Fluid Mechanics and Machineries- Problems in continuity equation

(14) (10)

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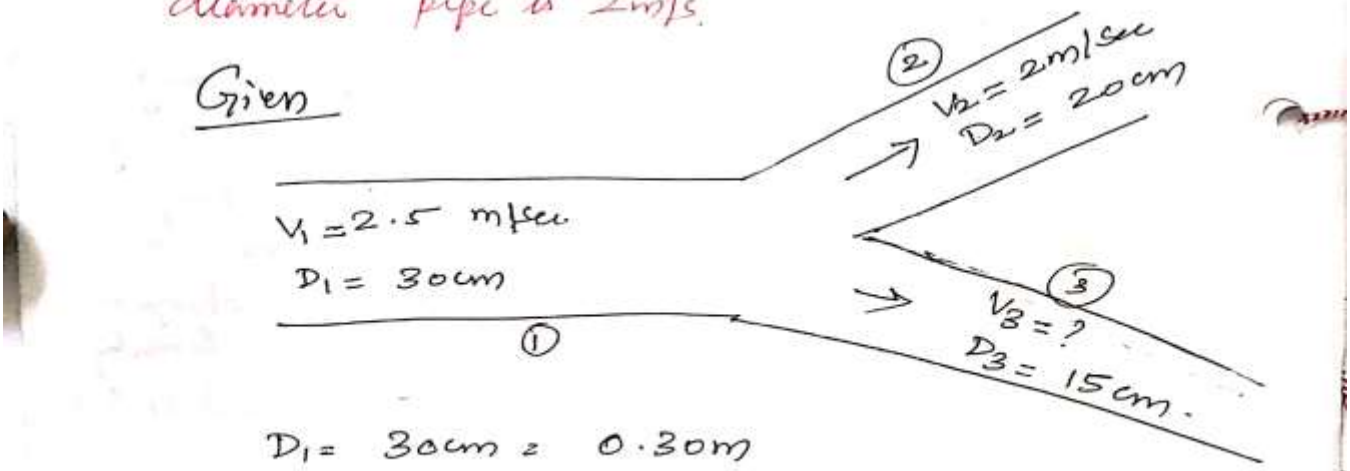
A 30 cm diameter pipe, conveying water, branches into two pipes of diameters 20cm and 15cm respectively. If the average velocity in the 30 cm diameter pipe is 2.5 m/s. Find the discharge in this pipe. Also determine the velocity in 15cm pipe if the average velocity in 20cm diameter pipe is 2m/s.

Given



$D_1 = 30\text{cm} = 0.30\text{m}$

$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} 0.3^2 = 0.07068\ m^2$

$V_1 = 2.5$ m/s

$D_2 = 20\text{ cm} = 0.20\text{ m}$

$A_2 = \frac{\pi}{4}(0.2)^2 = \frac{\pi}{4} \times 0.4 = 0.0314\ m^2$

$V_2 = 2$ m/s

$D_3 = 15\text{ cm} = 0.15\text{ m}$

$A_3 = \frac{\pi}{4}(0.15)^2 = \frac{\pi}{4} \times 0.225 = 0.01767\ m^2$

To find: (i) discharge in pipe 1 or Q_1
(ii) Velocity in pipe of dia 15cm or V_3

Let Q_1, Q_2 and Q_3 are discharges in pipe 1, 2 and 3 respectively.

Then according to Continuity equation

$$Q_1 = Q_2 + Q_3$$

(i) The discharge Q in pipe 1 is given by

$$Q_1 = A_1 V_1 = 0.07068 = 2.5 \text{ m}^3/\text{sec}$$

$$= 0.1767 \text{ m}^3/\text{s}$$

$Q = $ m³/sec.

