A jet of water of 30 mm diameter strikes a hinged square plate at its centre with a velocity of 20 m/s. The plate is deflected through an angle of 20°. Find the weight of the plate.

If the plate is not allowed, to swing, what will be the force required at the lower edge of the plate to keep the plate in vertical position.

Diameter of the jet, $d = 30 \text{ mm} = 3 \text{ cm} = 0.03 \text{ m}$

$\therefore$ Area, $a = \frac{\pi}{4} d^2 = \frac{\pi}{4}(.03)^2 = .0007068 \text{ m}^2$

Velocity of jet, $V = 20 \text{ m/s}$

Angle of swing, $\theta = 20°$

$$\sin\theta = \frac{\rho a V^2}{W}$$

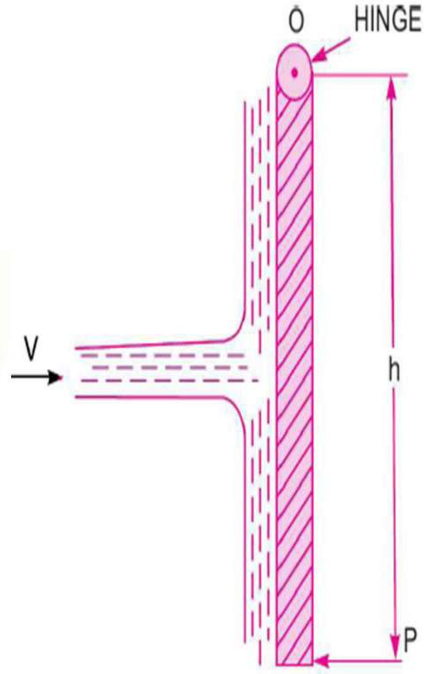
$$\sin 20^\circ = 1000 \times \frac{.0007068 \times 20^2}{W} = \frac{282.72}{W}$$

$$W = \frac{282.72}{\sin 20^\circ} = 826.6 \text{ N}$$

Let F = Force exerted by jet of water

h = Height of plate

= Distance of P from the hinge.



The jet strikes at the centre of the plate and hence distance of the centre of the jet from hinge = $\frac{h}{2}$.

Taking moments* about the hinge, O, $P \times h = F \times \frac{h}{2}$.

$$\therefore \quad P = \frac{F \times h}{2 \times h} = \frac{F}{2} = \frac{\rho a V^2}{2} \qquad \left(\because \quad F = \rho a V^2\right)$$

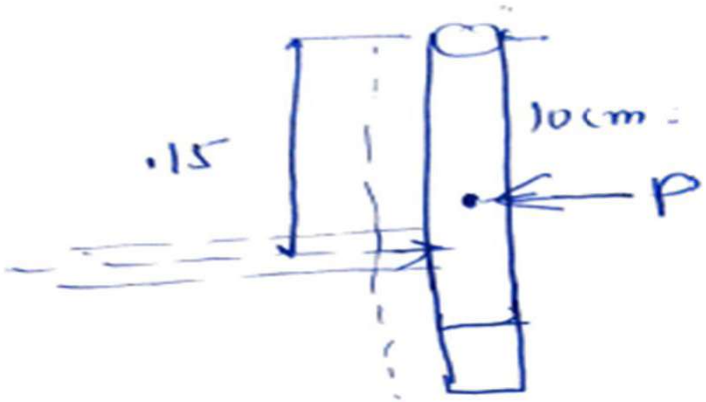
$$= 1000 \times \frac{.0007068 \times 20^2}{2} = \mathbf{141.36\ N.\ Ans.}$$

A rectangular plate, weighing 58.86 N is suspended vertically by a hinge on the top of horizontal edge. The centre of gravity of the plate is 10 cm from the hinge. A horizontal jet of water 2 cm diameter, whose axis is 15 cm below the hinge impinges normally on the plate with a velocity of 5 m/s. Find the horizontal force applied at the centre of the gravity to maintain the plate in its vertical position. Find the corresponding velocity of the jet, if the plate is deflected through 30° and the same force continues to act at the centre of gravity of the plate.

