Chapter 4 - Integral Form for a Control Volume

Lecture 13
Section 4.3

Introduction to Fluid Mechanics

Mechanical Engineering and Materials Science
University of Pittsburgh

Student Learning Objectives

Students should be able to:

- Understand the formulation of the Conservation of Linear Momentum equation in an RTT framework
- Apply the conservation of linear momentum to unsteady and two-dimensional problems, and unsteady problems

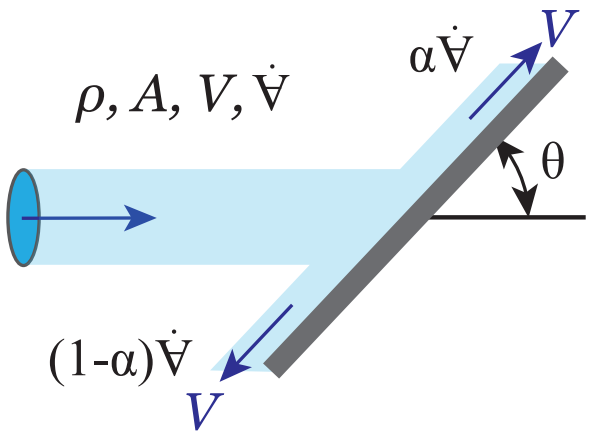
Conservation of Linear Momentum

- Recall the sum of all external forces acting on the C.∀. is equal to the time rate of change of the linear momentum of the fluid within the C.∀. plus the net flow rate of the linear momentum out of the C.∀. through the C.S.

$$\Sigma \vec{F}_b + \Sigma \vec{F}_s = \frac{\delta}{\delta t} \int_{C.\forall.} \rho \vec{V} d\forall + \int_{C.S.} \rho \vec{V} (\vec{V} \cdot \vec{n}) dA$$

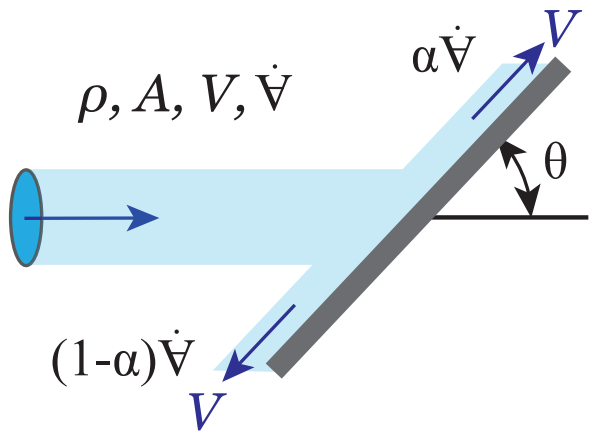
Example #1

- A jet of liquid is shot at an inclined plate and breaks into two equal jets with velocities equal to the original velocity of the incoming jet, but with different volumetric flow rates. α is a fraction of the original flow. The fluid exerts no frictional forces in the tangential direction of the plate. Find α as a function of the plate angle θ.



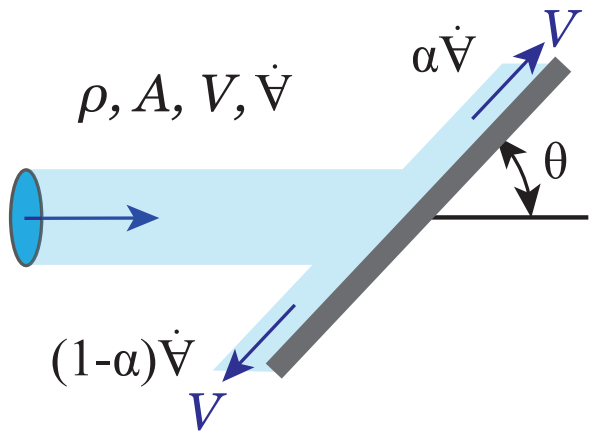
Example #1

- Solution:



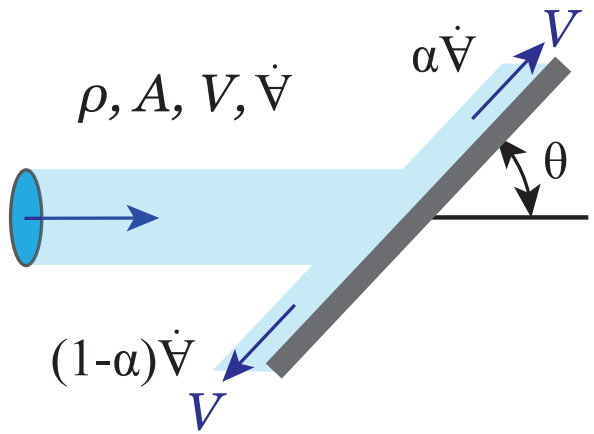
Example #1

- Solution:



Example #1

- Solution:



Example #2

- A satellite orbiting earth has a mass of 5,000 [kg] and is traveling at a constant velocity V_o. The rocket is able to change orbit by discharging gas in increments of 100 [kg] at a velocity of 3,000 [m/s] (relative to the satellite), in the direction opposite V_o. The gas is discharged for 2 [s] at a constant rate. Determine the acceleration of the satellite during this 2 [s] period, the change of the satellite's velocity, and the thrust exerted on the satellite.

Example #2

- Solution:

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- Solution: