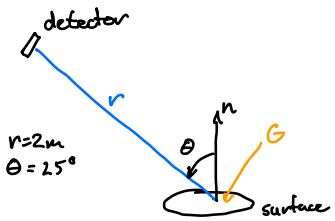
14E - 2ND CLASS



Surface
opaque
gray
diffuse

$G = 2500\ W/m^2$

$A_s = 10^{-4}\ m^2$
$T_s = 500K$
$\varepsilon = 0.8$

What is the rate at which the detector intercepts radiation from the surface?

from surface to detector

$$I_{e+r} = \frac{dq_{s-d}}{dA_s \cos\theta\, d\omega} \qquad \left[\frac{W}{m^2 \cdot sr}\right]$$

$$dq_{s-d} = I_{e+r}\, dA_s \cos\theta\, dA_s\, d\omega$$

$A_d \approx dA_d$
$A_s \approx dA_s$
$q_{s-d} \approx dq_{s-d}$
$\omega_{s-d} \approx d\omega_{s-d}$

Because A_s and A_d are small and r is large

So,

$$q_{s-d} = I_{e+r}\, A_s \cos\theta\, \omega_{s-d}$$

$$\omega_{s-d} = -\frac{A_d}{r^2} = 0.25 \times 10^{-6}\ sr$$

$$J = \int_0^{2\pi} \int_0^{\pi/2} I_{e+r} \cos\theta \sin\theta\, d\theta\, d\phi$$

$I_{e+r} \neq f(\theta, \phi)$ because diffuse

$$= \pi I_{e+r}$$

$$I_{e+r} = \frac{J}{\pi} \qquad \left[\frac{W}{m^2\ sr}\right] \Rightarrow$$

$\alpha + \rho = 1 \Rightarrow \rho = 1 - \varepsilon$

$$J = E + \rho G$$
$$= \varepsilon \sigma T_s^4 + (1-\varepsilon) G$$
$$= 3335\ \frac{W}{m^2}$$

$$I_{e+r} = 1062\ \frac{W}{m^2\, sr}$$

$$q_{s-d} = 2.41 \times 10^{-8}\ W$$

BLACK BODY

- Perfect absorber ($\alpha = 1$)
- Perfect emitter ($\varepsilon = 1$)
- Grey – radiation does not depend on (θ, ϕ) (Diffuse)
- emitted radiation is a function of λ and T

spectrial emissive power of a black body

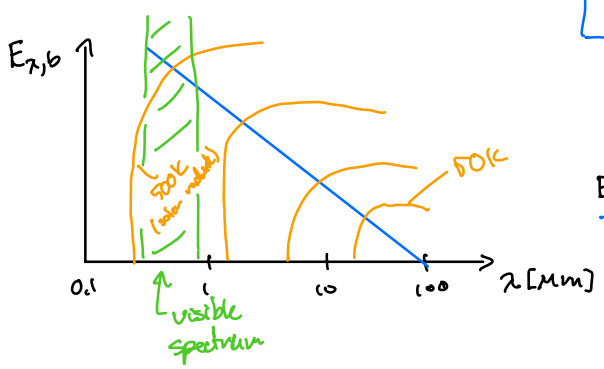
$$I_{\lambda,b}(\lambda,T) = \frac{2hC_o^2}{\lambda^5\left[e^{\frac{hC_o}{\lambda k_B T}} - 1\right]} \qquad \left[\frac{W}{m^2 \cdot sr \cdot \mu m}\right]$$

h = Planck's Constant $= 6.626 \times 10^{-34}\ J \cdot s$

C_o = speed of light

k_B = Boltzman's Constant $= 1.381 \times 10^{-23}\ \frac{J}{K}$

$$E_{\lambda,b} = \pi I_{\lambda,b} = \frac{C_1}{\lambda^5\left[e^{\frac{C_2}{\lambda T}} - 1\right]} = E_{\lambda,b}(\lambda,T)$$



$$E_b = \int_0^\infty E_{\lambda,b}\, d\lambda = \sigma T^4$$

$$\sigma = \frac{2\pi^5 k_B}{15 C_o^2 h^3} = 5.67 \times 10^{-8}\ \frac{W}{m^2 K^4}$$

$$E_b = \sigma T^4$$