ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 8

EO C440.06 – USE STAR CHARTS

Total Time: 60 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Obtain a desktop globe for use in TP 2.

Obtain planisphere star charts and red-filtered flashlights for each cadet for use in TP 4.

Create slides of Attachments A and B.

Photocopy Attachment C for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TPs 1–3 to introduce the cadets to star charts and give an overview of the subject.

A demonstration and performance was chosen for TP 4 as it allows the instructor to explain and demonstrate planisphere use while providing an opportunity for the cadets to practice the skill under supervision.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have used star charts to identify elements of the night sky.

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IMPORTANCE

It is important for cadets to be able to use star charts because this knowledge enhances the enjoyment of amateur astronomy while contributing to an understanding of the aerospace challenge.

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Teaching point 1 **Explain how the celestial sphere is divided.**

Time: 5 min Method: Interactive Lecture

HOW EARTH AND SKY ARE ASSUMED TO BE CONCENTRIC



Celestial sphere. An imaginary sphere with the observer at its centre and celestial objects located on its inner surface.

Concentric. Having a common centre.

At first sight, the complexity of the night sky may seem bewildering. Familiarity with the night sky, as well as determining and describing the locations of celestial objects such as stars and galaxies, requires a standardized coordinate system. Such a system allows workers in the field to communicate celestial positions so that the observation can be repeated by others. For this purpose, a standardized coordinate system known as the celestial sphere was created. The celestial sphere is an optical illusion resulting from the inability to discern distance to stars making them all appear to be the same distance away. This imaginary sphere, therefore, is of infinite radius with the Earth located at its centre. The poles of the celestial sphere are aligned with the poles of the Earth. The celestial equator lies along the celestial sphere in the same plane that includes the Earth's equator. This is designed for the convenience of observers on Earth. The optical illusion of the celestial sphere can only be seen, in its orientation showing the classic constellations, from within the solar system.



Show the cadets the slide of Figure A-1 located at Attachment A.

When considering the celestial sphere it is convenient to assume that the sky is solid and that the celestial sphere is concentric with, or has the same centre as, the surface of the Earth.

CELESTIAL POLES

The north pole of the celestial sphere is the point directly above the Earth's north pole and the south pole of the celestial sphere is the point directly below the Earth's south pole. The North Celestial Pole (NCP) and the South Celestial Pole (SCP) are simply the north and south poles of the Earth extended into space.



Show the cadets the slide of Figure A-2 located at Attachment A.

The NCP passes very close to the star Polaris. As the Earth rotates around the NCP, Polaris is the only object in the sky that appears to stand still.

CELESTIAL EQUATOR

The celestial equator is the Earth's equator, but at a much greater radius. If the Earth's equator was a rubber band, then the celestial equator is the same rubber band just stretched away from the Earth, out to infinity.

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CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What is the celestial sphere?

Q2. What are the NCP and the SCP?

Q3. Where is the celestial equator located?

ANTICIPATED ANSWERS:

A1. The celestial sphere is an imaginary sphere of infinite radius with the Earth located at its centre.

A2. The North Celestial Pole (NCP) and the South Celestial Pole (SCP) are simply the north and south poles of the Earth extended into space.

A3. The celestial equator lies along the celestial sphere in the same plane of the Earth's equator.

Teaching point 2 **Explain how the sphere of the sky is represented on star charts.**

Time: 5 min Method: Interactive Lecture

We can locate any object on the celestial sphere by giving it two coordinates, one called the object's declination and the other the object's right ascension. These are the object's celestial coordinates.



Show the cadets the slide of Figure A-1 located at Attachment A.

DECLINATION

The structure of the celestial coordinate lines is almost identical to that of the coordinates of the Earth's surface. To prevent confusion, the Earth's lines of latitude are re-labelled as "declination" lines when applied to the celestial sphere, but are numbered in degrees exactly the same as the Earth lines of latitude. However, to further avoid confusion, the celestial lines of declination are marked with a plus sign (+) in place of North and a minus sign (-) in place of South. Therefore, when a declination is shown as a negative number it is in the southern half of the celestial sphere.



Parts of the southern celestial sphere can be seen from Earth's northern hemisphere, especially during the northern hemisphere's winter months. The brightest star in the sky, Sirius, at minus 20 degrees, can be seen from Canada in the winter because, just as the northern hemisphere is inclined toward the North in the daytime, it is inclined toward the South in the nighttime.



