EQUATIONS

Conservation of Energy

$$\Delta E = Q - W \qquad \frac{dE}{dt} = \dot{Q} - \dot{W} \tag{1}$$

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

Entropy Balance

$$\Delta S = \int_1^2 \left(\frac{\delta Q}{T}\right)_b + \sigma \qquad \Delta S = \sum_j \frac{Q_j}{T_j} + \sigma \qquad \frac{dS}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \dot{\sigma} \tag{3}$$

$$\frac{dS_{C.V.}}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{\sigma}_{C.V.} \tag{4}$$

$$v = (1 - x) v_f + x v_g \tag{5}$$

$$\overline{R} = 8.314 \mathrm{kJ/kmole \cdot K} \quad \overline{R} = 1545 \mathrm{ft \cdot lbf/lbmol \cdot ^\circ R} \quad \overline{R} = 1.986 \mathrm{Btu/lbmol \cdot ^\circ R} \tag{6}$$

$$c_p = \left(\frac{\partial h}{\partial T}\right)_p \qquad c_v = \left(\frac{\partial u}{\partial T}\right)_v \tag{7}$$

$$\eta = \frac{W_{cycle}}{Q_H} = 1 - \frac{Q_C}{Q_H} \qquad \beta = \frac{Q_C}{Q_H - Q_C} \qquad \gamma = \frac{Q_H}{Q_H - Q_C} \tag{8}$$

$$\eta_{max} = 1 - \frac{T_C}{T_H} \qquad \beta_{max} = \frac{T_C}{T_H - T_C} \qquad \gamma_{max} = \frac{T_H}{T_H - T_C} \tag{9}$$

$$T ds = du + p dv \qquad T ds = dh - v dp \tag{10}$$

$$T(^\circ F) = T(^\circ R) - 459.67 \quad 1\mathrm{Btu} = 778.17 \mathrm{ft \cdot lbf} \qquad 1\mathrm{lbf} = 32.174 \mathrm{lb \cdot ft/s^2} \qquad 1\mathrm{J} = 0.73756 \mathrm{ft \cdot lbf} \tag{11}$$

Isentropic Relations, Ideal Gas

$$\frac{p_2}{p_1} = \frac{p_{r2}}{p_{r1}} \qquad \frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}} \tag{12}$$

Isentropic Relations, Ideal Gas, Constant Specific Heats

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} \qquad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1} \tag{13}$$

Ideal Gas

$$\Delta s = s^\circ(T_2) - s^\circ(T_1) - R ln(p_2/p_1) \qquad c_p = \frac{kR}{k-1} \qquad c_v = \frac{R}{k-1} \tag{14}$$

Isentropic Efficiencies

$$\eta_{turbine} = \frac{\dot{W}/\dot{m}}{(\dot{W}/\dot{m})_s} \qquad \eta_{compressor} = \frac{(\dot{W}/\dot{m})_s}{\dot{W}/\dot{m}} \qquad \eta_{nozzle} = \frac{V_2^2/2}{(V_2^2/2)_s} \tag{15}$$