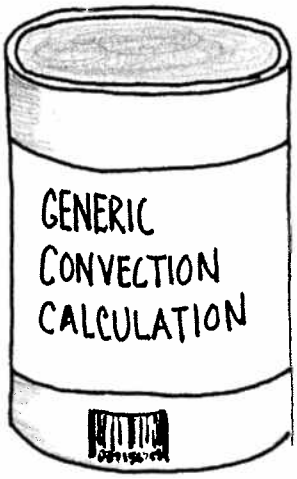
HOW TO PERFORM A → **II - Internal Flow**



1. BECOME AWARE of THE GEOMETRY. IF ITS A *NON-CIRCULAR DUCT*, FIND

$$D_h \equiv \frac{4A_c}{P}$$

THE HYDRAULIC DIAMETER

2. SPECIFY THE APPROPRIATE REFERENCE TEMPERATURE ∗ FIND THE FLUID PROPERTIES. USUALLY (NOT ALWAYS) YOU WANT THE

BULK MEAN FLUID TEMPERATURE

$$T_b \equiv \frac{T_{m,in} + T_{m,out}}{2}$$

3. CALCULATE THE REYNOLD'S NUMBER

$$Re \equiv \frac{\rho V (D \text{ or } D_h)}{\mu} = \frac{V (D \text{ or } D_h)}{\nu}$$

CAREFUL!

∗ DETERMINE IF THE FLOW IS

FULLY-DEVELOPED -or- DEVELOPING

4. DETERMINE THE BOUNDARY CONDITION. IF ITS T_s = CONSTANT (& YOU WANT THE AVERAGE h) YOU NEED THE

LOG MEAN TEMPERATURE DIFFERENCE

$$\Delta T_{LM} \equiv \frac{(T_s - T_{m,out}) - (T_s - T_{m,in})}{\ln \dfrac{T_s - T_{m,out}}{T_s - T_{m,in}}}$$

5. SELECT THE APPROPRIATE CORRELATION...

SUMMARY of CORRELATIONS (FOR INTERNAL FLOW)

Correlations for T_S = const. Boundary Condition

Correlation	Geometry	Conditions
$f = 64/Re_D$	Circular duct	Laminar, Fully developed, Use T_b
$Nu_D = 3.66$	Circular duct	Laminar, Fully developed, Use T_b
$Nu = 1.86\left(\frac{RePrD}{L}\right)^{1/3}\left(\frac{\mu}{\mu}\right)^{0.14}$	Circular duct	Laminar, Developing, Use T_b for all properties except μ_S, for which you use T_S
f = constant/Re_{Dh}	Non-circular duct	Laminar, Fully developed, Use T_b, Use Tables in text to find constant
Nu_{Dh} = constant	Non-circular duct	Laminar, Fully developed, Use T_b, Use Tables in text to find constant
$f = 0.184Re_{Dh}^{-0.2}$	Circular or non-circular ducts	Turbulent, Fully developed, **smooth surfaces**, Use T_b
$f \Rightarrow$ Use Moody Chart	Circular or non-circular ducts	Turbulent, Fully developed, smooth or rough surfaces, Use T_b
$Nu_{Dh} = 0.125*f*Re_{Dh}*Pr^{1/3}$	Circular or non-circular ducts	Turbulent, Fully developed, smooth or rough surfaces, Use T_b
$Nu_{Dh} = 0.023*Re_{Dh}^{0.8}*Pr^n$ n = 0.4 for heating, = 0.3 for cooling	Circular or non-circular ducts	Turbulent, Fully developed, smooth or rough surfaces, Use T_b, $0.7 < Pr < 160$, $Re > 10{,}000$

Correlations for $\dot{q}$ = const. Boundary Condition

Correlation	Geometry	Conditions
$Nu_D = 4.36$	Circular duct	Laminar, Fully developed, Use T_b
Nu_{Dh} = constant	Non-circular duct	Laminar, Fully developed, Use T_b, Use Tables in text to find constant

Turbulent flow is rather insensitive to boundary conditions. Use previous correlations.

TMA