Hand in your solutions by 5pm on Wednesday, December 6. You should put them in the lower box outside my office.

As always, neatness and clarity are important; state the governing equation before plugging in numbers or otherwise manipulating it; show your work; give explanations; use sketches when appropriate; express your answer including units.

Be especially careful to answer all parts of each question.

Problem 1

(a) Ryden & Peterson problem 18.1 (p. 431). Note that there is information about the Sun's rotation on p. 189 of the textbook. And further, you may assume that the Sun remains spherical and has the same radial density distribution after it shrinks as it did beforehand.

(b) If the collapsed sun actually became oblate (bigger at the equator), would your answer for part (a) get bigger, stay the same, or get smaller? Explain your reasoning.

(c) Could this smaller, faster-rotating Sun hold itself together with its own gravity, given the large centrifugal force associated with its rapid rotation? Justify your answer with a calculation.

(d) How would the length of the Earth year change if the Sun suddenly shrunk in size (but retained all of its mass)?

Problem 2

Ryden & Peterson problem 18.5 (p. 431). Note that 10 km/s is the sound speed in the ISM, so at that point, the supernova remnant is really just fading into the surrounding interstellar medium.

In addition to answering both parts of the problem in the textbook, answer the following questions about the supernova in the textbook problem:

(a) Is this likely a core-collapse supernova or a type Ia supernova? Explain your reasoning.

(b) What other forms besides kinetic does the energy output of this supernova take?

(c) If the volume swept up by the expanding supernova ejecta in part (b) of the textbook problem is spherical, what is the radius of that spherical volume? Use whatever common astronomical length unit makes the result closest to one.

(d) If the typical inter-star spacing is 1 parsec, then approximately how many stars will you find inside the supernova remnant when its expansion velocity has slowed to 10 km/s?

Problem 3

Ryden & Peterson problem 18.7 (p. 431-32). Don't forget to answer the second part of the problem, too – the part about Jupiter's center. For full credit you must have a clearly labeled and accurately drawn graph. There should be (mks) numbers on each axis. For the sake of uniformity, everyone should make the y-axis the temperature axis and the x-axis the density axis.

Problem 4

At the beginning of Ch. 19 we read about how William and Caroline Herschel used star counts to find our location in the Milky Way. Their results incorrectly placed us near the center of the distribution of stars – this mistake stemmed from not knowing about dust extinction (center of the galaxy has more stars but also more dust).

This method of looking at object counts vs. limiting brightness is a common way to explore the spatial distribution of classes of objects. Classically, it can distinguish between a uniform and unbounded distribution on one hand and a uniform but bounded (finite) distribution on the other. And for cosmological objects, it can even provide information about the curvature of space (since volume only scales as distance cubed in Euclidean space). Let's see how this works, but let's ignore the magnitude-based formalism in the book.

(a) Your task is to sketch a plot of the number of stars seen in an observation vs. the limiting flux (or minimum brightness) in that observation. You should make this a log-log plot and get the slope right (but unlike in the last problem, you won't have enough information to find the intercept – the equation you derive to enable you to make the plot will have some undefined constants in it so it will only be a proportionality not an equality).

Assume a uniform and infinite distribution of stars (say, with density ρ_* stars parsec^{-3}) and assume all stars are identical, with luminosity $L = L_*$.

Imagine you make several observations of the same part of the sky, each with different exposure times and thus with different limiting fluxes (different values for the fluxes of the faintest observable star in each image).

Write down expressions for the limiting flux and for the number of stars seen in a given image. Both should be a function of the distance out to which you can see any stars in that image.

It might be helpful to recognize that each image sees stars in a finite volume of space in front of your telescope. And that volume is a fixed fraction of a spherical volume centered on your telescope no matter what the value of the limiting flux – and associated distance – is.

Make your sketch of number of stars, N_*, vs. the limiting magnitude, $F_{\rm lim}$, and make it a log-log plot.

(b) Now, modify your plot by adding a dotted line to it showing how it would look if your distribution of stars was finite – uniform as in part (a) out to a particular distance, $d_{\rm max}$, and no stars beyond that distance.