Fluid Mechanics (ME EN 5700/6700)
Equations Sheet Mid-Term Exam, Fall 2025

$$\vec{u} = u\,\hat{i} + v\,\hat{j} + w\,\hat{k}$$

$$\vec{\nabla} = \frac{\partial}{\partial x}\,\hat{i} + \frac{\partial}{\partial y}\,\hat{j} + \frac{\partial}{\partial z}\,\hat{k}$$

$$e_{ij} = \frac{1}{2}\Big(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\Big)$$

$$\varepsilon_{ijk}\,\varepsilon_{klm} = \delta_{il}\delta_j m - \delta_{im}\delta_{jl}$$

$$\vec{\omega} = \vec{\nabla} \times \vec{u},$$

$$\omega_i = \varepsilon_{ijk}\frac{\partial u_k}{\partial x_j}.$$

$$\Gamma = \int_{\mathcal{S}} \vec{\omega} \cdot d\vec{\mathcal{S}},$$

$$r_{ij} = \frac{1}{2}\Big(\frac{\partial u_i}{\partial x_j} - \frac{\partial u_j}{\partial x_i}\Big),$$

$$r_{ij} = -\frac{1}{2}\varepsilon_{ijk}\,w_k.$$

$$u \equiv \frac{\partial \psi}{\partial y}, \qquad v \equiv -\frac{\partial \psi}{\partial x}$$

$$\frac{D}{Dt}\int_{V(t)} F(\vec{x},t)\,dV = \int_{V(t)} \frac{\partial F}{\partial t}\,dV + \int_{A(t)} F\,(\vec{u}\cdot d\vec{A})$$

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho\,u_i)}{\partial x_i} = 0$$

$$\frac{D\,(m\vec{u})}{Dt} = \vec{F}$$

$$\rho\frac{\partial u_i}{\partial t} + \rho\,u_j\frac{\partial u_i}{\partial x_j} = \rho\,g_i + \frac{\partial \tau_{ij}}{\partial x_j}.$$

$$\tau_{ij} = -p\delta_{ij} + \sigma_{ij}$$

$$\tau_{ij} = -p\delta_{ij} + \lambda e_{mm}\delta_{ij} + 2\mu e_{ij}.$$

$$\tau_{ij} = -p\delta_{ij} + \mu(2e_{ij} - \frac{2}{3}e_{mm}\delta_{ij}).$$

$$\rho\frac{Du_i}{Dt} = \rho g_i - \frac{\partial p}{\partial x_i} + \mu\frac{\partial^2 u_i}{\partial x_j \partial x_j} + \frac{\mu}{3}\frac{\partial}{\partial x_i}\Big(\frac{\partial u_m}{\partial x_m}\Big)$$

$$\rho\frac{\partial u_i}{\partial t} + u_j\frac{\partial u_i}{\partial x_j} = \rho g_i - \frac{\partial p}{\partial x_i} + \mu\frac{\partial^2 u_i}{\partial x_j \partial x_j}$$