Astronomy Homework #5

Name______________________________ DUE: **April 1** (by 11 PM)

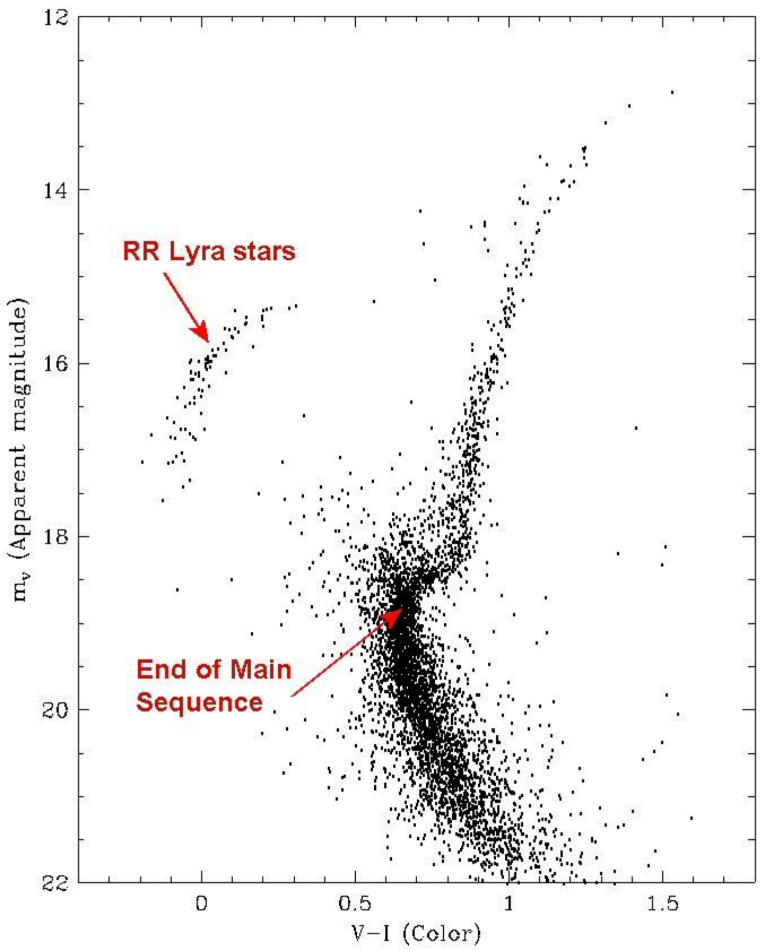
This homework is worth 30 points, so don't wait to do it until the last minute!

Your homework grade depends not only upon your getting the correct answer but also grammar, spelling and punctuation, particularly in questions that require explanations. Numerical answers to questions do not need to be written in complete sentences and you should show your work where ever it is appropriate. Partial credit may be given for showing your work even if your result is incorrect. You will also be graded on the use of significant figures, proper units of measure and proper scientific notation. You may work with others in determining the answers to the questions, but what you write should be in your own words – any homework assignments that look too similar to that of other students will receive no credit. Unless otherwise noted, all questions are worth 1 point. Homework can be turned in at the office Latham 121 during business hours, during class, or on-line at e-Learning.

1 (10 points total) At the course website there is link to a bunch of information about globular clusters. First you will be assigned a globular cluster based upon your student ID number.

Which cluster do you have _________________________

Follow the link to get the HR diagram for your cluster. This HR diagram is one that uses the apparent magnitude, m_v, rather than absolute magnitude since all the stars are at the same distance, along with a way of defining the color of the stars in the cluster, the V-I index.



There are several things you're going to do here, such as determining the distance and the age of your cluster. To help do this, you need to get a few bits of information from your HR diagram. First we'll figure out the distance to your cluster using the RR Lyra stars. To do that you need to determine the average apparent magnitude of the RR Lyra stars from the HR diagram. These are spread out a bit, so you'll want to estimate the location for the greatest concentration of their distribution.

a. What is the average apparent magnitude (m_v) for the RR Lyra stars?

To get the distance we also need the absolute magnitude (M_v). To do that we'll use a feature of RR Lyra that is rather interesting – their absolute magnitudes depend upon their chemical composition. So we need to get a value for this cluster's chemical composition. Follow the link to the *Globular Cluster Database* and use the search function at that page to look up the characteristics of your cluster. There is a lot of data provided and the one that describes the chemical composition is **[Fe/H]** which is a logarithmic value compared to the Sun's amount of metals. This is a negative value indicating that the amount of metals is less than that of the Sun.

b. What is your cluster's value for [Fe/H]?

