consider an initially empty reservoir with volume 2 m3 connected to a supply line through a valve as shown in the figure. Find the time it takes to fully fill the reservoir when the valve opens. ($t_{fill} = 636.6$ seconds)

$V_f(t)$ = volume of the tank at time t.
The flow at the supply line is assumed to be constant and incompressible.

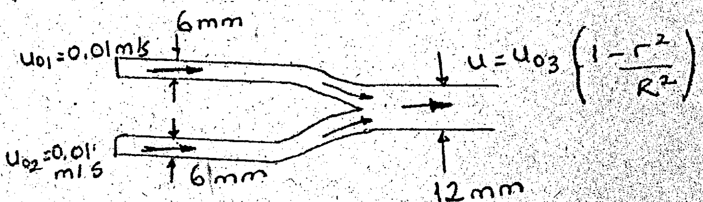



Q2) For steady viscous flow through a circular tube, the axial velocity profile is given by $u = U_0(1-\frac{r}{R})^m$ as shown in the figure. For laminar flow m≈1/2 while for turbulent flow m≈1/7. (a) Compute the average velocity if the density is constant (b) Suppose the density also varies, according to the formula $\rho = \frac{1}{2}\rho_0\left[1+(1-\frac{r}{R})^n\right]$. i.e. It increases from $0.5\rho_0$ at the walls to $\rho_0$ at the centreline. This simulates high speed gas flow through a tube with hot walls. Compute the average density and the average product of density and velocity, and compare. (For laminar flow $n \approx 1/2$ and for turbulent flow $n \approx 1/7$)

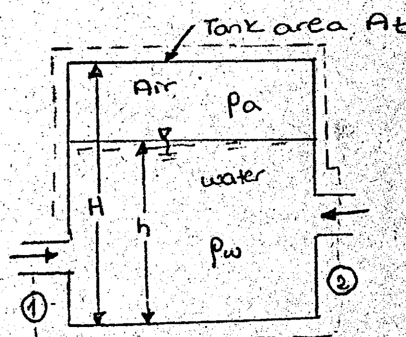



$V_{av} \cong 0.53 u_0$ (lam.) $\rho_{av} = 0.77\rho_0$ (lam.)
$V_{av} \cong 0.82 u_0$ (turb) $\rho_{av} = 0.91\rho_0$ (turb.)

Q3) Consider a device used to mix and deliver two liquids with roughly the same density 1050 kg/m3, as shown in the figure. For the conditions shown in the figure, find the maximum velocity after the two liquid streams mix. ($u_{03}$ = maximum velocity)
The flow is assumed to be steady and incompressible. $u_{03} = 0.01$ m/s

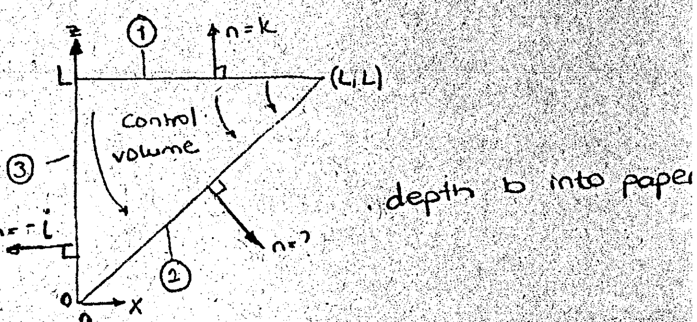



Q4) The tank given in the figure is being filled with water by two one-dimensional inletsç Air is trapped at the top of the tank. The water height is h. (a) Find an expression for the change in water height dh/dt. (b) Compute dh/dt if D1=2.5cm, D2=7.6 cm, V1= 0.91 m/s, V2=0.61 m/s and At=0.186 m2, assuming water at 20°C.




a) $\frac{dh}{dt} = \frac{Q_1+Q_2}{A_t}$ b) 0.0173 m/s

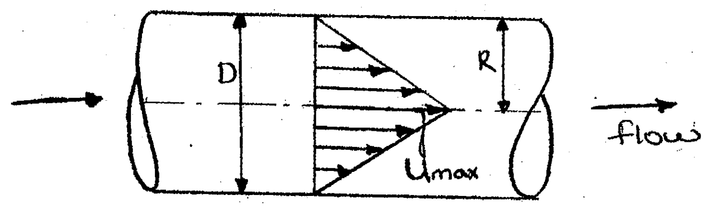
Q5) Consider the constant-density velocity field $u = \frac{V_0 x}{L}$, $v = 0$ and $w = -\frac{V_0 z}{L}$. Use the triangular contrl volume given in the figure, bounded by (0, 0), (L, L) and (0, L), with depth b into paper. Compute the volume flow through sections 1, 2 and 3 and compare to see whether maa is conserved.




