THE CELESTIAL SPHERE AND PLANISPHERES

1

OBJECTIVES

After completing this exercise the student should be able to:

1. locate stars and planets on a celestial globe using R.A. and Dec. coordinates.
2. identify the locations of the celestial poles, equator, and ecliptic.
3. use a celestial globe to find the Sun's position along the ecliptic for any day of the year.
4. use a planisphere to identify stars and constellations in tonight's sky.
5. use a planisphere to estimate the rising and setting times for bright stars and planets.

STUDENT MATERIALS

pencil
planispheres (optional)
current issue of ***Astronomy*** and/or ***Sky and Telescope*** (optional)

LAB MATERIALS

celestial globes
current planet coordinates
planispheres
current issue of ***Astronomy*** and/or ***Sky and Telescope*** (optional)

INTRODUCTION

You are probably taking this course because you are interested in learning about the night sky or because it was the only class which fit into your schedule. Assuming the former, then the best way to learn about the sky is to go outside and observe it for yourself. If you do go and observe the night sky, it will appear to be a giant sphere with the stars painted onto it. The celestial sphere is an imaginary sphere of infinite radius on which we imagine all the stars to be attached. As this sphere appears to rotate from east to west, it carries all the stars and constellations with it. One of the first things you can see is the daily rotation of the Earth. The celestial sphere appears to rotate from the east to the west. This is simply a reflection of the Earth's west-to-east rotation. Careful observation reveals that the celestial sphere makes one complete rotation in 23 hours and 56 minutes. Since our day is based on exactly 24 hours, then a star seen rising in the east tonight will rise 4 minutes earlier tomorrow night. It is this 4 minute daily shift which causes us to see different stars and constellations in summer than in winter. This westerly shift of the sky is caused by the Earth's orbital motion around the Sun. Notice that in one week the star will rise 30 minutes earlier and in a month it will rise 2 hours earlier. As this continues, you can deduce that eventually the star will be rising in the middle of the day and could not be observed at all. After one full year, you could again observe the same star rising at exactly the same clock time.

This annual shift of the sky is very easy to observe. Go out at some particular time, say 10:00P.M. and locate some bright star which is directly over a tree or antenna in the distance. In one week, go stand in this same location at 10:00P.M. and you will see this same star to be slightly west of the tree or antenna. You are actually observing the Earth's revolution around the Sun. Some time this week, try this observation for yourself; I think you will find it to be fun and educational.

By observing the night sky over several evenings, you will probably notice that your eyes begin to see patterns among the stars in the sky. These figures are not real but your brain loves to arrange things in logical terms, so it causes you to see boxes, lines, etc., among the stars. It is exactly this type of thinking that caused ancient people to place figures of heroes, fish, and other objects into the night sky. We know these figures as the constellations. Modern astronomers still recognize areas of the sky as being within the boundary of a particular constellation, but the figures of birds and monsters are generally not used.

However, it is still fun to try and visualize the original figures of the constellations. Currently there are 88 officially recognized constellations in the entire sky, including both northern and southern hemispheres. You will see many of these constellations on the celestial globes used in today's lab work. These globes are great for helping you visualize the celestial sphere in 3-D but they are not very good for helping you to learn to identify constellations in the actual night sky. A star wheel or planisphere is a much better tool for constellation finding. A planisphere is a flat disk which can be set to show you the sky at any time of day on any date of the year. It is a nifty little device.

During this lab exercise, you will use both a celestial globe and a planisphere to learn about the night sky. I hope you will use the techniques in this lab to go out and observe the motions of the sky and to become friendly with the brighter stars and constellations. After you learn the stars and constellations, they sort of become your "friends" and you look forward to seeing them each year. In addition, you will be able to impress your friends and neighbors by pointing out bright stars and constellations to them.

PROCEDURE

I. The Celestial Sphere

DO NOT MAKE ANY MARKS ON OUR CELESTIAL GLOBES. THANK YOU VERY MUCH FOR KEEPING OUR EQUIPMENT NEAT AND CLEAN.

