SIERRA COLLEGE OBSERVATIONAL ASTRONOMY LABORATORY EXERCISE
Lab N03: Celestial Navigation (Fall)

NAME	GROUP

OBJECTIVE:
- Learn about the Celestial Coordinate System.
- Learn about stellar designations.
- Learn about deep sky object designations.

INTRODUCTION:

The Horizon Coordinate System is simple, but flawed, because the altitude and azimuth measures of stars change as the sky rotates. Astronomers have developed an improved scheme called the *Celestial Coordinate System*, which is fixed with the stars. The two coordinates are *Right Ascension* and *Declination*. Declination ranges from the *North Celestial Pole* to the *South Celestial Pole*, with the *Celestial Equator* being a line around the sky at the midline of those two extremes.

We will use these coordinates when navigating using the *SC001* and *SC002* charts.

There are many ways to designate stars. The most common is called the *Bayer designations*. The Bayer designation of a star starts with a Greek letter. The brightest star in the constellation gets "alpha" (the first letter in the Greek alphabet), the second brightest star gets "beta," and so on. (The Greek alphabet is shown below.) The Bayer designation must also include the constellation name. There are only 24 letters in the Greek alphabet, so this system is obviously very limited.

The Greek alphabet

1) Alpha α	7) Eta η	13) Nu ν	19) Tau τ
2) Beta β	8) Theta θ	14) Xi ξ	20) Upsilon υ
3) Gamma γ	9) Iota ι	15) Omicron o	21) Phi φ
4) Delta δ	10) Kappa κ	16) Pi π	22) Chi χ
5) Epsilon ε	11) Lambda λ	17) Rho ρ	23) Psi ψ
6) Zeta ζ	12) Mu μ	18) Sigma σ	24) Omega ω

A more extensive naming system is called the *Flamsteed designation.* It is similar to the Bayer designation, but instead of a Greek letter it has a number. Flamsteed assigned this number to the stars in the constellation, in order of increasing right ascension.

There are other systems for naming stars, such as the HD (Henry Draper), HR (Harvard Revised) and SAO (Smithsonian Astrophysical Observatory) catalogs.

Non-stellar objects, which are not part of our solar system, are called *deep sky objects*. This includes objects such as star clusters and nebulae. The 110 brightest deep sky objects (more or less) in the northern sky were collected into a compendium called the Messier list. But just like in the case with stars, there are larger and more extensive lists—the most famous is the NGC (New General Catalogue), which lists 7840 objects. A bright deep sky object might have a Messier number (such as M 80) and an NGC designation (such as NGC 6093).

How bright the star looks in the sky is called the star's *apparent magnitude* (m). Stars barely visible to the eye are m=6. The brighter a star is, the smaller its apparent magnitude, so a star with m=1 is brighter than a star with m=4.

Magnitude scale—a sample calculation
A difference in 1 magnitude corresponds to a difference of approximately 2.5x in brightness.

How many times brighter is an m=1 star, compared to an m=4 star?

In this case, there is a three magnitude difference, so

2.5 x 2.5 x 2.5 = 15.6 brightness difference

A difference of 5 magnitudes means a difference of 100x—try it and see!

PROCEDURE I: Using the SC001 and SC002 charts

1. For each star in Table A, determine the following: which chart(s) portray them, its constellation, and its apparent magnitude.

2. For each star in Table A, measure and record its RA to the nearest ± 5 min, and its Dec to the nearest degree.

Table A: Celestial data from SC001/SC002

Star	Chart(s)	Constellation	RA	Dec
Antares				
Vega				
η Bootes				
β Draco				
Polaris				

3. For the three stars in Table B, use the SC001 chart to estimate their apparent (visual) magnitudes, rounding your magnitude estimates to whole numbers. (You will complete the final table column later in the lab.)

Table B: Magnitudes

| Star	Magnitude (from charts)	Magnitude (from sky program)
α Lyra		
γ Lyra		
ζ Lyra		

PROCEDURE II: Constellations and their borders

4. Figure 1 shows part of an SC001 chart. Use a ruler to draw a line from α Lyra to α Ophiuchus. Mark the midpoint of this line on Figure 1. What constellation do you think contains this midpoint? (It is ok if you are not correct—just make a reasonable guess.

