

TEST BANK



C H A P T E R 2

USER'S GUIDE TO THE SKY: PATTERNS AND CYCLES

CHAPTER OUTLINE

- 2.1 The Stars
 - Constellations
 - The Names of the Stars
 - The Brightness of Stars
- 2.2 The Sky and Its Motion
 - The Celestial Sphere
 - Precession
 - Article: Scientific Models*
 - Article: Astrology and Pseudoscience*
- 2.3 The Cycle of the Sun
 - The Annual Motion of the Sun
 - The Seasons
- 2.4 The Cycles of the Moon
 - The Motion of the Moon
 - The Cycle of Moon Phases
- 2.5 Eclipses
 - Solar Eclipses
 - Lunar Eclipses

SUMMARY

This chapter focuses on the appearance of the night sky. Many of the concepts presented were common knowledge before time became quantified on clocks and city lights blocked our nightly view of the sky. Most people today no longer have an understanding of the basic appearance or motions of the sky.

This chapter introduces the concept of a scientific model. It is important to emphasize here that science is not about who is right but about what explanation is most correct. Scientific arguments need to address all possible data and theories so that the best scientific explanation can be formulated. Scientific models do not have to be 100% accurate, 100% of the time to be useful. A discussion of the celestial sphere as a scientific model points out both the usefulness and limitations inherent in most scientific models. Other more familiar models might be briefly discussed as examples of scientific models (e.g. Bohr model of the atom). The concepts of model, theory, and hypothesis are used consistently and coherently throughout the book.

One topic presented in this chapter that is confusing for many students is the magnitude of a star. It is important to cover this topic because magnitudes will be used in later chapters. Most Hertzsprung-Russell diagrams used in connection with stellar evolution employ absolute visual magnitude, so the magnitude system will be encountered again.

This chapter uses numerous diagrams and pictures to communicate critical information. Emphasize the importance of looking at the figures and reading the figure captions. Astronomy is a visual science and pictures greatly add to the understanding of a concept. Think of a picture as a miniature scientific model.

One of the things that many of us who teach general education science courses believe we do is to help students learn to critically observe pictures and learn to read graphs and charts. Yet, few of us test this skill. Several of the exam questions in the test bank make use of pictures, tables, and graphs. It will help the students greatly in the course, and their development of critical reading skills, if they know at the beginning that understanding the diagrams, pictures, charts, and graphs is important and something they will be tested on.

This chapter also focuses on the effects of the motions of Earth around the sun, the moon around Earth, the revolution of Earth around the sun, and the tilt in Earth's rotation axis with respect to the orbital axis. From these descriptions the cause of the seasonal variations are described. I have found that many students will tell you that the seasons are caused by the tilt in Earth's axis, but when asked what the axis of rotation is tilted with respect to, they have no idea. Others believe that summer occurs when Earth is closest to the sun. The tilt in Earth's rotation axis with respect to the axis of the orbit needs to be stressed. Also stress that this tilt produces a variation in the angle at which sunlight hits the surface of Earth at a given location and produces the variation in the length of time that the sun is above the horizon at that location.

This chapter also covers motions of the moon and the changing appearance as a result of those motions (i.e., phases). Emphasize that it is the motion of the moon around Earth and the motion of Earth around the sun that produces the changing phases and the difference between the synodic and sidereal months. Another major topic is lunar and solar eclipses and how to predict them. It is important that the students are able to mentally remove themselves from the surface of Earth and look at the Earth-moon-sun system. This will help them understand the lunar phases, but is critical to understanding how eclipses occur and why they don't occur every month. Being able to understand a drawing of a three-dimensional model is necessary. This is a skill that is needed to understand many of the diagrams of the moon's orbit and shadow.

In summary, this chapter gave you a tour of the sky and vocabulary to describe it. This chapter also illustrates a powerful way to analyze certain kinds of problems. If a process repeats, you can understand it by searching for regular cycles. The daily, monthly, and yearly cycles of the sky have direct influences on your life and also produce dramatic sights.

RECAP

1. How do astronomers refer to stars?

Astronomers divide the sky into 88 constellations that originated in Greek and Middle Eastern mythology. Modern constellations were added to fill in spaces. Modern astronomers often refer to bright stars by a name composed of the constellation name plus a Greek letter assigned according to the star's brightness within the constellation.

2. How can you compare the brightness of stars?

The magnitude system is the astronomer's brightness scale. First-magnitude stars are brighter than second-magnitude stars, which are brighter than third magnitude stars, and so on. The magnitude you see when you look at a star in the sky is its apparent visual magnitude, which does not take into account its distance from Earth.

