ME3700 Exam 2 - Equations Sheet

$$\rho \frac{D\vec{V}}{Dt} = -\vec{\nabla}P + \rho\vec{g} + \mu\nabla^2\vec{V}$$

Continuity Equation:

$$\vec{\nabla} \bullet \vec{V} = 0$$

Euler-n Equation:

$$\frac{dP}{dn} = \rho\frac{V^2}{R}$$

Bernoulli's Equation:

$$\frac{P}{\rho} + \frac{V^2}{2} + gz = Const.$$

Integral form of Conservation of Mass (Non-deformable Control Volume):

$$\frac{DM_{sys}}{Dt} = 0 = \frac{\partial}{\partial t}\int_{C\forall} \rho d\forall + \int_{CS} \rho\left(\vec{V} \cdot \hat{n}\right)dA$$

Integral form of Conservation of Momentum (Non-deformable Control Volume):

$$\sum \vec{F} = \frac{D\overrightarrow{Mom}_{sys}}{Dt} = \frac{\partial}{\partial t}\int_{C\forall} \rho\vec{V}d\forall + \int_{CS} \rho\vec{V}\left(\vec{V} \cdot \hat{n}\right)dA$$

Integral form of Conservation of Energy (Non-deformable Control Volume):

$$\frac{DE_{sys}}{Dt} = \dot{Q} - \dot{W} = \frac{\partial}{\partial t}\int_{C\forall} \rho e d\forall + \int_{CS} \rho e\left(\vec{V} \cdot \hat{n}\right)dA$$

Specific Energy:

$$e = \tilde{u} + \frac{V^2}{2} + gz$$

Simplified Energy Equation:

$$-\frac{\dot{W}_{shaft}}{\dot{m}g} = -\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_1 + \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_2 + H_L$$

$$H_L = K\frac{V^2}{2g}$$

$$H_L = f\frac{L}{D}\frac{V^2}{2g}$$

Equation of state:

$$P = \rho RT$$

Vorticity:

$$\vec{\omega} = \vec{\nabla} \times \vec{V}$$

Solenoidal:

$$\vec{\nabla} \bullet \vec{\omega} = 0$$

Circulation:

$$\Gamma = \oint_C \vec{V} \bullet d\vec{l} = \int_A \omega \bullet \hat{n} dA$$

Displacement Length:

$$\delta^* = \int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right)dy$$

Momentum (deficit) Length:

$$\theta = \int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right)dy$$

Boundary Layer Wall Shear Stress:

$$\tau_w = \rho U_\infty^2 \frac{d\theta}{dx}$$

$$Fr = \frac{U}{\sqrt{gL}} \qquad St = \frac{fD}{U} \qquad \mathrm{Re}_D = \frac{UD}{\nu}$$