TASK 1

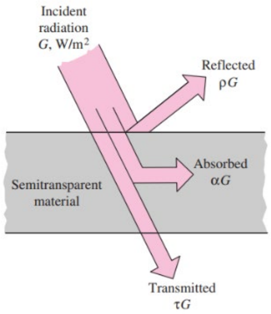
In you own words (which means in your own words) write a summary of the topics about radiative heat transfer we went through including the definitions of emissivity, absorptivity and reflectivity, the view factor, the heat exchange betweeen two black surfaces,the heat exchange between the two gray surface and finally the definition of radiative resistances

- **Emissivity**

The emissivity of a surface, donated by ε (which varies between zero and one, 0⩽ε⩽1), represents the ratio of the radiation emitted by the surface at a given temperature to the radiation emitted by a blackbody at the same temperature, affected by temperature of the surface as well as the wavelength and the direction of the emitted radiation.

- **Absorptivity, reflectivity, transmissivity**

When radiation strikes a surface, part of it is absorbed, part of it is reflected, and the remaining part, if any, is transmitted, as illustrated in the Figure. The fraction of irradiation absorbed by the surface is called the absorptivity α, the fraction reflected by the surface is called the reflectivity ρ, and the fraction transmitted is called the transmissivity τ .



Absorptivity: $$\alpha = \frac{\text{Absorbed radiation}}{\text{Incident radiation}} = \frac{G_{abs}}{G}, \qquad 0 \le \alpha \le 1$$

Reflectivity: $$\rho = \frac{\text{Reflected radiation}}{\text{Incident radiation}} = \frac{G_{ref}}{G}, \qquad 0 \le \rho \le 1$$

Transmissivity: $$\tau = \frac{\text{Transmitted radiation}}{\text{Incident radiation}} = \frac{G_{tr}}{G}, \qquad 0 \le \tau \le 1$$

- **View Factor**

View factor is defined to account for the effects of orientation on radiation heat transfer between two surfaces, which is a purely geometric quantity and is independent of the surface properties and temperature.

F_{ij} = the fraction of the radiation leaving surface i that strikes surface j directly

e.g. F_{12} represents the fraction of radiation leaving surface 1 that strikes surface 2 directly,

F_{21} represents the fraction of the radiation leaving surface 2 that strikes surface 1 directly.

● Heat Transfer Between Two Black Surfaces

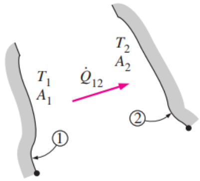


FIGURE 12–18
Two general black surfaces maintained at uniform temperatures T_1 and T_2.

Consider two black surfaces of arbitrary shape maintained at uniform temperatures T_1 and T_2, as shown in Figure 12–18. Recognizing that radiation leaves a black surface at a rate of $E_b = \sigma T^4$ per unit surface area and that the view factor $F_{1\rightarrow 2}$ represents the fraction of radiation leaving surface 1 that strikes surface 2, the net rate of radiation heat transfer from surface 1 to surface 2 can be expressed as

$$\dot{Q}_{1\rightarrow 2} = \begin{pmatrix}\text{Radiation leaving}\\ \text{the entire surface 1}\\ \text{that strikes surface 2}\end{pmatrix} - \begin{pmatrix}\text{Radiation leaving}\\ \text{the entire surface 2}\\ \text{that strikes surface 1}\end{pmatrix}$$
$$= A_1 E_{b1} F_{1\rightarrow 2} - A_2 E_{b2} F_{2\rightarrow 1} \qquad \text{(W)} \qquad \textbf{(12-18)}$$

Applying the reciprocity relation $A_1F_{1\rightarrow 2} = A_2F_{2\rightarrow 1}$ yields

$$\dot{Q}_{1\rightarrow 2} = A_1 F_{1\rightarrow 2}\, \sigma(T_1^4 - T_2^4) \qquad \text{(W)} \qquad \textbf{(12-19)}$$

which is the desired relation. A negative value for $\dot{Q}_{1\rightarrow 2}$ indicates that net radiation heat transfer is from surface 2 to surface 1.

● Heat Transfer Between Two Grey Surfaces

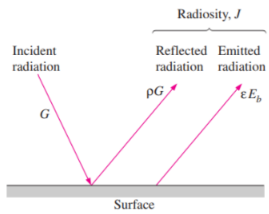


FIGURE 12–20
Radiosity represents the sum of the radiation energy emitted and reflected by a surface.

