Solutions For Homework #1

Problem 1:

If c is the speed of light, λ is the wavelength and f is the frequency, the equation $c = \lambda \cdot f$ can be used to calculate one of the the three values, if the two others are given. The speed of light is defined to be exactly $299792458\,\mathrm{m/s}$ ($\approx 3 \cdot 10^8\,\mathrm{m/s}$). Thus, for a frequency of $f = 10\,\mathrm{GHz} = 10 \cdot 10^9\,\mathrm{Hz}$,

$$\lambda = \frac{c}{f} = \frac{299792458\,\mathrm{m/s}}{10\,\mathrm{GHz}} \approx \frac{3 \cdot 10^8\,\mathrm{m/s}}{10^{10}\,\mathrm{Hz}} = 0.03m = 3\,\mathrm{cm}$$

and for a wavelength of $\lambda = 25\,\mathrm{cm} = 0.25m$

$$f = \frac{c}{\lambda} = \frac{299792458\,\mathrm{m/s}}{0.25m} \approx 12 \cdot 10^8\,\mathrm{Hz} = 1.2\,\mathrm{GHz}$$

Problem 2:

The boiling temperature of water at sea level is 100^oC. To convert this to degrees Kelvin, just add 273.15:

$$100^oC = (273.15 + 100)K = 373.15K$$

Problem 3:

The formula for the wavelength of the energy emission peak is

$$\lambda_{max} = \frac{2898\,\mu\mathrm{m}\,K}{T}$$

where T is the black-body temperature. Using the temperatures for the surface of the sun ($T = 6000K$) and an effective value for the earth ($T = 255K$), we get

sun: $0.483\,\mu\mathrm{m}$
earth: $11.4\,\mu\mathrm{m}$

Because the reflected radiation has the same spectrum as the

light incident from the sun, the peak wavelength is also the same, $0.483\,\mu\mathrm{m}$.

Problem 4:

Using the equation from problem 3 and the surface temperature of venus ($T_{Venus} = 750K$), we get

$$\lambda_{max} = \frac{2898\,\mu\mathrm{m}\,K}{750K} = 3.86\,\mu\mathrm{m}$$

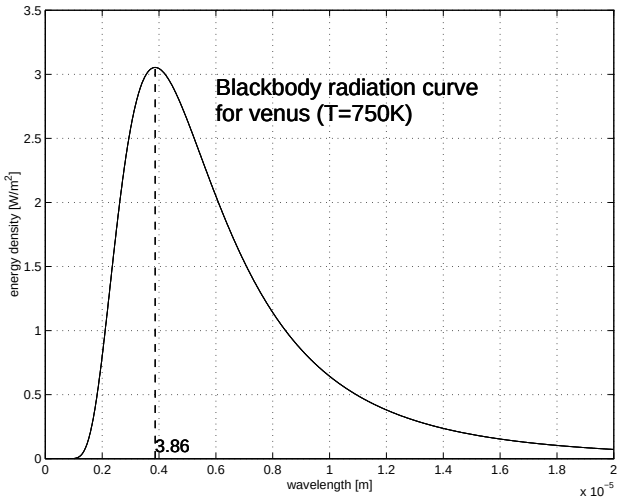

Figure 1: Blackbody curve for a temperature of $T = 750K$.

Problem 5:

An industrial pollutant absorbing radiation at $28\,\mu\mathrm{m}$ does not alter the transmissivity of the atmosphere at that wavelength very much. The absorption of this wavelength in the atmosphere is almost total anyway. For this reason, the pollutant would not be of much concern in the global warming context.

Note: The fact that the $28\,\mu\mathrm{m}$ wavelength does not coincide with either the sun's or the earth's peak emission wavelength does not mean that there is no significant amount of radiation at this wavelength.

Problem 6:

The distance in pixels between the Hoover tower and Memorial church can be calculated with the Pythagorean theorem:

$$d = \sqrt{(400-300)^2 + (250-300)^2} \approx 112 pixels$$

The distance in meters (estimated from a campus map) is approximately 325 meters. Thus, the pixel spacing is

$$\Delta d = \frac{325m}{112} = 2.9m$$