3. How does the sky appear to move as Earth rotates?

The celestial sphere is a model of the sky. The northern and southern celestial poles are the pivots on which the sky appears to rotate. The celestial equator, an imaginary line around the sky above Earth's equator, divides the sky in half. The angular distance from the horizon to the north celestial pole always equals your latitude. This is an important basis for celestial navigation. The gravitational forces of the moon and sun act on the spinning Earth and cause it to precess like a top. Earth's axis of rotation sweeps around in a circular motion with a period of 26,000 years, and consequently the celestial poles and celestial equator move slowly against the background of the stars.

4. What causes the seasons?

Because Earth orbits the sun, the sun appears to move eastward along the ecliptic. The inclination of the ecliptic means the sun is in the northern hemisphere half the year and the southern hemisphere the other

half. In the summer, the sun is above the horizon longer and shines more directly down on the ground. Both effects cause warmer weather.

5. Why does the moon go through phases?

Because you see the moon by reflected sunlight, its shape appears to change as it orbits Earth over a cycle of 29.53 days.

6. What is a solar eclipse?

A total solar eclipse occurs if a new moon passes directly between the sun and Earth and the moon's shadow sweeps over the part of the Earth's surface where you are located. If you are outside the path of totality but the penumbra sweeps over your location, you see a partial eclipse. During a total solar eclipse, the bright disk of the sun is covered, and you can see fainter features of the surrounding solar atmosphere. If the moon is in the farther part of its orbit during a solar eclipse, it does not appear large enough to cover the solar disk and you see only an annular eclipse.

7. What is a lunar eclipse?

If a full moon passes through Earth's shadow while you are on the night side of Earth, you see the moon darken in a lunar eclipse. The totally eclipsed moon looks copper-red because of sunlight refracted through Earth's atmosphere.

KEY TERMS

angular diameter (p. 17)
angular distance (p. 17)
annular eclipse (p. 26)
aphelion (p. 21)
apparent visual magnitude (*m_v*) (p. 13)
arc minute (p. 17)
arc second (p. 17)
asterism (p. 12)
autumnal equinox (p. 20)
celestial equator (p. 16)
celestial sphere (p. 14)
circumpolar constellation (p. 17)
constellation (p. 10)
ecliptic (p. 19)
evening star (p. 22)
flux (p. 13)
horizon (p. 16)
lunar eclipse (p. 28)
magnitude scale (p. 12)

morning star (p. 22)
nadir (p. 16)
north and south celestial poles (p. 16)
north, south, east, and west points (p. 16)
penumbra (p. 26)
perihelion (p. 21)
precession (p. 15)
revolution (p. 18)
rotation (p. 18)
Saros cycle (p. 29)
scientific model (p. 14)
solar eclipse (p. 26)
summer solstice (p. 20)
umbra (p. 26)
vernal equinox (p. 20)
winter solstice (p. 20)
zenith (p. 16)
zodiac (p. 19)

CLASS DEMONSTRATIONS

1. Try to have the class meet outside at night at least once. A flashlight with a fairly well focused beam makes a good pointer when working outside. Even with a large group you can use the flashlight to point out the locations of the north celestial pole, zenith, celestial equator, etc. Pointing out some of the bright constellations in addition to the celestial sphere can help students to begin to watch the sky.
2. When discussing the reasons for seasons, demonstrate the motion of Earth around the sun using a globe and a light bulb on a ring stand. As you start, emphasize the fact that the rotation axis of the Earth always points at the same point in space, i.e., the North Celestial Pole (NCP). If you hand them the globe and tell them to move it around a light bulb, most students will keep the axis tipped towards the light bulb rather than towards a fixed point in space. It can be useful to pin something on the north wall of the classroom (an "N" works nicely) to represent the NCP. This comes in handy later when reviewing the subject; simply pointing at the "N" reminds the students of the three-dimensional demonstration. During the demonstration, be sure to demonstrate the counter-examples, i.e., what are the differences if

Earth is not tilted, or if it is tilted by 90 degrees? This is a good time to incorporate Building Scientific Arguments #1.

