(AST 462) Problem Set 2, Due Mar 4

This problem set will require that you work through some of the sections in the text and synthesize the reading with the notes and class discussions:

1. Exercise on Accretion Disks (Read Chap 7 of Shu, section 5.7 Choudhuri):

a) For a steady, thin, axisymmetric accretion disk, find the Mach number associated with (i) the radial accretion speed of the gas and (ii) the orbital speed of the gas. Assume the location in the disk satisfies $r >> r_*$ far away from the stellar surface.

b) Do you expect there to be shocks in the simple accretion flow as described above?

c) Why is an enhanced viscosity often desired for astrophysical accretion flows?

d) Explain the difference between turbulent viscosity and microphysical viscosity.

e) When one uses a turbulent viscosity rather than microphysical viscosity, the fluid variables like radial and azimuthal velocity in the accretion disk equations mean something different than when the microphysical viscosity is used. Explain the difference.

2. Exercise on MHD Waves (Read Chapters 21-22 Shu). This exercise is intended to get you to swiftly penetrate the subject of MHD and see one important way in which MHD differs from fluid mechanics.

a) In class we derived the sound wave dispersion relation from perturbation theory. The same approach can be used in MHD. From the MHD equations derive the dispersion relation for MHD waves when a magneto-fluid has an initially uniform magnetic field.

b) Give the direction of fluid displacement and wave propagation for Alfvén waves, slow waves, and fast waves. For slow and fast waves the interpretation is different depending on whether the waves propagate perpendicular or parallel to the magnetic field, thus explain for both cases.

c) In fluid mechanics, there is 1 type of shock discontinuity. How many would you expect in MHD and why? Does the answer depend on angle of propagation with respect to the magnetic field?

d) Figure 22.4 is drawn for the case in which the sound speed is less than the Alfvén speed. Draw the analogous figure for the case in which the sound speed is greater than Alfvén speed.