ASTR-3760: Solar and Space Physics .... **Spring 2016**

Review material for midterm exam (Wednesday, March 16, 2016)

Will be done in class. No calculator is needed.

1. Be able to estimate the brightness temperature from a given plot of flux density versus radio wavelength (cf. Lecture 2, p. 20). Convert between $I_\nu(\nu, T)$ and $I_\lambda(\lambda, T)$ (cf. Lecture 3, p. 4).
2. Be able to estimate the energy production for fusion reactions given a periodic table with the atomic masses (cf. Lecture 4, p. 3).
3. Be able to convert quantities between different units (cf. Lecture 4, p. 4, Lecture 19, p. 6).
4. Estimate the production of helium and the production of neutrinos given the Sun's luminosity (cf. Lecture 4, p. 5, pp. 8–11).
5. Estimate the Sun's center to limb variation for a given temperature distribution (cf. Lecture 5, p. 6).
6. Explain when the Faraday displacement term can be neglected (cf. Lecture 5, p. 13).
7. Work with index notation in simple cases (cf. Lecture 6, p. 4).
8. Be able to plot or sketch experimental data in a meaningful way (cf. Lecture 7, p. 10; HW1, problem 1; or HW2, problem 1).
9. Be able to estimate the change of intensity in simple cases (cf. Lecture 7, p. 13; Lecture 8, pp. 6–7; HW1, problem 2).
10. Explain the relation between electric field vector and Stokes parameters (cf. Lecture 8, p. 17).
11. Interpret an absorption spectrum showing Zeeman splitting in terms of longitudinal and transverse magnetic fields (cf. Lecture 9, pp. 14–16; Stix, p. 126).
12. Compute mean molecular weight for neutral or ionized mixtures (cf. Lecture 10, p. 13).
13. Compute magnetic pressure gradient and tension force for a simple vector field (cf. Lecture 10, p. 15 and 16; Stix, Chap. 8.1.4).
14. Explain mass conservation in terms of the continuity equation and its volume-integrated form (cf. Lecture 11, p. 10).
15. Derive a dispersion relation for the frequency $\omega = \omega(k)$ as a function of wavenumber k. Understand what it means if the frequency if purely imaginary or even complex. Derive and explain the Doppler effect using the dispersion relation. See examples in Lectures 9 (pp. 7–12), 11 (pp. 11–12), 13 (p. 10), 19, 22.
16. Why are there two solutions for sounds waves, for example? Explain their meanings and discuss the superposition of waves. What are standing waves? (cf. Lecture 12, p. 3).
17. Explain why the lines in the $k\omega$ diagram present evidence that the 5-min oscillations of the Sun are global. (cf. Lecture 12, p. 12).

18. Discuss the lower boundary of the cavity for sound waves in the Sun both in terms of refraction (lower part of the wave plane propagates faster than the upper part) and mathematically in terms of the equation $k_z^2 = \omega^2/c_\mathrm{s}(z)^2 - k_x^2$ (cf. Lecture 12, p. 14, Stix, p. 203).

19. Looking at the run of $c_\mathrm{s}(r)$, explain why there is a kink near $r/R = 0.7$ and why there is a decrease below $r/R = 0.1$. (cf. Lecture 13, p. 3, Stix, p. 214).

20. Interpret the results of Fourier transform experiments; look at pp. 6 and 7 of Lecture 13.

21. Explain qualitatively why the Doppler effect can be used to learn about the internal angular velocity in the Sun, $\Omega(r, \theta, t)$ (cf. Lecture 13, p. 11–16, Stix, pp. 220–223 and pp. 226–228).

22. Explain the difference in change of internal energy related to work on or from the system on the one hand and change of heat on the other (cf. Lecture 14, pp. 4 and 7).

23. Given a certain profile of specific entropy, explain in words when the stratification is convectively stable (cf. Lecture 14, p. 9).

24. What causes changes in specific entropy (cf. Lecture 15, p. 12).

25. Explain qualitatively buoyancy oscillations (cf. Lecture 15, p. 15–16, and Lecture 16, pp. 10–12, Stix, pp. 203 and 210).

26. Describe qualitatively the solar butterfly diagram. Where do sunspots occur in the beginning and the end of the cycle, discuss the change in polarity of bipolar regions, and interpret this in terms of magnetically buoyant flux tubes (cf. Lecture 17, pp. 3–7).

27. Explain Ohm's law and the relation between comoving and lab frames (cf. Lecture 18, pp. 10–12).

28. Explain qualitatively the dynamo wave in the Sun (cf. Lecture 18, pp. 13–15).

29. Ohmic diffusion (cf. Lecture 19, pp. 7–8).

30. Alfvén speed (cf. Lecture 20, pp. 7–8).

31. Show that a solution of the form $T = (z_0 - z)\, g/c_p$ with $\rho \propto T^n$ obeys thermal and hydrostatic equilibrium. Derive the criterion for convective stability. (cf. Lecture 21, pp. 5–7).

32. Explain qualitatively the structure of convection in the Sun (cf. Lecture 22, pp. 7–10).