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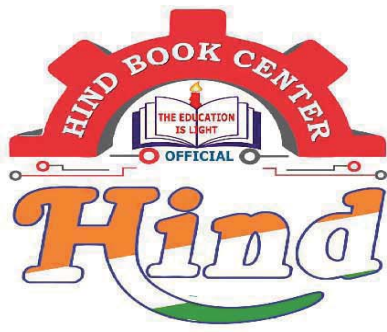
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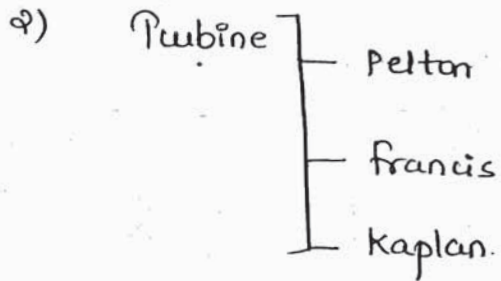
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# HYDRAULIC MACHINE -

①

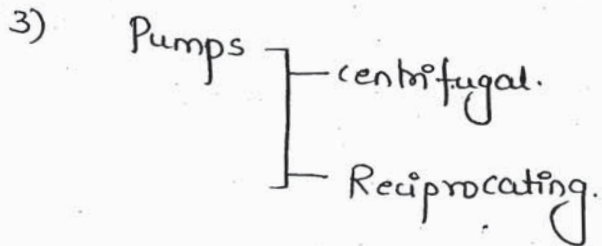
1) Impact of jets (Dynamic action of fluid)



