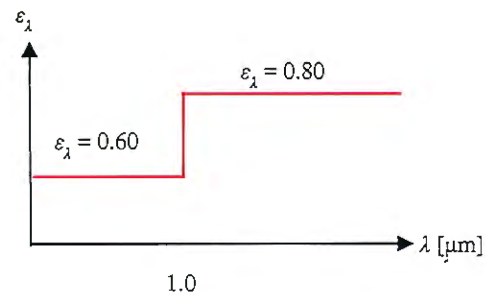
Grade: _____/20

Problem 1 [8 pts]

The filment of an incandest lightbulb at T=2800 K has a spectral emissivity as shown in the figure. The filament is well-modeled as being opaque.



(a) [4 pts] Find the total emissivity, ε, for the filament at this temperature.

$$\varepsilon = \varepsilon_{\lambda,1} f_{0-1\mu m} + \varepsilon_{\lambda,2} f_{1\mu m-\infty}$$
$$= \varepsilon_{\lambda,1} f_{0-1\mu m} + \varepsilon_{\lambda,2}(1 - f_{0-1\mu m})$$

$$\lambda T = (1\,\mu m)(2800\,K) = 2800\,\mu m \cdot K$$

$$\therefore f_{0-1\mu m} = 0.227897$$

$$\varepsilon = (0.60)(0.227897) + (0.80)(1 - 0.227897)$$

$$= 0.754$$ ← ANS

(b) [4 pts] Assume the answer to part (a) is 0.6. (It isn't.) Find the total absorptivity, α, and the total reflectivity, ρ for the filament at this temperature.

OPAQUE → $\tau = 0$

KIRCHHOFF'S LAW

$$\alpha \approx \varepsilon = 0.6$$

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

$$\rho = 1 - \alpha = 1 - 0.6 = 0.4$$ ← ANS

Problem 2 (6 pts)

(a) [2 pts] Check all that apply. A blackbody (or black surface)

- ☐ has a reflectivity equal to one
- ☑ absorbs 100% of all incident radiation on it
- ☐ will emit the same amount of radiation at all wavelengths
- ☐ will emit the same amount of radiation at all temperatures
- ☑ is also an opaque surface

(b) [2 pts] A certain blackbody emits more radiation at a wavelength of 2.899 μm than at any other wavelength. What is the temperature of the blackbody?

WIEN'S DISPLACEMENT LAW

$$\lambda_{MAX} T = 2897.8 \ \mu m \cdot K$$

$$T = \frac{2897.8 \ \mu m \cdot K}{\lambda_{MAX}} = \frac{2897.8 \ \mu m \cdot K}{2.899 \ \mu m}$$

$$= 999.6 \ K$$ ← ANS

(c) [2 pts] A gray, diffuse surface at $T_s = 1000$ K has an emissive power of 12,853 W/m². Find the total emissivity of the surface

$$E = \varepsilon E_b = \varepsilon \sigma T^4$$

$$\varepsilon = \frac{E}{\sigma T^4} = \frac{12,853 \ W/m^2}{(5.67\times10^{-8} \ W/m^2 \cdot K^4)(1000^4) \ K^4}$$

$$= 0.227$$ ← ANS

Problem 3 [5 pts]

For each radiation term in the left-hand column pick the best description from the right-hand column. (Note that not all terms in the right-hand column will be used.)

F Emissive power
B Gray
G Irradiation
C Thermal radiation
E Spectral

A. Independent of direction
B. Independent of wavelength
C. The part of the electromagnetic spectrum emitted by a surface due to its temperature
D. Over all directions
E. Per unit wavelength at a specific wavelength at a specific wavelength
F. Rate of radiation heat transfer emitted by a surface per unit area
G. Rate of radiation heat transfer incident on a surface per unit area