$W = 58.86\ N$

10cm from , $d = .02m$

$v = 5 m/s$



Force Exerted on Plate

$F = \rho A v^2$

$= 1000 \times \frac{\pi}{4} (.02)^2 \times (5)^2$

$f = 7.85 N$

$$\Sigma M_O = 0$$

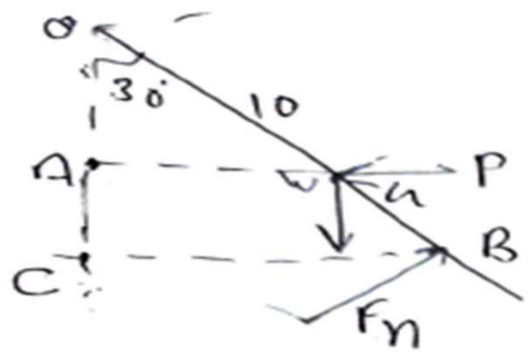
$$7.85 \times 15 = P \times 10$$

$$\boxed{P = 11.775 N}$$

$$F_x = \rho A v^2 \cos\theta$$

$$= 1000 \times \frac{\pi}{4} (02)^2 \times v^2 \times \cos 30$$

$$= .272 v^2$$



$OB =$

$OC = OB \cos 30°$

$OB = \frac{OC}{\cos 30°}$ $\cos =$

$= \frac{.15}{\cos 30}$

$= .1732 \; m$

$OA = OG \cos 30°$

$= .10 \cos 30 = .0866 \; m$

$AG = OG \sin 30 = .05 \; m$

$F_n \times OB = P \times OA + W \times AG$

$.2717 v^2 \times .1732 = 11.775 \times .0866 + 58.86 \times .05$

$V = 9.175 \; m/s$

A jet of water of diameter 10 cm strikes a flat plate normally with a velocity of 15 m/s. The plate is moving with a velocity of 6 m/s in the direction of the jet and away from the jet. Find:

(i) the force exerted by the jet on the plate

(ii) work done by the jet on the plate per second.

$d = .1 \, cm$

$V = 15 \, m/s$

$u = 6 \, m/s$

$F = \rho A V_r^2$

$= 1000 \times \frac{\pi}{4} \times (.1)^2 \times (15-6)^2$

$= 636.0 \, N$

work done / sec

$= F_x \times u$

$= 3816.3 \, Nm/s$

$$\eta = \frac{\text{output of jet / sec}}{\text{input of jet / sec}}$$

$$\frac{1}{2} m v^2 \quad \& \quad \rho A V$$

$$KE/sec = \frac{1}{2} \rho A V^3$$

$$\eta = \frac{3817.02}{\frac{1}{2}\, 1000 \times \frac{\pi}{4} \cdot 1^2 \times 15^2 \times 15}$$

$$= .28$$

$$\eta = 28.8\%$$

A 7.5 cm diameter jet having a velocity of 30 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate : (i) when the plate is stationary , and (ii) when the plate is moving with a velocity of 15 m/s and away from the jet. Also determine the power and efficiency of the jet when the plate is moving.

$$F_n = \rho A V^2 \sin 45 = 1000 \times \frac{\pi}{4} (.075)^2 \times 30^2 \times \sin 45$$

$$= 2810.98$$

$d = .075$ m

$V = 30$ m/s

$\theta = 45^\circ$

$V_r = V - u = 15$

$$F_n = \rho a (V - u)^2 \sin \theta \qquad \text{where } u = 15 \text{ m/s.}$$

$$= 1000 \times .004417 \times (30 - 15)^2 \times \sin 45^\circ = \mathbf{702.74\ N.\ Ans.}$$

Workdone/sec $= F_x \times u$

$= F_n \sin\theta \times u$

$= 702.74 \times \sin 45 \times 15$

$= 7453.6$

Power $= 7.41 kW$

$KE = \frac{1}{2} \rho A V^3$

$= \frac{1}{2} 1000 \times A V^3$

$\eta = \frac{7453.6}{\frac{1}{2} 1000 \times \frac{\pi}{4} \times (0.75)^2 \times 30^3}$

$= 12.15\%$

A nozzle of 50 mm diameter delivers a stream of water at 20 m/s perpendicular to a plate that moves away from the jet at 5 m/s. Find :

(i) the force on the plate,

(ii) the work done, and

(iii) the efficiency of jet.

$d = 50 = .05\ m$

$V = 20\ m/s$

$u = 5\ m/s$

$F = m^{o} [V_1 x - V_2 x]$

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

$= \rho A (V - u)^2$

$= 1000 \times \frac{\pi}{4} (.05)^2 \times (20 - 5)^2$

$F = 441.70\ N$

$W/s = F x \times u$

$= 441 \times 5$

$= 2208.5\ Nm/sec = W$

$\eta = \frac{2208.5}{\frac{1}{2} m v^2} = \frac{2208.5}{\frac{1}{2} \rho A V^3}$

$= 28\%$