ESE obj - 6 <sup>marks.</sup> Q obj

ESE conv. - 20-40

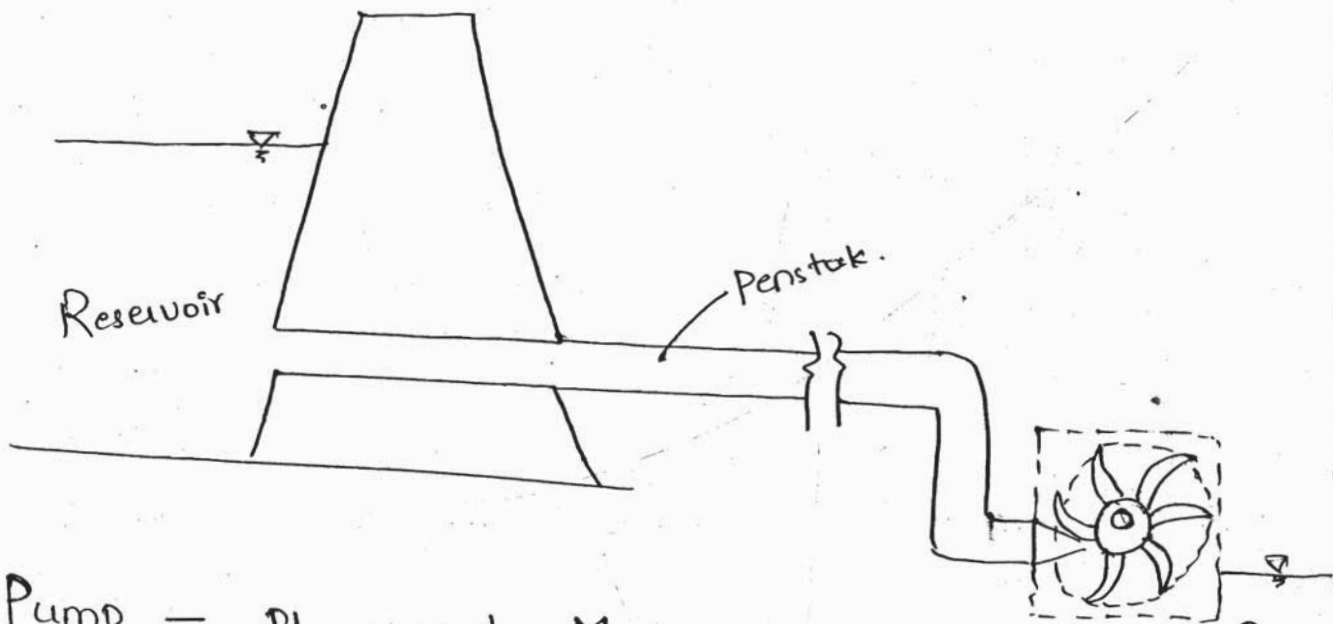
GATE - 2-4 marks



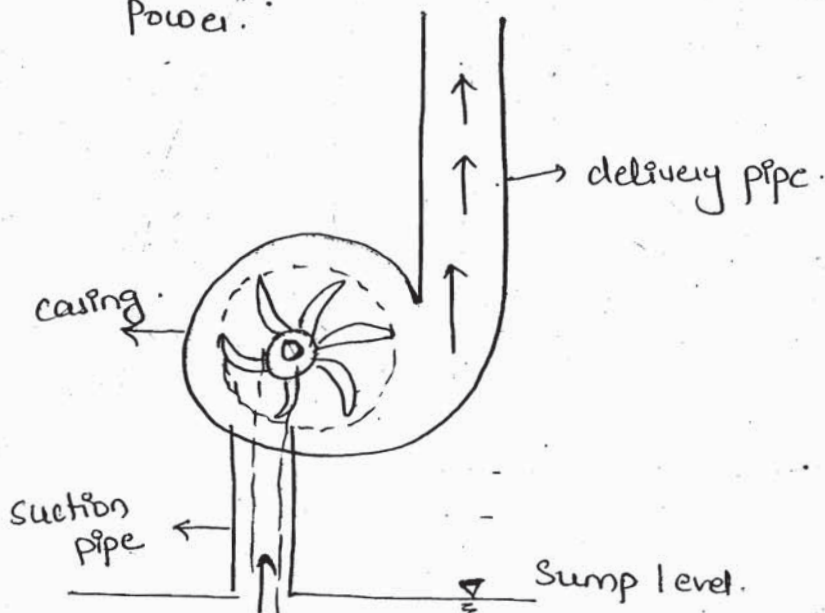
Turbine - It converts hydraulic power or water power into mechanical power.

# Introduction -

\* Turbine : It converts hydraulic power or water power into mechanical power.



\* Pump - It converts Mechanical Power to Hydraulic Power.



# Impact Of Jet - (Dynamic Action of fluid)

(2)

## FORCE CONCEPT -

Impulse -  
suddenly  
applied force

By applicatn  
of force  
the momentum  
will be change  
Ex - slap in  
• check.

## (1) Impulse Momentum Theorem :

Impulse = Change in momentum.

$$\boxed{F \cdot dt = mV_2 - mV_1} \quad \text{--- (1)}$$

In case of water we have to consider.

$$\text{Mass of flow rate } \left( \frac{dM}{dt} = \dot{M} \right) = \rho Q \text{ (kg/s)}$$

By differentiating equation (1),

$$F = \frac{d}{dt} (mV_2 - mV_1)$$

$$= \frac{d}{dt} mV_2 - \frac{d}{dt} mV_1$$

$$= \frac{dM}{dt} \cdot V_2 - \frac{dM}{dt} \cdot V_1$$

$$\boxed{F = \dot{M}V_2 - \dot{M}V_1}$$

force equal to rate of change of Momentum.

$$F_{(\text{external / Vanes / Blades})} = \dot{m}v_2 - \dot{m}v_1$$

$$F_{\text{water jet}} = -F_{\text{vane}}$$

$$= -(\dot{m}v_2 - \dot{m}v_1)$$

$$F_{\text{jet}} = \dot{m}v_1 - \dot{m}v_2$$

## Energy CONCEPT -

Energy (solid body)	Energy / sec (Power)	(Power or work done / sec) $\dot{m}g$ (Head)
$\frac{1}{2}mv^2$ (KE)	$\frac{1}{2}\dot{m}v^2$	$\frac{\frac{1}{2}\dot{m}v^2}{\dot{m}g} = \frac{v^2}{2g}$
$mgh$ (PE)	$\dot{m}gh$	$\frac{\dot{m}gh}{\dot{m}g} = h$
$F \cdot x$ (WD)	$F \cdot v$	$\frac{F \cdot v}{\dot{m}g}$

$v \rightarrow$  velocity of body जिसे force लागेगा

## \* Types of Vanes -

(3)

### 1) Flat plates -

Normal flat plates



Induced flat plates



### 2) Curved plates -

Curved vane with central splitter.



Normal curved vane.



## \* Assumptions :

1) At entry point section is assumed as ① - ①.  
At exit point section is assumed as ② - ②.

2) Pressure at ① = Pressure at ② =  $P_{atm}$ .

3)  $Z_1 = Z_2$ .

4) There is no friction loss over the vanes.

5) There is no impact loss (No-shock condition)

Note - (No shock condition) -

\* To achieve no shock condition the entry and exit

of water over the vanes should be <sup>Parallelly.</sup> (tangentially) to the vanes, hence water entry angle should be equal to inlet vane angle and exit angle of water should be equal to exit vane angle.