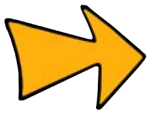
Use a globe to show the cadets how the northern hemisphere in winter changes from northern daytime skies to southern nighttime skies as night falls.

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RIGHT ASCENSION

To further prevent confusion, the longitude lines have been re-labelled as "right ascension" lines, and renumbered from 0 to 24 in hours. There is only an indirect connection to time here, even though hours, minutes and seconds are used to divide the angular distances between lines of right ascension. However, the celestial sphere, observed from the surface of Earth, is seen to complete one complete rotation overhead approximately once every 24 hours. Celestial rotation would be 24 hours exactly, if it were not for Earth's orbit around the Sun.

The right ascension of an object on the celestial sphere is measured along the celestial equator. By convention, 0 degrees is the point on the celestial equator where the Sun is found on the first day of spring (the vernal equinox).



Notice that 0 hours right ascension is unrelated to 0 degrees longitude. Using hours instead of degrees neatly avoids this conflict.

Stars and galaxies have (almost) fixed positions in right ascension and declination. The Sun and planets, on the other hand, move among the distant stars so that their coordinates change throughout the year. Due to the Earth's yearly orbital motion around the Sun, the Sun appears to circle the ecliptic.

THE PLANE OF THE ECLIPTIC

Plane of the ecliptic. The plane of the Earth's orbit around the Sun.

The plane of the ecliptic is an imaginary plane in which the Earth orbits the Sun. It is used as the primary reference plane when describing the position of bodies in the solar system.



Show the cadets the slide of Figure B-1 located at Attachment B.

Most objects in the solar system orbit in roughly this plane and in the same direction around the Sun as the Earth. There are exceptions such as many comets and a few minor planets (including the dwarf planet, Pluto), which have high inclinations, or tilt, compared to the reference plane—the plane of the ecliptic. Some comets even have retrograde orbits, such as Halley's comet, and orbit in the opposite direction to the planets.



Show the cadets the slide of Figure B-2 located at Attachment B.

The celestial sphere, viewed from Earth, shows the constellations that define the zodiac. The signs of the zodiac are the constellations that lie near the plane of the ecliptic and are visible at night in the months associated with these constellations.



Ask the cadets what the approximate date is in Figure B-2 located at Attachment B.

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CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What are a celestial object's two coordinates called?

Q2. On what is a celestial object's right ascension measured?

Q3. What is the plane of the ecliptic?

ANTICIPATED ANSWERS:

A1. Right ascension and declination.

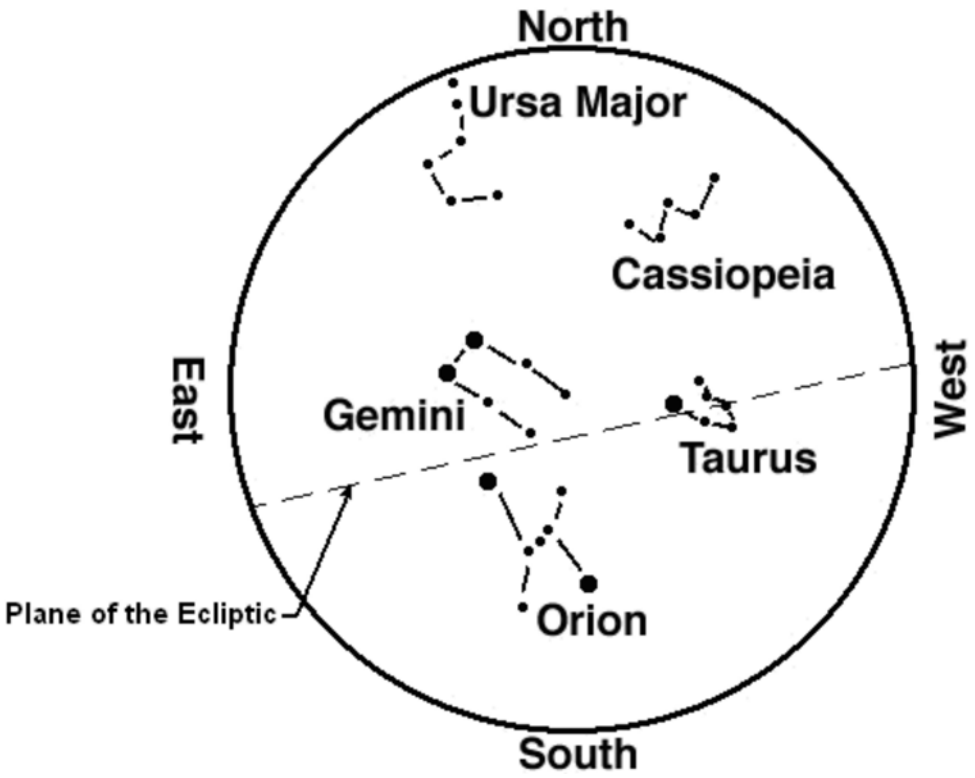
A2. The celestial equator.

