FLUID MECHANICS

&

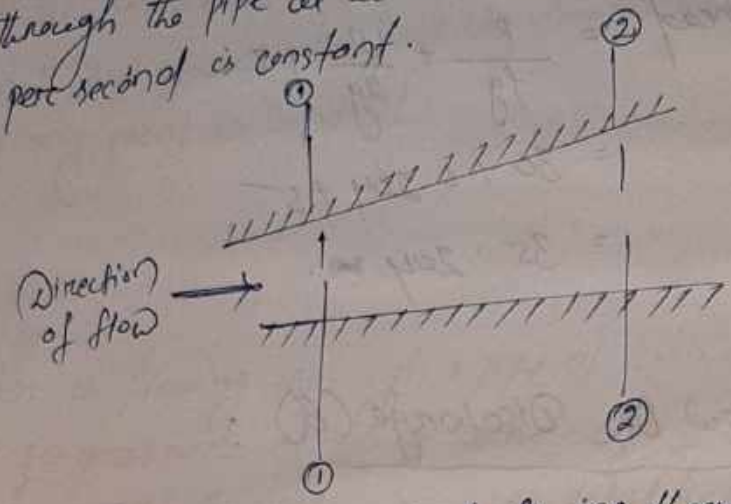
HEAT TRANSFER (4^{TH} SEM)

SWETANGINI NAIK

LECT. IN DEPT. OF BIOTECH. UCPES, BERHAMPURE

Continuity Equation :

The equation based on the ~~pipe~~ principle of conversion of mass is called continuity equation. Thus for a fluid flowing through the pipe at all the cross-section, the quantity of fluid per second is constant.



Fluid flowing through a pipe

Consider two cross-sections of a pipe.

Let V_1 = Average velocity at cross-section 1-1

ρ_1 = Density at section 1-1

A_1 = Area of pipe at section 1-1

and V_2, ρ_2, A_2 are corresponding values at section, 2-2

Then rate of flow at section 1-1 = $\rho_1 A_1 V_1$

Rate of flow at section 2-2 = $\rho_2 A_2 V_2$

According to law of conservation of mass

Rate of flow at section 1-1 = Rate of flow at section 2-2

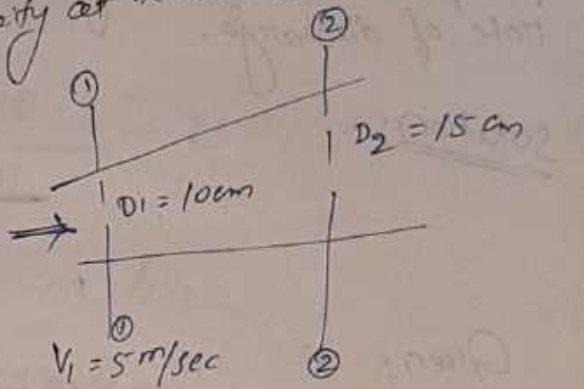
$$\boxed{\rho_1 A_1 V_1 = \rho_2 A_2 V_2} \quad \text{——— (1)}$$

If the fluid is incompressible, then $\rho_1 = \rho_2$ and continuity equation (1) reduces to

$$\boxed{A_1 V_1 = A_2 V_2}$$

Problem:

(Q2) The diameters of a pipe at the sections 1 and 2 are 10cm and 15cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5cm/s. Determining also the velocity at section 2.



Solution:

Given:

At section 1,

$D_1 = 10\text{cm} = 0.1\text{m}$

$A_1 = \frac{\pi}{4}(D_1)^2 = \frac{\pi}{4}(0.1)^2 = 0.007854\ m^2$

$V_1 = 5\ m/s$

At section 2,

$D_2 = 15\text{cm} = 0.15\text{m}$

$A_2 = \frac{\pi}{4}(0.15)^2 = 0.01767\ m^2$

(i) Discharge through the pipe is given

$Q = A_1 \times V_1$

$= 0.007854 \times 5$

$= 0.03927\ m^3/s$

(ii)

$A_1 V_1 = A_2 V_2$

$V_2 = \frac{A_1 V_1}{A_2}$

Rate of Flow OR Discharge (Q) :

It is defined as the quantity of a fluid flowing per second through a section of pipe or a channel.

For an incompressible fluid (or liquid) the rate of flow or discharge is expressed as the volume of fluid flowing across the section per second. For compressible fluids, the rate of flow is usually expressed as the weight of fluid flowing across the section. Thus

(i) for liquids the units of Q are m^3/s or liters/s

(ii) for gases the units of Q is kgf/s or Newton/s

Consider a liquid flowing through a pipe in which

A = cross-sectional area of pipe

V = Average velocity of fluid across the section

Then discharge $\boxed{Q = A \times V}$