Name:
Group Members:

Lab 6

I. The Milky Way

(A) Open up *Starry Night* and set the time/date to 8:00 pm on November 26. In the **Options** tab, under "Galactic Guides," click on *Equator* to help you find the band of the Milky Way. Under "Constellations" click on *Boundaries* and *Labels*. Traveling across the sky from east to west, list what constellations the band of the Milky Way passes through.

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(B) Return to the main Student Exercises page and go to *G: Galaxies and the Universe*, and choose *G1: Our Home Galaxy, the Milky Way*. Do exercises 1–6, answering questions 1–8 below:

1.____________ 2.____________ 3.____________ 4.____________

5.____________ 6.____________ 7.____________ 8.____________

II. The Messier Objects

(A) **The shape of the Milky Way:** Return to the main *SkyGuide* panel and go to Guided Tours > Night Sky Tours > Messier Objects and read through the tour.

Once you get to the Messier marathon, minimize or close Starry Night, and open this link to Wikipedia's List of Messier Objects. This list gives you a short description of each object and tells you what constellation it is in.

1. Figure 1 on the following page shows a map of the sky in galactic coordinates. Consider the hypothesis that the Sun lies close to the center of the Milky Way and its associated globular clusters. If this hypothesis were true, how would you expect the globular clusters to be distributed around the sky? For example, would you expect them to be clustered in one direction or spread evenly throughout the sky? Explain yourself.

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2. Find the globular clusters in the Messier list (it might help to sort them by type). Using Figure 1, put a "G" in the constellation where each globular cluster is located. If a constellation has multiple clusters in it, put multiple G's!