A3. The plane of the Earth's orbit around the Sun.

Teaching point 3 **Explain how to interpret a star chart.**

Time: 5 min Method: Interactive Lecture

A star chart is a map of the night sky. With it, you can identify and locate constellations and stars. A typical star chart shows the relative positions of the stars and their brightness.



Note. From "Astronomy Department at the University of Massachusetts", by T. Arny, 2002, Using a Star Chart, Copyright 2002, by T. Arny. Retrieved November 4, 2008, from http://www.astro.umass.edu/~arny/constel/constel_tutmod.html

Figure 1 A Northern Hemisphere Spring Star Chart

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DATE

A star chart is accurate only on a specific date because the night sky changes as Earth follows its orbit around the Sun. Also, planets move over a period of days.

TIME

A star chart will be correct for a very short time because celestial objects rise above the eastern horizon and follow a path overhead before finally setting in the West. Since different celestial objects are constantly rising and passing overhead and setting, a different set of celestial objects will occupy the sky at different times. The date and time of exact accuracy should be printed on the chart.

LATITUDE

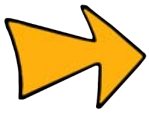
An observer on the ground can only see the sky above the horizon. Different locations on the planet have different views of the sky. Although a patient observer can wait for a certain celestial object to rise in the East, and a celestial object with a certain right ascension will eventually appear if it is at an observable declination, there are celestial objects that are not in an observable declination for a given Earth latitude. For example, Polaris, the North Star, will never be seen from the Earth's South Pole. Therefore, a star chart has a property known as latitude and it will only show the sky that can be seen at the Earth latitude for which the star chart was prepared. The star chart's Earth latitude is printed on the star chart.

ORIENTATION

For orientation, a star chart is held overhead and turned until the direction the observer is facing appears at the bottom. If the observer is facing south, the star chart, when held overhead, should be turned until South is on the bottom of the star chart. At this point, the pattern of celestial objects shown on the star chart will correspond to the pattern of celestial objects seen in the sky.

PLANETS

Planets add another layer of challenge to interpreting a star chart. Planets constantly change their position relative to fixed celestial objects.



Star charts can be retrieved from the Montreal Planetarium website: http://www.planetarium.montreal.qc.ca/Information/Documents/PDF/PocketPlanetariumV12N4.pdf and other websites, such as http://skymaps.com/downloads.html

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What are two reasons that a star chart is accurate only on a specific date?

Q2. Why is a star chart accurate only at a specific hour?

Q3. For orientation, how is a star chart is held?

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ANTICIPATED ANSWERS:

A1. The night sky changes as Earth follows its orbit around the Sun and planets constantly move.

A2. The night sky changes as Earth rotates on its axis.

A3. For orientation, a star chart is held overhead and turned until the direction the observer is facing appears at the bottom.

Teaching point 4 — **Explain, demonstrate and have the cadets identify elements of the night sky by exploring aspects of a planisphere.**

Time: 40 min — Method: Demonstration and Performance

Planisphere star chart. Analog computer for calculating the position of stars.



Distribute a planisphere star chart to each cadet.

A planisphere consists of two layers: a star map base and an overlay in which is set a clear oval window. The four steps to orienting a planisphere are as follows:

1. Locate the date, on the star map layer, on which the planisphere is to be used.

2. Rotate the overlay so that the time of use aligns with the date of use.

3. Identify North by locating the North Star.

4. The planisphere is then held above the user's head, map downward, with the middle of the oval window directly overhead and the midnight time mark toward the North.

