Fluid mechanic / Second Year

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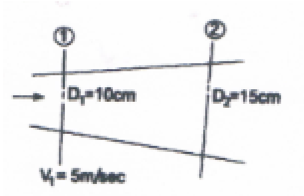
Problems of chapter Four

Problem 4.1 /

The diameter of the pipe at the section 1 and 2 are 10 cm and 15 cm respectively. Find the discharge (Q) through the pipe, if the velocity of water flowing through the pipe at section 1 is 5 m/s. Determine also the velocity at section 2.



Solution:

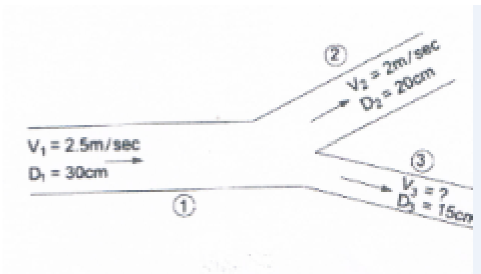
$$\text{Discharge (Q)} = A_1 V_1 = \frac{\pi d_1^2}{4} \times V_1 = \frac{\pi\,(0.1)^2}{4} \times 5 = 0.039\ m^3/s$$

Discharge (Q) = A_2 V_2

$$V_2 = \frac{Q}{A_2} = \frac{0.039}{\frac{\pi(0.15)^2}{4}} = 2.22\ m/s$$

Problem 4.2 /

A 30 cm diameter pipe, conveying water, branches into two pipes of diameters 20 cm and 15 cm 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 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/s.



Solution:

Discharge (Q_1) in pipe 1 = $A_1 V_1 = \frac{\pi (0.3)^2}{4} \times 2.5 = 0.1767\ m^3/s$

$$Q_2 = A_2 V_2 = \frac{\pi (0.2)^2}{4} \times 2 = 0.0628\ m^3/s$$

$$Q_1 = Q_2 + Q_3$$

$$Q_3 = Q_1 - Q_2 = 0.1767 - 0.0628 = 0.1139\ m^3/s$$

$$Q_3 = A_3 V_3$$

$$V_3 = \frac{Q_3}{A_3} = \frac{0.1139}{\frac{\pi (0.15)^2}{4}} = 6.44\ m/s$$

<u>Problem 4.3</u> /

A 25 cm diameter pipe carries oil of sp.gr. 0.9 at a velocity of 3 m/s . At another section the diameter is 20 cm. Find the velocity at this section and also mass rate of flow of oil.

Solution:

$$Q = A_1 V_1 = A_2 V_2$$

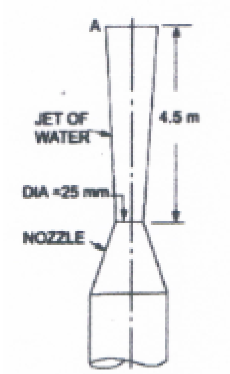
$$V_2 = \frac{A_1 V_1}{A_2} = \frac{\frac{\pi}{4} \times (0.25)^2 \times 3}{\frac{\pi}{4} (0.2)^2} = 4.68\ m/s$$

Mass flow rate of oil ($\dot{m}$) = $\rho A_1 V_1 = 0.9 \times 1000 \times \frac{\pi}{4} \times (0.25)^2 \times 3$

$$= 132.23\ kg/s$$

<u>Problem 4.4/</u>

A jet of water from a 25 mm 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 4.5 m above the nozzle, if the velocity with which the jet leaves the nozzle is 12 m/s.



Solution:

Initial velocity(V_1) = 12 m /s

Final velocity (V_2)

But, $(\Delta V)^2 = 2 g h$ (opposite free fall equation)

$$V_2^2 - V_1^2 = 2 g h$$

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

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

$$Q = A_1V_1 = A_2 V_2$$

$$A_2 = \frac{A_1V_1}{V_2} = \frac{\frac{\pi}{4}\times 0.025^2\times 12}{7.46} = 0.0007896 \text{ m}^2$$

$$A_2 = \frac{\pi D_2^2}{4} \quad , \quad D_2 = \sqrt{\frac{4 A_2}{\pi}} = \sqrt{\frac{4 \times 0.0007896}{\pi}} = 31.7 \text{ mm}$$

Problem 4.5 /

Which of the following velocity fields satisfies continuity equation ?

(A) $u = 4xy + y^2$, $v = 6xy + 3x$

To satisfy the continuity equation : $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

$\frac{\partial u}{\partial x}= 4y$, $\frac{\partial v}{\partial y}= 6x$

$4y + 6x = 0$, Therefore, it does not satisfy continuity equation.

(B) $u = 2x^2 + y^2$, $v = - 4xy$

Solution:

$\frac{\partial u}{\partial x} = 4x$, $\frac{\partial v}{\partial y} = - 4x$

$4x + (- 4 x) = 0$, Therefore, it does satisfy continuity equation.

(C) $u = 2x^2 – x y + z^2$, $v = x^2 -4xy + y^2$, $w = -2xy –y z + y^2$

Solution:

$\frac{\partial u}{\partial x} = 4x - y$, $\frac{\partial v}{\partial y} = -4x + 2y$, $\frac{\partial w}{\partial z} = - y$

$4x – y + (-4 x + 2y) + (- y) = 0$

$4x -y - 4x + 2 y - y =0$

$4x - 2 y - 4x + 2y = 0$, Therefore, it does satisfy continuity.

$0 = 0$

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