AT622
Homework 1

1\. – 8 Petty problems: 1.1, 2.3, 2.7, 2.10, 2.12, 2.13, 2.16, 2.18.

9\. Assume that a (super-old-fashioned-should-not-be-sold-anymore) 100W incandescent light bulb of 80% efficiency radiates isotropically. a) Calculate the average value of the Poynting vector (i.e., the flux in W/m^2) at a distance of 2 meters from the lamp. b) Calculate the amplitude of the electric and magnetic fields in SI units (which are Volts/m and Telsa (T), respectively). Compare the magnetic field to that of a typical refrigerator magnetic, ~ 5 milliTesla. c) Roughly how many photons per second are emitted by the light bulb, assuming all the flux is coming from photons with a wavelength of 500 nm. (*Note: Real incandescent light bulbs emit over a very broad spectrum of wavelengths, out into the thermal infrared.)*

10\. a. From Maxwell's equations in vacuum, show that $\vec{B}_0 = \frac{1}{c}\left(\hat{x} \times \vec{E}_0\right)$ for a plane wave solution in which both $\vec{E}$ and $\vec{B}$ are travelling in the $\hat{x}$ direction.

Hint: Use the fact that $\nabla \cdot \vec{E} = \nabla \cdot \vec{B} = 0$ *to show that both the electric and magnetic fields do not have* $\hat{x}$ *-components. Then write out Faraday's law,* $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$, *explicitly via components, and you should be able to derive the required expression.*

b. Explain why this result requires $\vec{E}$ and $\vec{B}$ to be perpendicular to each other in space, and in phase, and that $|B_0|=1/c\ |E_0|$.

11\. Assuming typical earth-sun and earth-moon distances, it can be shown that the lunar flux incident upon the earth when the full moon is overhead, $F_{FullMoon}$, is given by:

$$F_{FullMoon} = F_{in} A_M \frac{R_M^2}{D_{EM}^2}$$

where F_{in} is the incident solar flux upon the moon, A_M is the mean albedo (reflectivity) of the moon, R_M is the radius of the moon, and D_{EM} is the distance from the earth to the moon.

Assuming $A_M = 0.12$, what is the approximate flux from the full moon incident upon the earth? How does this compare to the value for the sun (~1370 W/m^2)?

12. [Extra Credit – REALLY! Only do if you have time] The broadband albedo of the earth was roughly known well before there were satellites, by using the moon (a natural satellite). In this problem, you will estimate the earth's albedo, given that the flux from the full moon incident upon the earth is 9300 times that from a new moon. You may assume that the distance from the earth to the moon is much smaller than the distance from the earth to the sun.

a. Using the general equation from problem 11, write down an equation for the flux of the "Full Earth" incident upon the moon when the sun, moon, and earth are in a "new moon" configuration.

b. Using the resulting equation from part 12a as the source of radiation to the moon (F_{in}), write down an equation for the total flux from the New Moon incident upon the earth.

c. Using the equations you derived in 11a and 12b, write down the equation for the ratio of the full moon flux at earth to the new moon flux at earth, and solve it for the albedo of the earth. Do not expect the resulting albedo to precisely equal the typically accepted value of 30%; in this problem we're just trying to get close!