$Q_1 = -V_0 bL$ $Q_2 = V_0 bL$
$Q_3 = 0$

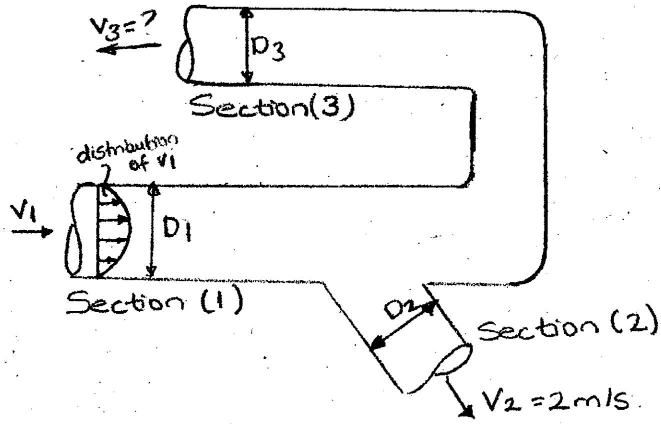
# CE 371 HOMEWORK 8

**Q1)** Water flowing out of a circular pipe is assumed to have a linearly varying velocity distribution as shown in the figure. What is the average velocity of the outward flow in terms of $U_{max}$. $\left(\frac{U_{max}}{3} = V_{ave}\right)$




**Q2)** Water flows into a branched pipe as shown in the figure. The diameters of the pipes are $D_1$=20cm, $D_2$=10cm and $D_3$=5cm. The velocity profile of the water entering the pipe is given by $V_1 = 0.25\left[1 - \frac{r^2}{R_1^2}\right]$ where $R_1$ is the radius of the pipe at Section 1.If the uniform velocity at Section 2 is $V_2$=2 m/s, then find the average velocity at Section 3.

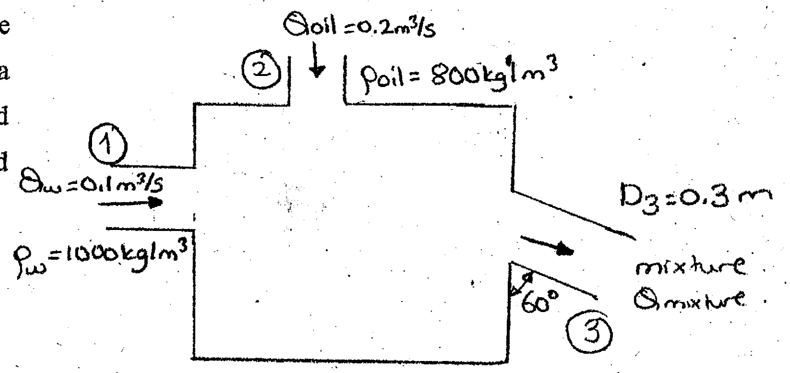
$V_3 = 6.01\ m/s$ (inward)




**Q3)** Oil and water are mixing in the tank and the mixture is flowing out from the pipe which has a diameter of 0.3m. If the discharge of oil is 0.2 $m^3$/s and the discharge of water is 0.1 $m^3$/s, find the velocity and the density of the mixture.

$V_{mix} = 4.244\ m/s$

$\rho_{mix} = 866.67\ kg/m^3$

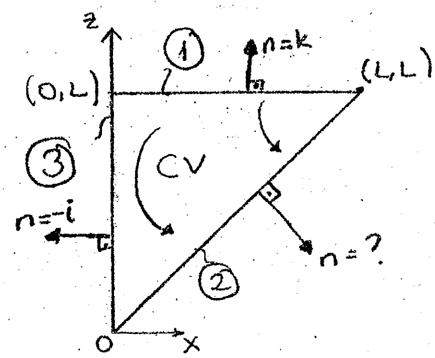



**Q4)** Consider the constant-density velocity field $u = \frac{V_0 x}{L}$, $v = 0$ and $w = -\frac{V_0 z}{L}$. Use the triangular control volume given in the figure , bounded by (0, 0), (L, L) and (0, L), with depth b into paper. Compute the volume flow through sections 1, 2 and 3 and compare to see whether mass is conserved.

$Q_1 = -V_0 bL$

$Q_3 = 0$

$Q_2 = V_0 bL$




**Q5)** Find the velocity $V_3$ using the values giving in the figure. $(V_3 = 1.47\ m/s)$

Velocity distribution at section 1 is given by

$V_1 = 2\left(1 - \frac{r^2}{R_1^2}\right)$

Uniform velocity is present at Section 2 and Section 3