E-Course on Fluid Mechanics and Hydraulic Machines

Subject code : 3141906

Subject: **Fluid Mechanics and Hydraulic machine**

Chapter : **Impact of Jet**

Impact of Jet

Newton's II^{nd} law

$\varphi = AV$

Newton's II^{nd} law

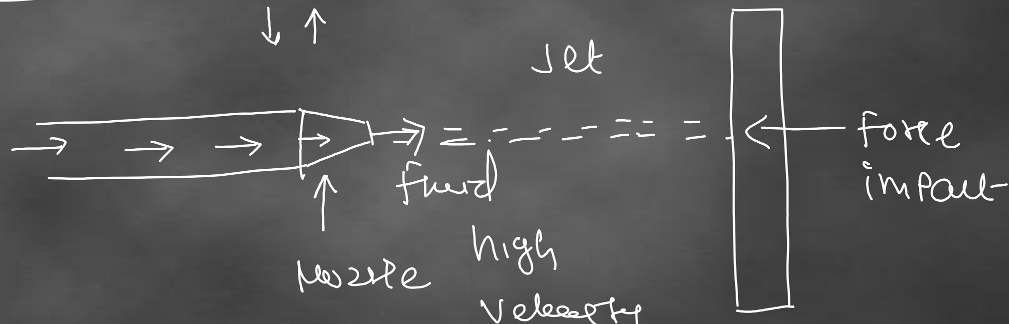
Force = Rate of change of momentum

$$F = \frac{d}{dt}(mV)$$

$$= m\frac{dV}{dt} = ma$$

$$\underline{F \cdot dt} = \underline{d(m \cdot V)}$$

↑ impulse ↑ change of momentum



$$F = \frac{d}{dt}(mV) = \frac{m(V-0)}{t} = \frac{m}{t}(V)$$

$$F = \dot{m}V \qquad \dot{m} = \rho\varphi$$

$$F = (\rho AV)V \qquad = \rho AV$$

$$\boxed{F = \rho AV^2}$$

(1) Impact of Jet on fixed vertical flat Plate

Let

V = Velocity of Jet

d = Diameter of Jet

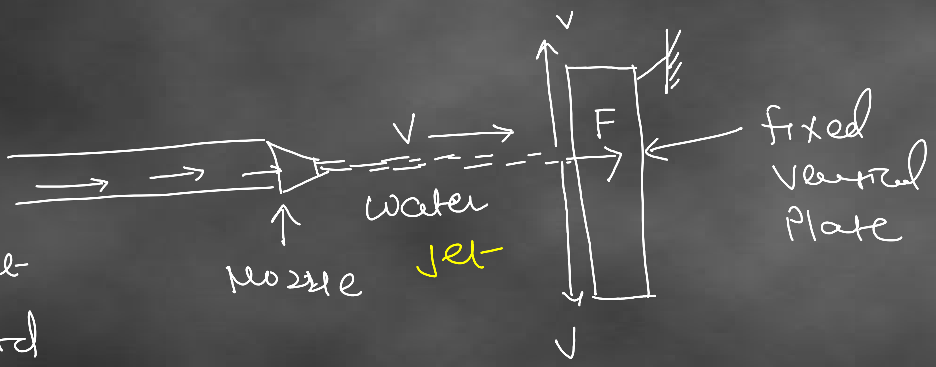
ρ = Density of fluid

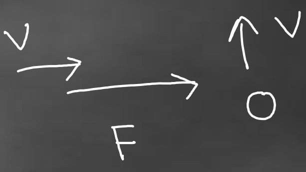
A = c/s area

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

$\dot{m}$ = mass flow Rate

$= \rho A V$





Impact of Jet (Force exerted by Jet on Plate)

