UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Physical Astronomy (ASTR 391) — Prof. Crossfield — Spring 2026

Problem Set 1
Due: Friday, Jan 30th at the start of class (0900 Kansas Time)
This problem set is worth **42 points**.

1. **Basic Review [12 pts].**

   (a) You study a star with radius R_*. What is its surface area and volume? (Your answer will be symbolic, not a specific number!) [3 pts]

   (b) How many microns (1 μm) are in one kilometer (1 km)? [2 pts]

   (c) How many radians are in 90 degrees? [2 pts]

   (d) Look at a computer screen at arm's length. Roughly estimate the screen width, screen area, and distance of the screen, all in SI units. [2 pts]

   (e) For the same computer screen: draw a sketch of your eyeball looking at the screen (as seen from overhead). Roughly how many degrees across is the screen, as viewed by you? [3 pts]

2. **Astronomical Concepts [14 pts].**

   (a) You have invented a matter-antimatter reactor that converts physical material (matter) into energy with 100% efficiency. Congratulations, Zefram: you're a shoo-in for the Nobel Prize. (i) If you put 1 kg of matter (and an equal amount of antimatter) in your reactor, approximately how much energy (E_{reactor}) is released when the mass is converted directly into energy? (ii) If the reactor takes 2 s to use that fuel, what was its approximate power output, in Watts and in Solar Luminosities ($L_\odot$)? (iii) How does E_{reactor} compare to the total amount of energy used on Earth in a year? [7 pts]

   (b) Explain how the wavelength, frequency, and energy of a photon are related to each other and to the speed of light, c. [7 pts]

3. **Order-of-Magnitude Estimation [16 pts].** Strive to do as many of these calculations in your head (or with pencil and paper) as possible, aside from looking up any necessary physical constants.

   (a) **City on a Hill [5 pts.]** Roughly estimate the mass of Mount Oread, in kg and in $M_\oplus$ (Earth masses).

   (b) **How Big? [5 pts].** The French revolutionaries of the late 18th century defined the meter by setting the Earth's equator-to-pole distance to be 10,000 km. Estimate the radius ($R_\oplus$), volume ($V_\oplus$), and mass ($M_\oplus$) of the Earth, in SI units.

   (c) **How Big?! [3 pts]** Jupiter is roughly 10× larger (in physical size) than the Earth (i.e., $R_{Jup} \approx 10 R_\oplus$), and the Sun is roughly 10× larger than Jupiter ($R_\odot \approx 10 R_{Jup}$). Roughly estimate the volume of both of these objects, *relative to the volume of the Earth* (i.e., in units of $V_\oplus$).

   (d) **In an Age Before Spotify... [3 pts].** Pick your favorite over-the-air radio station. What is the frequency at which it broadcasts its signals? Estimate the approximate wavelength of the station's radio wave signals.