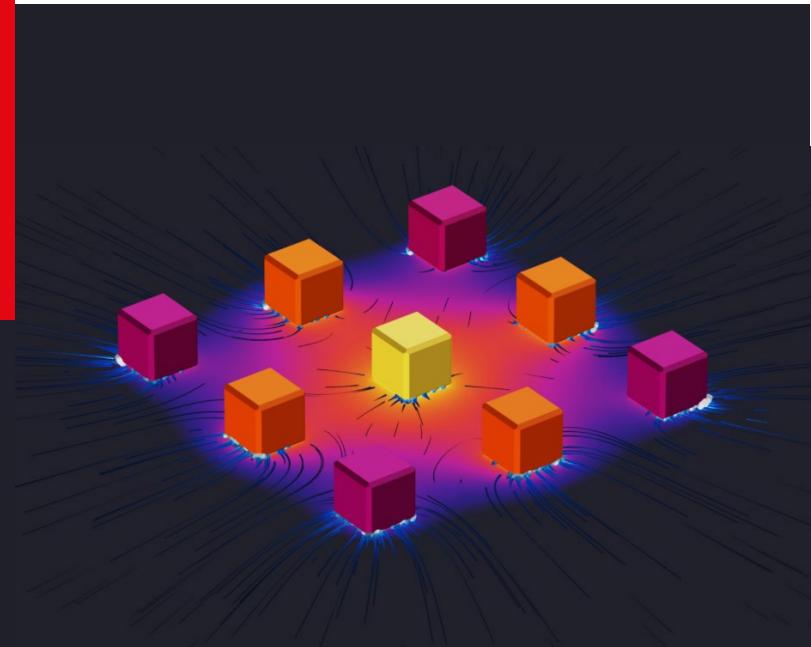


Heat and Mass Transfer

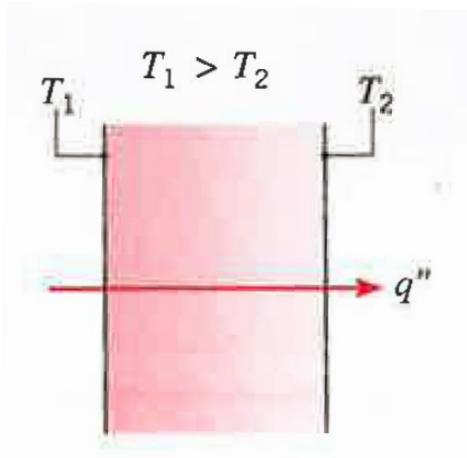
ME-341

Instructor: Giulia Tagliabue

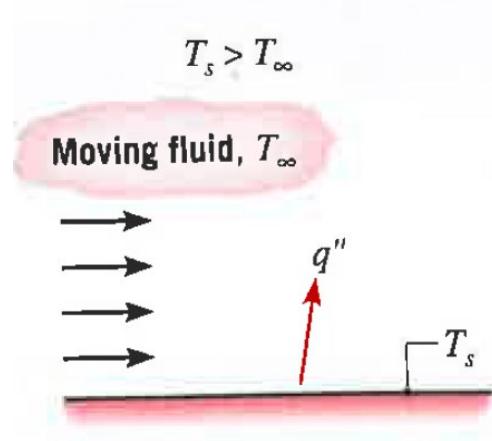


Heat Transfer Mechanisms

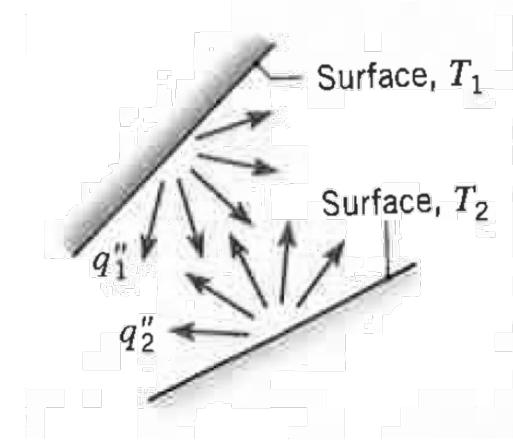
Conduction



Convection



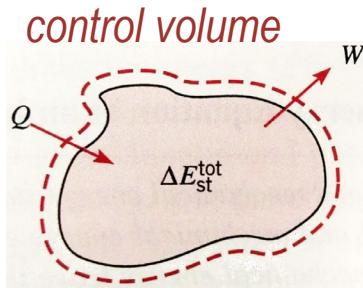
Radiation



Involves mass transport

Involve physical contact

Part I – Fourier's Law and Heat Conduction

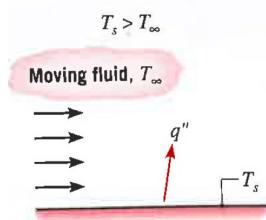


$$\frac{dE_{st}}{dt} = \dot{U} = Q - W + \dot{E}_{gen}$$

$$q'' = -k \frac{dT}{dx}$$

- Heat Diffusion Equation (HDE) 3D
- HDE Steady-state 1D Solutions with/without Heat Sources
