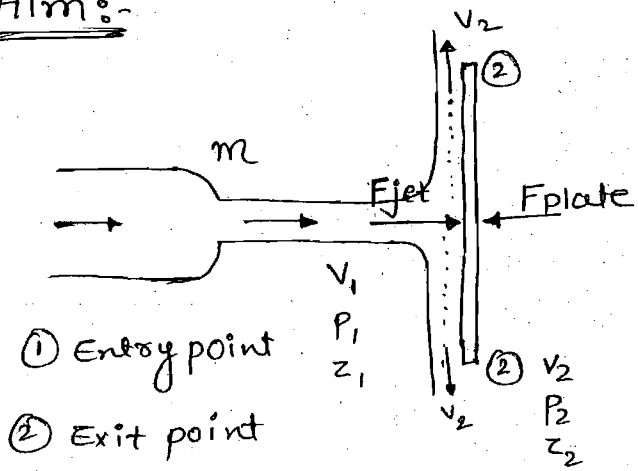
★ FLUID MACHINERY ★

Impact of Jet :-

Aim:-



Fplate = Rate of change of linear momentum

= Final momentum − Initial momentum

Fjet = − Fplate.

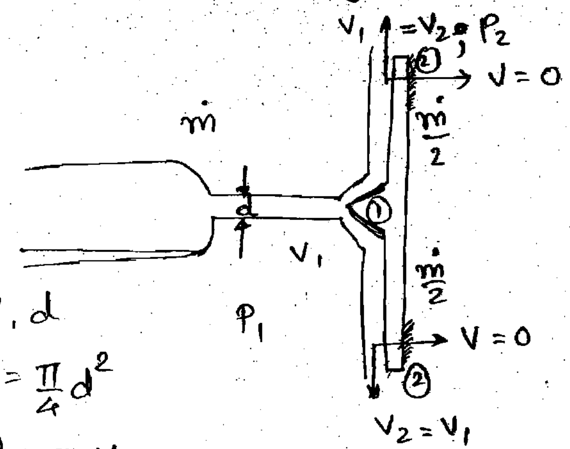
$\therefore F_{jet} = \dot{m} \times \vec{V_1} - \dot{m} \times \vec{V_2}$

V_1, V_2 = Absolute velocity of water w.r.t. ground

$\dot{m}$ = mass flow rate of water which strikes the plate

Aim: To find out the force applied by the water over the plate.

Jet strikes Stationary Flat plate :-



$a = \frac{\pi}{4} d^2$

$Q = a_1 V_1$

$P_1 = P_2 = P_{atm}$

$Z_1 = Z_2$

$\dot{m} = \rho a V_1$

$\rightarrow F_x = F_N = \dot{m} \times V_1 - \left[\frac{\dot{m}}{2} \times 0 + \frac{\dot{m}}{2} \times 0\right]$.

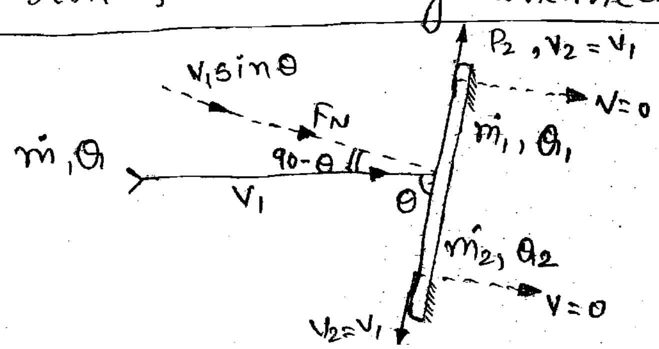
$\therefore \boxed{F_x = F_N = \dot{m} \times V_1 = \rho a V_1^2 \; N}$

$\rightarrow F_y = F_T = \dot{m} \times 0 - \left[\frac{\dot{m}}{2} \times V_2 + \frac{\dot{m}}{2} \times (-V_2)\right]$

$\therefore \boxed{F_y = F_T = 0}$

NOTE:- When jet strikes flat plate then it will apply the force only in normal dir^n to the plate, there will not be any force in tangential dir^n to the plate.