The coordinates of a celestial object shown on a planisphere can be determined by reading the hours of right ascension from the outer edge of the star map base. Lines of right ascension run from the edge of the star map base to the centre of the star map base. A celestial object's declination can be determined by interpolating between the concentric declination lines which circle the star map base, with the celestial equator shown at 0 degrees—passing through constellation Orion at 6 hours right ascension.



Instruct the cadets on how to use the specific planisphere star chart according to directions provided with the planisphere.

Planispheres generally have the following characteristics:

5. **Planisphere design.** A planisphere has this name because the celestial sphere is represented on a flat plane, such as paper. Since the Earth is constantly in motion, the time of day, time of year, and location influence the appearance of the sky. An individual star chart cannot accurately represent all of these combinations. This would take many different star charts. A preferable method is to use a planisphere star chart that allows the user to twist a dial to show the true position of the stars.

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6. **The lack of planetary data on a planisphere.** Since the planisphere is usable on any day, it cannot display planets because planets constantly move across the sky.

7. **Date.** The visible night time stars and constellations change as the Earth revolves around the Sun. The summer sky is therefore different than the winter sky because the Earth is facing the opposite direction. Therefore, the correct date must be selected on the planisphere.

8. **Time.** As the Earth turns on its axis, stars and constellations rise in the East and set in the West, just as the Sun does (the Sun is just one more star, but a close one). Therefore, the planisphere must be adjusted for correct time.

9. **Midnight time mark.** When applying the planisphere to the night sky, the planisphere is oriented so that the midnight mark is to the North, after the time of day on the overlay is aligned with the date on the star map base.

10. **Latitude.** Planispheres are specific to latitudes because each latitude allows a view of a different swath of the celestial sphere as the Earth rotates.

11. **Orientation.** For constellations to appear in their correct location on the planisphere at the correct time, it is necessary to align the planisphere correctly with True North. When that is done, constellations that are rising in the East will be shown on the east edge of the planisphere. The planisphere consists of two layers: a star map base and an overlay in which is set a clear oval window.

12. **Horizon.** The edges of the clear overlay window represent the viewer's approximate horizon.

13. **Constellations.** On most planispheres, the names of constellations are printed in capital letters.

14. **Stars.** On most planispheres, the names of stars are printed in lower case letters, except the first letter in the star's name, which is capitalized.

ACTIVITY

Time: 30 min

OBJECTIVE

The objective of this activity is to have the cadets identify elements of the night sky by exploring aspects of a planisphere.

RESOURCES

- Observation Record located at Attachment C,
- Planispheres, and
- Red-filtered flashlights.

ACTIVITY LAYOUT

- For the demonstration portion of this lesson, organize the cadets into a circle with the instructor as a member of the circle.
- For the performance portion of this lesson, the cadets keep within hearing distance of the instructor so the instructor can easily respond to questions.

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ACTIVITY INSTRUCTIONS

1. Distribute a photocopy of Attachment C to each cadet.

2. Distribute one red-filtered flashlight per four cadets and have the cadets orient their planispheres.

3. Have the cadets locate celestial objects and constellations, using a planisphere.

4. Have the cadets determine the coordinates of celestial objects by reading declination and right ascension from the star base map of the planisphere, including interpolation between the coordinate lines.

5. Have the cadets record their observations of the celestial sphere on Attachment C.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 4

The cadets' participation in identifying elements of the night sky by exploring aspects of a planisphere will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What is the celestial sphere?

Q2. Why are planispheres specific to latitudes on Earth?

Q3. Where does the name planisphere come from?

ANTICIPATED ANSWERS

A1. The celestial sphere is an imaginary sphere of infinite radius with the Earth located at its centre.

A2. Planispheres are specific to latitudes on Earth because each latitude allows a view of a different swath of the celestial sphere as the Earth rotates.

A3. A planisphere has this name because the celestial sphere is represented on a flat plane, such as paper.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Knowledge of how to use a star chart is very helpful in amateur astronomy and will aid in the identification of many celestial bodies that would otherwise be missed.

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INSTRUCTOR NOTES / REMARKS

TPs 1–3 may be taught in the classroom or in the field, as appropriate.