- Thermal Resistances and Equivalent Electrical Circuits
- Fins and Arrays of Fins
- Transient HDE
 - Lumped Capacitance Model $T(t)$
 - 1D Spatial Effects $T(X,t)$
 - Semi-Infinite Solid
 - Periodic BC

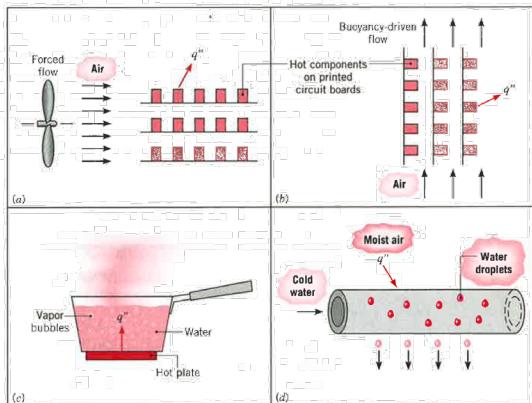
Part II: Newton's Law and Heat Convection



$$q'' = \bar{h} (T_s - T_\infty)$$

h = convective heat transfer coefficient,
[W/m²K]

Forced Convection

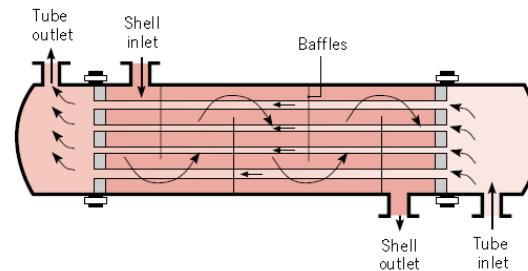


Free Convection



Boiling

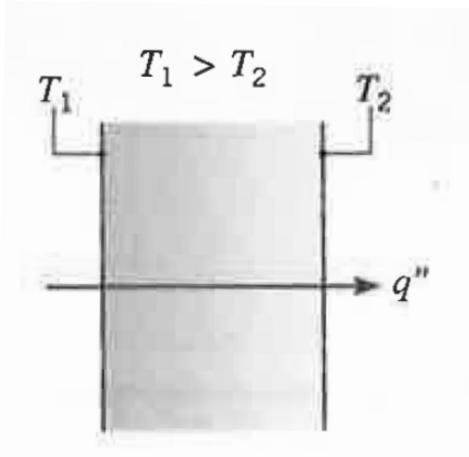
Condensation



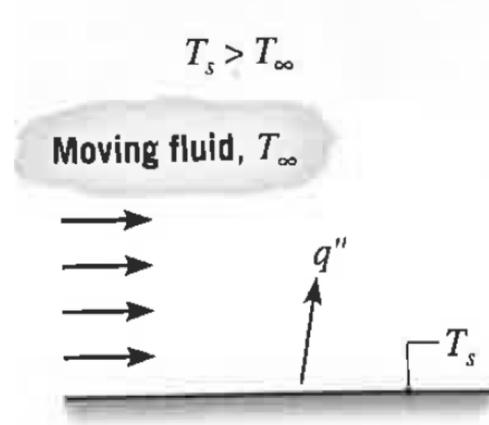
Heat Exchanger Design and Performance Analysis

