We'll have about 45 minutes for each of you to present some solutions, solve some follow-up problems, and discuss the meanings and interpretations of the astrophysics you've been thinking about and working on.

While we'll have a copy of the textbook and other resources available, the oral exam will be formally closed book. If a student needs to consult the book, I'll let them, but the general expectation is that students will be presenting solutions without the book open. However, the problems/topics that are the basis of the oral exam are listed below. And students should write up solutions and notes for each problem and bring those to the exam and will be able to consult those continuously throughout the oral exam.

You must work on these problems by yourself. You can use the textbook, handouts and other readings, and your notes, but not your classmates or the internet.

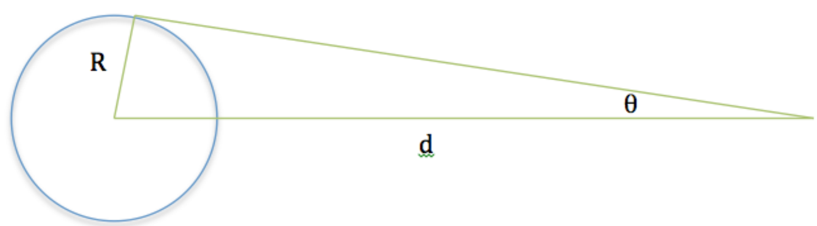
Some of the problems below invite follow-up questions, so you could prepare for that.

And there may be some new questions in the oral exam.

I'll ask you to give me your solutions/notes at the end of the exam.

Problem 1

Consider a spherical star with uniform specific intensity, I_o, radiated from its surface.



Schematic of a spherical star of radius R viewed by an observer at distance d. The star subtends an angle of 2θ (so its angular radius is θ). The radius segment shown forms a right angle with the line from the observer to the edge of the star.

(a) Compute the flux (given the definition of flux as a function of specific intensity) as measured by an observer at distance, d. Express your result in terms of d, R, and I_o.

(b) What is the luminosity of the star in terms of (some of) these same variables?

Note: it might come in handy to recall that $sin^2 + cos^2 = 1$.

Problem 2

Write down and justify the radiation transfer equation, in terms of z, j, and k, and then use the definition of the optical depth and source function to express the equation in terms of those quantities.

Solve the equation and interpret the terms in the solution.

Problem 2 continued on next page. . .

(a) Consider the spectrum emerging from an optically thin slab of gas in LTE with a temperature T and a background intensity, I_o, entering the slab from the back. Under what conditions is this spectrum an absorption line spectrum? You can assume the background intensity is given by the Planck function for an object with temperature T_o.

(b) Show that in a star, limb darkening is expected if the source function increases linearly with optical depth.

(c) If the opacity of the star is big at one frequency and small at another, at which frequency will the limb darkening be more extreme (in the sense of star's limb-to-center brightness contrast)? You can assume here too that the source function is linear with optical depth.

Problem 3

By how many centimeters would the Sun's radius have to shrink in one year in order for the Sun's (current) luminosity to be sustained solely by the conversion of gravitational potential energy to light? You may assume that the Sun's gravitational potential energy is given by the simple expression for a uniformly dense sphere.

Problem 4

At roughly what effective temperature does a white dwarf's atmosphere have about half singly ionized helium and half fully (doubly) ionized helium? Recall that singly ionized helium is a Rydberg (hydrogen-like, single-electron) atom. White dwarfs are roughly the mass of the Sun but the size of the Earth and can be very hot when they are young and cool as they age.

Problem 5

Consider a plane parallel gray atmosphere in LTE. In the context of the Eddington approximation (the intensity can be described simply by $I_{\rm out}$ for the hemisphere of outward going radiation and $I_{\rm in}$ for the hemisphere of inward going radiation), at what depth (at what optical depth) is the radiation field isotropic to a factor of 1%?