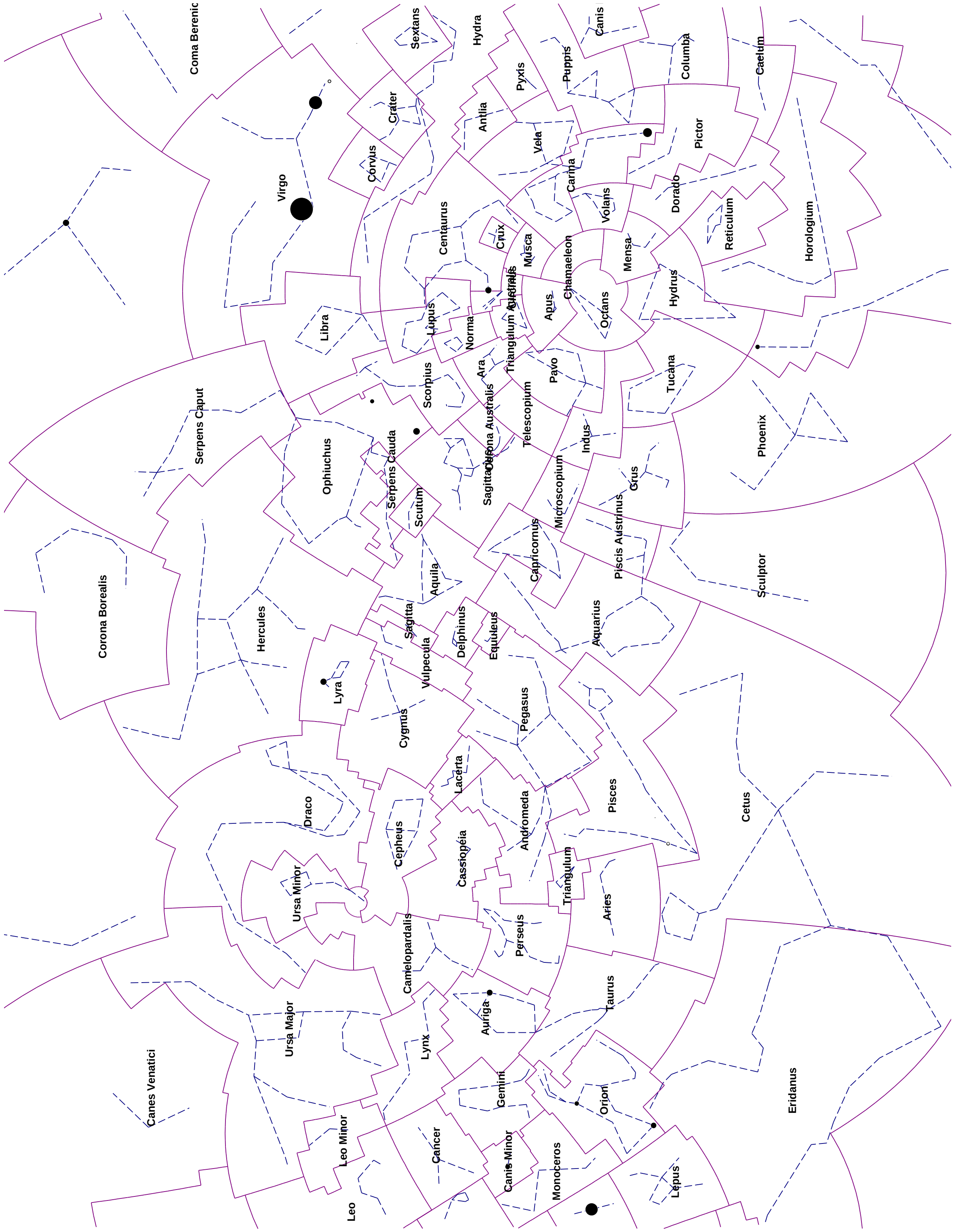

Figure 1: Map of the constellations in Galactic Coordinates

3. Does the distribution you found on your map support the hypothesis that the Earth lies close to the center of the Milky Way? Explain!

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III. **Rotation Curves:**

We have discussed in class how one of the main bits of evidence for how mass is distributed in a galaxy is that galaxy's rotation curve. Rotation curves show how fast objects are moving a certain distance from the galactic center, and give information about how much mass is *interior* to that point. Navigate your way to `http://www.glowscript.org/#/user/jjrembold/folder/Public/program/Orbits` to answer the following questions. I wrote this little demo myself, so be nice!

(A) Right-click and drag on the black window to rotate your view so you can see all the planets orbiting a sun. Try control or command click if you don't have a right click button. Would you say the current orbit of the planets is following a Keplerian orbit or a rigid-body orbit currently?

(A) ____________

(B) The two plots to the right indicate the mass distribution and velocity of the system as you move away from the center sun (Mass in red, velocity in blue). The velocity points should also roughly agree with the length of the lines trailing behind the planets (longer lines = faster velocity). Which color of planet is currently moving the fastest?

(B) ____________

(C) Click the button titled "Sun-Like" to change the distribution of mass in the system. Looking at the top plot, where is the majority of mass located at in this configuration?

(C) ____________

(D) Which color of planet is moving fastest now?

(D) ____________

(E) Finally, click the button titled "Flat-Like." Where is most of your mass distributed in this system?

(E) ____________

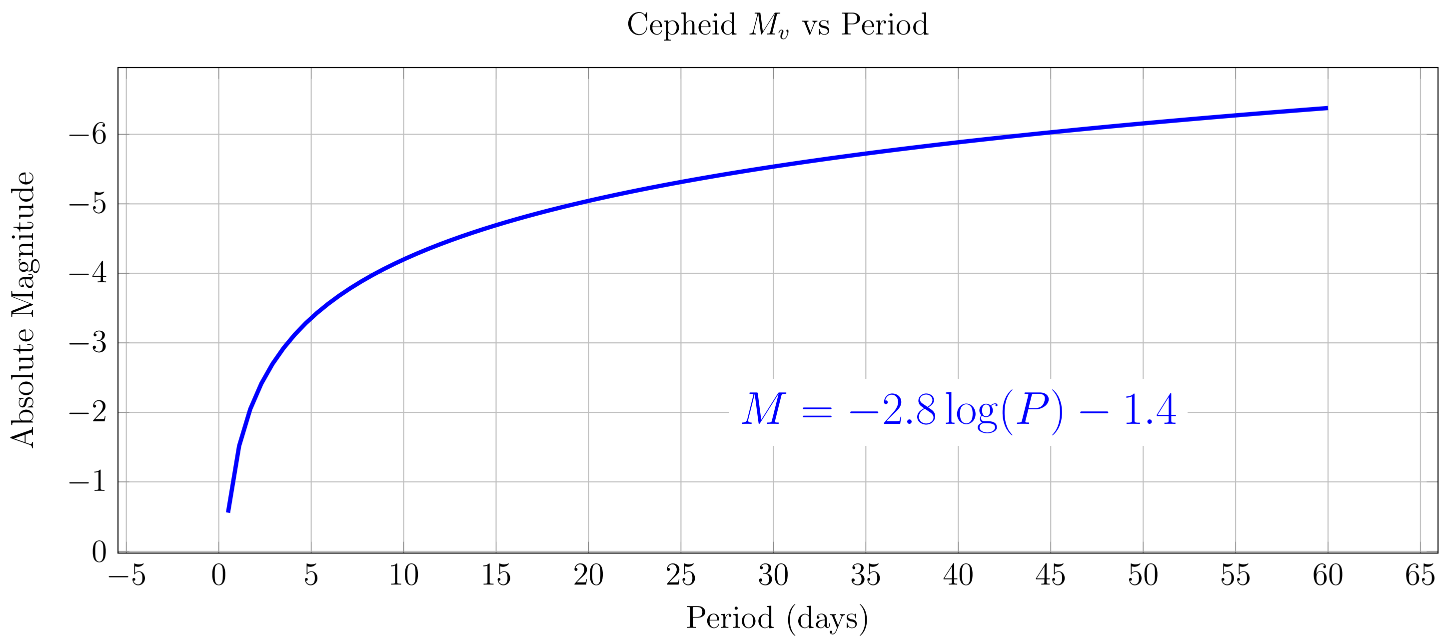
(F) Approximately how fast are all the planets moving in this configuration (the units are all made up, so you don't need to include any!)