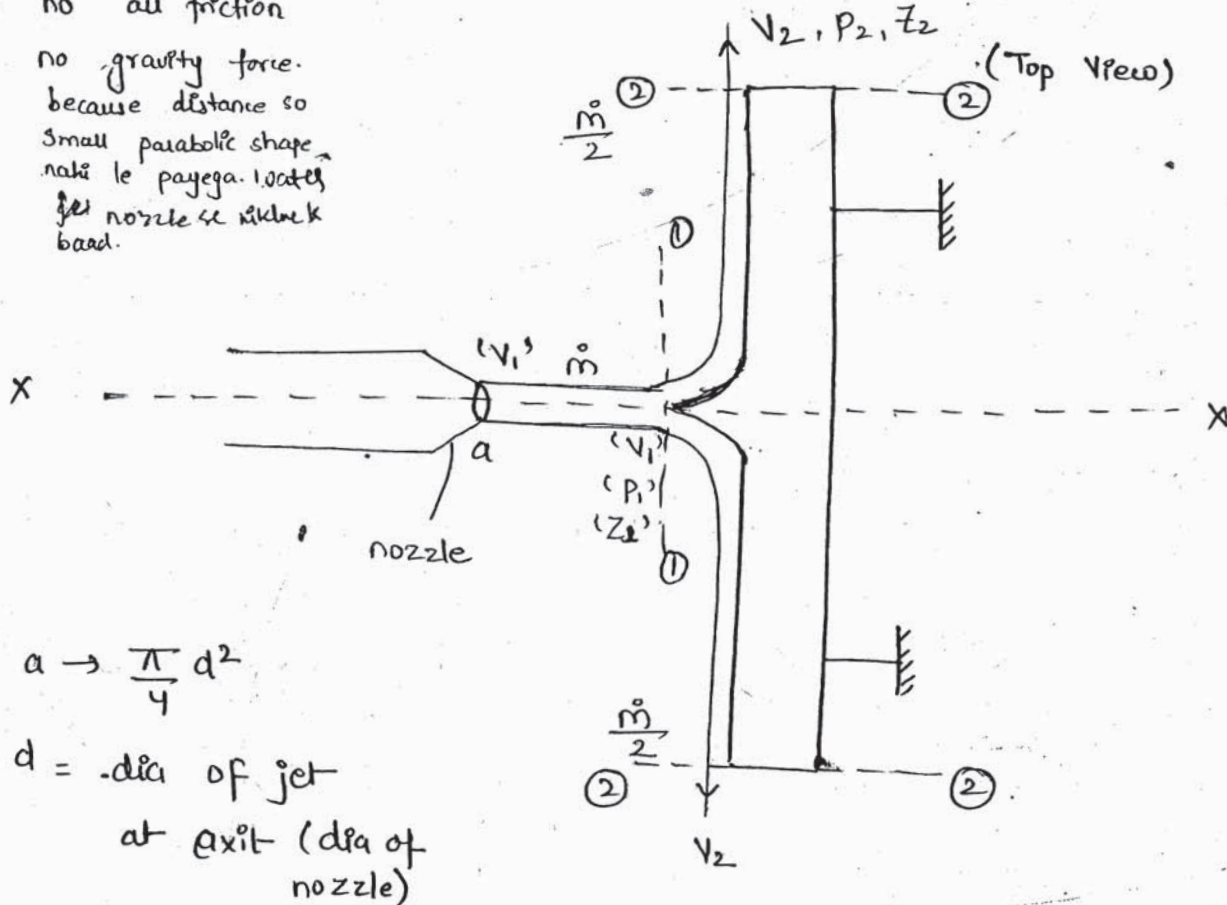
at starting shock hota h  
at exit shock hota h  
to starting ne parallelly move karna hota h for no shock

### \* Impact of jet on stationary Vanes -

case-1 Impact on flat Plate held normal -

(for analysis)

- \* no air friction
- \* no gravity force. because distance so small parabolic shape nahi le payega. water jet nozzle se nikalke bad.



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

$d$  = dia of jet at exit (dia of nozzle)

Mass of flow rate Impacting the value -

$$\dot{m} = \rho Q$$

$$= \rho a v_1$$



Applying Bernoulli's equation at ① & ②.

