Universiti Malaysia PAHANG
Engineering • Technology • Creativity

Fluid Mechanics

Momentum and Its Application

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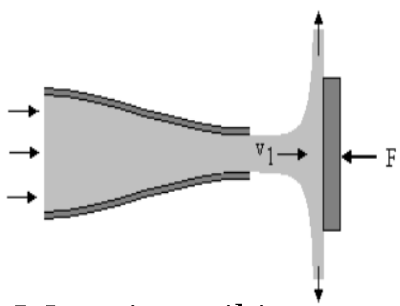
Course outcome :

- Introduce the momentum equation for a fluid
- Demonstrate how the momentum equation and principle of conservation of momentum is used to predict forces induced by flowing fluids

WEEK	CHAPTER	TOPIC	
8	**4**	**Momentum and its application**	
		4.1	Derivation of Momentum Equation
		4.2	The Force of Impact

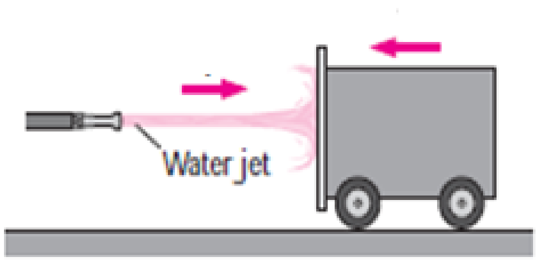
4.2 Application of the Momentum Equation : The Force of Impact

1. Force exerted on a flat plate.



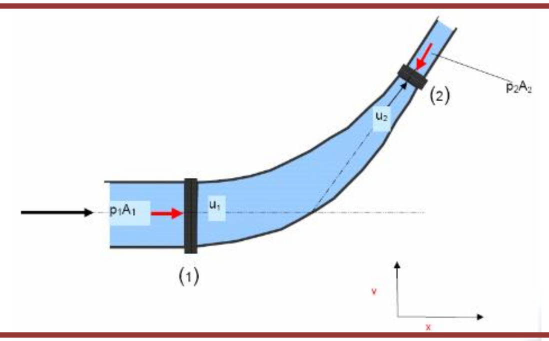
Water jet striking a stationary plate

Water jet striking a plate with velocity, *v*→



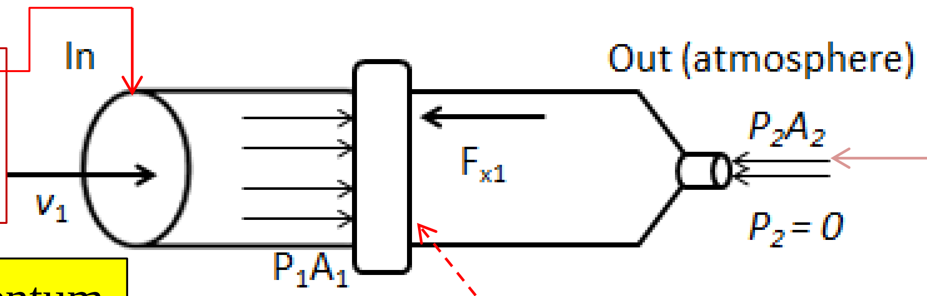
Water jet striking a plate with velocity, *v*←

2. Force exerted on pipe bend and closed conduits.



4.2.1 Force exerted on a stationary flat plate

F_3, force due to the pressure P_1 and P_2 of the fluid outside the control volume.



Force = rate of change of momentum

F_1, force exerted by the walls of the pipe

Momentum equation :

$$F = \rho Q(v_{out} - v_{in})$$

$$F_1 + F_3 = \rho Q(v_2 - v_1)$$

$$F_1 + (P_1A_1 - P_2A_2) = \rho Q(v_2 - v_1)$$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$\therefore P_1 = \left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right)\rho g$$

as $P_2 = 0$

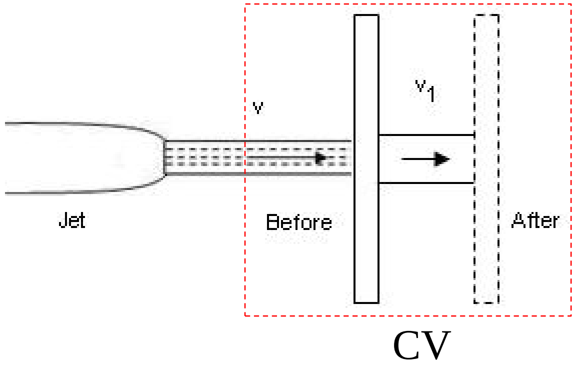
thus $F_1 + (P_1A_1) = \rho Q(v_2 - v_1)$

Continuity equation :

$$v_1 = \frac{Q}{A_1}; \quad Q_1 = Q_2 \quad \text{thus, } v_2 = \frac{v_1A_1}{A_2}$$

Force exerted on a moving flat plate

- Plate moving with velocity, $v(\rightarrow)$



Efective velocity, v_e

$$v_e = v - v_1$$

Efective discharge, Q_e

$$Q_e = Av_e$$

$$Q_e = A(v - v_1)$$

Momentum equation :

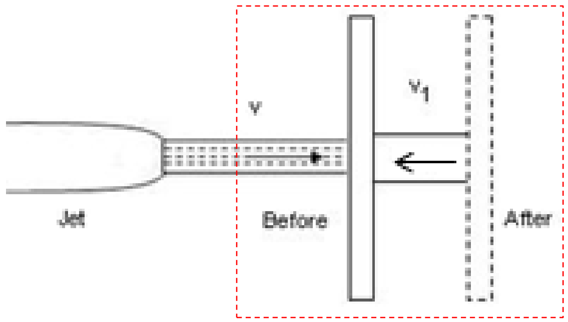
$$F = \rho Q_e v_e$$

$$F = \rho(Av_e)v_e$$

$$F = \rho A(v - v_1)(v - v_1)$$

$$F = \rho A(v - v_1)^2$$

- Plate moving with velocity, $v(\leftarrow)$



Efective velocity, v_e

$$v_e = v + v_1$$

Efective discharge, Q_e

$$Q_e = Av_e$$

$$Q_e = A(v + v_1)$$

Momentum equation :

$$F = \rho Q_e v_e$$

$$F = \rho(Av_e)v_e$$

$$F = \rho A(v + v_1)(v + v_1)$$

$$F = \rho A(v + v_1)^2$$