Hand in your solutions by noon on Monday, November 12. 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**

Ryden & Peterson problem 16.4 (p. 392). The big picture here is that dust forms where hot gas cools to temperatures where the substances that compose dust (hydrocarbons, silicates) can condense and become solids. This hot gas often comes from stars (in the form of stellar winds, but also supernova explosions, planetary nebula ejections and other outflows of gas from stars), but the dust can’t form until the material is far enough away from the star to be cool enough for solids to condense out. Relatedly, if a dust grain wanders too close to a star, it may be destroyed (melted and evaporated).

In this problem, you’re calculating that critical distance for graphite dust to form (or be destroyed, if it already exists) given the temperature at which graphite solidifies and the properties of (two different) stars. Here’s how you should think about solving the problem – the dust grain can be treated as a sphere of radius $R_d$. It is heated by absorbing star light. That star light has a certain flux at the location of the dust that depends on the star’s luminosity (which in turn depends on the radius and temperature of the star in question) and the distance the dust grain is from the star. If the dust grain is in equilibrium (i.e. temperature is not increasing or decreasing) then the power (Watts) of star light absorbed by the dust grain equals the power it radiates back out into space. For this problem, you can assume it radiates as a blackbody (so, what’s the surface flux or radiated energy over all wavelengths? ...should be a relatively simple function of temperature) – don’t forget that the luminosity of a light-emitting object is equal to its surface area times the flux of light emitted by each square meter of surface. In this problem, you may assume the dust is rotating or tumbling so its entire surface is uniformly hot and so radiates uniformly from its entire surface. But in terms of the power absorbed by the dust, assume it absorbs star light only on one side – the side facing the star – and furthermore, that it presents an area to absorb that light that’s *not* the surface area of a sphere or hemisphere, but rather the cross sectional area of a sphere. Finally, remember that the *albedo* tells you what fraction of the light that hits an object is reflected. This must affect how much power is absorbed.
Problem 2

Ryden & Peterson problem 16.6 (p. 392). Collisions between objects can heat them up by transforming kinetic energy to thermal energy. In reality, not all of the energy is converted to thermal energy, some goes into compressing the gas too. And in the limit of weak collisions, a lot of the energy is dissipated as sound waves. But in a strong collision, like that caused by a supernova explosion hitting an interstellar cloud, most of the energy goes into heat initially and the amount of heating can be enormous (though it’s pretty modest in this problem – 10 km s\(^{-1}\) is not huge speed. Supernova explosions can be a thousand times faster (and so a million times the kinetic energy).

Problem 3

Ryden & Peterson problem 16.7 (p. 392). Do all four parts! Think about the logic: star looks redder than it should because of ISM dust; measuring how much redder tells us how much dust, which then tells us how much dimmer the star looks than it would if the ISM weren’t absorbing (really, scattering) some of the light. Accounting for this dimness is important if we want to use the inverse square law to measure the distance to the star.

Problem 4

Ryden & Peterson problem 16.9 (p. 392). For part (d) think about how the rate at which excited electrons spontaneously de-excite is equal to the rate at which photons are emitted.

Problem 5

Ryden & Peterson problem 16.10 (p. 392). This brings you back to a concept you learned in Ch. 5. Feel free to use the scaled equation from that chapter. For the second part of the question – comparing the line width to that observed in the Sun, do not look up the line width in the Sun's spectrum, rather simply use your knowledge of the Sun’s temperature and the cloud’s temperature to compute how many times bigger or smaller the line width would be in the Sun.