1. From the equation of radiative transfer appropriate for a plane-parallel atmosphere for which time-dependent effects and gravitational and magnetic potential gradients are neglected, and under the assumption of coherent isotropic scattering, derive the emergent intensity $I(\mu, \tau = 0)$ assuming the source function behaves like $S(t) = at + b$. Assume that the stellar surface is unilluminated from above. What is the variation of the emergent intensity with the viewing angle called? What kind of information can be obtained from its observation?

2. Use the simplest method possible to show how the line intensity, parametrized by the equivalent width, depends upon the number of scatterers (actually their column density) for a weak line and for a very strong line. State your assumptions.

3. Assume that one star ($M_1$) in a binary with a circular orbit instantaneously loses a mass $\Delta M$ with no preferred direction. Derive the largest $\Delta M$ that will leave the binary bound.

4. Redo the preceding problem assuming that the mass is lost in a preferred direction with a velocity magnitude $v$. Assume two cases for the preferred direction: i) $v$ in the same direction as $v_1$, ii) $v$ directed oppositely to $v_1$. Hint: establish the “kick” velocity imparted to star 1.

5. Using dimensional analysis, prove the result that a strong explosion inside a uniform density star produces an initial luminosity at the surface

$$L_0 \sim \frac{cE_{SN}R_0}{\kappa_o M}$$

where $E_{SN}$ is the total explosion energy, $R_0$ is the initial stellar radius, $M$ is the total ejected (stellar) mass, and $\kappa_o$ is the opacity (which can be assumed to be due to electron scattering and is therefore independent of density and temperature). Don’t worry about factors of 2 or $\pi$. You should only need to use the first law of thermodynamics, radiative energy transport, and an equation of state dominated by radiation pressure to demonstrate this result.

6. Using the result of the preceding problem, would you expect the initial luminosity from a Type Ia supernova to be larger or smaller than that of a Type II supernova? Assume that $E_{SN}$ is the same for both. Physically explain this result.