Heat Transfer Mechanisms

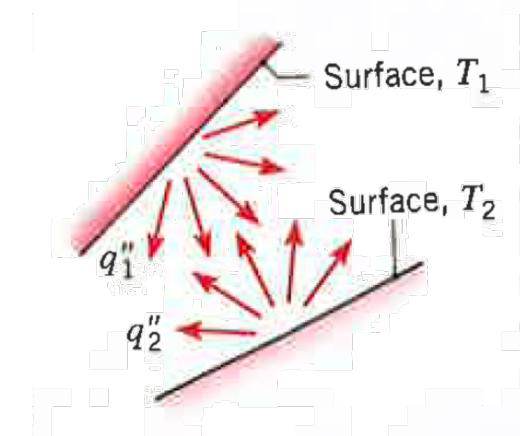
Conduction



Convection



Radiation



Involves mass transport

Involve physical contact

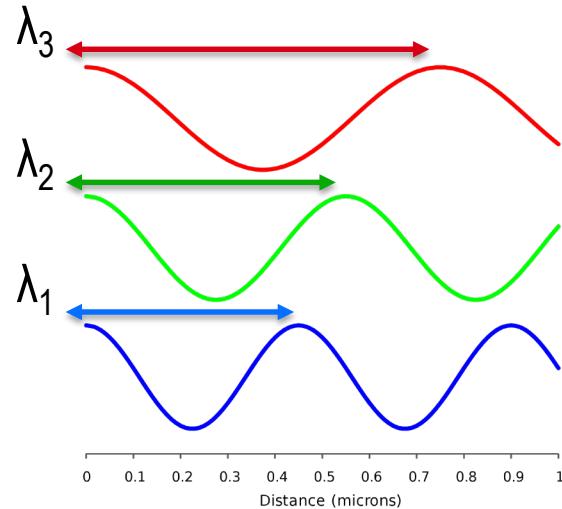
This Lecture

- Introduction to Radiation

Electromagnetic Radiation

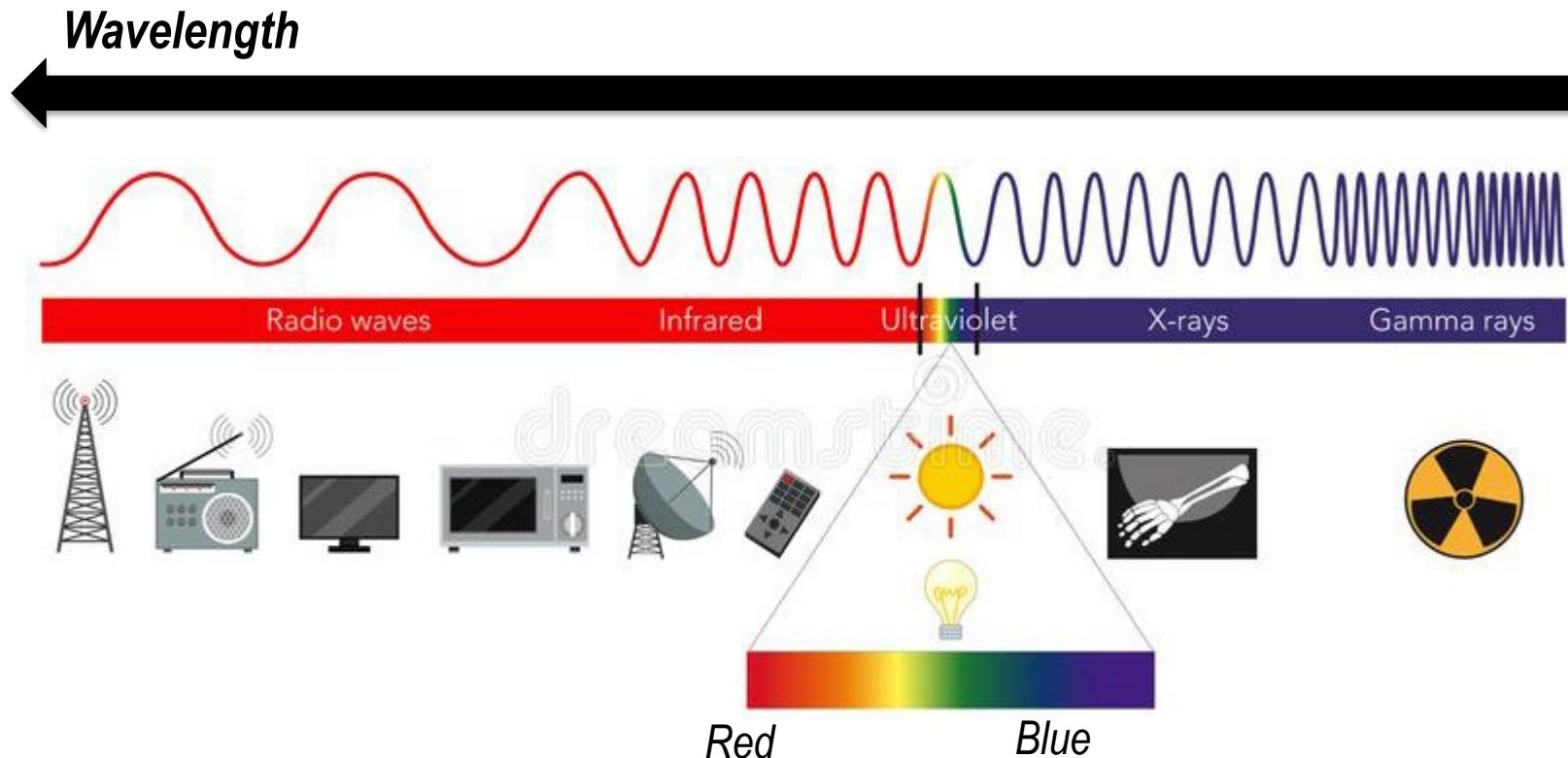


$\lambda = \text{wavelength}$



$$c = \lambda v$$

