

Formula sheet

**Mass Conservation Law**

$$\frac{d}{dt} \int_{CV} \rho dV + \int_{CS} \rho (\vec{v}_{rel} \cdot \vec{n}) dA = 0$$

**Linear Momentum Conservation Law**

$$\sum \vec{F} = \frac{d}{dt} \int_{CV} \rho \vec{v} dV + \int_{CS} \rho \vec{v} (\vec{v}_{rel} \cdot \vec{n}) dA$$

**Angular Momentum Conservation Law**

$$\frac{d\vec{H}_O}{dt} = \sum (\vec{r} \times \vec{F}) = \sum \vec{M}_O = \frac{d}{dt} \int_{CV} (\vec{r} \times \rho \vec{v}) dV + \int_{CS} (\vec{r} \times \rho \vec{v}) (\vec{v}_{rel} \cdot \vec{n}) dA$$

**Energy Conservation Law**

$$\dot{Q} - \dot{W}_s - \dot{W}_v = \frac{\partial}{\partial t} \int_{CV} (\hat{u} + \frac{1}{2} v^2) \rho dV + \int_{CS} (\hat{h} + \frac{1}{2} v^2 + gz) \rho (\vec{v} \cdot \vec{n}) dA$$

Incompressible (low speed), steady flow through a pipe

$$\left( \frac{p}{\rho g} + \frac{\alpha V^2}{2g} + z \right)_{in} = \left( \frac{p}{\rho g} + \frac{\alpha V^2}{2g} + z \right)_{out} + h_{turbine} - h_{pump} - h_{friction}$$

$\alpha$  = kinetic energy correction factor

Ideal Gas Law

$$p = \rho RT$$

Enthalpy

$$\hat{h} = C_p T$$

$$R = 287 \frac{J}{kg \cdot K} = 1716 \frac{ft \cdot lbf}{slug \cdot R}$$

**Bernoulli Equation**

Steady, frictionless incompressible flow along a streamline

$$\frac{p}{\rho} + \frac{1}{2} V^2 + gz = const$$