Cadets who are qualified Advanced Aerospace may assist with this instruction.

REFERENCES

C3-176 ISBN 1-55407-071-6 Moore, P. (2005). *Atlas of the universe*. Richmond Hill: Firefly Books.

C3-179 ISBN 1-55209-302-6 Dickenson, T. (2001). *Night watch: A practical guide to viewing the universe*. Willowdale, ON: Firefly Books.

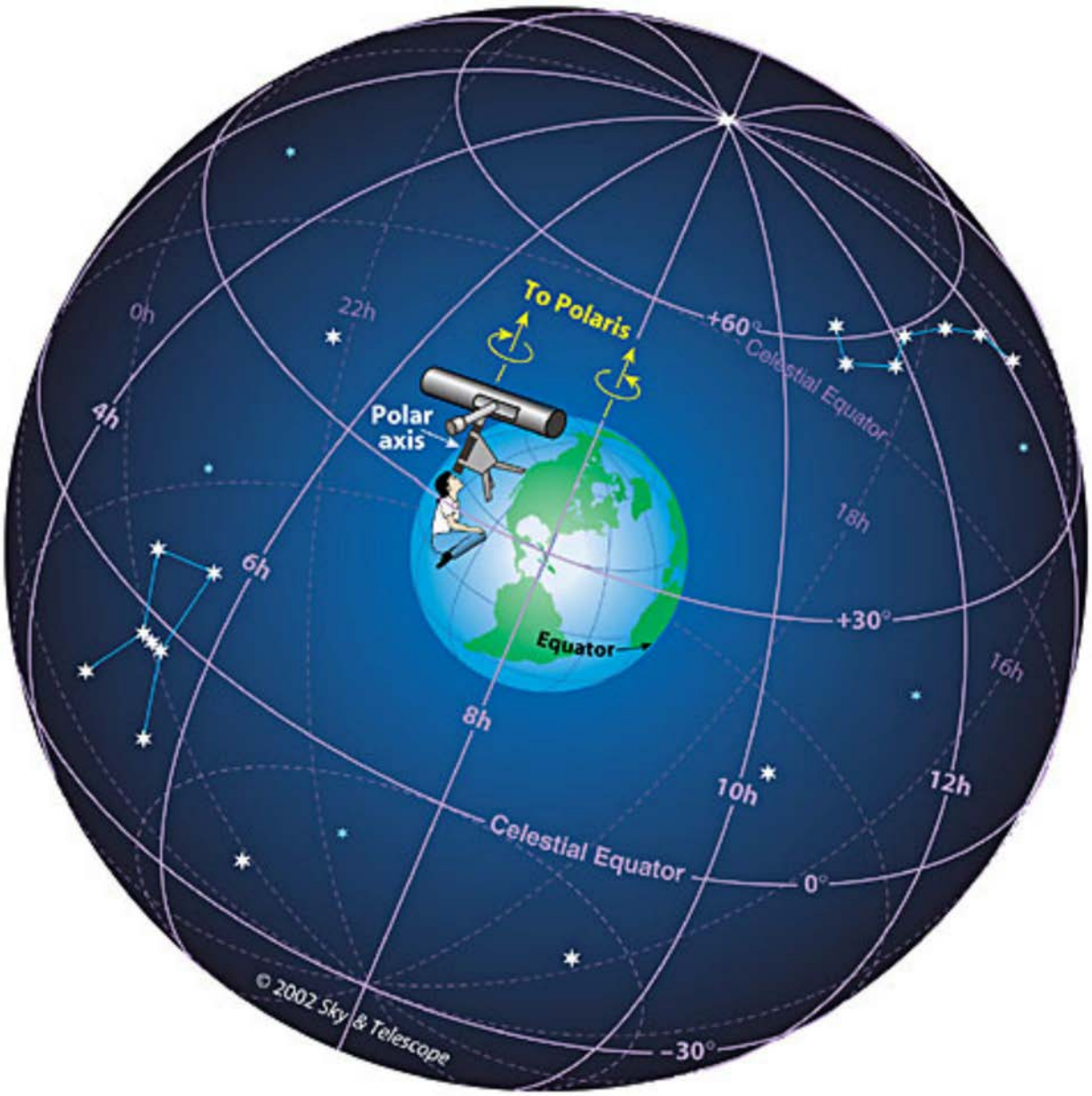
C3-180 ISBN 1-55297-853-2 Scagell, R. (2004). *Firefly planisphere: Latitude 42 deg N*. Willowdale, ON: Firefly Books.

