Midterm 1 Relations Sheet

Conservation of Energy (rate basis) $\dot{E}_{in} + \dot{E}_g + \dot{E}_{out} = \dot{E}_{st}$

Heat Diffusion Equation: $\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{q} = \rho c_p \frac{\partial T}{\partial t}$

Fourier's Law (Cartesian): $q_x = -kA\frac{dT}{dx}$

Fourier's Law (cylindrical): $q_r = -kA\frac{dT}{dr}$

Newton's Law: $q = hA\left(T - T_\infty\right)$

<u>Thermal Resistances</u>

Conduction Resistance, Plane Wall: $R_{t,cond} = \frac{L}{kA}$

Conduction Resistance, Cylinder: $R_{t,cond} = \frac{\ln\left(r_2 / r_1\right)}{2\pi Lk}$

Conduction Resistance, Sphere: $R_{t,cond} = \frac{1}{4\pi k}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

Contact Resistance: $R''_{t,c} = \frac{T_A - T_B}{q''_x}$

Convection Resistance: $R_{t,conv} = \frac{1}{hA}$

<u>Extended Surfaces</u>

Temperature distribution, very long fin: $\frac{\theta}{\theta_b} = e^{-\sqrt{\frac{hP}{kA_c}}x}$

Fin effectiveness: $\varepsilon_f = \frac{q_f}{hA_{c,b}\theta_b}$

Fin efficiency: $\eta_f = \frac{q_f}{q_{\max}} = \frac{q_f}{hA_f\theta_b}$

<u>Transient Heat Transfer</u>

Biot Number: $B_i = \frac{hL}{k}$

Lumped Capacitance Method: $\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\left(\frac{hA_s}{\rho Vc}\right)t\right]$

Characteristic Lengths:

Plane Wall, thickness 2L: $L_c = L$

Cylinder: $L_c = r_0 / 2$

Sphere: $L_c = r_0 / 3$