Astron 211 Problem Set 4

Given: Sep 27. Due: Wednesday, Oct 4 at the beginning of class

Homework Policy: You can consult class notes and books. Always try to solve the problems yourself; if you cannot make progress after some effort, you can discuss with your classmates or ask the instructor. However, you cannot copy other's work: what you turn in must be your own. Make sure you are clear about the process you use to solve the problems: partial credit will be awarded.
Reading: Kutner Chapters 2, 3, 9, 22.4, 6.2

Problem 1 Kutner Problem 2.13 [10 pts]

As we will see later, the universe is filled with blackbody radiation at a temperature of 2.7 K.

a. At what wavelength does the spectrum of that radiation peak?

b. What part of the electromagnetic spectrum is this?

Problem 2 Kutner Problem 2.14 [10 pts]

a. We observe the blackbody spectrum from a star to peak at 400 nm. What is the temperature of that star?

b. What about one that peaks at 450 nm?

Problem 3 Kutner Problem 2.18 [10 pts]

a. What is the energy of a photon in the middle of the visible spectrum ($\lambda \approx 550\,\mathrm{nm}$)?

b. Approximately how many photons per second are emitted by a 100 W light bulb? By the Sun?

Problem 4 Kutner Problem 2.19 [10 pts]

If we double the temperature of a blackbody by how much must we decrease the surface area to keep the luminosity constant?

Problem 5 Kutner Problem 9.6 [10 pts]

What is the rate at which the Sun is converting mass into energy?

Problem 6 Order of Magnitude: Hamburgers [20 pts]

a. If you drive by a McDonalds, you will see (depending on where you are) "95 billion served." Estimate the number of cows that required.

b. Would the energy of all the calories you have consumed as food be enough to eject you from the solar system? To escape from the solar system you would need to escape from the Earth, then escape from the Sun.

c. NASA pays about \$20,000 per kilogram to get rockets away from Earth. For comparison, 1kW hr=3.6×10^6 J costs about 15 cents and 1 gal gas $\sim 10^8$ J costs about \$1.50. Is NASA wasting our money by sending rockets away from the Earth?

d. There are about 1000 kcal in a bacon double cheeseburger. If that was being perfectly converted to thrust, at what rate would you have to eat burgers to maintain escape velocity near Earth's surface? Remember that power (energy per time) is force (the force needed to resist gravity and maintain a constant velocity) times velocity.