C3-221 National Research Council of Canada. (2007). *Explore the night sky*. Retrieved December 3, 2007, from http://www.nrc-cnrc.gc.ca/eng/education/astronomy/constellations/html.html

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Note. From "Sky and Telescope" by A. M. MacRobert, 2001, Understanding Celestial Coordinates. Retrieved October 30, 2008, from http://www.skyandtelescope.com/howto/basics/Celestial_Coordinates.htm

Figure A-1 Aligning With Polaris

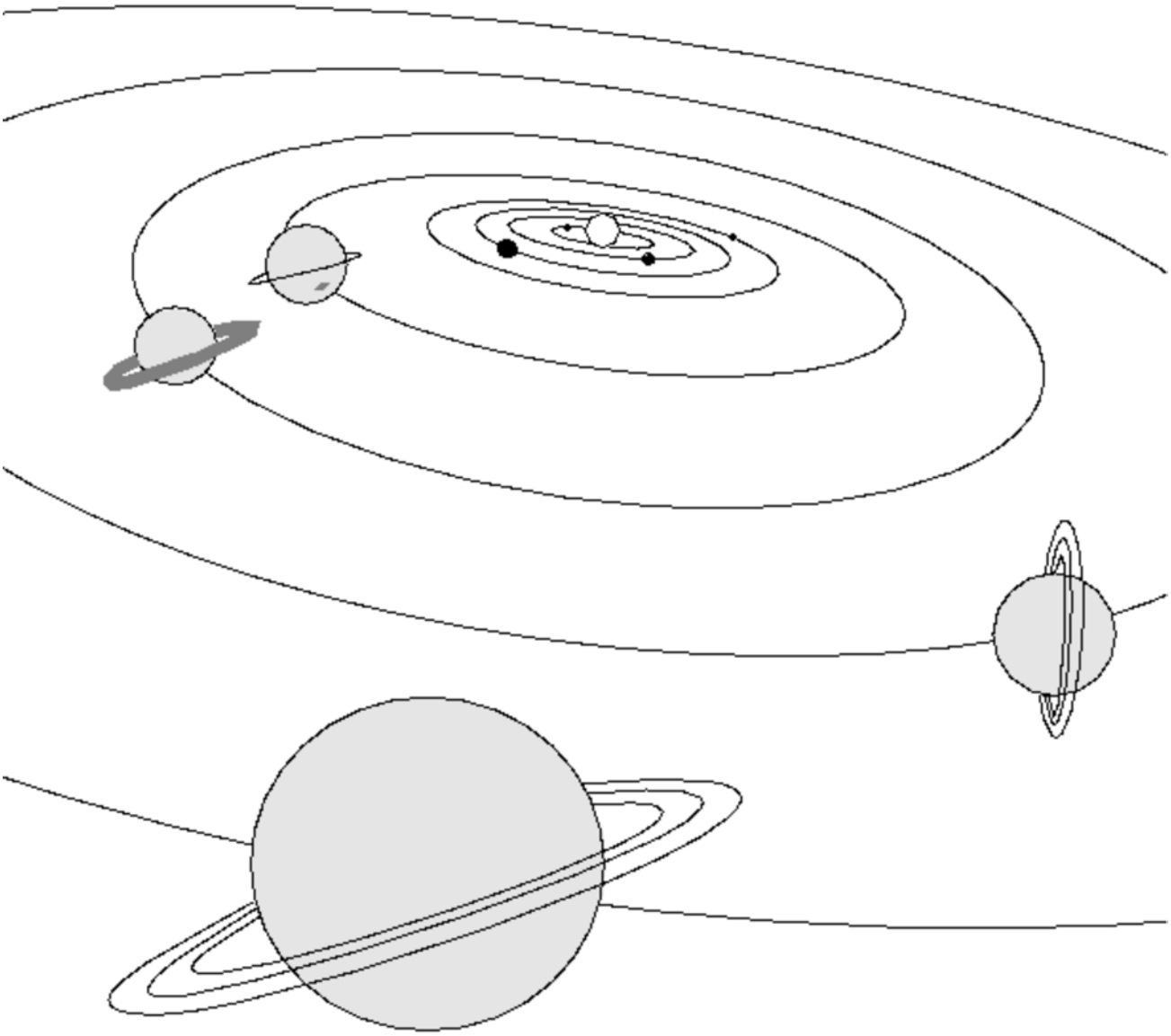
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Note. From "Sky and Telescope" by A. M. MacRobert, 2001, Understanding Celestial Coordinates. Retrieved October 30, 2008, from http://www.skyandtelescope.com/howto/basics/Celestial_Coordinates.html

