* IMPULSE MOMENTUM EQUATIONS *

Moment of momentum :- (Torque)

$P = \frac{2\pi N T}{60}$

m = mass flow rate

R = radius

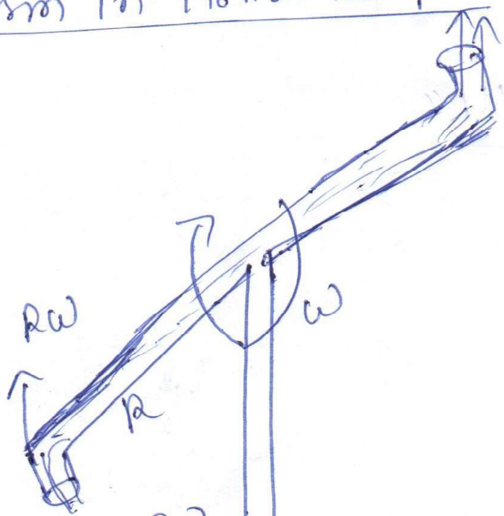
$T = \frac{d}{dt}\left[\dot{m} V r\right]$

V = velocity

$\boxed{\text{lawn sprinkler}}$ Application

Arm in Horizontal plane

U = velocity of flow in

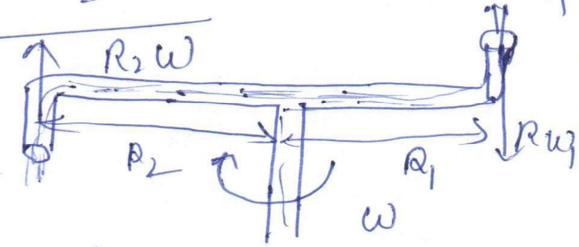


$V = U \pm R\omega$

(minus)

