2025 ASTR794 SAMPLE FINAL EXAM QUESTIONS

Final exam will be held on Wednesday, May 14th at 1230-1500 in MAL 2055

1. Start with the radiative diffusion equation and the equation for hydrostatic equilibrium, and derive the expression for the Eddington Luminosity.

2. Derive the Stefan-Boltzmann law by integrating the Planck blackbody spectrum over all wavelengths or frequencies.

3. Using the appropriate equation(s) of stellar structure and noting the sign of the radial gradients, show that the condition for stability against convection can be recast as a condition on the luminosity profile

4. For generic index n, derive the Lane-Emden equation from the equation of hydrostatic equilibrium.

5. Derive the general solution (for constant source function) for the equation of radiative transfer.

6. Given an analytic density profile, derive and sketch the enclose mass profile, internal gravity profile, pressure profile, and thermal profile.

7. Show that in a plane-parallel, gray atmosphere under the Eddington Approximation:
    1. (a) $S = \langle I \rangle$,
    2. (b) Prad = F (τ + Q) / c(where Q is a constant of integration),
    3. (c) S = 3F (τ + 2/3) / 4 pi
    4. (d) T (τ) = Teff ($3\tau/4 + 1/2)^{1/4}$

8. Derive the equilibrium temperature of a planet heated solely by external irradiation from its host star, under the assumption that the night-side temperature is zero Kelvin.

9. Derive an expression for the surface temperature of a planet with a simple one-layer atmosphere with visible atmospheric optical depth τ_{VIS}, infrared atmospheric optical depth τ_{IR}, surface Bond albedo A_B, and assuming that the atmosphere emits only in the infrared.

10. Derive the condition for stability against convection, and the adiabatic convection-driven thermal profile in a stellar or planetary atmosphere.