HOMEWORK #5 (due start of class Jan 29)

LEARNING GOALS for this assignment:

1. To understand the concepts of electromagnetic energy (i.e., light).
2. To apply this understanding in practical situations in modern astronomy.

TO RECEIVE FULL CREDIT:

1. Staple multiple pages and identify yourself by Star Name (worth 5 points!).
2. You must **show how** you derived your answer by writing all the logical steps that led you to it. Follow the format of the "Homework Example" on our Web site.
3. All sentence responses must be typewritten and in complete sentences. You may handwrite any arithmetic. Use good English grammar.
4. **If you work more than three hours on this assignment, you should stop, record your work here, and contact Dr. McCarthy or Mr. Hammer (our Teaching Assistant) for help.**

Light and Electromagnetic Radiation

Part I. In the online textbook at the link below, please read Section 5.2.

Part II. Answer two of the following three questions.

1. The energy (E) of a photon of light depends directly on its frequency (ν) and inversely on its wavelength (λ):

$E = h\nu = hc/\lambda$, where h is the Planck constant = 6.63×10^{-34} kg m^2/sec .

a. Use your knowledge of physics (mechanics) to show that the dimensions of "$h\nu$" correspond to units of energy.

b. A common unit of energy is the electron-volt (ev) = 1.6×10^{-19} Joules. One ev is the energy equal to the work done on an electron in accelerating it through a potential difference of one volt (i.e., a small battery). Express the energy of the $\lambda = 21$ cm emission line of hydrogen in units of electron-volts.

c. Assume that all the energy from a 100 Watt light bulb is associated with blue photons of λ = 400 nm. How many photons per second are emitted by the bulb? Based on your intuition, do you think the human eye could detect a single blue photon? [1 Watt = 1 Joule/sec = 1 kg m^2 /sec^3]

2. In order to measure the brightness of celestial objects far away, astronomers generally do not isolate and analyze single wavelengths of light, Instead, to increase signal strength, they measure the energy over a range of wavelengths, or frequencies. That range is called "bandwidth." Given the relationship ($c = \lambda\nu$) between wavelength (λ) and frequency (ν), use calculus to determine the relationship of a bandwidth expressed in wavelength units ($d\lambda$) to the bandwidth expressed in frequency units ($d\nu$).

3. In the television series "*Cosmos*," Carl Sagan says: *"The total amount of energy from outside the solar system ever received by all the radio telescopes on the planet Earth is less than the energy of a single snowflake striking the ground."*

a. Using your background in physics (mechanics), calculate the number of photons ($\lambda = 21$ cm) that would be equivalent to the energy of the single snowflake.

b. If you had the same number of photons of visible light, determine the height of an equivalent column of falling snowflakes.