Astronomy 505: Homework #12 (Galaxies & Stars)

You may find it helpful to consult a galactic astronomy text, such as Binney & Merrifield's *Galactic Astronomy*, to determine certain stellar values for this problem set.

1. **Carroll & Ostlie, Problem 7.6**:
   From the light and velocity curves of an eclipsing, spectroscopic binary star system, it is determined that the orbital period is 6.31 years, and the maximum radial velocities of stars A and B are 5.4 km s^{-1} and 22.4 km s^{-1} respectively. Furthermore, the time period between first contact and minimum light ($t_b - t_a$) is 0.58 d, the length of the primary minimum ($t_c - t_b$) is 0.64 d, and the apparent bolometric magnitudes of maxium, primary minimum, and secondary minimum are 5.40 magnitudes, 9.20 magnitudes, and 5.44 magnitudes respectively. From this information, and assuming circular orbits, find the
   (a) Ratio of the stellar masses. (3 pts)
   (b) Sum of the masses (assume $i \simeq 90°$). (3 pts)
   (c) Individual masses. (3 pts)
   (d) Individual radii. (5 pts)
   (e) Ratio of the effective temperatures of the two stars. (5 pts)
2. **Carroll & Ostlie, Problem 10.2**:
   Prove that the gravitational force on a point mass m located anywhere inside a hollow, spherically symmetric shell is zero. Assume that the mass of the shell is M and has a constant density ρ, and that the radii of the inside and outside surfaces of the shell are r_1 and r_2. (If you use Gauss's Law, you need to first prove it by working out the spatial integrals.) (10 pts)
3. Use the Hertzsprung-Russell diagram and the stellar spectra within the lecture notes to answer the following questions.
   (a) If a K-type star has a luminosity of 10^4 $L_\odot$, what is its luminosity class? (3 pts)
   (b) If a Main Sequence star is three times as hot as the Sun, estimate (roughly) its luminosity, spectral type, B-V colour, and radius. (5 pts)
   (c) What key parameter determines the position of a white dwarf along the temperature sequence? (*Hint: consider the narrow range of progenitor star characteristics.*) (2 pts)
4. The center of the Milky Way is at (1950 epoch) $\alpha = 17^h 42^m 29.3^s \pm 0.15^s$, $\delta = -28^d 59' 18'' \pm 3''$. What are its Galactic coordinates? (3 pts)
5. **Carroll & Ostlie, Problem 24.8**:
   (a) Plot (e.g., with Supermongo) the old thin disk's luminosity density (Eq. 24.10) as a function of z for $R = 8.0$ kpc. (5 pts)
   (b) Prove that for $z \gg z_o$
   $$L(R, z) \simeq 4 L_o \, e^{-\frac{R}{h_R}} \, e^{\frac{-2z}{z_o}}$$
   and so $z_o = 2 z_{thin}$ is the effective scale height of the luminosity density function. (3 pts)
6. **Carroll & Ostlie, Problem 27.9**: Assuming that the Sculptor group of galaxies (see Carroll & Ostlie, pg. 1061) occupies a spherical volume of space, find the difference in magnitude between two identical objects located at the very front and back of the group. (6 pts)
7. Use LaTeX to formally present your solution to Problem 6. If your solution did not include a figure, add one now for practice. You will need to first draw the figure in a separate environment (e.g., SuperMongo), save your output in postscript form, and then include the postscript figure within the LaTeX document. Bonus points will be awarded for creativity ... (10 pts)