Day-6

Graded Tut-1

1:) Assuming water is incompressible and flow is steady,

$$Q_1 = \frac{\pi}{4}(0.05)^2 v_1$$

$$Q_2 = \frac{\pi}{4}(0.075)^2 \times 2$$

$$= 0.0088 \ m^3 s^{-1} = Q_1$$

so $v_1 = 2 \times \left(\frac{0.075}{0.05}\right)^2$

$$= 2 \times 2.25 = 4.5 \ ms^{-1}$$

$$Q_2 = Q_3 + Q_4$$
$$= 2Q_4 + Q_4 = 3Q_4$$

$$\Rightarrow \frac{\pi}{4}(0.075)^2 \times 2 = 3 \times \frac{\pi}{4}(0.03)^2 \times v_4$$

$$\Rightarrow v_4 = \frac{2}{3} \times \left(\frac{0.075}{0.03}\right)^2$$

$$= \frac{2}{3} \times 6.25 \ ms^{-1}$$

$$= \frac{12.5}{3} \ ms^{-1}$$

$$\approx 4.167 \ ms^{-1}$$

$$Q_3 = 2Q_4 = 2\frac{Q_2}{3}$$

$$\Rightarrow \pi/4 \, d^2 \times 1.5 = 2/3 \times \pi/4 \, (0.075)^2 \times 2$$

$$\Rightarrow d = 0.075\sqrt{\frac{4}{3}\times\frac{1}{1.5}}$$

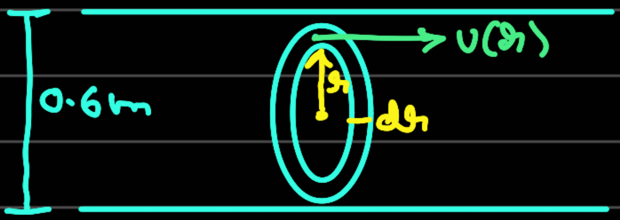
$$= 0.075\sqrt{\frac{8}{9}}$$

$$= 0.05\sqrt{2}\ m$$

$$= 0.07071\ m$$

$$= 70.71\ mm$$

2.)



Assume an annular ring as shown of radius r and width dr.

$$d\dot{V} = u(r)\,dA$$

$$= u(r)\,2\pi r\,dr$$

$$= 2\pi\,(5r^2 - 0.45)\,r\,dr$$

$$= \pi\,(10r^3 - 0.9r)\,dr$$

$$\Rightarrow \dot{V} = \int_0^{0.3} \pi\,(10r^3 - 0.9r)\,dr$$

$$= \pi\left[\frac{10}{4}\times(0.3)^4 - \frac{0.9}{2}(0.3)^2\right]$$

$$= 0.09\pi\,(2.5\times 0.09 - 0.45)\ m^3s^{-1}$$

$$= 0.09\pi\,(0.225 - 0.45)\ m^3s^{-1}$$

$= -0.09\pi \times 0.225 \ m^3s^{-1}$
$\approx -0.064 \ m^3s^{-1}$ (Take + sign)

$$V_{avg} = \frac{-0.064}{\pi \times (0.3)^2}$$

$= -0.225 \ ms^{-1}$ (Take + sign)

3.) Per branch:

$Q_{PB} = (40+1) \times 8$ lps
$= 328$ lps

$$v_{PB} = \frac{328 \times 10^{-3}}{0.2 \times 0.5} \ ms^{-1}$$
$= 3.28 \ ms^{-1}$

Central branch:

Now, $Q_c = 6 \times 0.328 \ m^3s^{-1}$
$= 1.968 \ m^3s^{-1}$

$$h_c = \frac{1.968}{0.5 \times 1.75}$$
$= 2.25$ m

4.) $P_1A_1 - P_2A_2 = 3.5 \times 10^5 \times \frac{\pi}{4}(0.3)^2$
$- 0.35 \times 10^5 \times \frac{\pi}{4}(0.06)^2$

$= 3.5 \times \frac{\pi}{4} \times 10^5 (0.09 - 0.1 \times 0.0036)$

$= 0.24641 \times 10^5$ N
$= 24641$ N

$$\rho A_2 v_2^2 - \rho A_1 v_1^2 = 0.8 \times 1000 \left[\frac{Q^2}{A_2} - \frac{Q^2}{A_1}\right]$$

$$= 800 \times (0.1)^2 \left(\frac{1}{\frac{\pi}{4} \times (0.06)^2} - \frac{1}{\frac{\pi}{4} \times (0.3)^2} \right)$$

$$= 8 \times \frac{4}{\pi} \left(\frac{1}{0.0036} - \frac{1}{0.09} \right)$$

$$= \frac{32}{\pi} \times \frac{1}{0.09} \left(\frac{1}{0.04} - 1 \right)$$

$$= \frac{3200}{9\pi} \times 24 \quad N$$

$$= 2716.24 \quad N$$

$$\therefore \; F = |2716.24 - 24641| \; N$$

$$= 21924.76 \; N$$

5.) S1 : $\dot{m}_1 = \frac{2000}{60} \; s^{-1} = 33.33 \; kg s^{-1}$

S2 : $\dot{m}_2 = \frac{3150}{60} \; m^3 s^{-1} = 52.5 \; kg s^{-1}$

By theory : (Assume $u = 0$ when water is just exiting pipe)

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 10} \; ms^{-1}$$
$$= 14 \; ms^{-1}$$

$$\dot{m} = \pi \times (0.025)^2 \times 14 \times 1000$$
$$= 27.4889 \; kg s^{-1}$$ (steady flow assumed)

Assumed that when water exits the pipe, it still flows taking the pipe shape.
Since Q_1 is closer, so S1 is correct.

The reason why the discrepancy occurred is because the weighing scale experiences not only the normal force exerted by the water already in the tank but also by the flowing water which just enters the tank, hence the weight measured by student 2 was much greater and hence, the incorrect mass flow rate was calculated.

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