HEAT TRANSFER

There are three modes of heat transfer: conduction, convection, and radiation.

BASIC HEAT TRANSFER RATE EQUATIONS

Conduction

Fourier's Law of Conduction

$$\dot{Q} = -kA\frac{dT}{dx}, \text{ where}$$

$\dot{Q}$ = rate of heat transfer (W)
k = the thermal conductivity [W/(m•K)]
A = the surface area perpendicular to direction of heat transfer (m^2)

Convection

Newton's Law of Cooling

$$\dot{Q} = hA\left(T_w - T_\infty\right), \text{ where}$$

h = the convection heat transfer coefficient of the fluid [W/(m^2•K)]
A = the convection surface area (m^2)
T_w = the wall surface temperature (K)
T_∞ = the bulk fluid temperature (K)

Radiation

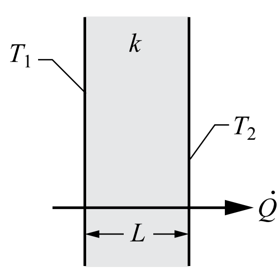
The radiation emitted by a body is given by

$$\dot{Q} = \varepsilon\sigma A T^4, \text{ where}$$

ε = the emissivity of the body
σ = the Stefan-Boltzmann constant
= 5.67×10^{-8} W/(m^2•K^4)
A = the body surface area (m^2)
T = the absolute temperature (K)

CONDUCTION

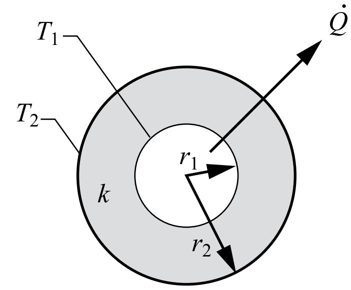
Conduction Through a Plane Wall



$$\dot{Q} = \frac{-kA\left(T_2 - T_1\right)}{L}, \text{ where}$$

A = wall surface area normal to heat flow (m^2)
L = wall thickness (m)
T_1 = temperature of one surface of the wall (K)
T_2 = temperature of the other surface of the wall (K)

Conduction Through a Cylindrical Wall

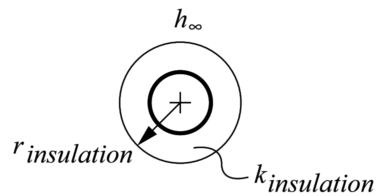


Cylinder (Length = L)

$$\dot{Q} = \frac{2\pi kL\left(T_1 - T_2\right)}{\ln\left(\frac{r_2}{r_1}\right)}$$

Critical Insulation Radius

$$r_{cr} = \frac{k_{insulation}}{h_\infty}$$



Thermal Resistance (R)

$$\dot{Q} = \frac{\Delta T}{R_{total}}$$

Resistances in series are added: $R_{total} = \Sigma R$, where

Plane Wall Conduction Resistance (K/W): $R = \frac{L}{kA}$, where
L = wall thickness

Cylindrical Wall Conduction Resistance (K/W): $R = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi kL}$, where
L = cylinder length

Convection Resistance (K/W) : $R = \frac{1}{hA}$

Composite Plane Wall