Radiation Heat Transfer

- Radiation is the energy emitted by matter in the form of *electromagnetic waves* as a result of the changes in the electronic configurations of the atoms or molecules.
- In heat transfer studies we are interested in *thermal radiation* (radiation emitted by bodies because of their temperature).
- Although we will focus on radiation from solid surfaces, emissions may also occur from liquids and gases.
- Heat transfer by radiation does not require the presence of an *intervening medium*.
- Heat transfer through a vacuum is by radiation only since conduction or convection requires the presence of a material medium.

Radiation - Emission

- The maximum rate of radiation that can be emitted from a surface **(emissive power)** at a thermodynamic temperature T_s (in K or R) is given by the Stefan–Boltzmann law as

$$\dot{Q}_{emit,\max} = \sigma A_s T_s^4 \qquad \text{(W)}$$

σ = 5.670*10^{-8} W/m^2·K^4 is the *Stefan–Boltzmann constant.*

- The **idealized surface** that emits radiation at this **maximum rate** is called a **blackbody.**

- The radiation heat flux emitted by all real surfaces is less than the radiation emitted by a blackbody at the same temperature, and is expressed as

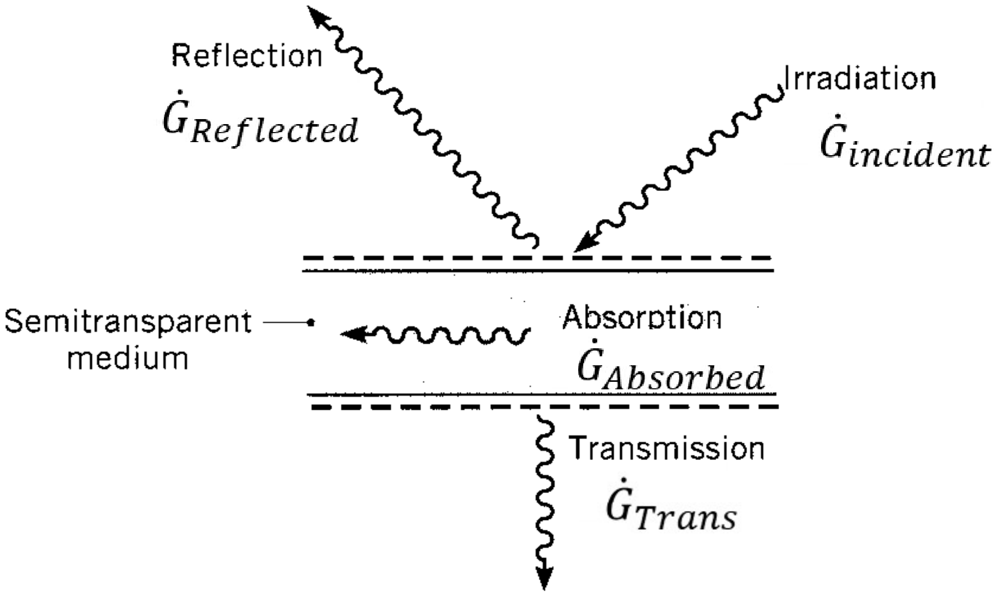
$$\dot{Q}_{emit} = \varepsilon \sigma A_\sigma T_s^4 \qquad \text{(W)}$$

$$0 \leq \varepsilon \leq 1$$

- ε is the **emissivity** of the surface (Table 1-6)

Radiation - Emission

- This property provides a measure of how efficiently a surface emits energy relative to a blackbody. It depends strongly on the surface material and finish.
- Radiation may also be *incident* on a surface from its surroundings.
- The radiation may originate from a special source, such as the sun, or from other surfaces to which the surface of interest is exposed.
- Irrespective of the source(s), we designate the rate at which all such radiation is incident on a unit area of the surface as (irradiation, $\dot{G}_{incident}$),



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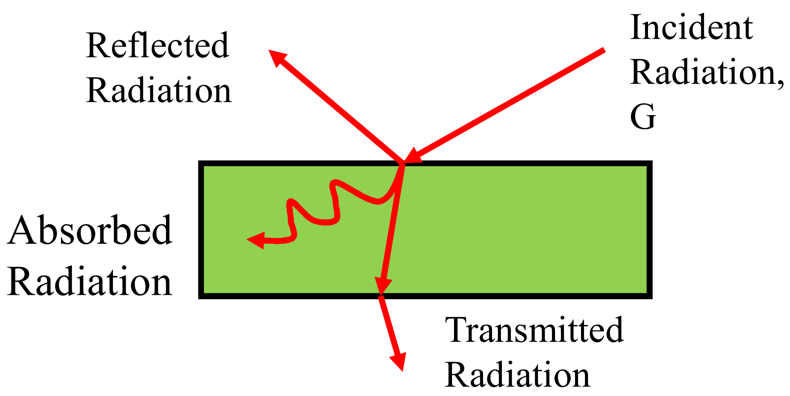
Receiving Properties

Targets receive radiation in one of three ways; they absorption, reflection or transmission.

- Absorptivity, α, the fraction of incident radiation absorbed.
- Reflectivity, ρ, the fraction of incident radiation reflected.
- Transmissivity, τ, the fraction of incident radiation transmitted.



We see, from Conservation of Energy, that:

$$\alpha + \rho + \tau = 1$$

In this course, we will deal with only opaque surfaces, $\tau = 0$, so that:

$$\alpha + \rho = 1$$

Radiation - Absorption

- However, whereas absorbed and emitted radiation increase and reduce, respectively, the thermal energy of matter, reflected and transmitted radiation have no effect on this energy.

- The rate at which a surface absorbs radiation is:

$$\dot{G}_{absorbed} = \alpha \dot{G}_{incident}$$

α : The absorptivity of the surface $\quad 0 \le \alpha \le 1$

- A special case that occurs frequently involves radiation exchange between a small surface at T_s and a much larger, isothermal surface that completely surrounds the smaller one.
- The *surroundings* could, for example, be the walls of a room or a furnace whose temperature T_{surr}..
- For such a condition, the irradiation may be approximated by emission froma blackbody at T_{surr}.

$\dot{G}_{incident}$: The rate at which radiation is incident on the surface $= \sigma A_s T_{surr}^4, \quad (W)$

$$\longrightarrow \quad \dot{Q}_{absorbed} = \alpha \sigma A_s T_{surr}^4, \quad (W)$$