

Balance Laws 2

Lecture 3



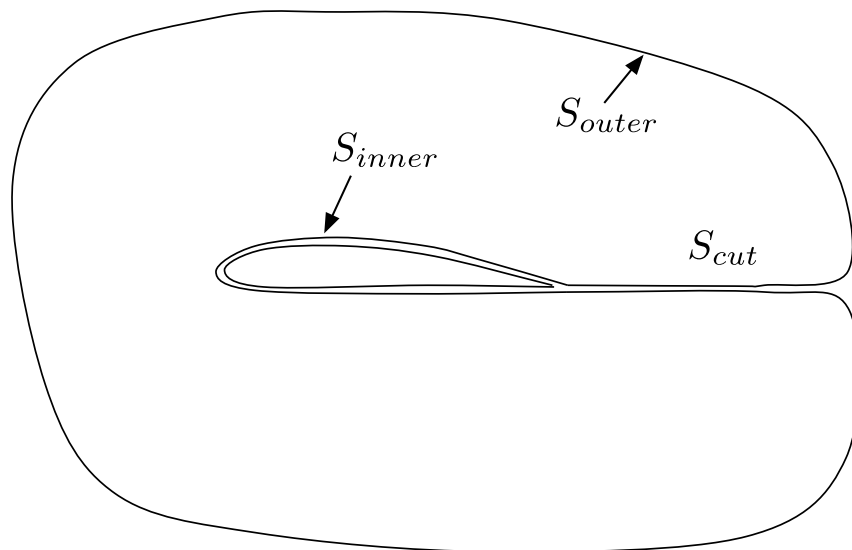
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Outline

Examples

Examples

Far-field Forces



No time dependence or other external forces:

$$\begin{aligned} & \cancel{\frac{\partial}{\partial t} \int_V \rho \vec{V} dV} + \int_S \rho \vec{V} (\vec{W} \cdot d\vec{A}) = \\ & - \int_S p d\vec{A} + \int_S \vec{\tau} \cdot d\vec{A} + \cancel{\sum \vec{F}_{other}} \end{aligned}$$

Rewrite:

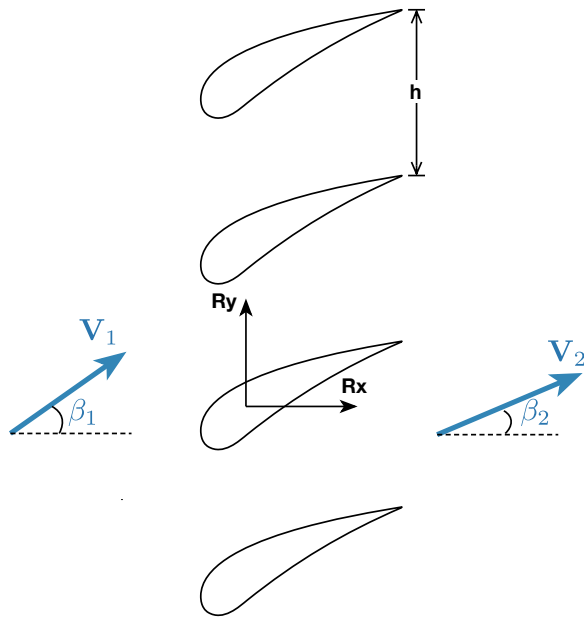
$$\int_S \left(\rho \vec{V} (\vec{W} \cdot \hat{n}) + p \hat{n} - \vec{\tau} \cdot \hat{n} \right) dA = 0$$

$$\int_{S_{inner}} (-) dA + \int_{S_{outer}} (-) dA + \int_{\cancel{S_{cut}}} (-) dA = 0$$

$$\int_{S_{inner}} \left(\rho \vec{V} (\vec{W} \cdot \hat{n}) + p \hat{n} - \vec{\tau} \cdot \hat{n} \right) dA = \vec{F}_b$$

$$\vec{F}_b = - \int_{S_{outer}} \left(\rho \vec{V} (\vec{W} \cdot \hat{n}) + p \hat{n} \right) dA$$

Stator vanes on a jet engine



- Infinite cascade of airfoils
- Incompressible
- Velocity/pressure constant at stations 1 and 2
- Find reaction forces to keep a vane in place.

Jet impinging on cart

