MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING

2.051 Introduction to Heat Transfer

Equation Sheet (Fall 2015)

Mode of Heat Transfer	Equation	
Conduction	$\dot{q} = -k\vec{\nabla}T$	Fourier's Law
Convection	$\dot{Q} = hA(T_s - T_\infty)$	Newton's law of cooling
Radiation	$\dot{Q}_{12} = \varepsilon_1 \sigma A(T_1^4 - T_2^4)$ where $\sigma = 5.67\times10^{-8}\ \mathrm{W/(m^2K^4)}$, ε_1 = emissivity of object (1)	Radiation heat transfer from a small grey object (1) to a large isothermal environment (2)

STEADY HEAT TRANSFER:

Mode of Heat Transfer		Resistance [K/W]
Conduction	Slab	$R_{cond} = L/(kA)$
	Cylindrical (radial direction)	$R_{cond} = \dfrac{\ln(r_{out}/r_{in})}{2\pi kL}$
	Spherical (radial direction)	$R_{cond} = \left(\frac{1}{r_{in}} - \frac{1}{r_{out}}\right)\Big/\left(4\pi k\right)$
Convection		$R_{conv} = 1/(hA)$
Radiation		$R_{rad} = 1/(h_r A)$ where $h_r = 4\varepsilon_1 \sigma T_{avg}^3$ when $T_1 \approx T_2$

Steady state heat equation with energy generation:

Planar coordinate $$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{q}_{gen} = 0$$

Cylindrical coordinate $$\frac{1}{r}\frac{\partial}{\partial r}\left(kr\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial}{\partial \phi}\left(k\frac{\partial T}{\partial \phi}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{q}_{gen} = 0$$

2.051 Introduction to Heat Transfer
Fall 2015