Electromagnetic Radiation



Thermal Radiation

High T



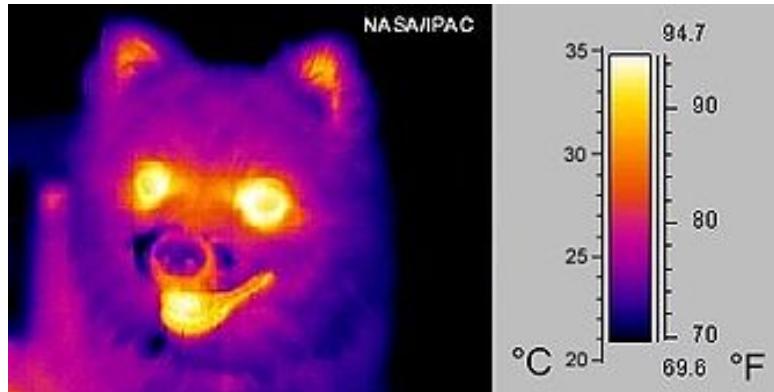
Very Bright Visible Light Emission

Medium T



Visible Light Emission

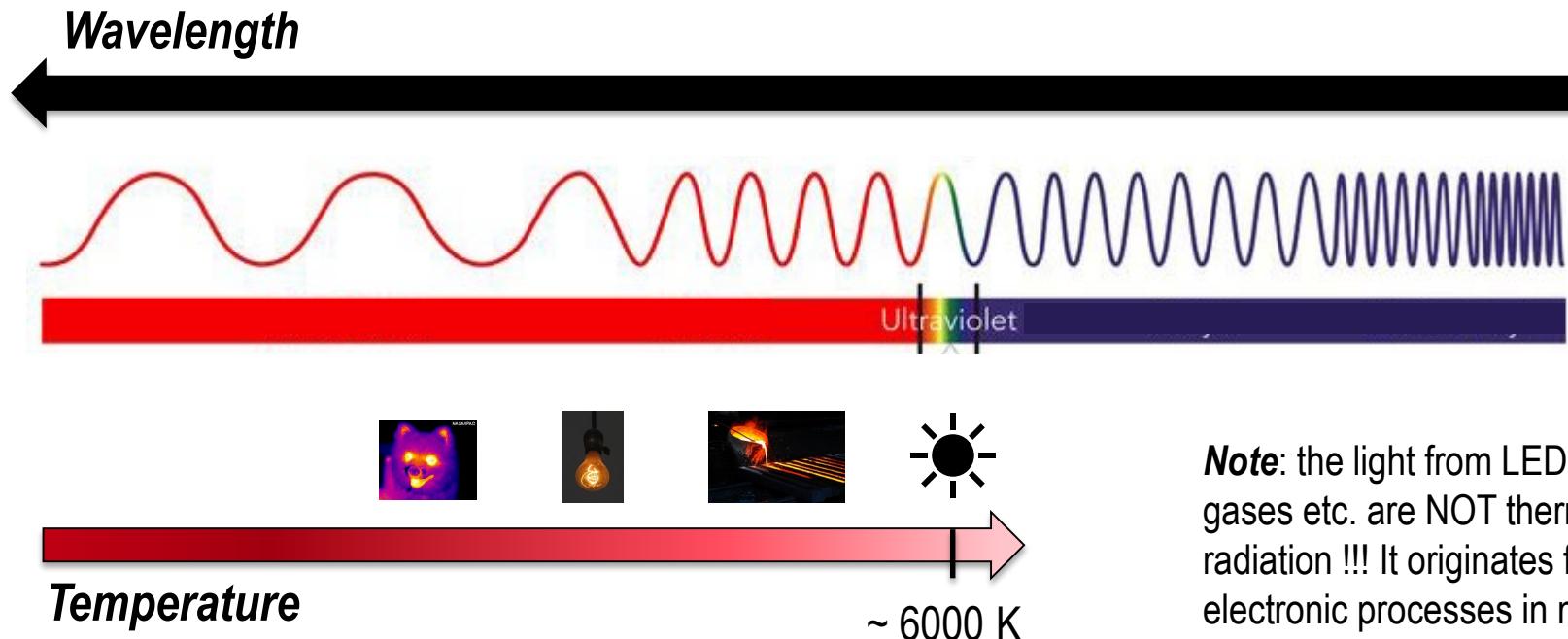
Low T



Infrared Light Emission (needs IR camera)

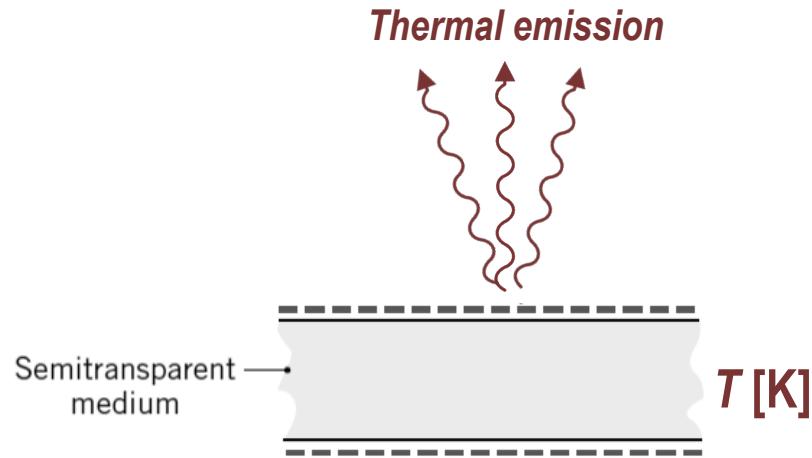
What is the relationship between the temperature of an object and