FIRST ASSIGNMENT: ASTRONOMY 8100
 STELLAR STRUCTURE AND EVOLUTION: DUE 3 FEBRUARY 2004
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Read Sections 1–4 and 6 of Kippenhahn and Wiegert (hereafter, KW), assuming that we have gotten the book. You may skip §2.6. I’ve attached the pages from §3 that you need to answer question 2 in case the book hasn’t arrived in time.

The point value of each question is given in brackets.

1. Explicitly prove that
\[ \frac{\partial \Phi}{\partial r} = \frac{Gm}{r^2} \]

is a solution of
\[ \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 \frac{\partial \Phi}{\partial r} \right) = 4\pi G\rho. \]

(My questions don’t get any easier than this!) [12]

2. Derive the following version of the virial theorem for an ideal gas which is more general than that given by (3.6) of KW (i.e., \( E_g = -2E_i \)), by explicitly allowing the time-averaged bulk kinetic energy, \( <E_k> \) of the material to be included:
\[ 2 <E_k> + 2 <E_i> + <E_g> = 0. \]

You may wish to refer to Chapter 1 of The Fundamentals of Stellar Astrophysics by G. Collins II in answering this question. [24]

3. Below I’ve listed the properties of 4 stars. Give the spectral and luminosity classification for each, e.g., G3V, and also give their approximate luminosities in solar units, and mean densities in g cm\(^{-3}\). You will probably have to perform some research to answer this question. [24]
   
   (a) \( R = 200 \, R_\odot, \, M = 12.6M_\odot \).
   (b) \( R = 3.80 \, R_\odot, \, M = 6.46M_\odot \).
   (c) \( R = 25.1 \, R_\odot, \, M = 5.0M_\odot \).
   (d) \( R = 0.50 \, R_\odot, \, M = 0.39M_\odot \).

4. On the back of this sheet you will find light-curves and/or radial velocity curves and/or coarse spectra for 5 binary systems. In some cases, additional information, such as the period (P) or distance (D) to the system, and/or its maximum angular separation (\( \sigma \)) are provided. For each of them, compute and/or estimate (if possible, given the information provided) the following parameters: \( M_1, \, M_2, \, T_1, \, T_2, \, R_1, \, R_2, \, a_1, \, a_2, \, i, \) and \( e \). Note that you will probably have to do a bit of research to garner enough information to complete this part of the assignment, as little relevant information is in your texts. Most of the time you will only be able to obtain ratios or sums of some of these parameters, but your goal is to extract as much information as possible about these stellar systems. [40]