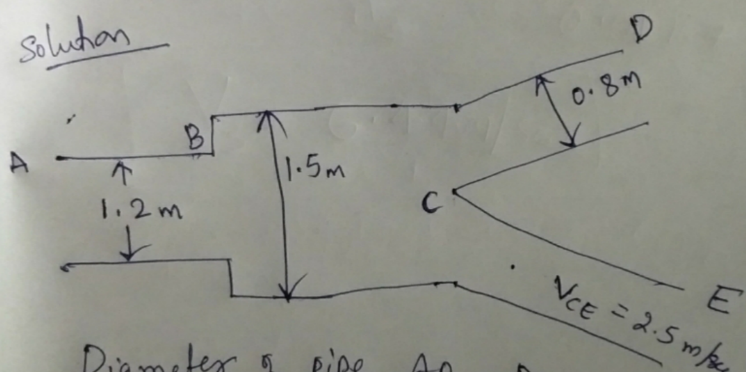
(3) water flows through a pipe AB 1.2 m diameter at 3m/sec and then passes through a pipe BC 1.5 m diameter. At C, the pipe branches Branch CD is 0.8 m in diameter and carries one third of the flow in AB. The flow velocity in branch CE is 2.5 m/sec. Find the volume rate of flow in AB, the velocity in BC, the velocity in CD and the diameter of CE.

Solution



Diameter of pipe AB = D_{AB} = 1.2 m

Diameter of pipe BC = D_{BC} = 1.5 m

Diameter of pipe CD = D_{CD} = 0.8 m.

Velocity of flow through AB = V_{AB} = 3 m/sec

Velocity of flow in pipe $CE = V_{CE} = 2.5 \frac{m}{sec}$

let the flow rate in pipe $AB = Q$ m^3/sec

flow rate in pipe $CD = Q_1$ m^3/sec

flow rate in pipe $CE = Q_2$ m^3/sec

velocity of flow in pipe $BC = V_{BC}$ m/sec

velocity of flow in pipe $CD = V_{CD}$ m/sec

Diameter of pipe $CE = D_{CE}$

$\boxed{\text{Then flow rate through } CD = Q/3}$

Then flow rate through $CE = Q - Q_1$

$$Q_2 = Q - Q/3 = 2Q/3$$

The volumetric flow rate in AB ie Q

$$Q_{AB} = V_{AB} \times \text{Area of AB pipe}$$

$$Q_{AB} = 3 \times \frac{\pi (D_{AB})^2}{4}$$

$$Q_{AB} = 3 \times \pi/4 \times (1.2)^2 = 3.393 \ m^3/sec$$

$Q_{AB} = 3.393\ m^3/sec.$

(ii) Then flow rate through pipe CD, ie $Q_{CD} = Q_1$

$$Q_1 = Q/3 = \frac{3.393}{3} = 1.131\ m^3/sec$$

(iii) flow rate through pipe CE

$$Q_2 = \frac{2Q}{3} = \frac{2 \times 3.393}{3} = 2.262\ m^3/sec$$

(iv) Velocity in pipe BC, ie V_{BC}

$$Q_{BC} = Q_{AB} \quad \text{(applying continuity equation)}$$

Area of BC × V_{BC} = Area of AB pipe × V_{AB}

$$\frac{\pi (1.5)^2}{4} \times V_{BC} = \frac{\pi \times (1.2)^2}{4} \times 3$$

$$\boxed{V_{BC} = 1.92\ m/sec}$$

V ~~Diameter~~ velocity in pipe CD, V_{CD}

$Q_1 = 1.131\ m^3/sec$

$$Q_1 = V_{CD} \times \text{Area of pipe CD}$$

$$1.131 = V_{CD} \times \frac{\pi (0.8)^2}{4}$$

$$\boxed{V_{CD} = 2.25 \text{ m/sec}}$$

(vi) Diameter of pipe CE = D_{CE}

$$Q_2 = 2.262 \text{ m}^3/\text{sec}$$

$$Q_2 = V_{CE} \times \text{Area of pipe CE}$$

$$Q_2 = V_{CE} \times \frac{\pi (D_{CE})^2}{4}$$

$$2.262 = 2.5 \times \frac{\pi}{4} (D_{CE})^2$$

$$\boxed{D_{CE} = \text{Diameter of pipe CE} = 1.07355 \text{ m}}$$

Dynamics of fluid flow

It is the study of fluid motion with the forces causing flow.

In the fluid flow, the flowing forces are present

(1) Gravity force, F_g
(2) The pressure force, F_p
(3) Force due to Viscosity, F_v
(4) Force due to turbulence, F_t
(5) Force due to Compressibility F_c

The net force F_x is

$$\boxed{F_x = (F_g)_x + (F_p)_x + (F_v)_x + (F_t)_x + (F_c)_x}$$

↳ This is called equation of motion.

If the force due to compressibility (F_c) is negligible, then resulting net force is

$$\boxed{F_x = (F_g)_x + (F_p)_x + (F_v)_x + (F_t)_x}$$

This equation of motions are called Reynol's equation of motion.

(ii) If the force due to turbulent ie F_t is negligible, then resulting equation of motion are known as Navier stokes equation.

(iii) If the flow is assumed to be ideal, then Viscous force F_v is negligible and equation of motions are known as Euler's equation of motion.