(4)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + 0$$

$$P_1 = P_2$$

$$Z_1 = Z_2$$

$$\boxed{V_1 = V_2}$$

$$F_{\text{jet}} (\text{x-direction or Normal direction}) = \dot{m} V_1 - \left( \frac{\dot{m}}{2} x_0 + \frac{\dot{m}}{2} x_0 \right) = \dot{m} V_1$$

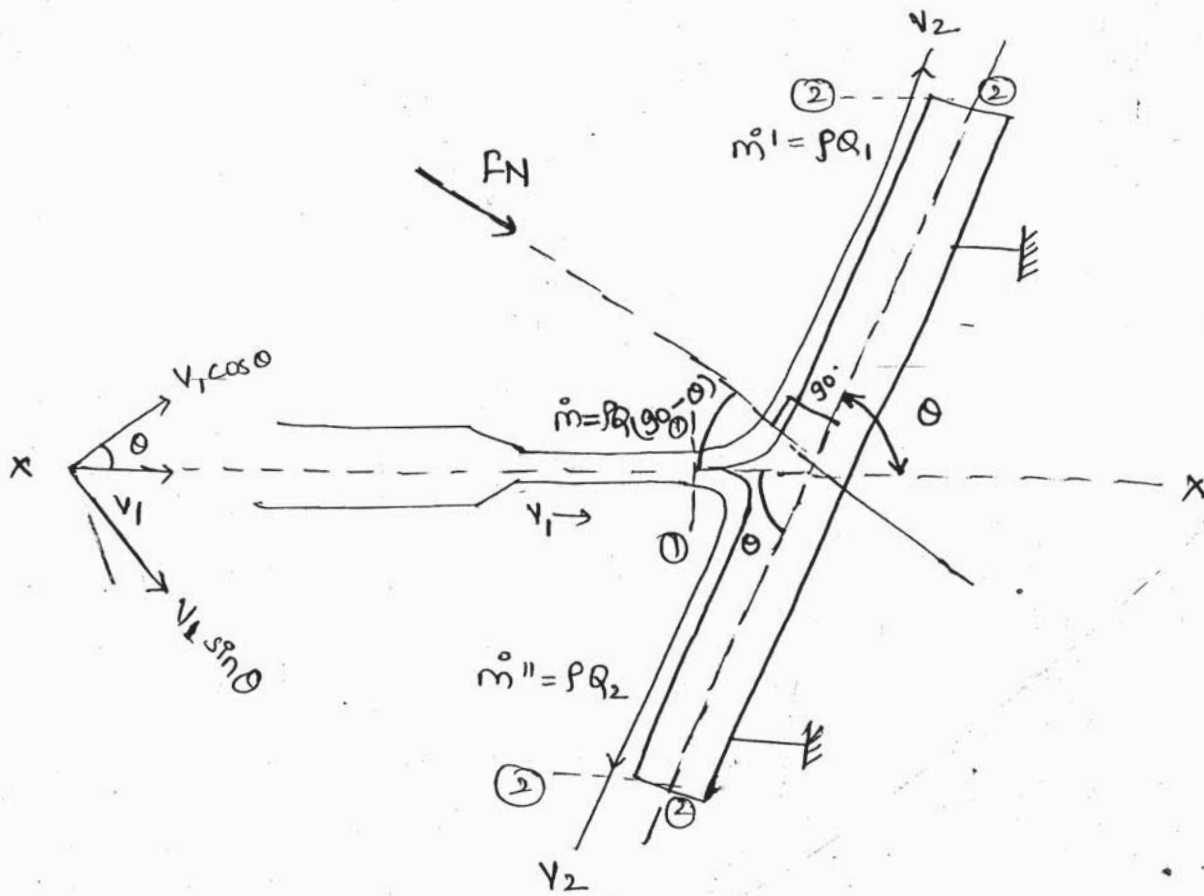
$$\boxed{F_x \text{ or } F_{\text{normal}} = \rho a V_1^2}$$

$$F_{\text{jet}} (\text{y-direction or Tangential}) = \dot{m} x_0 - \left( \frac{\dot{m}}{2} x V_2 + \frac{\dot{m}}{2} (-V_2) \right) = 0$$

Note

The force in tangential direction is zero. because water is flowing in two opposite direction in such a way that momentum is balanced.

(case-2) Impact over a Inclined flat plate -



$$F_N = \dot{m} v_1 \sin \theta - (\rho Q_1 v_2 + \rho Q_2 v_2)$$

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

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

$$F_x = F_N \cos (90^\circ - \theta) = F_N \sin \theta = \rho a v_1^2 \sin^2 \theta$$

$$F_y = F_N \sin (90^\circ - \theta) = F_N \cos \theta = \rho a v_1^2 \sin \theta \cos \theta$$

$$F_T = \dot{m} v_1 \cos \theta - (\rho Q_1 v_2 + \rho Q_2 (-v_2))$$

$$F_T = \dot{m} v_1 \cos \theta - (\rho Q_1 v_2 - \rho Q_2 v_2)$$