Hand in your solutions by 9pm on Sunday, December 9. You should put them in the lower box outside my office.

Here are a few guidelines for this – and every – homework assignment:

Use a *symbolic* approach (often aided by sketches and careful definition of variables) – using variables to denote relevant quantities and then, only at the end, when you've derived an expression that solves the problem at hand, plug in numbers.

Use units; don't go crazy with significant figures. Remember – you can never justify more significant figures in your answer than the *least* significant of the inputs to the problem.

Please show your work, write neatly – be organized. Explain what you are doing. Use sketches when you think they'd be helpful.

For full credit, you must show a reasonable amount of work and explain what you're doing.

Problem 1

The Jeans mass provides a simple criterion for star formation to initiate – there are also issues of angular momentum conservation, fragmentation (and the formation of binary stars), and external forces initiating cloud collapse. Stars range in mass from 0.08 $M_\odot$ to about 200 $M_\odot$.

(a) If the Jeans mass criterion were all that mattered for the formation of a single star from a single small cloud or cloud fragment, how cold would a cloud have to be to form a very low mass star? What about a very high mass star?

To answer this question (two questions – two temperatures), assume: (i) the initial cloud is pure molecular hydrogen (each particle comprises two hydrogen atoms), (ii) the density of the cloud is $n = 10^{12}$ particles m^{-3}, and (iii) when a cloud collapses and forms a star, the star ends up with about half the mass of the cloud (the other half is blown out of the system by the protostar's wind).

(b) If all clouds were very cold, would only low mass stars form?

(c) If all clouds were hot, would only high mass stars form?

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.

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

The Milky Way has a lot of stars. I wonder how far you could fly a space ship in a straight line before running into a star. Please calculate the mean free path of a space ship in the disk of the Milky Way. Assume the disk has 10^{10} stars and model them as distributed uniformly in a thin cylinder that's 1 kpc (kiloparsec, 10^3 pc) thick and 15 kpc in radius. These numbers all come from section 1 of chapter 19. Note that you may get a value somewhat different from what we've considered to be the typical inter-star spacing in the Solar neighborhood. But that's because we're averaging over the entire disk of the Galaxy here.

Assume that the "cross section" of each star is the size of our Solar System (take that to be 50 AU in radius). This makes sense because if the space ship flies close to a star it will feel its gravity (or at least notice).

So, **(a)** What is the mean free path of a spaceship in the Galactic disk, in units of kpc?

(b) Is a spaceship likely or unlikely to encounter a star if it flies through the Milky Way's disk, the long way (a path length of 30 kpc)?

Problem 5

When you look out in the plane of the Milky Way's disk, you see stars moving mostly due to the rotation of the Galaxy (once you get past the nearby stars, whose motion relative to the Sun is dominated by random motion since they are moving more or less the same direction and speed around the Galactic center as we are).

If the galactic rotation is modeled as being 220 km s^{-1} everywhere, then when you look through the disk the Milky Way in a direction 60 degrees away from the Galactic center:

(a) What will be the maximum radial velocity you'll measure of a star or a cloud of gas relative to the Sun? Assume all velocities are due just to the rotation of the Galaxy. Give your answer in km s^{-1}. Note that positive radial velocities correspond to red shifts – motion *away* from the observer.

(b) How far away from you will the star or gas cloud with that maximum Doppler shift be?

You can assume that we are 8 kpc from the Galactic center.

For full credit, include a labeled sketch explaining your solution.