$V_2 = U_2 + R\omega$

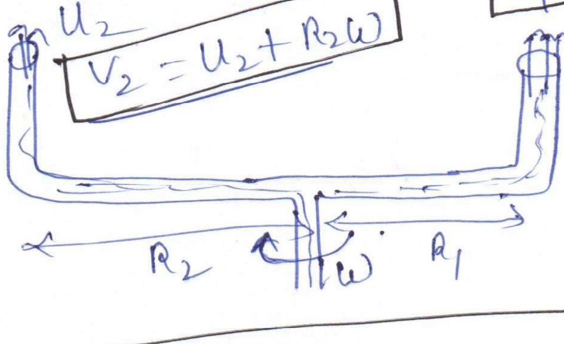
$V_1 = U_1 - R_1\omega$



$T = m_1 V_1 R + m_2 V_2 R_2$

$\boxed{V_2 = U_2 + R_2\omega}$

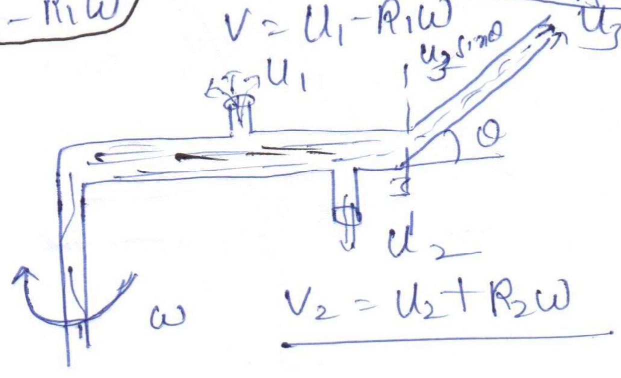
$\boxed{V_1 = U_1 - R_1\omega}$



$\boxed{T = +m_1 V_1 R_1 - m_2 V_2 R_2}$

$\boxed{V_3 = U_3 \sin\theta - R_3\omega}$

$V = U_1 - R_1\omega$



$V_2 = U_2 + R_2\omega$

$T = +m_1 V_1 R_1 - m_2 V_2 R_2 + m_3 V_3 R$

Impect of jet

(1) on flat, smooth, vertical fixed

plate | Blade

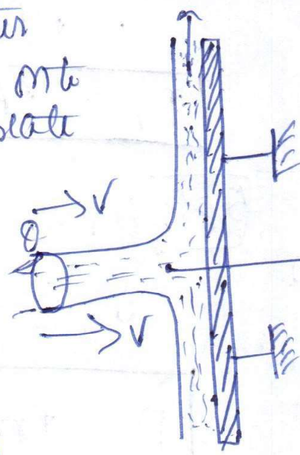
Vane | Bucket

1) Flat plate

$\boxed{\text{power} = 0}$, P = pressure

F_n = Force on the plate

* Impact of water
* Energy is forced onto wrt the plate



→ Fn (Normal Force) Force on the vertical plate

* F = ma

$= m \times \frac{(\Delta vel)}{time}$

$= \frac{m}{time} \times (\Delta vel)$

$\boxed{F_n = \dot{m}(\Delta vel)_n = \boxed{\rho Q(V_1 - V_2)_n}}$

$\boxed{\text{power} = F_n \times \text{Vel}}$

$P = F_n \times \cancel{V}^{0}$

$\underline{\underline{P = 0}}$

P = Fn × Ve (blade)

u = blade velocity

$\boxed{P = F_n \times u}$

→ $F_n = \dot{m}\,(\Delta vel)$

$= \rho AV(V - 0)$

$F_n = \rho AV^2$

&

→ $\underline{\text{Power}} = F_n \times \cancel{u}^{0}$

$= 0$

* The flow is transferred in to tangential

&

$\boxed{F_n}$	$\boxed{\text{Power}}$
ρAV^2	0

Frictionless i.e power '0'

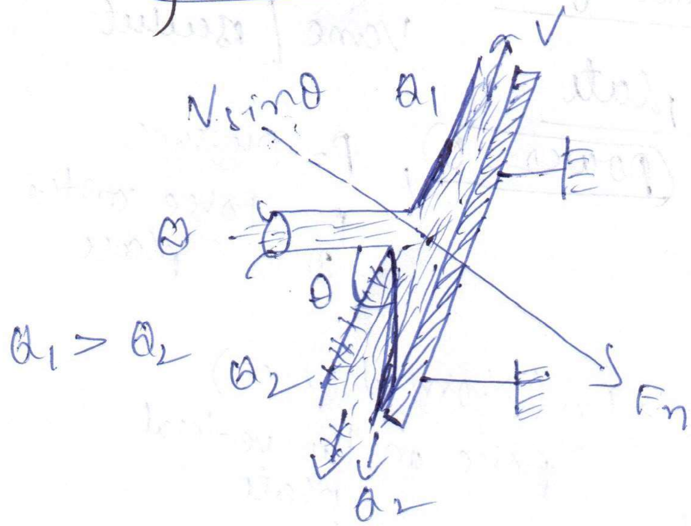
F = ma

W = F × dist

$P = \frac{work}{time} = \frac{F \times distance}{time}$

$\boxed{P = F \times vel}$

2) Inclined plane :-



$F_n = \dot{m}\,(\Delta vel)_n$

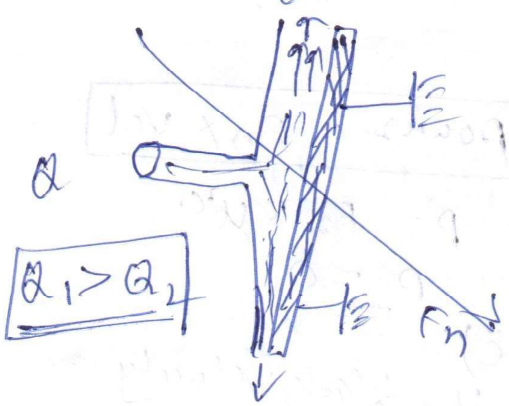
$= \rho A V(V\sin\theta - 0)$ After impact

