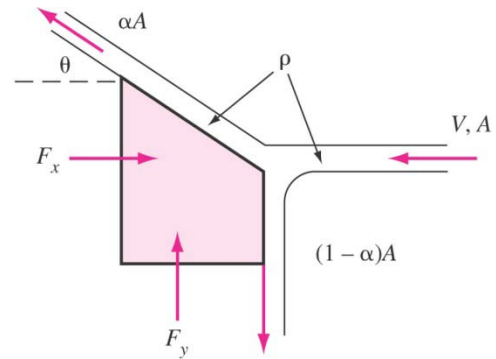


October 15, 2010

NAME

Fluids-ID

Quiz 6. A liquid jet of density ρ and area A strikes a block and splits into two jets, as shown in the figure. All three jets have the same velocity V . The upper jet exits at angle θ and area αA , the lower jet turns down at 90° and area $(1 - \alpha)A$. Determine the forces (a) F_x and (b) F_y required to support the block against momentum changes if $\rho = 999 \text{ kg/m}^3$ (for water), $A = 0.1 \text{ m}^2$, $V = 10 \text{ m/s}$, $\theta = 30^\circ$, and $\alpha = 0.7$.



- Linear momentum equation:

$$\frac{\partial}{\partial t} \int_{CV} \underline{V} \rho dV + \sum_{CS} \dot{m}_{out} \underline{V}_{out} - \sum_{CS} \dot{m}_{in} \underline{V}_{in} = \sum \underline{F}$$

Solution:

(a) From the linear momentum equation in the x -direction

$$\frac{\partial}{\partial t} \int_{CV} (\underline{V} \cdot \hat{i}) \rho dV + \alpha \dot{m} (-V \cos \theta) - \dot{m} (-V) = F_x$$

$$\therefore F_x = \dot{m} V (1 - \alpha \cos \theta) \quad (+3 \text{ points})$$

where $\dot{m} = \rho A V = \left(999 \frac{\text{kg}}{\text{m}^3}\right) (0.1 \text{ m}^2) \left(10 \frac{\text{m}}{\text{s}}\right) = 999 \frac{\text{kg}}{\text{s}}$. Thus,

$$F_x = \left(999 \frac{\text{kg}}{\text{s}}\right) \left(10 \frac{\text{m}}{\text{s}}\right) (1 - 0.7 \cos 30^\circ) = \mathbf{3.9 \text{ kN}} \quad (+2 \text{ points})$$

(b) From the linear momentum equation in the y -direction

$$\frac{\partial}{\partial t} \int_{CV} (\underline{V} \cdot \hat{j}) \rho dV + \{\alpha \dot{m} (V \sin \theta) + (1 - \alpha) \dot{m} (-V)\} - 0 = F_y$$

(+3 points)

$$\therefore F_y = \dot{m} V (\alpha \sin \theta + \alpha - 1)$$

Thus,

$$F_y = \left(999 \frac{\text{kg}}{\text{s}}\right) \left(10 \frac{\text{m}}{\text{s}}\right) (0.7 \sin 30^\circ + 0.7 - 1) = \mathbf{0.5 \text{ kN}} \quad (+2 \text{ points})$$