Figure A-2 Observing Polaris

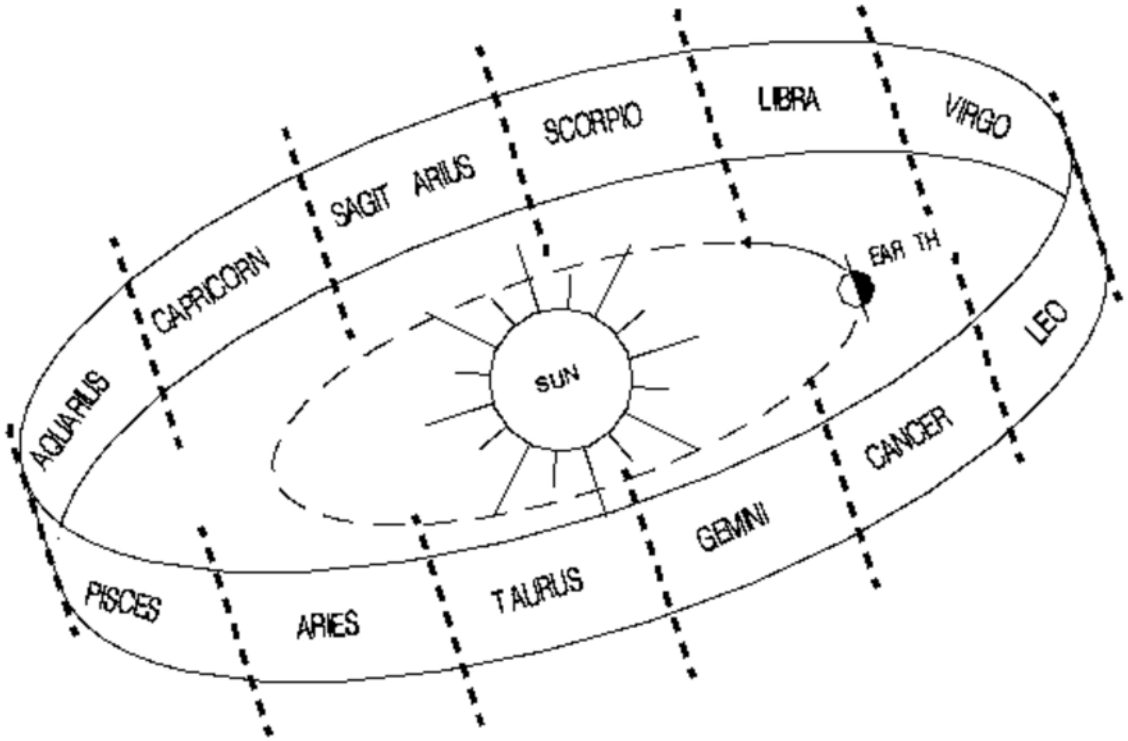
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Note. From "CSE@SSL", by B. Napier, 1995, Demonstration: The Plane of the Ecliptic, Copyright 1995 by Regents of the University of California. Retrieved October 30, 2008, from http://cse.ssl.berkeley.edu/img/eclip.gif

Figure B-1 Third Rock from the Sun

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Note. From "CSE@SSL", by B. Napier, 1995, Demonstration: The Plane of the Ecliptic, Copyright 1995 by Regents of the University of California. Retrieved October 30, 2008, from http://cse.ssl.berkeley.edu/lessons/indiv/beth/beth_intro.html

Figure B-2 The Zodiac and its Constellations

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Observation Record	
Date:	Time:
Place:	Instruments used:
Conditions:	
Observations:	

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