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

$\boxed{Q > Q_2}$ $Q_1 = Q/2\,[1+\cos\theta)$

$Q_2 = Q/2\,[1-\cos\theta)$

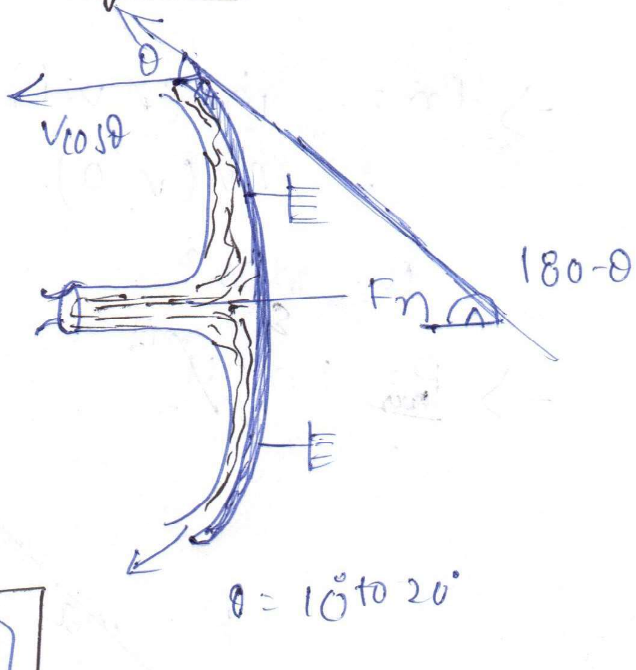
$\boxed{P = F_n \times \cancel{u}^{0}}$



U = velocity of the plate in the direction of jet

3) Curved surface plane :- (Symmetric)

Diffection angle optimum 160° to 170°



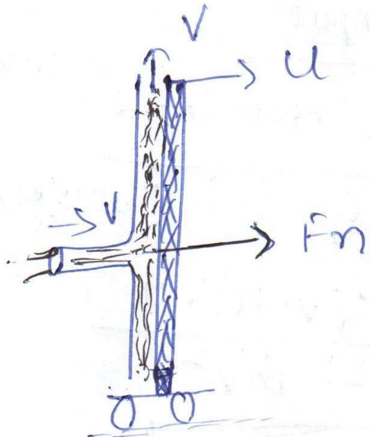
$F_n = \dot{m}\,(\Delta vel)_n$

$F_n = \rho A V\,(V - (-V\cos\theta)]$

Power $P = F_n \times \cancel{u}^{0} = 0$

$\boxed{F_n = \rho A V^2 [1+\cos\theta]}$

4) Moving plate :- $u < v$



$$F_n = \dot{m}(\Delta vel)_n$$

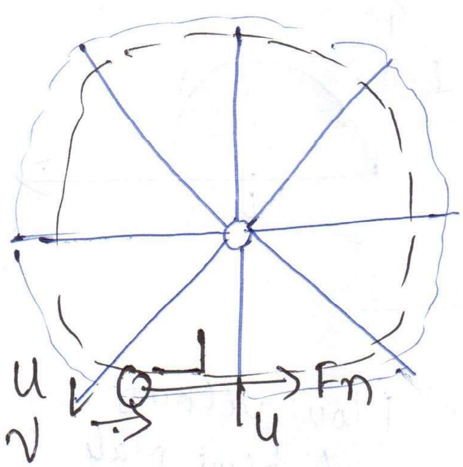
$$F_n = \rho A(v-u)(v-u)$$

$$\boxed{F_n = \rho A(v-u)^2}$$

$$P = F_n \times u$$

$$\boxed{P = \rho A(v-u)^2 \cdot u}$$

5) Series of blades :-



→ In series of blades are connected them

→ $(v-u)+u$

→ Blade is ~~not~~ connect with only one at a time all others not hit but rotated

$$F_n = \dot{m}(\Delta vel)_n$$

$$= \rho A v[(v-u)-0]$$

$$\boxed{F_n = \rho A v[v-u]}$$

$$\boxed{P = F_n \times u = \rho A v[v-u) \cdot u}$$

$$\eta_{transmission} = \frac{\text{output}}{\text{Input}}$$

$$= \frac{\text{power developed} \rightarrow \text{watt}}{\text{K.E of jet } \left(\frac{\text{Joules}}{\text{sec}}\right)}$$

