Due at the beginning of class, 12:30 p.m. Thursday, May 13. Please write your work and answers on a separate sheet of paper, with your name at the top and all pages stapled together.

1. Star on a Diet

A star's energy comes from fusion, which converts mass to energy. How much of a star's mass is converted to energy during its lifetime? Let's figure this out, one step at a time.

(a) Suppose there is a star with 4 times the luminosity of the Sun. Using Einstein's most famous equation, $E = mc^2$, compute how many kilograms per second are burned up in the core of that star. (Hint: luminosity is energy produced per unit time and Einstein's formula relates mass to energy.)

(b) Convert your answer in part (a) to solar masses (the mass of our Sun) per year. (Hint: What is the mass of the Sun in kilograms and how many seconds are in a year?)

(c) If that star burns for 5 billion years, how many solar masses are burned up? What fraction of the stars original mass is that? Assume that the original mass of the star is 1.4 solar masses.

2. Distant Solar System

(a) If a star is 10 parsecs away, what is its parallax (also known as the "parallactic angle")?

(b) Suppose this star has planet with the same mass as Jupiter, which orbits at 5 A.U. from the star. As seen from Earth, what is the maximum angular separation between the star and planet?

(c) Using a ground-based optical telescope, would you see the star and planet as distinct objects, or would they be blurred into one? Explain your answer.

(d) Suppose you observe the distant star-planet system using the Hubble Space Telescope, which has a 2.4m diameter mirror, with angular resolution of 0.04arcsec, so resolution is no problem. What other problem might you have detecting the planet?

3. Spectral Classes, Luminosity, Temperature, and Radius

(a) A star has a surface temperature that is ten times that of the Sun. What spectral class is it?

(b) The Sun will burn hydrogen to helium on the main sequence for about 10 billion (10^{10}) years. Approximately how long will a star that has eight times the mass of the Sun be on the main sequence?

(c) Two stars have the same surface temperature. Star A has a radius that is half as large as star B. What is the ratio of luminosities of these two stars?

4. Magnitudes

(a) When Venus is brightest, it has apparent magnitude $m = -4.4$. The brightest star in the Northern Hemisphere is Sirius, with apparent magnitude of $m = -1.4$. Which is brighter, Venus or Sirius? Also, what is the ratio of brightness?

(b) The faintest stars that can be seen with a 1m telescope have apparent magnitude of 18. What is the apparent magnitude of the faintest star that you could see with a 4m telescope?

5. Energy from the Center of the Sun

Describe the steps by which energy is produced at the center of the Sun and how it makes its way to your eyes on Earth. You may present this as a narrative (life of a photon, from the center of the Sun to Earth) or simply as a bullet-pointed list. Try to include as many steps as you can think of as energy moves through the Sun to your eyes. You description *must* include how the energy is produced, how it moves out through the Sun, and what happens when it reaches Earth.