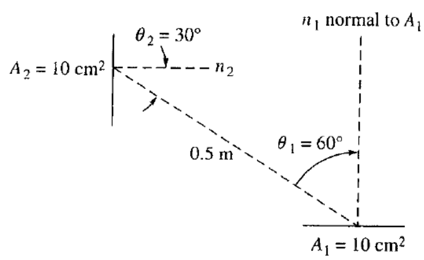
ME 331 Homework Assignment #7
Due Friday May 26, by 5 pm in MEB main office

1. A flat, black surface of area $A_1 = 10\ cm^2$ emits $1000\ W/(m^2\ sr)$ in the normal direction. A small surface A_2 having the same area as A_1 is placed relative to A_1 as shown in the figure, at a distance of 0.50m. Determine the solid angle subtended by A_2 and the rate at which A_2 is irradiated by A_1.

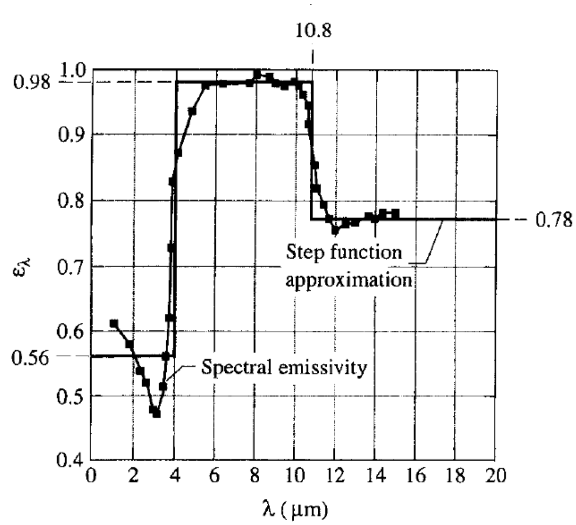


2. Determine the following: (a) the wavelength at which the spectral emissive power of a tungsten filament at 1400 K is maximized, (b) the spectral emissive power at that wavelength, and (c) the spectral emissive power at 5.0 μm.

3. The filament of an incandescent lamp emits radiation in the visible and infrared wavelength ranges. A halogen lamp is an incandescent lamp with a halogen gas added to reduce evaporation of the filament. Halogen lamps operate at higher temperatures than standard incandescent lamps. Assuming that the filament temperatures of standard incandescent lamps and halogen lamps are 2500 K and 4000 K, respectively, and that both lamps radiate as blackbodies, find the fraction of radiation emitted in the visible range for these two lamps. Comment on the efficiencies of converting electrical energy into visible light.

4. A plane, gray, diffuse, opaque surface with absorptivity 0.70 and a surface area of 0.50 m^2, is maintained at 500°C and receives radiant energy at a rate of 10,000 W/m^2. Determine per unit time: (a) the energy absorbed, (b) the radiant energy emitted, (c) the total energy leaving the surface per unit area, (d) the radiant energy emitted by the surface in the wave band 0.20 μm to 4.0 μm, and (e) the net radiation heat transfer from the surface.

5. The spectral hemispherical emissivity of an aluminum oxide surface is shown in the figure. Determine the total hemispherical emissivity and the emissive power at 1255 K.



6. A specially coated diffuse, opaque surface with spectral absorptivity of 1.0 for $0 < \lambda < 2$ and 0.10 for $2\ \mu m < \lambda < \infty$ is exposed to solar radiation in the outer reaches of the atmosphere. Determine: (a) the heat flux by radiation from the surface to the surroundings if the surface is maintained at 100°C by a coolant, (b) the equilibrium temperature of the surface, if the coolant flow stops and the surface is insulated on the side that does not receive solar radiation, (c) compare the values in parts a and b if the surface is black.