Lecture 34, Dec 1, 2022

Momentum Equation

- The Eulerian form of the momentum equation: $\sum \vec{F}_{cv} = \frac{\mathrm{d}}{\mathrm{d}t}\vec{M}_{cv} + \dot{\vec{M}}_{out} - \dot{\vec{M}}_{in}$
  - For a steady flow, $\sum F_{cv} = \dot{\vec{M}}_{out} - \dot{\vec{M}}_{in}$
- In a 1D problem: $\sum \vec{F}_{cv} = \sum \dot{m}_{out}\vec{V}_{out} - \sum \dot{m}_{in}\vec{V}_{in}$
- We draw force diagrams of forces acting on the control volume similar to a free body diagram for solid analysis
- Example: Flow inside a pipe
  - The forces acting on the control volume would include the shear force on the walls $\tau\pi DL$, the net pressure force $(p_1 - p_2)\pi\frac{D^2}{4}$, and weight $\rho g\pi\frac{D^2}{4}L$
  - However if we make the control volume bigger than the pipe wall, we no longer have shear forces; however we'd get a force due to the rest of the pipe wall, and the weight of the pipe material

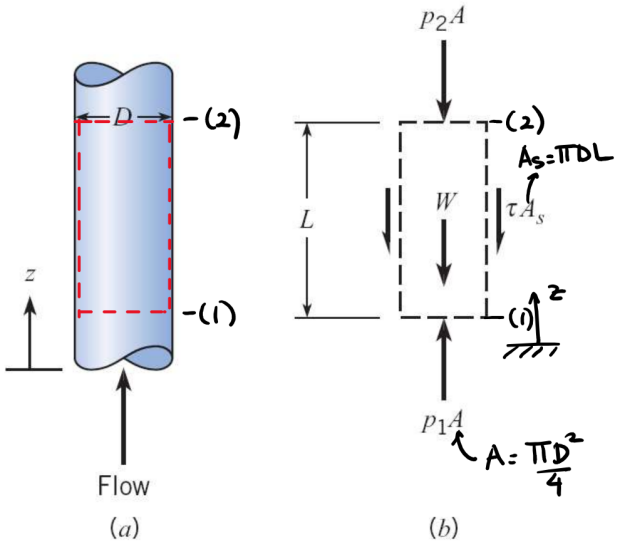

Figure 1: Flow inside a pipe

- Choice of the control volume depends on what information we want to find
- When expressing pressure forces acting on control surfaces, we ignore atmospheric pressure, because it cancels out