ME 353 HEAT TRANSFER I
SUMMARY OF CONVECTION CORRELATION EQUATIONS

Laminar and Turbulent Forced External Flow

Flat Plate, Laminar Boundary Layer Flow

$\delta = 5xRe_x^{-1/2}$	$100 < Re_x < 500,000$	Local
$C_{f,x} = 0.664Re_x^{-1/2}$	$100 < Re_x < 500,000$	Local
$\bar{C}_{f,x} = 1.328Re_x^{-1/2}$	$100 < Re_x < 500,000$	Area-Average
$\Delta = \delta Pr^{-1/3}$	$100 < Re_x < 500,000$	Local
$\frac{Nu_x}{Re_x^{1/2}} = 0.3387Pr^{1/3}$	$100 < Re_x < 500,000$	Local, UWT, $Pr \to \infty$
$\frac{Nu_x}{Re_x^{1/2}} = 0.564Pr^{1/2}$	$100 < Re_x < 500,000$	Local, UWT, $Pr \to 0$
$\frac{Nu_x}{Re_x^{1/2}} = \frac{0.3387Pr^{1/3}}{\left[1+(0.0468/Pr)^{2/3}\right]^{1/4}}$	$100 < Re_x < 500,000$	Local, UWT, $0 < Pr < \infty$
$\frac{Nu_x}{Re_x^{1/2}} = 0.4637Pr^{1/3}$	$100 < Re_x < 500,000$	Local, UWF, $Pr \to \infty$
$\frac{Nu_x}{Re_x^{1/2}} = 0.886Pr^{1/2}$	$100 < Re_x < 500,000$	Local, UWF, $Pr \to 0$
$\frac{Nu_x}{Re_x^{1/2}} = \frac{0.4637Pr^{1/3}}{\left[1+(0.0205/Pr)^{2/3}\right]^{1/4}}$	$100 < Re_x < 500,000$	Local, UWF, $0 < Pr < \infty$
$\frac{Nu_L}{Re_L^{1/2}} = \frac{0.6774Pr^{1/3}}{\left[1+(0.0468/Pr)^{2/3}\right]^{1/4}}$	$100 < Re_L < 500,000$	Average, UWT, $0 < Pr < \infty$
$\frac{\bar{N}u_L}{Re_L^{1/2}} = \frac{0.9274Pr^{1/3}}{\left[1+(0.0205/Pr)^{2/3}\right]^{1/4}}$	$100 < Re_L < 500,000$	Average, UWF, $0 < Pr < \infty$

Flat Plate, Turbulent Boundary Layer Flow

$\delta = 0.37xRe_x^{-1/5}$	$5 \times 10^5 < Re_x < 10^8$	Local
$C_{f,x} = 0.0592Re_x^{-1/5}$	$5 \times 10^5 < Re_x < 10^8$	Local
$\bar{C}_{f,L} = 0.074Re_L^{-1/5} - 1742Re_L^{-1}$	$Re_{x,c} = 5 \times 10^5$	Mixed-Average
$\Delta = \delta Pr^{-1/3}$	$100 < Re_x < 500,000$	Local
$Nu_x = 0.0296Re_x^{4/5}Pr^{1/3}$	$100 < Re_x < 500,000$	Local, UWT, $0.6 < Pr < 60$
$\bar{N}u_L = \left(0.037Re_L^{4/5} - 871\right) Pr^{1/3}$	$100 < Re_x < 500,000$	Average, UWT, $0.6 < Pr < 60$

Cross Flow Over Circular Cylinders

$\bar{N}u_D = S_D^\star + \frac{0.6 Re_D^{1/2} Pr^{1/3}}{\left[1+(0.4/Pr)^{2/3}\right]^{1/4}} \left[1 + \left(\frac{Re_D}{282{,}000}\right)^{5/8}\right]^{4/5}$	$100 < Re_D < 10^7$	Average, UWT, $0 < Pr < \infty$
$S_D^\star = \frac{4}{\pi}\left(\frac{1+0.869(L/D)^{0.76}}{0.5+L/D}\right)$	$0 \leq L/D \leq 8$	Diffusive Limit $Re_D \to 0$
$S_D^\star = \frac{4}{\sqrt{\pi}}\left(\frac{1}{\sqrt{1+0.5D/L}}\right)\frac{1}{\ln(2L/D)}$	$L/D \geq 8$	Diffusive Limit, Asymptote

Flow Over Spheres

$C_D = 0.4 + \frac{24}{Re_D} + \frac{6}{1+\sqrt{Re_D}}$	$0 \leq Re_D \leq 2 \times 10^5$	Total Drag, $\pm 10\%$
$\bar{N}u_D = 2 + \frac{0.6 Re_D^{1/2} Pr^{1/3}}{\left[1+(0.4/Pr)^{2/3}\right]^{1/4}} \left[1 + \left(\frac{Re_D}{282{,}000}\right)^{5/8}\right]^{4/5}$	$100 < Re_D < 10^7$	Average, UWT, $0 < Pr < \infty$

Laminar and Turbulent Forced Internal Flow

Laminar Flow Inside Circular Pipes $Re_D < 2300$

Definitions and Notation

Hydraulic Diameter, $D_h = 4\frac{A}{P}$, A is the cross-section area, and P is the wetted perimeter of the cross-section.

Dimensionless axial distance:

$x^\star = \frac{x}{D_h Pe} = \frac{x}{D_h Re Pr} = \frac{\pi}{4}\frac{1}{Gz}$

Local, Isothermal Wall, Nusselt number:

$Nu_{x,T} = \frac{q_w(x)}{[T_w - T_m(x)]}\frac{D_h}{k}$

Mean-value, Isothermal Wall, Nusselt number:

$Nu_{m,T} = \frac{q_w}{[T_w - T_m(x)]}\frac{D_h}{k}$

Local, Isoflux Wall, Nusselt number:

$Nu_{x,q} = \frac{q_w}{[T_w(x) - T_m(x)]}\frac{D_h}{k}$

Mean-value, Isoflux Wall, Nusselt number:

$Nu_{x,q} = \frac{q_w}{[T_w(x) - T_m(x)]}\frac{D_h}{k}$