MADE EASY
CIVIL ENGINEERING
HYDRAULIC MACHINES
BY-KAURAV SIR

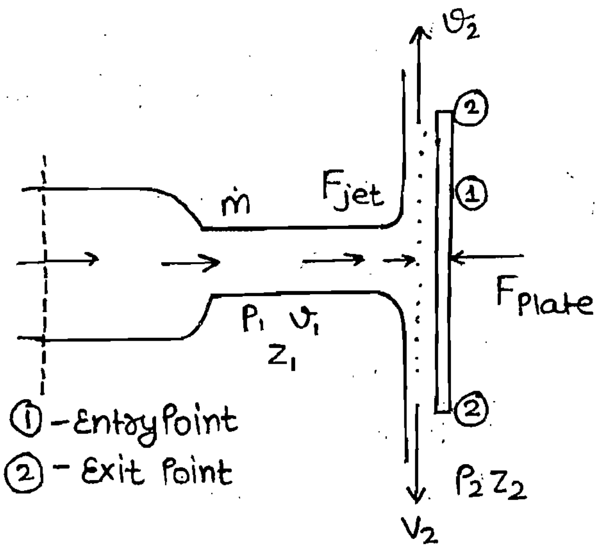
- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

Fluid Machinery

- Impact of Jet
- Turbine
  - Impulse → Pelton Wheel
  - Reaction
    - Francis
    - Kaplan
    - Propeller
- Pump
  - Centrifugal Pump
  - Reciprocating Pump (ESE only)

<u>Book</u> :→ R.K. Bansal
D.S. KUMAR

Impact of Jet :→



Water → Reaction force
Plate → Initial force

Newton's II Law

F_{Plate} = Rate of change in Linear Momentum of jet

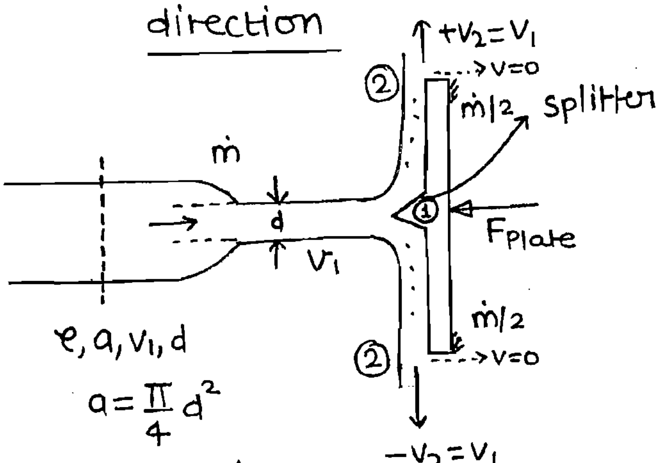
F_{Plate} = (Final - Initial) momentum of Water

$$\boxed{F_{jet} = -F_{Plate} = \dot{m}\vec{V_1} - \dot{m}\vec{V_2}}$$

$\dot{m}$ = mass flow rate of Water which strike the Plate / body.

Case: I

Jet strikes Stationary flat Plate in Normal direction



ρ, a, V_1, d

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

$Q = a_1 v_1$

$P_1 = P_2 = P_{atm}$

$Z_1 = Z_2$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f$$

→ Smooth Plate ($V_2 = V_1$)

→ Rough Plate ($V_2 < V_1$)

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

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

→ $F_x = F_N = \dot{m}V_1$

$= \rho a V_1^2 \text{ N}$

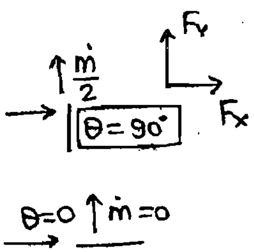
→ $F_y = F_T = \dot{m} \times 0 - \left[\frac{\dot{m}}{2} \times V_2 + \frac{\dot{m}}{2}(-V_2)\right]$