Jet strikes stationary Inclined plane :-



$\boxed{P_1 = P_{atm} = P_2}$

→ $\dot{m} = \dot{m}_1 + \dot{m}_2$

$$Q = Q_1 + Q_2$$

→ $$\dot{m} = \rho a v_1$$

→ $F_n = \dot{m} \times v_1 \sin\theta - [\dot{m}_1 \times 0 + \dot{m}_2 \times 0]$

$$\therefore F_n = \rho a v_1^2 \sin\theta$$

→ $F_x = F_N \sin\theta = \rho a v_1^2 \sin^2\theta$

→ $F_y = F_n \cos\theta = \rho a v_1^2 \sin\theta . \cos\theta.$

→ $F_T = 0$

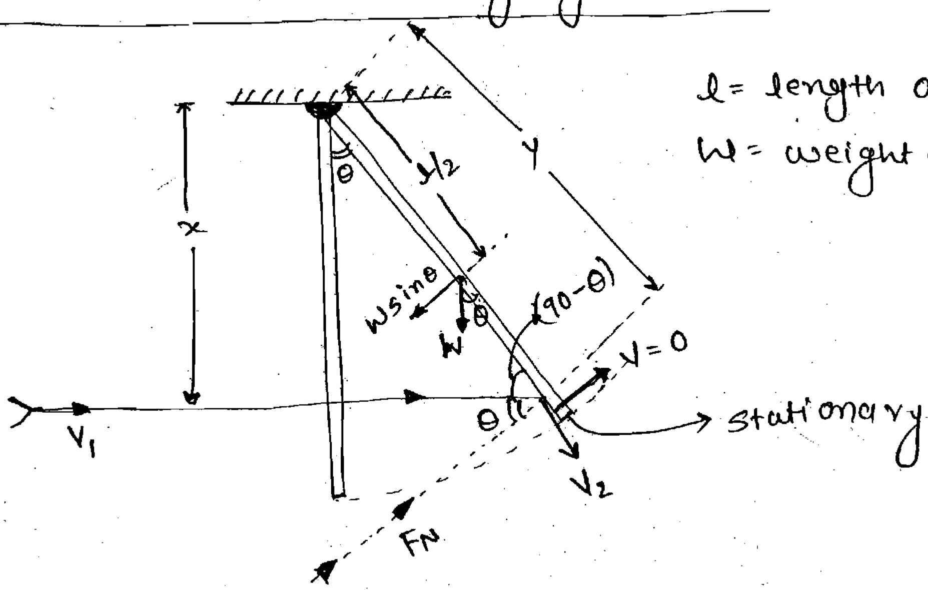
$\therefore \dot{m} \times v_1 \cos\theta - [\dot{m}_1 \times v_2 + m_2 \times (-v_2)] = 0$

$\rho Q v_1 \cos\theta - \rho Q_1 v_2 + \rho Q_2 v_2 = 0$

$$\therefore Q \cos\theta - Q_1 + Q_2 = 0 \quad \text{—(1)}$$

$$Q = Q_1 + Q_2 \quad \text{—(2)}$$

Jet strikes vertical hunging plate:-



l = length of plate

W = weight of plate.