K.E of jet $= \frac{1/2\, mv^2}{\text{time}}$

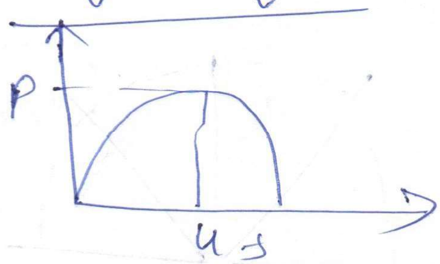
$$\frac{1}{2}\dot{m}v^2 \qquad = \frac{\rho A v (v-u)\cdot u}{\frac{1}{2}\dot{m}v^2}$$

$$\boxed{\eta = \frac{2u(v-u)}{v^2}}$$

→ Condition for η_{max}

$$\boxed{u = v/2}$$

$\uparrow P \downarrow = F_n \downarrow \times u\uparrow$



$$\eta = \frac{2u(v-u)}{v^2}$$

$$\frac{d\eta}{du} = 0 \quad \frac{d}{du}\left[\frac{2(vu - u^2)}{v^2}\right] = 0$$

$$\frac{2}{v^2}[v - 2u] = 0$$

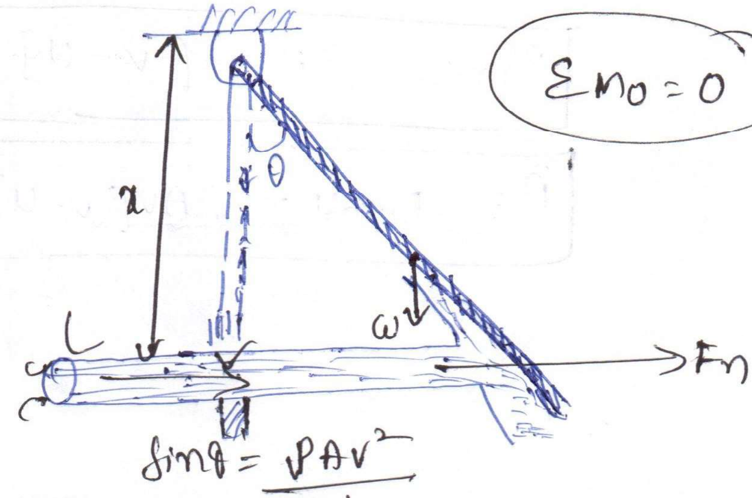
$$\boxed{u = v/2}$$

Flow velocity of that plate

$P_{out} = \rho A V(V - u\uparrow)\, u\uparrow$

as $u\uparrow \Rightarrow F_n\downarrow$

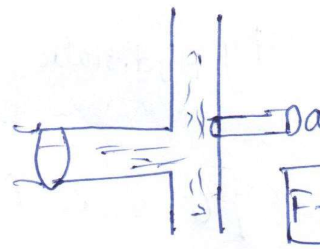
Sp. case:-



$$\Sigma M_O = 0$$

$$\sin\theta = \frac{\rho A v^2}{W}$$

$$\boxed{\sin\theta = \frac{2\rho A V^2 \cdot x}{w \cdot L}}$$



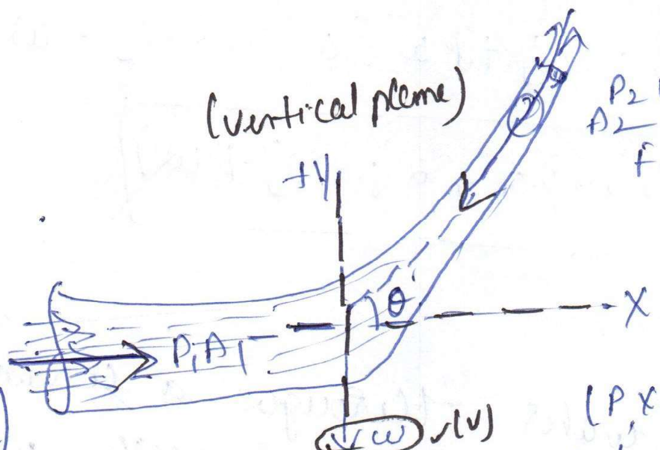
$$\boxed{F_n = \rho(A-a)V^2}$$

$F_n = \rho A V^2$ $\quad V = \sqrt{2gH}$

→ Force in pipe Bend ←

Horizontal plane (Reducing Bend)