3. One simple way of addressing students' preconceived scale of the Earth–Moon system is as follows. At the beginning of class you can draw a circle with a diameter of 4 cm on the board. This circle represents the Earth. Have enough sticky notes prepared for each student, each with a 1 cm diameter circle drawn on it. Each student should put his or her name on a sticky note, and then put the sticky note on the board in the spot that best represents the true scale of the Earth–Moon system. You can even offer a prize such as an astronomy poster for the person who comes the closest. The correct answer is that the moon is about $\frac{1}{4}$ the diameter of the Earth, but is about 30 Earth-diameters distant, or about 120 cm on this scale. After years of looking at moon-phase diagrams that show a completely different scale, most students will guess a distance much smaller than this.
4. The answer to the question “Why is there not an eclipse every month?” is also best demonstrated three-dimensionally. Use a light bulb (or anything, really) to represent the sun, and then two balls of different sizes for Earth and the moon. Have the “moon” orbit around “Earth”, pointing out the five degree tilt in the lunar orbit with respect to the ecliptic. When exaggerated for the sake of the demonstration, it is fairly easy for students to see why there can only be an eclipse when the moon is passing through the ecliptic plane, or about every six months. All three bodies just need to be lined up!

BUILDING SCIENTIFIC ARGUMENTS AND CRITICAL THINKING

1. How does the elliptical shape of Earth's orbit affect the seasons?

In the critical analysis of an idea, it can be helpful to exaggerate the importance of a single factor. Doing so not only reveals the effect of that factor but can also reveal the inner workings of the process itself. Earth's orbit is nearly circular, so its distance from the sun varies by only about 3.3 percent from nearest to farthest. You might try to imagine what life on Earth would be like if Earth's orbit were more elliptical than it really is. Earth is at perihelion—closest to the sun—about January 3. If Earth's orbit were more elliptical, winters in the northern hemisphere would be warmer than they are now; and the weather in the southern hemisphere, normally warm in January, would be extremely hot. Six months later, about July 5, Earth reaches aphelion, its farthest point from the sun. If Earth had a more elliptical orbit, the northern hemisphere would experience a much cooler summer than it now does, and in the southern hemisphere the cool season would be bitterly cold. You can see that the net effect of the elliptical shape of Earth's orbit is to make northern seasons milder and southern seasons more extreme, but the effect is hardly noticeable. Now use exaggeration to analyze the true cause of the seasons.

Ask students to imagine what the seasons would be like if Earth's equator were inclined more than the present 23.5 degrees or less than the present 23.5 degrees, relative to the plane of its orbit.

2. What would solar eclipses be like if the moon's orbit were not tipped to the plane of Earth's orbit?

One way to analyze a complex process is to change one thing and imagine what would happen. In this case, you can review your understanding of real eclipses by trying to imagine a geometry that does not exist. If the moon's orbit were not inclined, then the moon would follow the ecliptic, and it would cross in front of the sun at every new moon. There would be a solar eclipse every month at new moon and a lunar eclipse every month at full moon. You could repeat this analysis for lunar eclipses, but it might be more interesting to change a different factor.

What would lunar eclipses look like if Earth had no atmosphere?

DISCUSSION QUESTIONS

1. All cultures on Earth have named constellations. Why do you suppose this was such a common practice?

People from different cultures all see the same stars, but the asterisms and constellations are different. Technically, we would now all see the same constellations, because these have official definitions and borders; however, this designation might not be well accepted by people of various cultures. The asterisms are certainly dependent on the culture. The images we see in the sky depend on how we view different objects and the value we place on them. Even within a culture we can have different asterisms.

2. **If you were lost at sea, you could find your approximate latitude by measuring the altitude of Polaris. But Polaris isn't exactly at the celestial pole. What else would you need to know to measure your latitude more accurately?**

Your latitude can be determined by observing the angle between your northern horizon and the north celestial pole. However, you also need to know that Polaris, the North Star, is within 1° of the north celestial pole. With this knowledge, Polaris can be used as a fairly accurate marker of the north celestial pole.

3. **Do planets orbiting other stars have ecliptics? Could they have seasons?**
4. **Why would it be difficult to see faint features in the solar atmosphere if you were on the moon during a total lunar eclipse?**

REVIEW QUESTIONS FROM STUDENT EDITION

1. **Do people from other cultures on Earth see the same stars you see? The same constellations and asterisms?**

People from different cultures all see the same stars, but the asterisms and constellations are different. Technically, we would now all see the same constellations, because these have official definitions and borders; however, this designation might not be well accepted by people of various cultures. The asterisms are certainly dependent on the culture. The images we see in the sky depend on how we view different objects and the value we place on them. Even within a culture we can have different asterisms. My son sees a small duck in the sky. I have had him point it out in the planetarium, and see only a loose collection of faint stars, but year after year he points out the same group of stars as a duck, so something definitely appears as a duck to him.

2. **In what ways is the celestial sphere a scientific model?**

The celestial sphere is an excellent scientific model. It is an accurate representation of what we observe when we view the night sky. Note that as we look out at the night sky, all the stars appear to be an equal distance away as if they were dots painted on a giant ceiling. Consequently, the celestial sphere does represent what we see, and permits us to discuss what would happen if Earth is at the center and Earth rotated on its axis, and/or revolved around the sun. It provides us with a way to step back and picture in our minds what is going on as Earth rotates on its axis and revolves around the sun.