F = Rate of change of momentum

$$= \frac{(mV)_I - (mV)_F}{\text{time}}$$

$$= \dot{m}\,(V_I - V_F)$$

$$= \rho A V\,(V - 0) = \rho A V^2$$

$$\boxed{F = \rho A V^2}$$

(II) fixed inclined flat plate

V = Velocity of jet

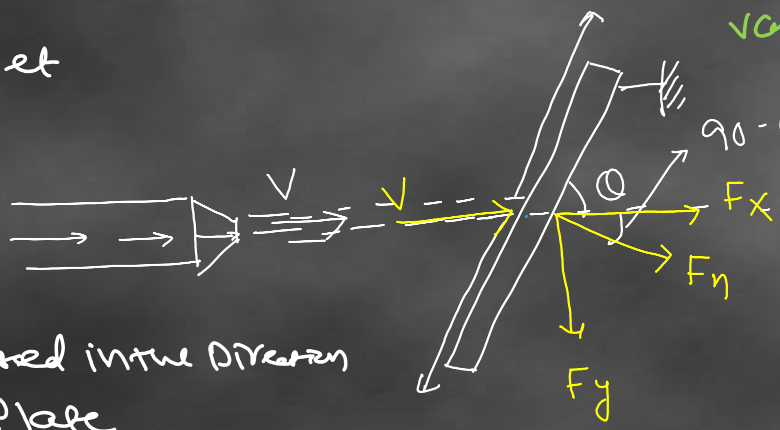
A = c/s area

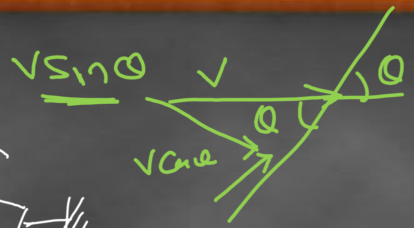
θ = inclination with jet

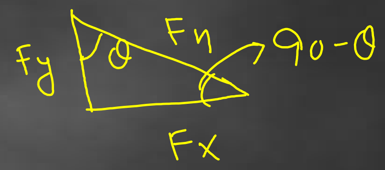
F_n = Force exerted in the Direction Normal to Plate

F_x =

F_y =







$$F_x = F_n \cos(90-\theta)$$

$$F_y = F_n \cos\theta$$

$$F_n = \frac{\text{mass}}{\text{Time}}(V_I - V_F)$$

$$= \dot{m}(V\sin\theta - 0)$$

$$= \rho A V (V \sin\theta)$$

$$F_n = \rho A V^2 \sin\theta$$

$$F_x = F_n \cos(90-\theta)$$

$$= F_n \sin\theta$$

$$= \rho A V^2 \sin\theta \cdot \sin\theta$$

✓ $\boxed{F_x = \rho A V^2 \sin^2\theta}$

$$F_y = F_n \cos\theta$$

$$= \rho A V^2 \sin\theta \cdot \cos\theta$$

✓ $\boxed{F_y = \rho A V^2 \sin\theta \cos\theta}$

(III) Impact of jet on hinged plate

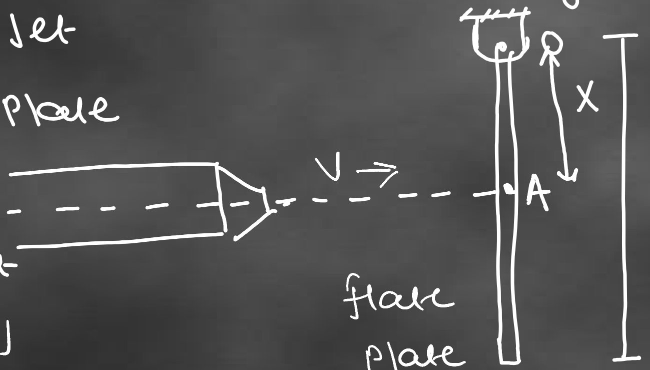
let V = Velocity of jet

h = height of plate

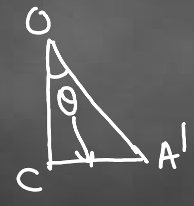
x = Distance of centre of jet from O (hinge)

