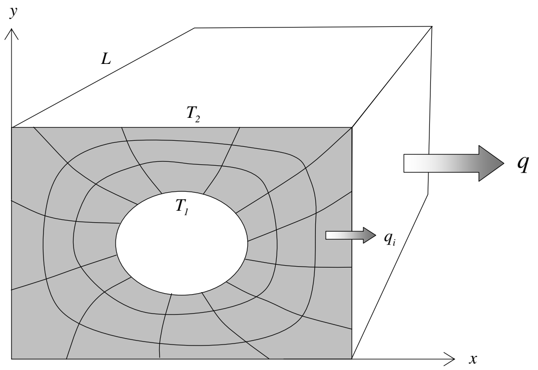
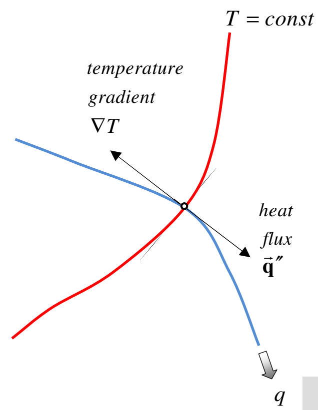
SHAPE FACTOR 2-D STEADY STATE CONDUCTION *graphical method*

Graphical method: construct a network of isotherms and adiabates



Regions with adiabatic and isothermal boundaries:

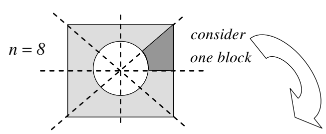


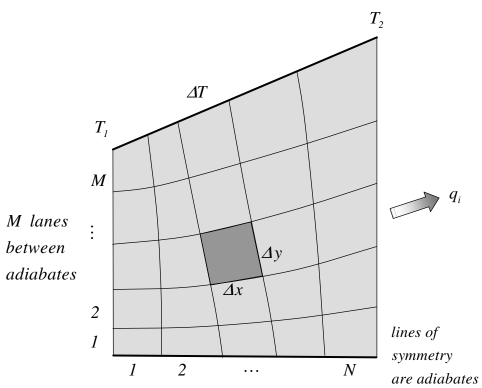
isotherms *are lines of constant temperature*

isotherms and adiabates are perpendicular to each other at the points of intersection

adiabates *are lines of heat flow*

Graphical Method



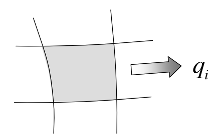


N lanes between isotherms

1. *Find lines of symmetry (to consider the smallest region)*
   n = number of symmetric blocks

2. *Sketch evenly distributed isotherms T = const :*
   N = number of lanes between isotherms

3. *Sketch heat flow lines (adiabates)*
   to create a network with approximately square cells:
   M = number of lanes between adiabates



4. *Calculate:*

$$q_i = q_i'' \cdot A = k \cdot \frac{\Delta T}{\cancel{\boxed{\Delta x}}} \cdot \cancel{\boxed{\Delta y}} \cdot L = k \cdot \frac{T_1 - T_2}{N} \cdot L$$

heat transfer from one lane

$$q = q_i \cdot M \cdot n = \left(k \cdot \frac{T_1 - T_2}{N} \cdot L \right) \cdot M \cdot n = k \cdot (T_1 - T_2) \cdot \overbrace{\left(\frac{L \cdot M}{N} \right)}^{S} \cdot n$$

total rate of heat transfer

5. *Calculate the* ***shape factor****:*

$$S = \frac{M \cdot L}{N}$$

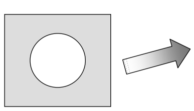
2 – D conduction resistance:

$$R_{t,2D} = \frac{1}{k \cdot S}$$

6. *Calculate the heat transfer rate:*

$$q = k \cdot S \cdot (T_1 - T_2) \cdot n$$

$$q = \frac{T_1 - T_2}{R_{t,2D}} \cdot n$$



total rate of heat transfer

$$q = q_i \cdot M \cdot n$$

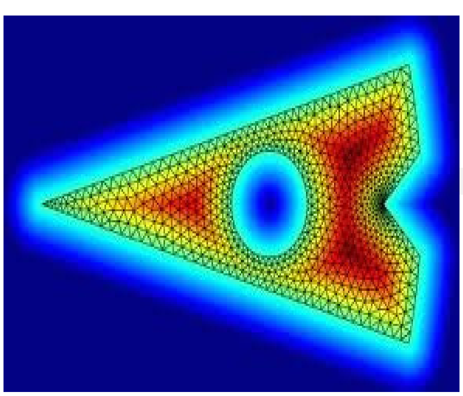
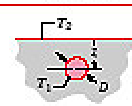
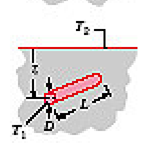


TABLE 4.1 Conduction shape factors and dimensionless conduction heat rates for selected systems.

(a) Shape factors [$q = Sk(T_1 - T_2)$]

System	Schematic	Restrictions	Shape Factor
Case 1 Isothermal sphere buried in a semi-infinite medium		$z > D/2$	$\frac{2\pi D}{1 - D/4z}$
Case 2 Horizontal isothermal cylinder of length L buried in a semi-infinite medium		$L \gg D$ $L \gg D$ $z > 3D/2$	$\frac{2\pi L}{\cosh^{-1}(2z/D)}$ $\frac{2\pi L}{\ln(4z/D)}$