A_1
P_1
V_1



$R = \sqrt{F_x^2 + F_y^2}$

$\phi = \tan^{-1}(F_y/F_x)$

$F_{Total} = F_{Static} + F_{Hyd\text{-}dyn}$

h static $\quad$ h dyn

$$z + \frac{P}{\rho g} + \frac{V^2}{2g}$$

$(P \times A)$

$F_{Total} = F_{Static} + F_{Hyd\text{-}dyn}$

$m(\Delta vel)_n$

$(P \times A)$

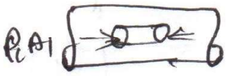
$$\boxed{F_x\ Total = (F_x\ Hyd\cdot Stc) + (F_x\ hyd\cdot dyn)\ m(\Delta vel)_x}$$

$F_x = [P_1A_1 - P_2A_2\cos\theta]$

$F_x = [P_1A_1 - P_2A_2\cos\theta] \Rightarrow \boxed{F_x = [P_1A_1 - P_2A_2\cos\theta]}$

$$\rightarrow \boxed{F_x = [P_1A_1 - P_2A_2\cos\theta] + \rho Q[V_1 - (V_2\cos\theta)}$$

$F_{y_{Total}} = F_{y\,Hyd.static} + F_{y\,Hyd.dynamic}$



$$F_y = [0 - P_2A_2 \sin\theta] + \rho Q[0 - V_2 \sin\theta].$$

$$F_y = -[P_2A_2 \sin\theta + \rho Q V_2 \sin\theta]$$

Vertical plane

$$F_x = [P_1A_1 - P_2A_2 \cos\theta] + \rho Q[V_1 - (V_2 \cos\theta)]$$

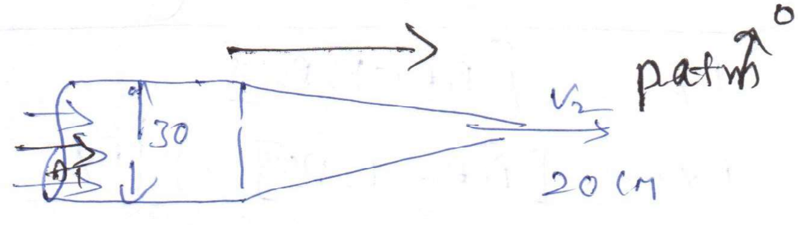
do same

$$F_y = [0 - P_2A_2 \sin\theta] + \rho Q[0 - V_2 \sin\theta] - W$$

$$F_y \quad \boxed{-[P_2A_2 \sin\theta + \rho Q \sin\theta] + W}$$

(1) For a flow water through a circular pipe with 30CM dia attached with nozzle whose exit dia is 20CM with flow rate 50L.P.S releasing into atmosphere. Find the force exerted by the water on the nozzle

Sol:-



30 cm dia

20CM

50.L.P.S

$Q = 0.05 m^3/sec$

$$F_{Total} = F_{Hyd.Static} + F_{Hyd.dyn}$$

$$= [P_1A_1 - \cancel{P_2A_2}] + \rho Q[V_1 - V_2]$$

($P_2 = 0$; $V_1 = Q/A_1$, $V_2 = Q/A_2$)

$$\left[\cancel{z}_1 + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_1 = \left[\cancel{z} + \frac{P}{\rho g} + \frac{V^2}{2g}\right]$$

$d_1 = A_1$ ✓

$= \frac{\pi d_1^2}{4}$

$= 0.0707 m^2$

$d_2 = A_2$

$= \frac{\pi d_2^2}{4}$

$= 0.0314 m^2$

$$\frac{P_1}{\rho g} = \frac{V_2^2 - V_1^2}{2g} = \frac{\left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2}{2}$$

$$P_1 = \frac{Q^2}{2} \cdot \rho \left[\frac{1}{A_2^2} - \frac{1}{A_1^2}\right]$$

$$P_1 = \frac{(50 \times 10^3)^2}{2} 10^3 \left[\frac{1}{(0.0314)^2} - \frac{1}{(0.0707)^2}\right]$$

$$P_1 = 1.016 \, kPa$$

Then $(P_1 A_1) + \rho Q^2 [V_1 - V_2]$

$$= (1016 \times 0.0707) + 10^3 (50 \times 10^3)^2 \left[\frac{1}{0.0707} - \frac{1}{0.0314}\right]$$

$F_T = 27.6 \, N$ ✓

Self learning

→ pumps

→ performance curves

→ Hydraulic devices