The exam will be a 25 minute oral “discussion”. I will not be asking you to have memorize formulae, like the full Saha equation, etc. I will not be asking you to derive equations. I will be probing general knowledge and understanding. Chances are you will not need to use the white board but can simply discuss the topics.

The web page http://astronomy.nmsu.edu/cwc/Teaching/ASTR545/Class-Notes provides the general outline of the course material by “Chapter”. All material will be open to discussion except for “Chapter 8”, which we did not cover. In terms of these “Chapters”, I provide some assistance with the emphasis you should consider as you prepare for your oral. Remember, we will be discussing these topics. Do not try to memorize rigorous details but focus on the big picture and general scaling behaviors. The details given below are to help remind you of some of the background material that is incorporated in building intuition for the big picture.

**Chapter 1a: Introduction**

There are five main properties that govern the spectral lines and continuum shape. You should know what they are and how they affect the spectrum of a star. Consider an absorption profile. Consider the Continuum. Some of this material was dealt with in more detail in the final two chapters (6 and 7) in terms of absorption cross-sections and opacities. What is opacity? What is optical depth? What is column density? How does column density related to number density? Be able to by-eye estimate the optical depth in an absorption line. Understand and know the curve of growth.

**Chapter 1b: HR Diagram and Stellar Classification**

Know the HR diagram and how stellar radius behaves on this diagram. Know how Spectral and Luminosity Classes are defined. Know the general behavior of log(g) on the HR diagram.

**Chapter 1c: Photometric Systems**

What are some common photometric systems (filter set AND standards)? What is the definition of magnitude? What is the difference between Vega and AB magnitudes? What is the difference between flux and flux density? What are Stromgren’s c₁ and m₁ indices used for?
Chapter 2: Atomic Transitions

Hydrogen Model: What are the differences and similarities of the Bohr and Schrödinger models of the hydrogen atom? What are excitation energy, ionization energy, and ionization potential? What is the physical source of fine structure? What is the Lamb shift? What is the statistical weight? What are the dipole selection rules for transitions? What is the physical basis for why there is a damping constant?

Multi-Electron Atoms: What is spectral notation and what does it describe about the state of an atom/ion? What are the dipole selection rules for multi-electron atoms?

Chapter 3a: Gas Physics I

What are and what are the differences between strict thermal equilibrium (TE), local TE (LTE), and non-LTE? What is the difference between abundance fractions and mass fractions? What do X, Y, Z describe? What does [X/H] describe? What does the mean molecular weight describe and why is it useful to know?

Chapter 3b: Gas Physics II

Be able to describe various bound-bound, bound-free, and free-free processes in a gas. Understanding particle and charge conservation and the behavior of excitation and ionization, be able to discuss the how ionization balance and ionization fractions change/behave in a gas as a function of pressure, temperature, and density. How does chemical composition affect the balance? Why are metals important at low temperature?

Chapter 3c: Gas Physics II

Know the equation of state for an ideal gas with and without radiation (i.e., $\beta=1$). Consider the relation $d\rho/\rho$ and have an intuition for the relative behavior of $dP/P$, $dT/T$, and $d\mu/\mu$. Have intuition for the first law of thermodynamics, $dQ=dU+PdV$. What is the specific heat? What defines a constant entropy process? What defines an adiabatic process? How are gradients defined? What are the three main gradients we discussed? What is the Schwarzschild Criterion of for the onset of convection? What is the mixing length model? Why is the “true” gradient in the convective region not equal to the radiative nor the adiabatic gradient in convective regions? What is the difference between the convective flux and the radiative flux?

Chapter 4: Radiative Transfer

What are the differences between specific intensity, mean intensity, flux, and mean momentum? Where does the $\cos\theta$ term originate in the higher moments? Which one is related to radiation pressure? What is the Eddington flux? What are the
absorption and emission coefficients? How is the source function defined? What does it represent? How does the solution to the radiative transfer equation behave with and without a source function? What are the Einstein coefficients? Why is there a stimulated emission correction to the absorption coefficient? In equilibrium, what is the relationship between the mean intensity, source function, and Planck function?

Chapter 5: Stellar Atmospheres

Why can we apply a plane parallel approximation to stellar atmospheres? What do we mean by the grey atmosphere model? What is Eddington's two-stream treatment to the radiation field? What is an exponential integral? What physically is it accounting for in the computation of the mean intensity, flux, and mean momentum? Why is \( \frac{dH}{dz} = 0 \) at all layers? Why is it that \( I_{\text{out}} - I_{\text{in}} = 4H \) at all layers? What is the \( T(\tau) \) relationship? What is the Hopf function and why is it used? What is the Rosseland mean opacity? What is the general behavior of the Rosseland mean opacity as a function of density and temperature in the sun (what are some typical values?) Explain in principle how you solve the pressure gradient in a grey stellar atmosphere model? How does log(\( g \)) affect pressure?

Chapter 6a: Absorption Lines I

What are the physical processes that broaden lines in an observed spectrum (natural, thermal, turbulent, pressure, instrumental spread function)? What functional form does each take? What are the characteristics of a Lorentzian as compared to a Gaussian? How do Lorentzians convolve? How do Gaussians convolve? What is a Voigt function/profile? What is a Doppler b parameter? What is the reason why high column density absorbers can have very broad damping wings in their absorption lines?

Chapter 6b: Absorption Lines II

What are the four main pressure-broadening mechanisms (linear and quadratic Stark, resonance, and van der Waals)? What are the \( n \) values associated with each? Be able to briefly discuss what lines and atoms/ions are affected by which mechanisms. Roughly know the types of stars that are slow rotators and those which can be either slow or fast rotators. At what point does the rotational broadening function get convolved with the radiative transfer model? How is the resolution \( R \) of a spectrograph defined? When does the instrumental spread function get convolved with the radiative transfer model?
Chapter 7: The Continuum

What are the major sources of continuum opacity in stars of various spectral classes and luminosity classes? In general, how does the H b-f cross section behave? The H f-f? The H b-f and f-f? Describe the behavior of the Balmer decrement as a function of spectral type; why does it peak in A0 stars? How does metallicity affect the Balmer decrement? When is electron scattering an important source of continuum opacity? In principle, how do you determine the total continuum opacity from all possible sources?