Now that you have the value for [Fe/H], you can determine the value of the RR Lyra star's average absolute magnitude, M_v, which is given by this formula –

$$M_v = 0.32\ [Fe/H] + 1.01$$

c. What is the value of your cluster's RR Lyra stars average absolute magnitude (M_v)?

Now that you have a value for m_v and M_v you can calculate the distance to the cluster. We'll use the same formula that we used on the last homework, $d = 10^{(m-M+5)/5}$, where *d* is the distance in parsecs.

d. What is the distance of the cluster from us?

Now you'll determine the age of the cluster. This will depend upon where the end of the Main Sequence is located. You should use the central distribution of MS stars and approximate where the MS starts to curve towards the right (towards the Red Giant location). Once you have found this location, determine as accurately as possible the value for V-I for a star found in the end of the MS.

e. What is the V-I value for the center of the end of the MS for your cluster?

Now we need to turn that value into a temperature. Use the V-I conversion program tool provided with the cluster links to determine the temperature for a star that would be found at the end of your cluster's MS.

f. End of MS temperature: ______________________

You'll need to go to the *Main Sequence Characteristics* link to find the mass for the star located at the end of the MS. This table should look familiar since you used it previously. Find the appropriate spectral type and mass for the temperature of this star. You may have to estimate both these values, so be careful since it is not likely that your star's temperature exactly matches one of the spectral types.

g. Your star's spectral type :_____________ and Mass: ________________________ .

A star located at the end of the MS would provide the age for the cluster since it is still on the MS. You can determine the age of the star, and therefore the cluster by using the formula
Age = 10^{10} (1/*Mass*$^{2.5}$) years where *Mass* is the mass in solar masses.

h. How old is the star (and consequently, your globular cluster)?

i. How does your cluster age compare to the currently observationally determined age for the Universe, 13.8 billion years? Provide both a quantitative and qualitative comparison.

2. (10 points) **Galaxy Classification**. At the website there is a link to images of 20 galaxies. Determine the type for each galaxy. Your options are Spiral, Barred Spiral, Elliptical and Irregular. Provide only one type for each galaxy.

Galaxy 1

Galaxy 2

Galaxy 3

Galaxy 4

Galaxy 5

Galaxy 6

Galaxy 7

Galaxy 8

Galaxy 9

Galaxy 10

Galaxy 11

Galaxy 12

Galaxy 13

Galaxy 14

Galaxy 15

Galaxy 16

Galaxy 17

Galaxy 18

Galaxy 19

Galaxy 20

3. (10 points) At the course website is an image of the Hubble Ultra Deep Field (HUDF). This is a compilation of images from the *Hubble Space Telescope* taken over a time that is equivalent to 600 hours of exposures during a 10 year span. By combining the images together, it is possible to see incredibly faint objects.

a. Nearly every object in the HUDF is a galaxy. What different colors do you see for the galaxies?

b. (2 points) Why do galaxies have different colors? There are multiple reasons, but provide only two distinct reasons.

The HUDF can give us an estimate to the number of observable galaxies in the Universe. To do this you'll need to count how many galaxies are in the image. I suspect you don't want to do that, so you will not – we'll do this using a different method. There are links to images of small parts of the HUDF, which are labeled 0-9. You'll count the galaxies in two of these images. To randomize things a bit, you'll use the last two numbers (rightmost) in your student ID. If those numbers are identical, just randomly pick a different number.

c. Indicate the numbers from your ID in the table below.

Two Numbers (based on ID)	Number of galaxies in corresponding image

d. For each of the images, count the number of galaxies. These images are actually negatives, since it is easier to see objects in a light background rather than a dark background. Make sure you count each object that is distinct from the background level of light.

e. What is the average of your galaxy count values?

f. The regions that you looked at were only 1.74 x 10^{-5} of a square degree in size. To determine the number of galaxies that would be visible, on average, in a square degree, use your average from part "e" and divide it by 1.74 x 10^{-5}. How many galaxies would you expect to see in a square degree?

g. There are approximately 41,250 square degrees in the total sky. If you take your answer from part "f" and multiply it by 41,250 you'll get the number of galaxies that would be visible in images of the entire sky that are made like the HUDF. How many total galaxies would be visible in the sky in all directions?

h. (2 points) Astronomers find about 10,000 galaxies in the entire HUDF and estimate that there would be a total of 325 billion galaxies visible in all directions of the sky. Compare this value to the number you got in part "g", both quantitatively and qualitatively.