(F) ____________

IV. **Distance Measurements:**

The discovery of Cepheid variables in the Andromeda galaxy was key to developing an understanding of the scale of galaxies and the universe. Similarly, if less somewhat less dramatically, observations of Cepheids in the Virgo Cluster galaxies made an accurate measurement of the Hubble constant possible and set the state for our understanding of the age of the universe and the existence of dark energy.

Cepheids are useful as standard candles because there is a close correlation between their pulsation periods and their intrinsic luminosities, as seen in the plot below.



In this part of the lab you will use the light curves of six Cepheids in the Virgo cluster galaxy M100 to make an estimate of the distance to M100.

(A) The figures on page 6 show light curves (graphs that show how the *apparent* magnitude changes over time) of six Cepheids in the Virgo Cluster galaxy M100.

1. For each of the stars, use its light curve to determine its pulsation period (the time between successive peaks in the light curve) and its maximum and minimum apparent magnitude. Enter those values in Table 1 on the next page. The values for the first star are already given to get you going.
2. Use the maximum and minimum values of apparent magnitude to calculate an average magnitude m_{avg} for each star.
3. For each star, use the equation of the graph on page 4 and the star's pulsation period to find the absolute magnitude M, which is a measure of the intrinsic luminosity.
4. Because magnitude is measured on a logarithmic scale, the *difference* between a star's apparent magnitude and its absolute magnitude, is related to its distance. Calculate the difference (or in fancy speak, the *distance modulus*) for each star and enter in the appropriate values.

5. Finally, get a distance estimate for each star. The distance modulus to parsec calculator here: http://astro.unl.edu/naap/distance/distance_modulus.html will be of use. The value it reports will be in parsecs, so then divide by 10^6 to get the desired value in megaparsecs (Mpc).

Cepheid Number	Period (days)	Absolute Mag (M)	Max App Mag (m_{max})	Min App Mag (m_{min})	Average App Mag (m_{avg})	Difference ($m_{avg} - M$)	Distance (Mpc)
1	53	-6.2	24.5	25.4	24.95	31.15	16.6
2							
3							
4							
5							
6							

Table 1: Your mission (which you must accept): Complete this table!

(B) What is the average distance of these stars in Mpc?

(B) ____________

(C) What is the difference between the largest and smallest distances in Mpc?

(C) ____________

(D) Even with careful measurements, the "scatter" in your distances will likely by larger than the actual physical size of M100. However, our view of at least some of these stars is probably partially obscured by dust in the disk of M100, making the stars appear dimmer than they would otherwise. Would dust along the line of sight cause this method to over or underestimate the distance to the star? Explain!