$\sum M_A = 0$

$\therefore F_N \times y = \omega \sin\theta \times \frac{l}{2}$

$\rightarrow \dot{m} = \rho a v_1$

$\rightarrow F_N = \dot{m} \times v_1 \cos\theta - \dot{m} \times 0$

$F_N = \dot{m} v_1 \cos\theta$

$= \rho a v_1^2 \cos\theta$

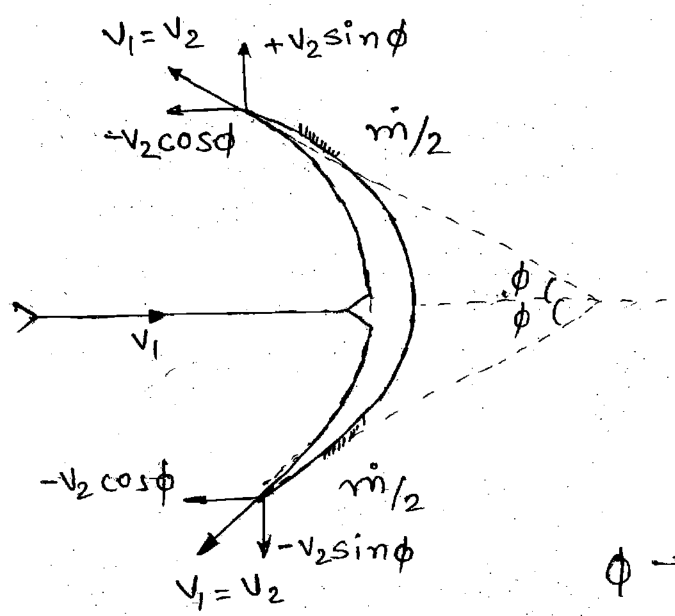
$\rightarrow \cos\theta = \frac{x}{y} \Rightarrow y = \frac{x}{\cos\theta}$

$\rightarrow \rho a v_1^2 \cos\theta \times \frac{x}{\cos\theta} = \omega \sin\theta \times \frac{l}{2}$

$$\therefore \boxed{\sin\theta = \frac{2 \rho a v_1^2 \cdot x}{\omega l}}$$

Jet strikes at the centre of stationary vane:-

(Blade/curve plate)



$\phi \rightarrow$ vane angle @ exit.

$$\boxed{P_2 = P_1 = P_{atm}}$$

→ $\dot{m} = \rho a v_1$

→ $F_x = \dot{m} \times v_1 - \left[\frac{\dot{m}}{2}(-v_2 \cos\phi) + \frac{\dot{m}}{2}(-v_2 \cos\phi) \right]$

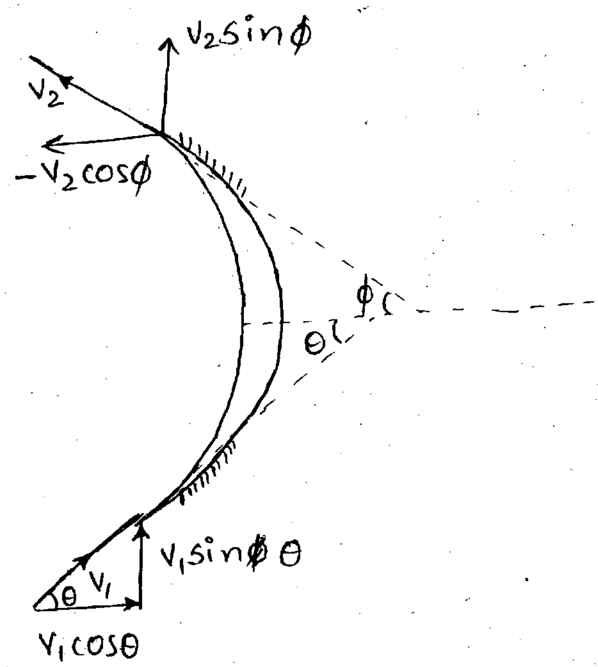
$\therefore F_x = \dot{m} v_1 + \dot{m} v_2 \cos\phi$

$$\boxed{F_x = \dot{m} v_1 (1 + \cos\phi) \ \text{N}}$$

→ $F_y = \dot{m} \times 0 - \left[\frac{\dot{m}}{2} \times v_2 \sin\phi + \frac{\dot{m}}{2} \times (-v_2 \sin\phi) \right]$

$$\therefore \boxed{F_y = 0}$$

Jet strikes at the tip of stationary vane:



θ = vane angle @ entry

ϕ = vane angle @ exit

symmetrical vane ($\theta = \phi$)

→ $\dot{m} = \rho a v_1$

→ $F_x = \dot{m} \times v_1 \cos\theta - \dot{m}(-v_2 \cos\phi)$

$$\boxed{F_x = \dot{m} v_1 (\cos\theta + \cos\phi)}$$

→ $F_y = \dot{m} v_1 \sin\theta - \dot{m} v_2 \sin\phi$

$$\boxed{F_y = \dot{m} v_1 (\sin\theta - \sin\phi)}$$