The celestial globes are small, 3-D representations of the entire sky. The first thing you will notice on the globe are the drawings of the constellations and the bright stars. Each globe maker writes the names differently. Your lab instructor may need to point out which names belong to constellations and which ones are for stars. Some other things you should find on your globe are the celestial equator, the north and south celestial poles, and the ecliptic. On many globes, the celestial equator is where the manufacturer has glued the two halves together. The north and south celestial poles are located at the two rotation points because the real sky appears to rotate around these same two locations. Unfortunately, the real sky does not have these nice mechanical supports and so the celestial poles are more difficult to find when you go outside. In addition, you can only observe the north celestial pole from locations north of the Earth's equator. The ecliptic is the apparent path of the Sun among the background of stars and it runs around the globe making a 23.5 degree angle with the celestial equator. Be sure that you can locate the celestial equator, celestial north and south poles, and the ecliptic on your celestial globe. If you are having trouble, feel free to ask your lab instructor for assistance.

In order to locate objects on the celestial sphere, astronomers have developed a two-dimensional coordinate system which is attached to the sky and rotates along with it. This system is similar to the longitude and latitude positions on the Earth's surface. The east-west coordinate is called Right Ascension (R.A.) and is measured in units of time, such as hour (h), minutes (m), and seconds (s). Declination (Dec.) is the north (+) and south (–) coordinate, and is measured in angular units of degrees (°), arc minutes (′), and arc seconds (″). The origin of this system (R.A. = 00h 00m 00s, Dec. = 00° 00′ 00″) is located at the Spring Equinox, where the ecliptic intersects the celestial equator in the spring. Locate this equinox on your celestial globe by finding where the ecliptic crosses the equator in a south-to-north direction near March 21st. Looking along the globe's equator, find the R.A. hour lines which run north and south and are usually labeled with the hour coordinate from 00h to 23h. You can estimate between the hour lines to the nearest 10 minutes of time. It is not possible to read the R.A. to any higher precision. To the north (+) and south (–) of the equator, the Dec. coordinate circles can be seen. These are usually drawn on the globes at intervals of 5, 10, or 15 degrees, depending upon the globe makers preference. You should be able to estimate the Dec. coordinate to within 1 or 2 degrees. The equator has a Dec. of 0° and the north and south

NAME: _____

LAB SECTION: _____

celestial poles have Dec.'s of +90° and –90°, respectively. It is possible to locate any star or planet using this coordinate system.

1. The coordinates for ten bright stars are given in **Table I**. Use these positions to identify each star and to find the constellation to which it belongs. To find the first star, go along the equator to an R.A. of 06h 43m and then go south to a Dec. of –17°. You should find the star Sirius in the constellation of Canis Major. Write these results down in **Table I** for star 1. Complete **Table I** for the other nine stars.

Table I

Positions of ten bright stars

STAR	R.A. Hrs:Min.	Dec. Degrees	Star Name	Constellation Name
1	06:43	–17		
2	07:37	+05		
3	20:40	+45		
4	19:48	+09		
5	05:13	+46		
6	05:13	–08		
7	14:10	+19		
8	05:53	+07		
9	16:27	–26		
10	18:36	+39		

2. The planets are always moving to new coordinates and so they are not plotted on any celestial globe. On the board in the front of the lab room, the current coordinates of the planets are given. Copy these coordinates into **Table II**. Using these positions, locate the constellation in which each planet is presently located. Write the results in **Table II**. This information will be used in Part II of this lab exercise.

Table II

Current planetary positions

Planet	Constellation Location
Mercury	
Venus	
Mars	
Jupiter	
Saturn	

3. The ecliptic is the apparent path of the Sun among the stars, so the Sun is always located precisely on the ecliptic. Look carefully at the ecliptic on your celestial globe. It should have a series of tick marks or dots along it with dates associated with them. The date may only be written every five or ten days. These dates show you exactly where the Sun is located along the ecliptic on each day of the year. Locate the Sun's position along the ecliptic on March 21st, the first day of spring. Because this is an equinox date, you should expect to find the Sun directly on the equator at 00h 00m and 0°. Complete **Table III** by writing in the coordinates of the Sun for the dates given.