(ii) Value of V_3

$$Q_2 = A_2 V_2 = 0.0314 \times 2 = 0.0628 \text{ m}^3/\text{s}$$

Substituting the values of Q_1 and Q_2 in eq (1)

$$0.1767 = 0.0628 + Q_3$$

$$Q_3 = 0.1767 - 0.0628 = 0.1139 \text{ m}^3/\text{s}$$

$$Q_3 = A_3 \times V_3 = 0.01767 \times V_3$$

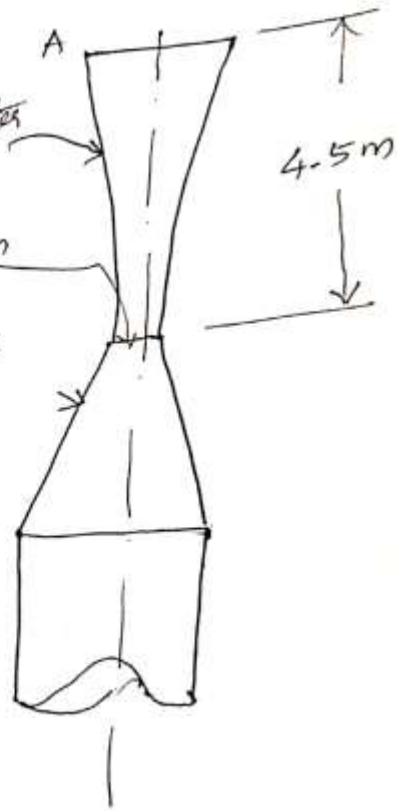
(or)

$$0.1139 = 0.01767 \times V_3$$

$$V_3 = \frac{0.1139}{0.01767}$$

$$\boxed{V_3 = 6.44 \text{ m/sec}}$$

A Jet of water from a 25mm diameter nozzle is directed vertically upwards, Assuming that the Jet remains circular and neglecting any loss of energy, that will be the diameter at a point 4.5m above the nozzle, if the velocity which the Jet leaves the nozzle is 12 m/s



Dia of NOZZLE $D_1 = 25mm$
$= 0.025m$

Velocity of Jet at NOZZLE $V_1 = 12 m/s$

Height of point A $h = 4.5m$

Let the velocity of Jet at height $4.5m = V_2$

Consider the vertical motion of the Jet from the outlet of the nozzle to the point A (Neglecting any loss of energy)

Initial velocity $u = V_1 = 12 m/s$

Final velocity $V = V_2$

Value of $g = -9.81 \ m/s^2$ and $h = 4.5m$

Using $V^2 - u^2 = 2gh$

$V_2^2 - 12^2 = 2 \times (-9.81) \times 4.5$

$$V_2 = \sqrt{12^2 - 2 \times 9.81 \times 4.5}$$

$$V_2 = \sqrt{144 - 88.29}$$

$$V_2 = 7.46 \text{ m/s}$$

Now applying Continuity equation to the outlet of nozzle and at point A we get

$$A_1 V_1 = A_2 V_2$$

or $$A_2 = \frac{A_1 V_1}{V_2} = \frac{\frac{\pi}{4} D_1^2 \times V_1}{V_2} = \frac{\pi \times (0.025)^2 \times 12}{4 \times 7.46}$$

$$A_2 = 0.0007896$$

D_2 = Diameter of Jet at point A

$$A_2 = \frac{\pi}{2} D_2^2 \text{ (or) } 0.0007896 = \frac{\pi}{4} D_2^2$$

$$D_2 = \sqrt{\frac{0.0007896 \times 4}{\pi}}$$

$$D_2 = 0.0317 \text{ m}$$

$$\boxed{D_2 = 31.7 \text{ mm}}$$

Problem A 25 cm diameter pipe carries oil of Sp. Gravity 0.9 at a velocity of 3 m/s. At another Section the diameter is 20cm. Find the velocity at this Section and also mass rate of flow of oil Ans $V_2 = 4.68$ m/s, $\rho_{oil} = 900 \text{ kg/m}^3$, $m = 132.23$ kg/s.