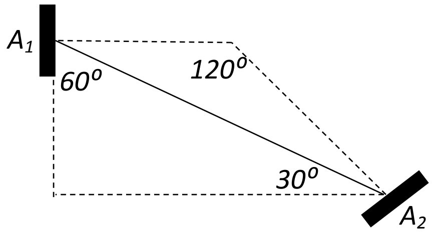
Radiation Heat Transfer

Practice problems

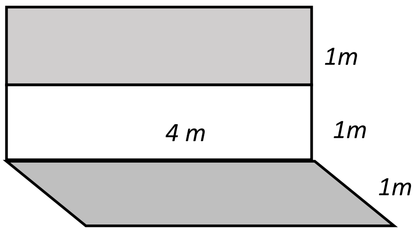
1. The black surface A_1=1cm^2 emits radiation with total intensity i_1=1400w/m^2-sr. A portion of this radiation strikes surface A_2=1cm^2. The distance between A_1 and A_2 is 1-m and two angles are 30° and 60° as shown in the figure. Calculate the radiation heat transfer from A_1 and A_2.



[Ans: 1.05 x 10^{-5} W]

2. Fresh snow absorbs 80% of incident solar radiation with $\lambda < \lambda_1$=0.4μ-m, 10% of irradiation between λ_1 and λ_2=1μ-m and 100% of irradiation for $\lambda > \lambda_2$. The solar surface can be approximated as a black surface at T = 5800K. Calculate the fraction of total incident solar radiation that is absorbed by fresh snow. *[Ans: 0.43]*

3. Calculate the shape factor F_{1-2} for two surfaces shown in the figure below. *[Ans: 0.07]*



4. The variation of monochromatic irradiation incident on an opaque surface and monochromatic absorptivity of the surface with wavelength is as follows:

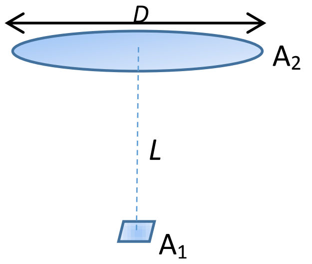
H_λ	= 0	$0 \le \lambda \le 2$ μ-m	α_λ	= 1.0	$0 \le \lambda \le 4$ μ-m
	=7500	$2 \le \lambda \le 8$ μ-m		= 0.5	4 μ-m $< \lambda <$ 8 μ-m
	= 0	$\lambda \ge 8$μ-m		= 0	$\lambda > 8$ μ-m

Calculate the absorbed radiant flux, absorptivity and reflectivity of the surface

[Ans: H_a=3000W/m^2, α = 0.667; ρ = 0.3333]

5. A class room is 14m long, 10.5m wide and 3.5m wide in height. If the ceiling and the floor of the room are at 35°C and 25°C respectively. Calculate the rate at which heat is exchanged by radiation between two surfaces. Take shape factor between floor and ceiling to be 0.6. Also calculate the rate at which energy is supplied through the ceiling if the four side walls are re-radiating surfaces. Assume all the surfaces to be black.

6. Consider a circular disc of diameter D and area A_2 above a plane, surface of area A_1 where $A_1 << A_2$. The surfaces are parallel to each other and separated by distance L. calculate shape factor $F_{1\text{-}2}$. *[Ans: $F_{1\text{-}2} = D^2/(D^2+L^2)$]*



7. Consider two large opposite parallel plates, one at $T_1=400^0$C, $\varepsilon_1=0.8$ and other at $T_2=300^0$C, $\varepsilon_2=0.4$. An aluminum radiation shield with $\varepsilon_3=0.05$ is placed between the plates. Compare the rate of radiation heat transfer with and without the radiation shield.

8. With a clear sky, the solar radiation incident on earth's surface may be divided into two components, direct and diffuse. The direct component consists of parallel rays at a certain zenith angle ψ, while the diffuse component consists of radiation coming from all directions of the sky. On a particular day and time, the direct component is 900 W/m^2 (based on an area normal to the rays) at a zenith angle of 30^0C. In the diffuse component, the total intensity of radiation incident normally on a earth's surface is 800W/m^2-sr. Make any reasonable assumption and calculate the total solar radiation (W/m^2) falling on earth's surface.

9. A glass plate 30 cm^2 in area is used to view radiation from a furnace. The transmissivity of the glass is 0.5 in the wavelength of 0.2 to 3.5μ-m and zero elsewhere. The emissivity is 0.3 for $\lambda \leq 3.5\mu$m and 0.9 for $\lambda > 3.5\mu$m. Assuming the furnace to be blackbody at 2000^0C, calculate the radiation flux absorbed in the glass and energy transmitted. Assume glass to be a diffuse surface. *[Ans: 52.76W, 58.2KW]*

10. A truncated cone has top and bottom diameter of 10 and 20 cm and a height of 10 cm. calculate the shape factor between the top surface and the side, and shape factor between side and itself. *[Ans: 0.525, 0.0775, 0.397]*