

**ENGR 222 Formula Sheet**  
**Please do not write on this sheet**

$$F = ma = \frac{mg}{g_c} \quad g_c = 1 \frac{kg \, m}{s^2 N} = 32.2 \frac{lbm \, ft}{s^2 \, lbf} \quad \rho = \frac{m}{V} \quad v = \frac{1}{\rho}$$

$$SG = \frac{\rho}{\rho_{H2O}} \quad \gamma = \rho g \quad P_{abs} = P_{gage} + P_{atm} = P_{atm} - P_{vac} \quad \Delta P = \rho g \Delta z$$

$$V = IR \quad \dot{W}_{elec} = VI \quad \dot{W}_{shaft} = 2\pi \dot{N} T \quad W_{spring} = \frac{k}{2}(x_2^2 - x_1^2) \quad W = \int F \, ds$$

$$ke = \frac{\vec{v}^2}{2} \quad pe = gz \quad E = m e \quad \dot{m} = \rho A \vec{v} \quad \eta = \frac{E_{output}}{E_{input}} \quad PV = ZmRT$$

$$Q - W = \Delta E_{sys} = \Delta U + \Delta KE + \Delta PE \quad x = \frac{m_{vapor}}{m_{total}} \quad v = v_f + x v_{fg} \quad v_{fg} = v_g - v_f$$

$$\Delta \dot{E}_{mech,fluid} = \dot{m} \left[ \frac{P_2 - P_1}{\rho} + \frac{\vec{v}_2^2 - \vec{v}_1^2}{2} + g(z_2 - z_1) \right] \quad P_R = \frac{P}{P_{cr}} \quad T_R = \frac{T}{T_{cr}}$$

$$T(K) = T(^{\circ}C) + 273.15 \quad T(R) = T(^{\circ}F) + 459.67$$

$$W_b = \int_1^2 P dV \quad W_b = P \Delta V = mP(v_2 - v_1) \quad W_b = P_1 V_1 \ln \left( \frac{V_2}{V_1} \right) = mRT \ln \left( \frac{P_1}{P_2} \right)$$

$$\Delta u = c_v \Delta T \quad \Delta h = c_p \Delta T \quad h = u + Pv \quad c_p = c_v + R \quad k = \frac{c_p}{c_v}$$

$$\dot{m} = \rho \dot{V} = \rho A \vec{v}_{avg} \quad m_{in} - m_{out} = \Delta m_{CV} = m_2 - m_1$$

$$\theta = Pv + u + pe + ke = h + pe + ke \quad e = u + ke + pe$$

$$Q_{in} - Q_{out} + W_{in} - W_{out} + \sum m_{in} \theta_{in} - \sum m_{out} \theta_{out} = \Delta E_{CV} = m_2 e_2 - m_1 e_1$$

$$\eta_{th} = \frac{W_{net,out}}{Q_H} = 1 - \frac{Q_L}{Q_H} \quad COP_R = \frac{Q_L}{W_{in}} = \frac{1}{\frac{Q_H}{Q_L} - 1} \quad COP_{HP} = \frac{Q_H}{W_{in}} = \frac{1}{1 - \frac{Q_L}{Q_H}} = 1 + COP_R$$

$$\left(\frac{Q_H}{Q_L}\right)_{rev} = \frac{T_H}{T_L} \quad \eta_{th,rev} = 1 - \frac{T_L}{T_H} \quad COP_{R,rev} = \frac{1}{\frac{T_H}{T_L} - 1} \quad COP_{HP,rev} = \frac{1}{1 - \frac{T_L}{T_H}}$$

$$T ds = du + P dv = dh - v dP \quad \Delta S \cong c_{avg} \ln\left(\frac{T_2}{T_1}\right) \quad \Delta S = \frac{Q}{T_0}$$

$$\Delta S \cong c_{v,avg} \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{v_2}{v_1}\right) \quad \Delta S \cong c_{p,avg} \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)$$

$$\Delta S = s_2^o - s_1^o - R \ln\left(\frac{P_2}{P_1}\right) \quad \left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = \left(\frac{v_1}{v_2}\right)^{k-1} \quad \frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}}$$

$$\eta_T = \frac{w_a}{w_s} \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}} \quad \eta_C = \frac{w_s}{w_a} \cong \frac{h_{2s} - h_1}{h_{2a} - h_1} \quad \eta_P = \frac{w_s}{w_a} \cong \frac{v(P_2 - P_1)}{h_{2a} - h_1}$$

$$\eta_N = \frac{\tilde{v}_{2a}^2}{\tilde{v}_{2s}^2} \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}} \quad \Delta S_{sys} = S_2 - S_1 = \frac{Q}{T} + S_{gen} \quad S_{gen} = \Delta S_{sys} + \Delta S_{surr}$$

$$(S_2 - S_1)_{CV} = \frac{Q}{T} + \sum m_{in} s_{in} - \sum m_{out} s_{out} + S_{gen}$$

$$r_p = \frac{P_2}{P_1} \quad \eta_{th,Brayton} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

$$\frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}} \quad r_v = \frac{v_1}{v_2} \quad \eta_{th,Otto} = 1 - \frac{1}{r_v^{k-1}}$$