W = weight of plate

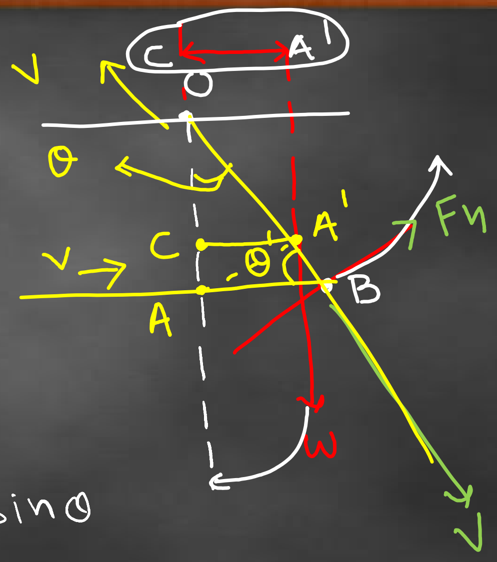
$OA = OA' = x = h/2$

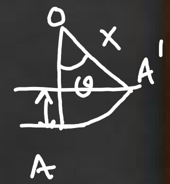


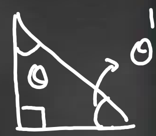
$x = h/2$



$CA' = OA' \sin\theta$







$180 = 90 + \theta + \theta'$

$\theta + \theta' = 90$

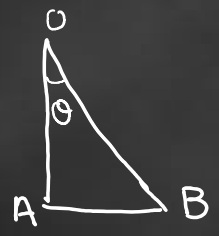
$\theta' = 90 - \theta$

equilibrium moment of force about O

Clockwise moment = Anticlockwise

$F_n \times OB = W \times CA'$

$F_n \times OB - W \times CA' = 0$



$\cos\theta = \frac{OA}{OB}$

$OB = \frac{OA}{\cos\theta}$

$F_n = \rho A V^2 \sin\theta'$ θ' = Angle betn Jet & Plate

$= \rho A V^2 \sin(90 - \theta)$

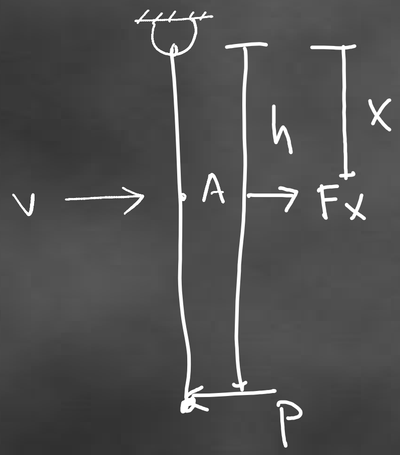
$F_n = \rho A V^2 \cos\theta$

$\rho A V^2 \cos\theta \times OB = W \times CA'$

$\rho A V^2 \times \cos\theta \times \frac{OA}{\cos\theta} = W \times OA' \sin\theta$

$\rho A V^2 = W \sin\theta$

$\sin\theta = \rho A V^2 / W$



$$F_x \times x = P \times h$$

$$x = h/2$$

$$F_x \cdot \frac{h}{2} = P h$$

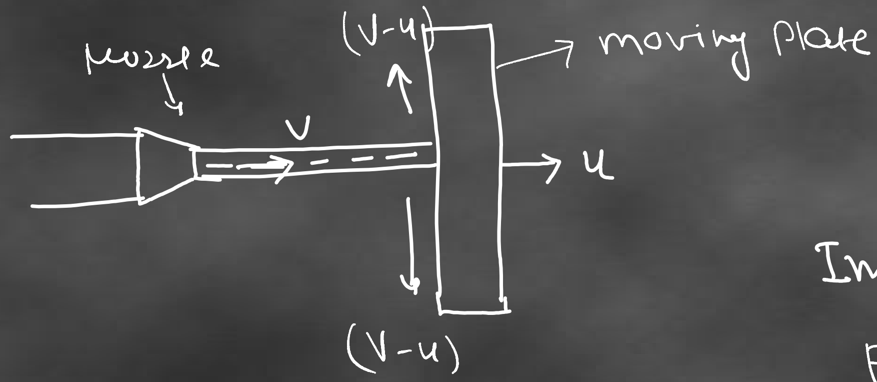
$$\boxed{P = \frac{F_x}{2}}$$

* Impact of jet on a moving plate

let V = Velocity of jet

A = c/s area

u = Velocity of plate



Mass of water striking per second

$$= \rho A(V-u)$$

$$W.D = \frac{F.D}{time} = F \cdot D/t$$

$$= F_x \times u$$

$$\boxed{W = \rho A(V-u)^2 \times u}$$ ✓

Impact of jet

$$F_x = \dot{m}\,(V_I - V_F)$$

$$= \rho A(V-u)\,\big((V-u) - (u-u)\big)$$

$$= \rho A(V-u)\,(V-u)$$

$$F_x = \rho A(V-u)^2 \rightarrow \text{(u)}$$

$$F_x = \rho A V^2 \rightarrow \text{fixed}$$