The total radiation energy leaving a surface per unit time and per unit area is the radiosity and is denoted by J. For a surface i that is gray and opaque, the radiosity can be expressed as

$$J_i = \begin{pmatrix}\text{Radiation emitted}\\ \text{by surface } i\end{pmatrix} + \begin{pmatrix}\text{Radiation reflected}\\ \text{by surface } i\end{pmatrix}$$
$$= \varepsilon_i E_{bi} + \rho_i G_i$$
$$= \varepsilon_i E_{bi} + (1 - \varepsilon_i) G_i \qquad \text{(W/m}^2\text{)} \qquad \textbf{(12-21)}$$

where $E_{bi} = \sigma {T_i}^4$ is the blackbody emissive power of surface i and G_i is irradiation (i.e., the radiation energy incident on surface i per unit time per unit area). For a surface that can be approximated as a blackbody (ε_i =1), the radiosity relation reduces to

$$J_i = E_{bi} = \sigma T_i^4 \qquad \text{(blackbody)} \qquad \textbf{(12-22)}$$

That is, the radiosity of a blackbody is equal to its emissive power. This is expected, since a blackbody does not reflect any radiation, and thus radiation coming from a blackbody is due to emission only.

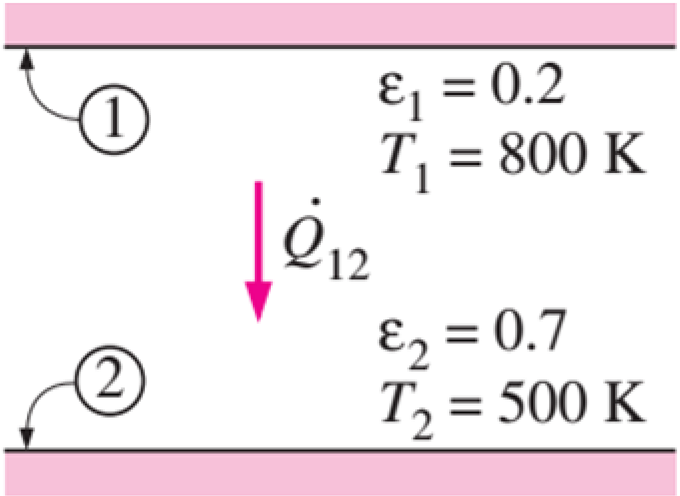
- **Radiative resistance**

Radiative resistance is a value to measure the energy depleted by loss resistance which is converted to heat radiation; the energy lost by radiation resistance is converted to radio waves. $R_i = \frac{1-\varepsilon_i}{A_i\varepsilon_i}$

TASK 2

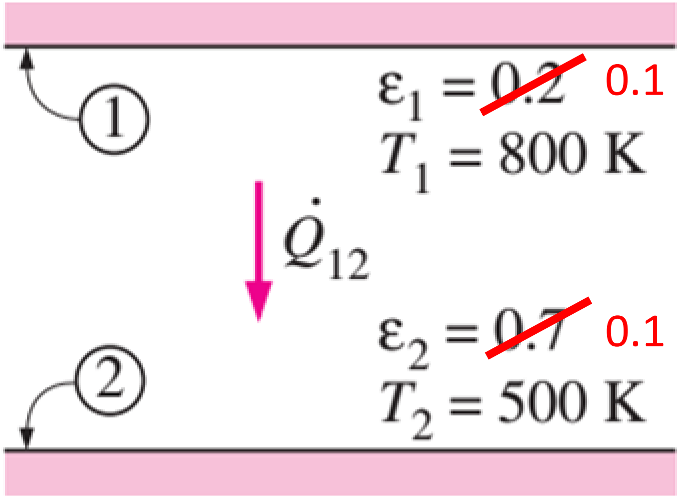
Solve the last example you solved in the class (radiative heat exchange between two parallel plates) awhile considering the two emissivities to be 0.1, what can you conclude from the result?

In the class



$$\dot{q} = \frac{\dot{Q}}{A} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{5.67 \times 10^{-8} \times (800^4 - 500^4)}{\frac{1}{0.2} + \frac{1}{0.7} - 1} W/m^2 = 3625.4W/m^2$$

When the two emissivities to be 0.1



$$\dot{q} = \frac{\dot{Q}}{A} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{5.67 \times 10^{-8} \times (800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} W/m^2 = 1035.8 W/m^2$$

<u>As we can cee from the significant change when we declined the emissive value of both parallel plates, the radiation heat transfer could be reduced by decreasing the emissivity values.</u>