Climate & Sustainability

PHYS 189 — Fall 2017

Problem Assignment # 2

due 09-11-17

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1. Current events. Read the following contrasting commentaries relating Hurricane Harvey to climate change:

   - http://fortune.com/2017/08/29/hurricane-harvey-global-warming/
   - https://www.heartland.org/news-opinion/news/press-release-heartland-institute-experts-comment-on-hurricane-harvey

   Neither of these are published in peer-review journals. Which of these offers a more reliable perspective? What makes it more reliable? How did you come to your conclusion?

2. What is the difference between kinetic and potential energy? List at least one example of each.

3. Energy transfer

   (a) Conduction and convection are alike in that they both transfer heat within a substance. What is the critical difference between them?

   (b) How does radiation differ from conduction and convection?

4. Why is wavelength important in radiative transfer? In other words, when discussing radiation, why isn't it enough to specify the amount of energy transfer?

5. Go to `http://phet.colorado.edu/en/simulation/blackbody-spectrum` and run the simulation for black body radiation.

   (a) Vary the temperature. How does the intensity of radiation from the sun compare to the intensity of radiation emitted from a light bulb? From Earth? Please estimate the intensity from the graph (note you can change the values on the y-axis by clicking "+" or "-" on the upper left of the simulation).

   (b) What is the wavelength of maximum intensity for the sun? For a light bulb? For Earth? Given what you know about the relationship between photon energy and wavelength, does this make sense?

   (c) Wien's Law gives a relationship between the wavelength of maximum intensity and the temperature of the black body:

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

   where temperature is measured in Kelvin (K). From your answers to part (c), what are the temperatures of the sun, the light bulb, and the Earth? Do these make sense?

   (d) Given the temperature of a black body, the Stefan-Boltzmann equation determines the *intensity* (energy radiated per unit area per unit time) of the radiation source. It is given by

   $$I = \sigma T^4 \quad ,$$

   where $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4 is the Stefan-Boltzmann constant. Based on the temperatures from part (d), what is the intensity of the sun, the light bulb, and the Earth?

(e) Draw or print an example of a black body spectrum. What is the relationship between Wien's Law and the Stefan-Boltzmann equation to the black body spectrum? Carefully label the figure to help answer this question.

6. Solar constant

   (a) What is the solar constant?

   (b) Earth's solar constant (called *solar irradiance* in your book) is 1365 W/m^2. Following the procedure from class, calculate the solar constant for Mars (show your work).

   (c) Mars's albedo is 0.25. Assuming Mars is in energy balance with the sun, calculate the black body temperature of Mars.

   (d) The observed mean surface temperature of Mars is about -55°C. Compare this to your calculation in part (c). Based on these values, would you assume that there is a strong or weak greenhouse effect in the Martian atmosphere?

   Note: You'll need additional astronomical data that is not given in this problem.

7. Re-read Chapter 1 of your book. Are there any concepts you still don't understand? If so, what are they?