its **emission** of electromagnetic waves (intensity and wavelength)?

Thermal Radiation



Note: the light from LEDs, from gases etc. are NOT thermal radiation !!! It originates from electronic processes in materials.

Thermal Radiation



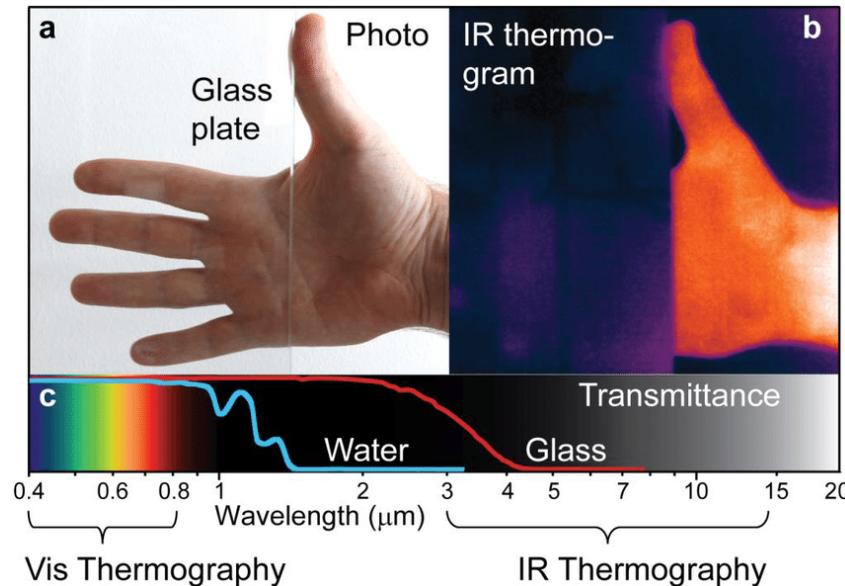
Temperature and material properties determine how an object EMIT thermal radiation.