   Constellation of line midpoint: _____

5. In Figure 1, carefully draw a loop around the stars α, β, and κ in Ophiuchus.

Figure 1: SC001
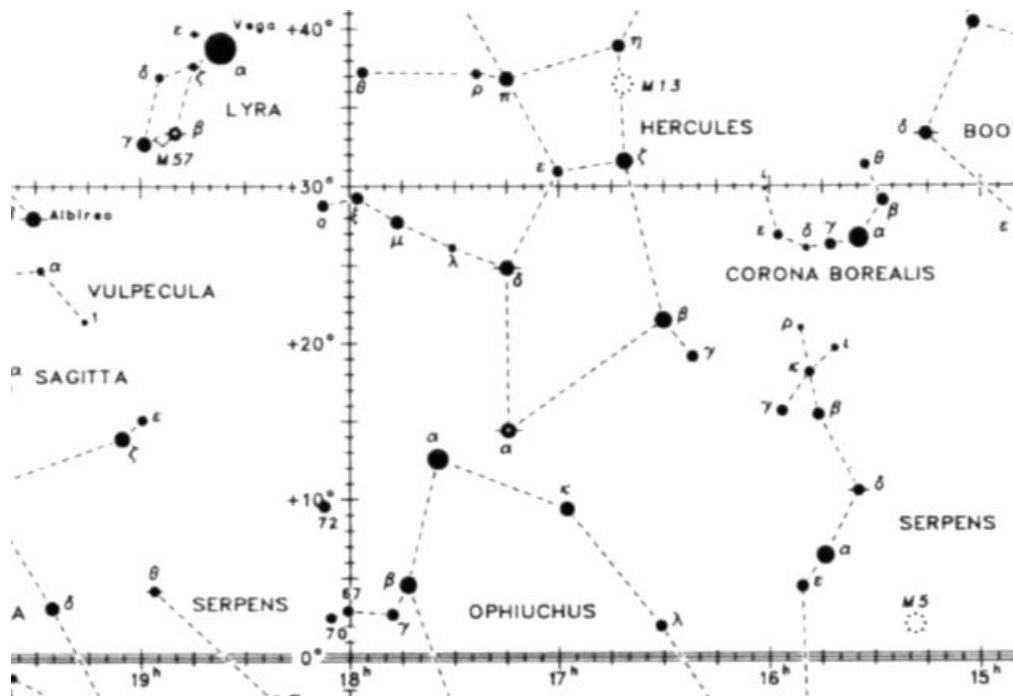
6. Refer to Figure 2 on the next page. Again, carefully draw a loop around the stars α, β, and κ in Ophiuchus.

   Notice that the authors of the different star charts did not draw the constellation Ophiuchus the same way. There is no official way to draw the constellations.

7. Note the presence of constellation boundaries in Figure 2. Constellation boundaries are officially designated. Use a ruler to draw a line from α Lyra to α Ophiuchus, and again find the midpoint of this line. What constellation actually contains this midpoint?

   Constellation of line midpoint: _____

PROCEDURE III: Refining our data

8. Complete Table B by using the sky simulation program to look up the stars' apparent magnitudes.

9. For the three stars in Table C, use the sky simulation software to measure their RA and Dec values to the nearest minute for the date and times given.

**Table C: Right Ascension and Declination in Time**

	September 1 at 9 pm		September 1 at 11 pm	
Star	**RA**	**Dec**	**RA**	**Dec**
Altair				
Arcturus				
Polaris				

10. For each star in Table D, use the sky simulation program to look up the star's Bayer designation, Flamsteed designation, and any other designations provided (such as HR, HD, SAO #).

