Homework # 3

Due before Tuesday, October 27th

README: Make sure you write down all steps to solve the problems, so that I can give partial credit if needed. If I do not see the procedure you followed to solve the problem, you will get a zero on that problem. Also, be careful with units: they are extremely important! Only use the constants and values provided to solve the problems. Finally, make sure you write neatly so that I can understand it: if I don't understand what you wrote, you will get a zero. Scan the solution (into a single PDF, preferably) and send it back to me before the deadline. When a comparison between quantities is asked for, you need to calculate the ratio between the two quantities. When asked to make a figure/plot/diagram, make sure you produce this figure electronically, either with python coding (preferably) or with Excel (or similar).

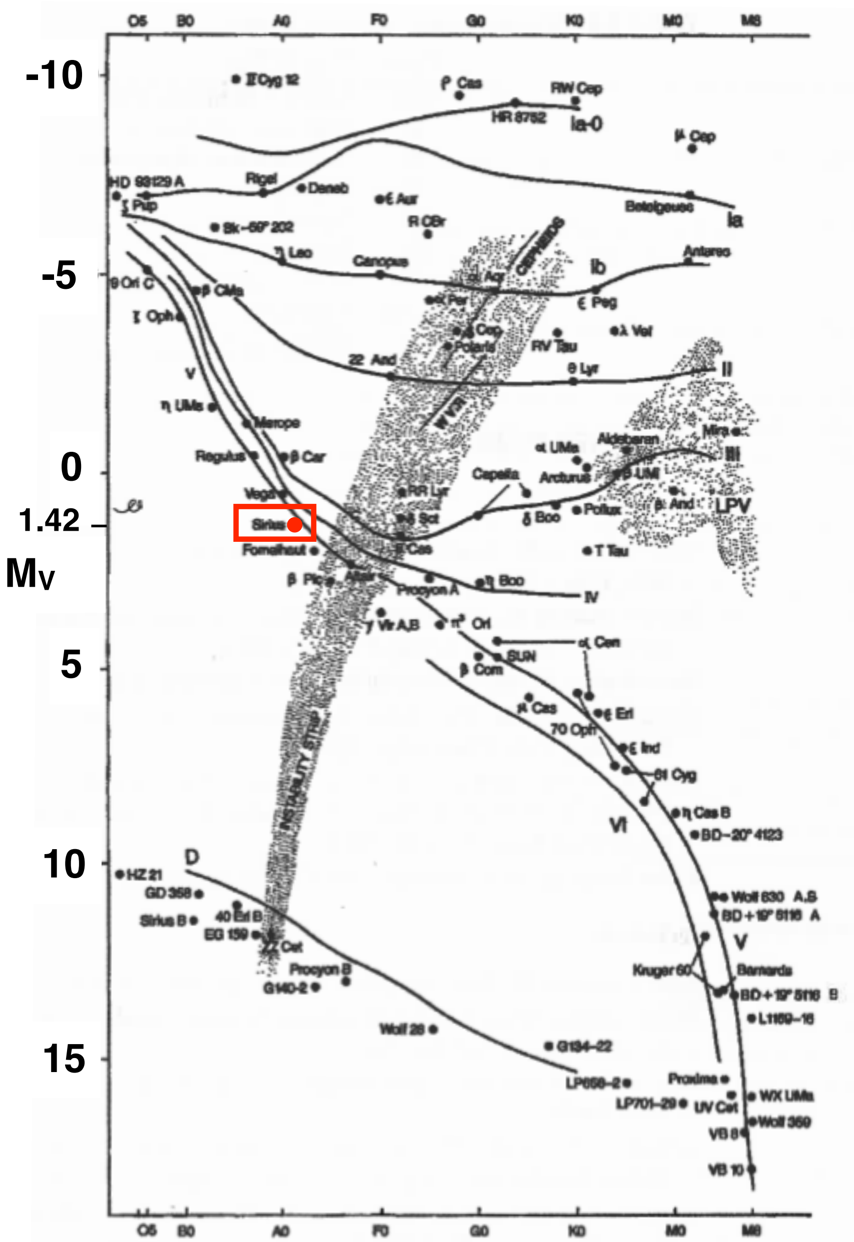
CONSTANTS and OTHER VALUES (only use the provided constants/values to solve the problems):

H_{alpha} wavelength at rest = 656.281 nm
Speed of light: $c = 3 \times 10^5$ km/s
Rydberg constant for Hydrogen: $R_H = 1.09677583 \times 10^7$ m^{-1}
$M_{Sun} = 1.989 \times 10^{30}$ kg $\quad$ $R_{Sun} = 6.95508 \times 10^8$ m $\quad$ $L_{Sun} = 3.839 \times 10^{26}$ W
$R_{Earth} = 6.378136 \times 10^6$ m
Stefan-Boltzmann constant sigma = 5.6704×10^{-8} W m^{-2} K^{-4}

1) Barnard's star is an orange star in the constellation Ophiuchus. It has the largest proper motion (10.3 arcsec/yr) and the fourth largest parallax angle (p=0.54 arcsec). In the spectrum of Barnard's star, the Halpha absorption line is observed to have a wavelength of 656.034 nm when measured from the ground.

   A. determine the radial velocity of Barnard's star in km/s
   B. determine the transverse velocity of Barnard's star in km/s
   C. calculate the speed of Barnard's star through space in km/s

2) Calculate the shortest vacuum-wavelength (in nm) produced by a downward electron transition in the Lyman, Balmer, and Paschen series. Specify whether these transitions are in emission or in absorption of photons. These wavelengths are known as the series limits. In which regions of the electromagnetic spectrum are these wavelengths found?



3) The blue-white star Sirius has an apparent visual magnitude of $m_V = -1.46$. Use the H-R diagram above to determine the distance to this star.

4) For a gas of neutral hydrogen atoms, at what temperature is the number of atoms in the first excited state only 3% of the number of atoms in the ground state? At what temperature is the number of atoms in the first excited state 15% of the number of atoms in the ground state?

5) We have learned that a white dwarf star typically has a radius that is only 1% of the Sun's radius. Determine the average density (in kg/m^3) of a 1.2 M_{Sun} white dwarf, and compare it to the average density of the Sun (i.e., calculate the ratio between the average density of the white dwarf and that of the Sun).

6) Estimate the hydrogen-burning lifetimes of stars near the lower and upper ends of the main sequence. The lower end of the main sequence occurs near 0.072 M_{Sun}, with logT=3.23 and $\log(L/L_{Sun})$=-4.3. On the other hand, an 85 M_{Sun} star near the upper end of the main sequence has an effective temperature and luminosity of logT=4.705 and $\log(L/L_{Sun})$=6.006, respectively. Assume that the 0.072 M_{Sun} star is entirely convective so that, through convective mixing, all of its hydrogen, rather than just the inner 10%, becomes available for burning (as in the case for a high-mass star)

7) Using the information given in problem 6, calculate the radii (in units of solar radius) of a 0.072 M_{Sun} star and a 85 M_{Sun} star. What is the ratio of their radii?