Thermal Radiation



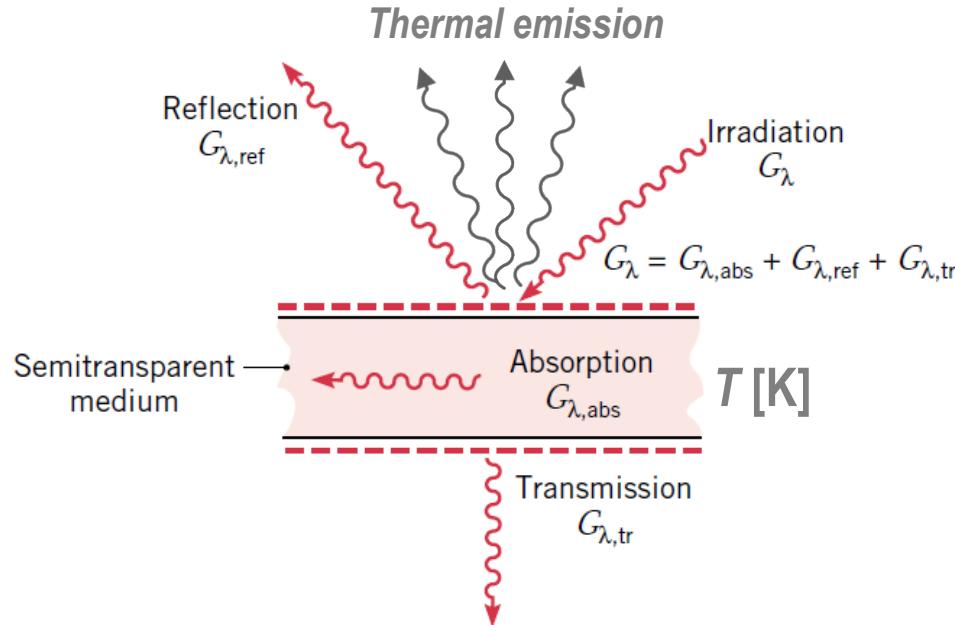
How does thermal radiation **interacts** with various objects?

Thermal Radiation



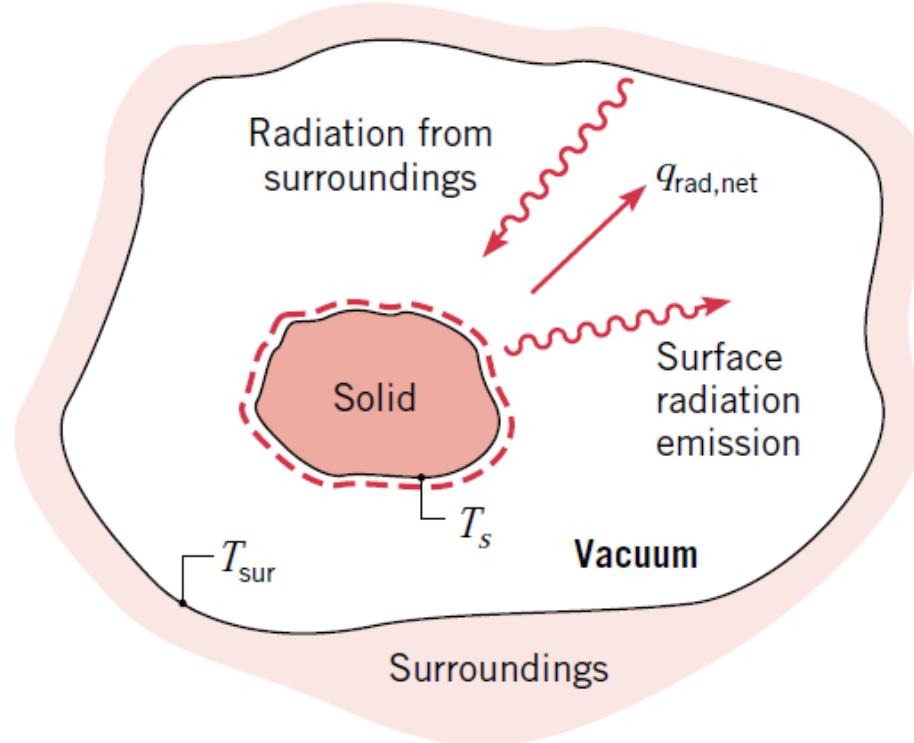
How does thermal radiation **interacts** with various objects?

Thermal Radiation



Wavelength and material properties determine how thermal radiation interacts with objects.

Radiative Heat Transfer



This Lecture



Introduction to Radiation

Next Lectures

- Emission of Thermal Radiation
 - Spatial distribution and Diffuse Emitter
 - Spectral distribution
 - Stephan-Boltzmann and Wien's laws
- Interaction of Thermal Radiation with Matter
 - Absorptivity, Reflectivity and Transmissivity
 - Irradiation and Radiosity
- Black-body
- Real surfaces: Emissivity, Diffuse & Gray Surfaces, Kirchoff's Laws