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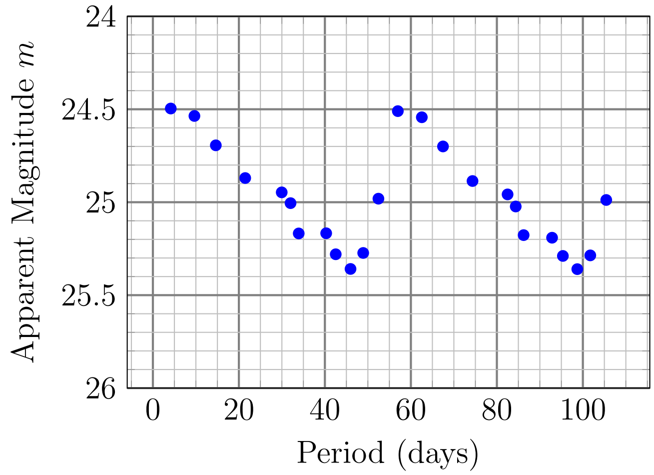
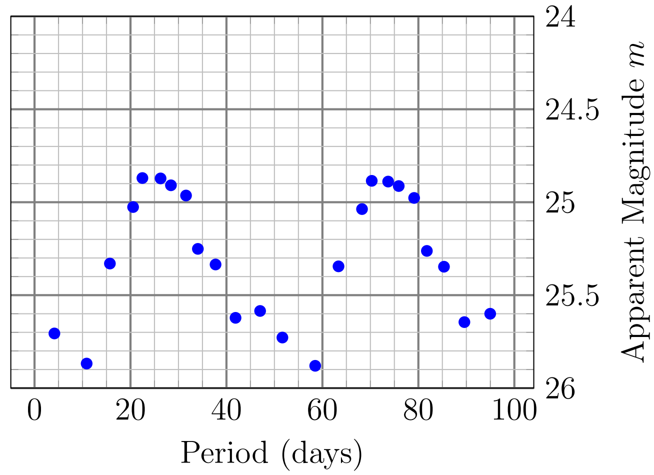
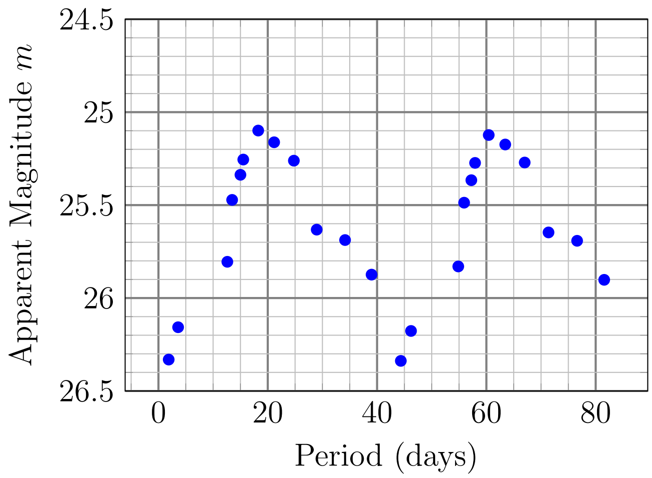
Cepheid 1



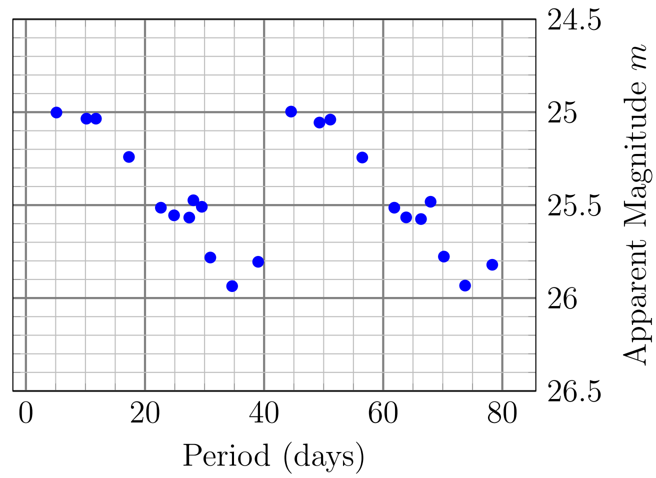
Cepheid 2



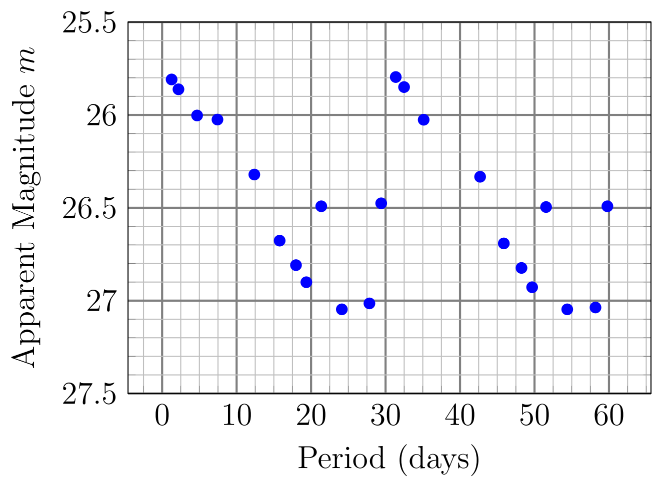
Cepheid 3



Cepheid 4



Cepheid 5



Cepheid 6