Ay 10 - Problem Set #7
Due: October 25, 11am

Please write your full name, section number, and GSI's name at the top of your homework. Also, be sure to put your homework in the correct box in the basement of Campbell Hall. There is a 20% penalty per day for the late submission of assignments, however you do get one "freebie" (see course syllabus for more info).

Remember to always show your work; no credit will be given for just a final answer. However, if you get most of the question right but get the final answer wrong, you will get most of the points. Use a calculator where necessary and don't forget units if the answer requires them.

If you use any resource besides the textbook, lecture, or section (*e.g.* a web site), be sure to include proper attribution for the reference. Feel free to work with other students in the class, but remember that all work turned in must be your own (*i.e.* don't just copy the work of another student).

1. **(5 points)** How Old is This Cluster?

   Figure 1 is an H-R diagram of a star cluster. Note that while many of the stars in the cluster lie along the main sequence, many stars have also begun to "turn off" the main sequence. The stars that are turning off the main sequence are reaching the end of their stellar life cycle. Using the information from Section 17.8 of your book, how old is this cluster?

2. **(5 points)** Fun with Fusion

   (a) How long does it take for the Sun to convert one Earth mass of hydrogen into helium through fusion? HINT: Recall that the luminosity of the Sun is 3.8×10^{26} Watts and that 1 Watt = 1 J/s).

   (b) The power consumption of the US is about 5×10^{12} Watts. If hydrogen fusion could be performed as efficiently on Earth as it is in the Sun (i.e. release the same amount of energy per hydrogen nucleus), how many kilograms of hydrogen would need to be fused per second to power the US? Comment on the implications of your result.

3. **(8 points)** What the Flux?!?!

   (a) If you want to make a star twice as luminous, would you increase or decrease its temperature? By how much?

   (b) If you want to make a star half as luminous, would you increase or decrease its radius? By how much?

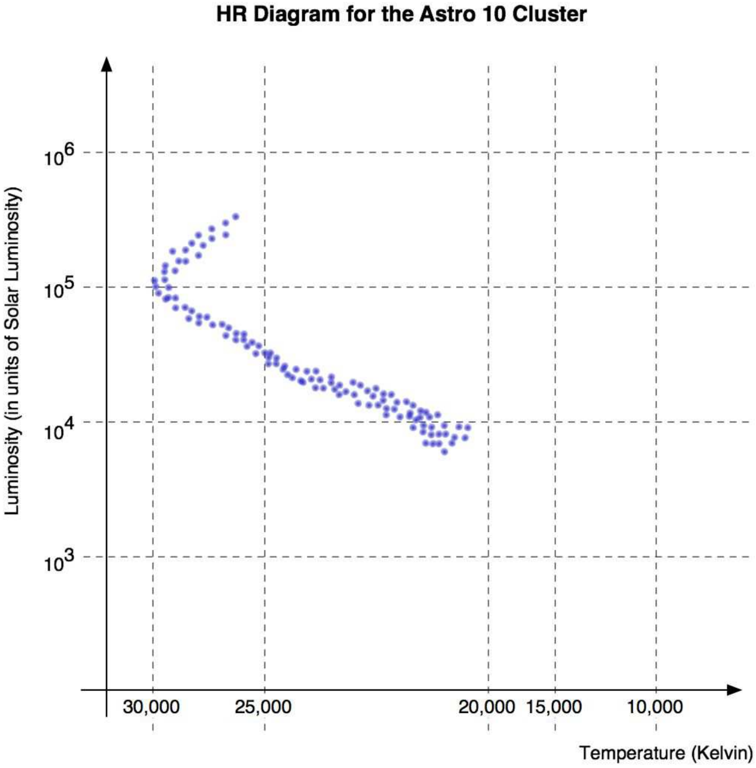

Figure 1: An H-R Diagram of a star cluster

(c) What's the luminosity in solar units of a hypothetical star whose radius is 0.1 solar radius and whose surface temperature is 580 K (0.1 times that of the Sun)?

(d) A main sequence star is 20 pc away and is barely visible through a certain telescope. The star subsequently evolves to become a red giant, during which time its temperature drops by a factor of three and its radius increases to a hundred times its old radius. What is the new maximum distance at which the star would still be visible in the same telescope?

4. **(7 points)** Movin' On Up...and Down the H-R Diagram

For this question refer to the H-R Diagram in Figure 2.

(a) A star at Point A in Figure 2 is in what stage of stellar evolution?

(b) What is happening to a star as it progresses from Point A towards Point B?

(c) The Algol binary system consists of a $3M_\odot$ main sequence star (Point B) and a $0.8M_\odot$ main sequence star (Point C) with an orbital period of 2.87 days. Use Newton's version of Kepler's third law to calculate the orbital separation of the system (in AU).

(d) How does the separation you computed above compare with the typical size of a red giant star?

(e) Assuming that both stars in the Algol system reached the main sequence at the same time, which star will be the first to become a red giant? When this happens, will it's size be large enough to engulf the other star?

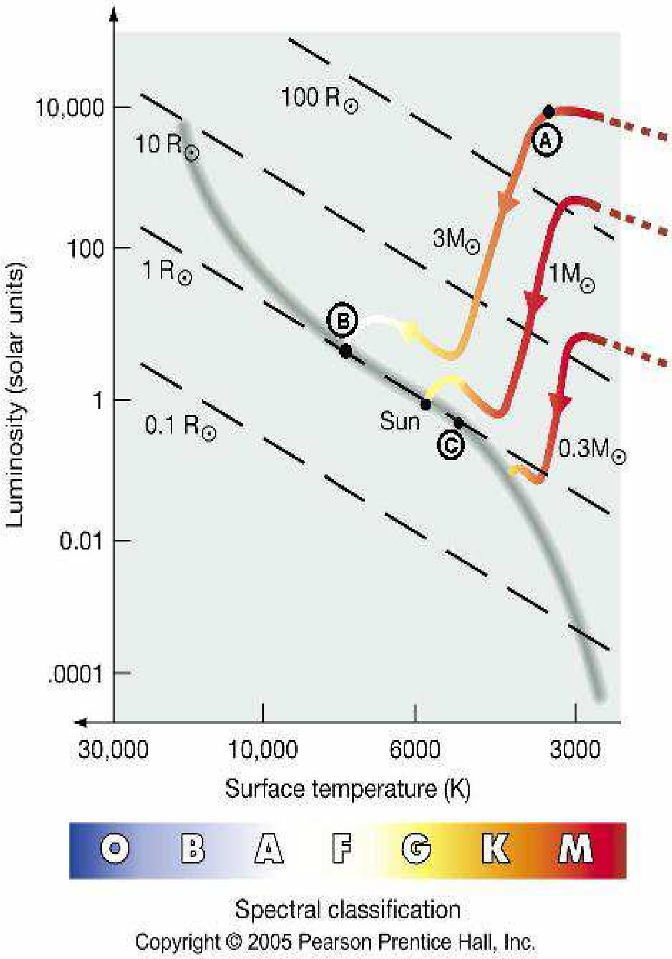

Figure 2: An H-R Diagram