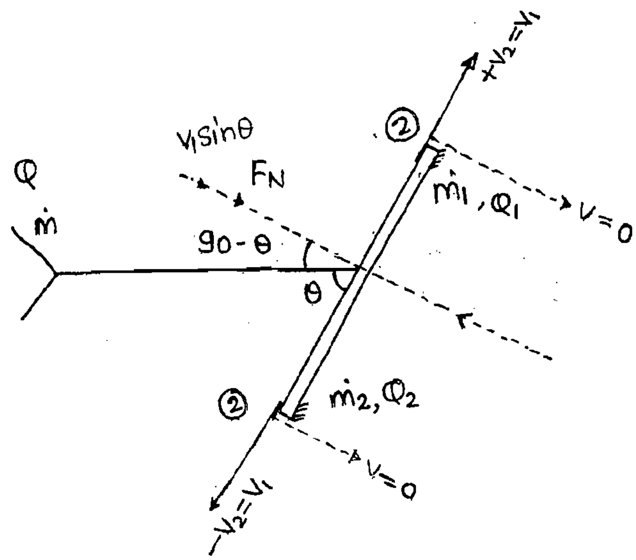
$$\boxed{F_y = F_T = 0}$$

NOTE→ When Jet strikes over a Flat Plate then it will apply the force only in Normal direction to Plate, there will not be any force in tangential direction to Plate.

case : II

Jet strikes stationary Inclined Plate





$\dot m = \dot m_1 + \dot m_2 \Rightarrow \boxed{Q = Q_1 + Q_2} \rightarrow (I)$

$$\boxed{\dot m = \rho a v_1 = \rho Q}$$

$$F_N = \dot m V_1 \sin\theta - [\dot m_1 \times 0 + \dot m_2 \times 0]$$

$$F_N = \dot m V_1 \sin\theta = \rho a V_1^2 \sin\theta$$

$$F_X = F_N \sin\theta = \rho a V_1^2 \sin^2\theta$$

$$F_Y = F_N \cos\theta = \rho a V_1^2 \sin\theta \cdot \cos\theta$$

$\dot m_1, \dot m_2 \,/\, Q_1, Q_2 = ?$

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

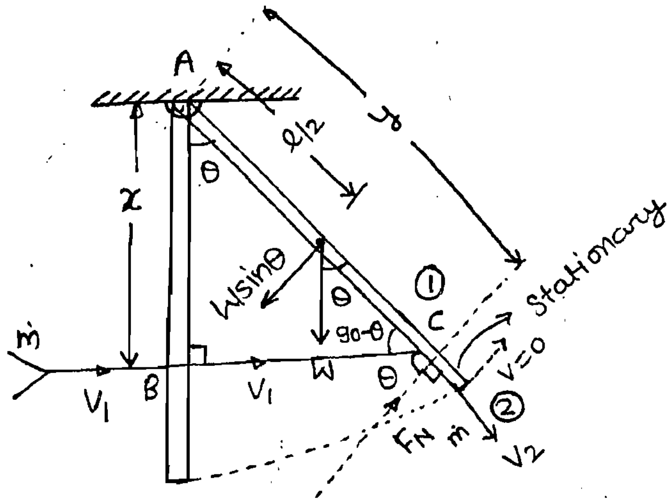
→ $\dot m V_1 \cos\theta - (\dot m_1 \times v_1 + \dot m_2 \times (-v_1)) = 0$

$$Q\cos\theta - Q_1 + Q_2 = 0 \rightarrow (II)$$

$$Q = Q_1 + Q_2 \longrightarrow (I)$$

Case-III

Jet Strikes Vertical Hanging Plate



l = length of Plate

W = Weight of Plate = Mg

$\rightarrow \Sigma M_A = 0$

$\rightarrow F_y \cdot y = W\sin\theta \cdot \frac{l}{2}$

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

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

$$\boxed{F_N = \rho a v_1^2 \cos\theta}$$ (Newton)

ΔABC

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

$$\rho a v_1^2 \cos\theta \cdot \frac{x}{\cos\theta} = W\sin\theta \cdot \frac{l}{2}$$

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