ENGR 222 Formula Sheet
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$$F = ma = \frac{mg}{g_c} \qquad g_c = 1\frac{kg\ m}{s^2 N} = 32.2\ \frac{lbm\ ft}{s^2\ lbf} \qquad \rho = \frac{m}{V} \qquad v = \frac{1}{\rho}$$

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

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

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

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

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

$$T(K) = T(°C) + 273.15 \qquad T(R) = T(°F) + 459.67$$

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

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

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

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

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

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

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

$$T\,ds = du + P\,dv = dh - v\,dP \qquad \Delta s \cong c_{avg} \ln\left(\frac{T_2}{T_1}\right)$$

$$\Delta s \cong c_{v,avg} \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{v_2}{v_1}\right) \qquad \Delta s \cong c_{p,avg} \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right) \qquad \Delta S = \frac{Q}{T_0}$$

$$\left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$\Delta s = s_2^o - s_1^o - R \ln\left(\frac{P_2}{P_1}\right) \qquad \left(\frac{P_2}{P_1}\right)_{s=const.} = \frac{P_{r2}}{P_{r1}} \qquad \left(\frac{v_2}{v_1}\right)_{s=const.} = \frac{v_{r2}}{v_{r1}}$$

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

$$\eta_N = \frac{\frac{1}{2}\vec{v}_{2a}^2}{\frac{1}{2}\vec{v}_{2s}^2} \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}} \qquad \Delta S_{sys} = S_2 - S_1 = \frac{Q}{T} + S_{gen} \qquad S_{gen} = \Delta S_{sys} + \Delta S_{surr}$$

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

$$r_p = \frac{P_2}{P_1} \qquad \eta_{th,Brayton} = 1 - \frac{1}{r_p^{\frac{(k-1)}{k}}} \qquad MEP = \frac{w_{net}}{v_{max} - v_{min}}$$

$$r_v = \frac{v_1}{v_2} \qquad \eta_{th,Otto} = 1 - \frac{1}{r_v^{k-1}} \qquad r_c = \frac{v_3}{v_2} \qquad \eta_{th,Diesel} = 1 - \frac{1}{r_v^{k-1}}\left[\frac{r_c^k - 1}{k(r_c - 1)}\right]$$