EQUATION SHEET - FINAL EXAM

Miscellaneous

$$1\text{bar} = 10^5\text{Pa} \qquad 1\text{hp} = 550\text{ft}\cdot\text{lbf/s} \qquad 1\text{hp} = 2545\text{Btu/hr} \quad 1\text{Btu} = 778.17\text{ft}\cdot\text{lbf} \tag{1}$$

$$T(^\circ F) = T(^\circ R) - 459.67 \quad 1\text{lb}_\text{f} = 32.17\text{lb}\cdot\text{ft/s}^2 \tag{2}$$

$$v = \frac{1}{\rho} \quad \gamma = \rho g \quad SG = \frac{\rho}{\rho_{\text{H}_2\text{O}}} \quad c_p = \left(\frac{\partial h}{\partial T}\right)_p \quad c_v = \left(\frac{\partial u}{\partial T}\right)_v \tag{3}$$

Quality (using v as the relevant property)

$$v = (1-x)v_f + xv_g = v_f + x(v_g - v_f) \tag{4}$$

Shear stress

$$\tau = \mu\frac{du}{dy} \tag{5}$$

Ideal Gas Law

$$\overline{R} = 8.314\text{kJ/kmol}\cdot\text{K} \qquad \overline{R} = 1545\text{ft}\cdot\text{lbf/lbmol}\cdot^\circ\text{R} \tag{6}$$

$$p = \rho RT \qquad pv = RT \qquad p\overline{v} = \overline{R}T \qquad pV = mRT \qquad pV = n\overline{R}T \tag{7}$$

Fluid Statics

$$-\nabla p - \gamma\hat{\mathbf{k}} = \rho\mathbf{a} \tag{8}$$

With $\mathbf{a} = \mathbf{0}$

$$\nabla p + \gamma\hat{\mathbf{k}} = 0 \tag{9}$$

in component form

$$\frac{\partial p}{\partial x} = 0 \quad \frac{\partial p}{\partial y} = 0 \quad \frac{\partial p}{\partial z} = -\gamma \tag{10}$$

therefore

$$\frac{dp}{dz} = -\gamma \tag{11}$$

Inviscid, Incompressible, Steady Flow

$$p + \frac{1}{2}\rho V^2 + \gamma z = \text{constant} \quad \text{along} \quad \text{streamline} \tag{12}$$

$$p + \rho \int \frac{V^2}{\mathbf{R}} dn + \gamma z = \text{constant} \quad \text{across} \quad \text{streamline} \tag{13}$$

where $\mathbf{R}$ is the radius of curvature.

Conservation of Energy (Fluids text perspective)

$$\frac{dE}{dt} + \int_{CS} (\breve{u} + \frac{p}{\rho} + \frac{V^2}{2} + gz)\rho \vec{V} \cdot \hat{n} dA = \dot{Q} + \dot{W} \tag{14}$$

$$\frac{p_e}{\rho} + \frac{V_e^2}{2} + gz_e = \frac{p_i}{\rho} + \frac{V_i^2}{2} + gz_i - \text{loss} + w_s \tag{15}$$

$$\frac{p_e}{\rho g} + \frac{V_e^2}{2g} + z_e = \frac{p_i}{\rho g} + \frac{V_i^2}{2g} + z_i - h_L + h_s \tag{16}$$

$$w_s = \frac{\dot{W}_s}{\dot{m}} \quad h_S = w_S / g \tag{17}$$

Conservation of Energy (Thermodynamics text perspective)

$$\Delta E = Q - W \tag{18}$$

$$\frac{dE}{dt} = \dot{Q} - \dot{W} \tag{19}$$

$$\frac{dE_{C.V.}}{dt} = \dot{Q}_{C.V.} - \dot{W}_{C.V.} + \sum_i \dot{m}_i (h_i + \frac{V_i^2}{2} + gz_i) - \sum_e \dot{m}_e (h_e + \frac{V_e^2}{2} + gz_e) \tag{20}$$

Reynolds Transport Theorem

$$\frac{DB_{sys}}{Dt} = \frac{\partial}{\partial t} \int_{CV} \rho b d\forall + \int_{CS} \rho b \vec{V} \cdot \hat{n} dA \tag{21}$$

Conservation of Mass (Continuity)

$$0 = \frac{\partial}{\partial t} \int_{CV} \rho d\forall + \int_{CS} \rho \vec{V} \cdot \hat{n} dA \tag{22}$$

$$\overline{V} = \frac{\int_A \rho \vec{V} \cdot \hat{n} dA}{\rho A} \tag{23}$$

Conservation of Momentum

$$\frac{\partial}{\partial t} \int_{CV} \vec{V} \rho d\forall + \int_{CS} \vec{V} \rho \vec{V} \cdot \hat{n} dA = \Sigma \vec{F} \tag{24}$$

Head loss for laminar pipe flow

$$h_{_L} = \frac{128 \mu l \dot{\forall}}{\pi D^4 \rho g} \tag{25}$$
