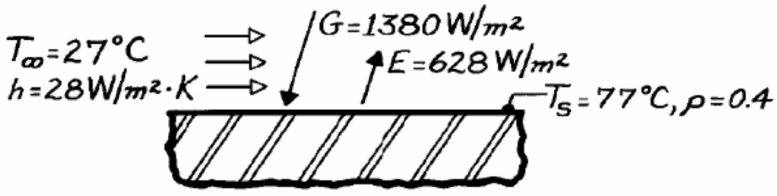
Exercise 12.1

A horizontal, opaque surface at steady-state temperature of $77°C$ is exposed to an airflow having a free stream temperature of $27°C$ with a convection heat transfer coefficient of $28W/m^2K$. The emissive power of the surface is $628W/m^2$, the irradiation is $1380W/m^2$ and the reflectivity is 0.40. Determine:

a) the net radiation heat transfer rate for this surface. Is this heat transfer to the surface or from the surface ?

b) the combined heat transfer rate for the surface. Is this heat transfer to the surface or from the surface ?

c) the emissivity of the surface. Is this a gray surface or not?



Solutions:

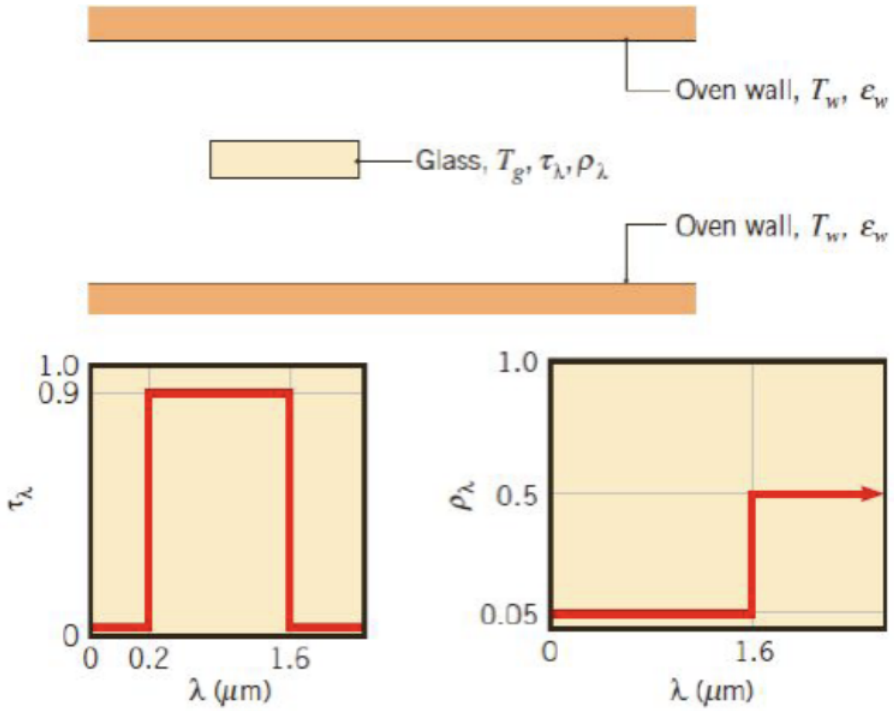
a) $q''_{net,rad} = 200W/m^2$, To the surface

b) $q''_{net} = -1200W/m^2$, From the surface

c) $\epsilon = 0.74 \neq \alpha$, not a gray surface

Exercise 12.2

A special diffuse glass with prescribed spectral radiation properties is heated in a large oven. The walls of the oven are lined with a diffuse, gray refractory brick having an emissivity of 0.75 and are maintained at $T_w = 1800K$. Consider conditions for which the glass temperature is $T_g = 750K$.



a) What are the total transmissivity τ, the total reflectivity ρ and the total emissivity ε of the glass? *Hint*: what is the relationship between ϵ_λ and α_λ for a diffuse surface?

b) What is the net radiative heat flux, $q''_{net,in}\,(W/m^2)$, to the glass? *Hint*: note that both surfaces of the glass piece are exposed to the incident radiation...

Solutions:

a) $\tau = 0.225$, $\rho = 0.388$, $\alpha = 0.387$, $\epsilon = 0.5$

b) $q''_{net,in} = 442.8kW/m^2$

Exercise 12.3

Consider two very large parallel plates with diffuse, gray surfaces. Determine:

a) the irradiation for the upper plate

b) the radiosity for the upper plate

c) the radiosity for the lower plate

d) What is the net radiation exchange between the plates per unit area of the plates? *Hint*: based on what you calculated in (a) and (b), what is the net heat that leaves/reaches each of the two surfaces?

Solutions:

a) $G_1 = 14175 W/m^2$

b) $J_1 = 56700 W/m^2$

c) $J_2 = 14175 W/m^2$

d) $q_1'' = q_{12}'' = 42525 W/m^2$