Table D: Stellar designations

Star	**Bayer**	**Flamsteed**	**Other**
Antares			
Vega			
Polaris			

Figure 2: Star chart with boundaries
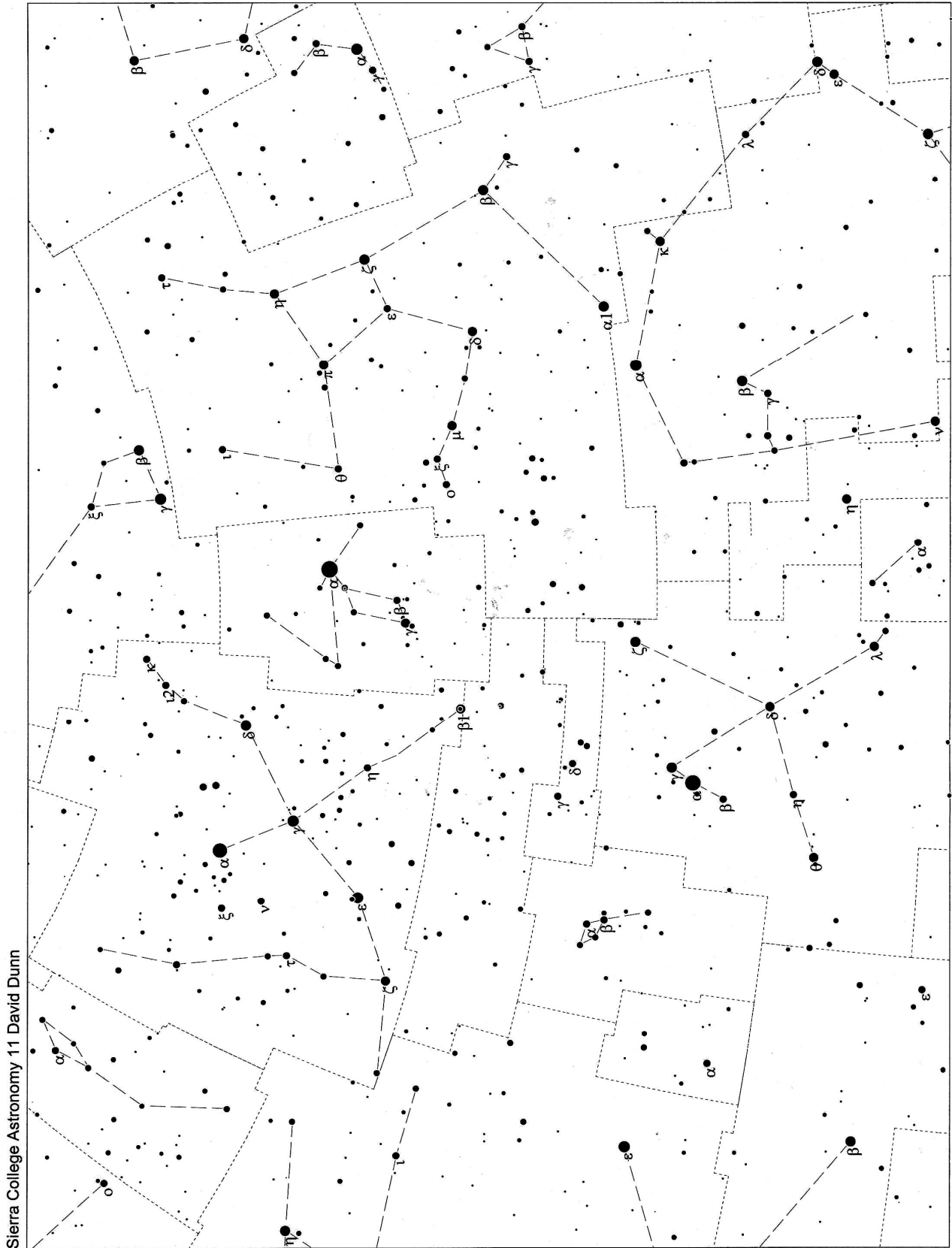
Sierra College Astronomy 11 David Dunn

PROCEDURE IV: Deep sky objects

11. Table E lists four deep sky objects by their Messier numbers. Look up each object in the sky simulation software to find its location. Carefully mark the location of each object (including a name label) on Figure 2.

12. Look up the Wikipedia entry for each object in Table E. Record the object's NGC #, constellation, and also the object's common name if it has one (for objects with multiple common names, use the first listed).

Table E: Deep sky objects

Object	NGC #	Constellation	Common name
M13			
M27			
M57			
M71			

VOCABULARY:

Celestial Coordinate System	**Magnitude system**
Right Ascension	**Bayer and Flamsteed designation**
Declination	**HD, HR, SAO designations**
North and South Celestial Poles	**Deep sky objects**
Celestial Equator	**Messier list**
SC001, SC002 charts	**NGC catalog**

QUESTIONS/ANALYSIS:

1) Referring to Table B, calculate the magnitude difference between the stars α Lyra and γ Lyra, between γ Lyra and ζ Lyra, and between α Lyra and ζ Lyra. What are the brightness factors that correspond to these magnitude differences? Organize your results in Table F, below.

Table F: Magnitude differences and brightness factors

Stars	Magnitude difference	Brightness factor
α Lyra vs. γ Lyra		
γ Lyra vs. ζ Lyra		
α Lyra vs. ζ Lyra		

2) Use the SC001 or SC002 charts to determine the name of the constellation that contains NGC 2419, at RA= 7h 38m, Dec = +39°.

3) Find the constellation Cassiopeia. (Hint: near RA = 1h, Dec =+60°) What is the Bayer designation for the brightest variable star in the constellation? What about the brightest double star in the constellation?

  Brightest variable: _____   Brightest double: _____

4) Refer to Table C in the previous lab (Lab N02), as well as Table C in the current lab. As the sky spins during the course of the night, which coordinate system—Horizon Coordinate System or Celestial Coordinate System—has the advantage of having values that do not change with time?

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