Table III

Solar positions along the ecliptic

Date	R.A. Hrs:Min.	Dec. Degrees
March 21st		
June 21st		
Sept. 21st		
Dec. 21st		
Today _____		

II. The Planisphere

DO NOT MAKE ANY MARKS ON OUR PLANISPHERES. THANK YOU VERY MUCH FOR KEEPING OUR EQUIPMENT NEAT AND CLEAN.

A planisphere or star wheel is a fantastic device for learning how to identify bright stars and constellations in the sky. They easily show you which stars are visible at any time of the day on any date of the year. This is done by aligning the date on the rotating wheel with the time along the frame edge. The stars visible in the sky on the date and time selected will be shown within the oval-shaped window. The center of the window represents the stars near the zenith, directly overhead. Stars rising in the east are on the left side of the window, while stars setting in the west are near the right side of the oval. The north celestial pole (NCP) is located at the metal grommet about which the wheel rotates. If you rotate the wheel one full turn you will notice that stars and constellations near the NCP never rise or set. These circumpolar stars are always visible from your location on the Earth. Of course, the number of circumpolar stars is dependant on your latitude. If you are visiting the North Pole, then all the stars visible to you will be circumpolar. Similarly, if you are lying on a beach at the Earth's equator, then no stars will be circumpolar.

To locate stars and constellations in the real sky, set your planisphere for today's date and local time. Go outside and hold the planisphere over your head with the north point on the planisphere aimed toward the north and the east point aimed to the east. This will orient the planisphere with the actual north, south, east, and west directions in the sky. Constellations seen near the center of the planisphere's little window are the constellations visible near your zenith, directly overhead. If you want to observe constellations which are rising in the east, you must face east and hold the east side of the planisphere facing down toward the eastern horizon. The constellations on the east border of the planisphere window will be oriented in the same way as the real constellations in the eastern sky. Similarly, you can locate stars in the northern, southern, and western portions of the sky.

NAME: _____

LAB SECTION: _____

Align your planisphere for tonight at 9:00P.M. and answer the following questions.

QUESTIONS

1. Name the constellation which is:
   a. On the zenith: _____
   b. Rising due east at the celestial equator: _____
   c. Setting due west at the celestial equator: _____

2. Name a constellation which can be seen almost the entire night, excluding circumpolar constellations.

   _____

3. In **Table II** of this lab you made a list of the bright planets and the constellations in which they are located. Place a check mark beside the planets visible tonight at 9:00P.M.

   _____ Mercury
   _____ Venus
   _____ Mars
   _____ Jupiter
   _____ Saturn
   _____ No planets are currently visible in the evening sky

To answer the following questions, your planisphere can be moved to any positions necessary. It no longer has to be set for tonight's sky.

4. Again using **Table II**, identify the planets visible at 6:00A.M. tomorrow morning by placing a check mark beside them.

   _____ Mercury
   _____ Venus
   _____ Mars
   _____ Jupiter
   _____ Saturn
   _____ No planets are currently visible in the morning sky

5. Name two circumpolar constellations shown on your planisphere.

   a. _____

   b. _____

6. Approximately what time does the constellation of Orion rise tonight?

   _____

7. When is Orion best viewed tonight? Circle the letter of the best response.

   a. evening before midnight

   b. early morning after midnight

   c. almost the entire night

   d. not visible at any time tonight

8. On what date can the star Sirius be seen rising at 6:00A.M.?

   _____

9. On what date will the star Vega be seen near the zenith at the following times?

   a. 8:00P.M. _____

   b. 10:00P.M. _____

   c. midnight _____

   d. 2:00A.M. _____

As I have already stated, the best way to learn the night sky is to observe it. You should now be able to use a planisphere to help you identify stars and constellations. I hope you will take advantage of this new knowledge to make the sky a more friendly place for you to enjoy year after year.