MECH ENG 3RO3 Formula Sheet

formula sheet

Change in Internal Energy

$Q = mc_p\Delta T$

$q = m'c_p\Delta T$

$m' = \frac{q}{H}$

Steady-Heat Transfer without Heat Sources, without Radiation

Plates,

$$q = \frac{A\Delta T}{\frac{1}{h_i}+\sum_{i=1}^{n}\frac{L_i}{k_i}+\frac{1}{h_o}}$$

Cylinders,

$$q = \frac{2\pi L\Delta T}{\frac{1}{h_i r_i}+\sum_{i=1}^{n}\frac{\ln\left(\frac{r_{i+1}}{r_i}\right)}{k_i}+\frac{1}{h_o r_0}}$$

Spheres,

$$q = \frac{4\pi\Delta T}{\frac{1}{h_i r_i^2}+\sum_{i=1}^{n}\frac{\frac{1}{r_i}-\frac{1}{r_{i+1}}}{k_i}+\frac{1}{h_o r_0^2}}$$

Radiation

$q = \varepsilon\sigma A(T_1^4 - T_2^4)$

$\sigma = 5.67 \times 10^{-8}\frac{W}{m^2 * K}$

$\varepsilon = Surface Emisivity, 0 < \varepsilon < 1$

Heat Transfer with Heat Sources

Plates,

...

Sphere,

$r_{crit} = \frac{2k}{...}$

$\frac{...}{T_b - T_\infty} = \frac{...}{\cosh(mL)}$

$q = \sqrt{hpkA_c}\Delta T \tanh(mL)$

Specified fin tip temperature,

$$\frac{T(x)-T_\infty}{T_b-T_\infty} = \frac{\left[\frac{T_L-T_\infty}{T_b-T_\infty}\right]\sinh(mx)+\sinh(m(L-x))}{\sinh(mL)}$$

$$q = \sqrt{hpkA_c}\Delta T\frac{\cosh(mL)-\left[\frac{T_L-T_\infty}{T_b-T_\infty}\right]}{\sinh(mL)}$$

Convection from Fin Tip,

$$\frac{T(x)-T_\infty}{T_b-T_\infty} = \frac{\cosh(m(L-x))+\left(\frac{h}{mk}\right)\sinh(m(L-x))}{\cosh(mL)+\left(\frac{h}{mk}\right)\sinh(mL)}$$

$$q = \sqrt{hpkA_c}\Delta T\frac{\sinh(mL)+\left(\frac{h}{mk}\right)\cosh(mL)}{\cosh(mL)+\left(\frac{h}{mk}\right)\sinh(mL)}$$

Fin Efficiency,

$\eta_{fin} = \frac{q_{fin}}{q_{fin,max}}$

$\eta_{longfin} = \frac{1}{mL}$

$\eta_{adiabatictip} = \frac{\tanh(mL)}{mL}$

$\eta_{fin} \sim L_c^{\frac{3}{2}}\left(\frac{h}{kA_p}\right)^{\frac{1}{2}} = L_c\left(\frac{h}{kt}\right)^{\frac{1}{2}}$

$L_c = \frac{...}{A_s}$

4-2
4
255

$Re_x = \frac{\rho V x}{\mu} = \frac{Vx}{\nu}$

$Nu_x = \frac{h_x x}{k_f}$

$Pr = \frac{\nu}{\alpha} = \frac{\mu c_p}{k}$

External Forced Convection

$Nu = CRe_L^m Pr^n$

Flat Plate, pg. 430

Across Cylinder/Sphere, pg. 442

Across Tube Bank, pg. 446

Internal Forced Convection

$Nu = CRe_{Dh}^m Pr^n$

$D_h = 4\frac{A_{cross-section}}{perimeter}$

$\Delta T_{LM}^* = \frac{T_{in}-T_{out}}{\ln\left(\frac{T_S-T_{out}}{T_S-T_{in}}\right)}$

$T_{properties} = \frac{T_{in}+T_{out}}{2}$

*Use T_{LM} when $T_S = C$

$q'^{**} = m'c_p(T_{out} - T_{in})$

**For $q' = C$

...inar $\approx 0.05RePrD$

...ulent $\approx 10D$

...w, pg. 485

...low, pg. 496

...vection

$Gr_L = \frac{g\beta(T_s-T_\infty)L_c^3}{\nu^2}$