3. **Why does the number of circumpolar constellations depend on the latitude of the observer?**

Circumpolar constellations are those constellations close enough to the celestial pole so that they never pass below an observer's horizon, but instead pass directly between the observer's celestial pole and northern or southern horizon at their lowest points in the sky. At different latitudes the celestial pole will be at different distance above an observer's horizon. If the observer is at latitude of 60° N, then all constellations within 60° of the north celestial pole will be circumpolar. However, if an observer is at a latitude of only 30° N, then only those constellations within 30° of the north celestial pole will be circumpolar.

4. **How could you detect Earth's precession by examining star charts from ancient Egypt?**

One of the easiest ways to detect the existence of precession by examining ancient Egyptian star charts would be to look at which stars they show as circumpolar and which are circumpolar in Egypt now. Since the location of the north celestial pole moves relative to the stars because of precession, the stars that appear within the circumpolar zone also changes. If on the ancient charts, Thuban is listed as "nearest the pole", then at the latitude of approximately 30° N, Polaris would have been circumpolar, but would have been very near the horizon at its lowest point. Additionally, all of the Big Dipper asterism would have been circumpolar, while today only one of the seven bright stars forming the Big Dipper is circumpolar at Egypt's latitude.

5. **What phase would you see Earth in if you were on the moon when the moon is full? When the moon is at first quarter?**

ADDITIONAL REVIEW QUESTIONS

These are additional review questions featured only in this instructor's manual.

1. Why have astronomers added constellations to the sky in the past few hundred years?

Most of the constellations that were not handed down from ancient civilizations were added during the 15th to 17th centuries. Some of the added constellations were very small constellations composed of faint stars located in the Northern Hemisphere. These constellations filled in gaps between larger and brighter constellations. Also added were constellations in the Southern Hemisphere that had not been observed by western civilization. When sailors and explorers began to sail south of the tropics, new star patterns were observed and named to help in remembering them for navigation.

2. What is the difference between an asterism and a constellation? Give some examples.

An asterism is a group of stars that is not formally recognized as a constellation by the International Astronomical Union (IAU). Many asterisms are part of larger constellations. There are 88 constellations officially recognized by the IAU. Examples of asterisms include the Big Dipper (part of Ursa Major), the Great Square (part of Pegasus), the Water Jug (part of Aquarius), the Summer Triangle (composed of three bright stars in the constellations of Lyra, Cygnus, and Aquilla), Medusa's Head (part of Perseus).

3. What characteristic do stars in a constellation or asterism share?

The stars in a constellation or an asterism are generally close to each other in the sky and have a shape that suggests a particular object, person, or animal to the people of a given culture.

5. How does the Greek-letter designation of a star give you a clue to its brightness?

The Greek letter designations generally indicate the brightnesses because the stars in a given constellation were given Greek letter designations running in alphabetical order from brightest to faintest within that constellation. This system does not allow us to compare the relative brightnesses of stars in different constellations with certainty since the brightest star in each constellation is generally designated α , but not all constellations contain a really bright star.

6. How did the magnitude system originate in a classification of stars by brightness?

The magnitude system is sometimes said to be backwards because the brightest stars have the smallest magnitudes. The reverse order of the system comes about from placing the stars in order of brightness. The brightest stars were placed in the first group, magnitude 1; the next brightest stars were placed in the second group, magnitude 2 and so on. Consequently, bright stars have small numerical magnitude values, while faint stars have very large numerical magnitude values. This seems backwards because a 5th magnitude star is fainter than a 1st magnitude star.

7. What does the word *apparent* mean in *apparent visual magnitude*?

The word *apparent* in *apparent visual magnitude* means simply that it is the magnitude of the star as it *appears* to us when viewing the star from here on Earth. Apparent visual magnitude does not take into account any corrections for the star's distance or size or temperature or the amount of dust between us and the star. It is simply the brightness as it appears to us in the night sky.

8. Why do astronomers use the word *on* to describe angles on the sky rather than angles *in* the sky?

The use of the word *on* instead of the word *in* when referring to angular distance between celestial objects comes about because all of the objects appear to be *on* the celestial sphere and at an indeterminable distance. While we know that objects are at different distances *in* the sky, their distance from Earth is irrelevant in determining the angular distance between the two objects as viewed from Earth.

9. If Earth did not rotate, could you define the celestial poles and celestial equator?

The celestial poles and celestial equator exist because Earth rotates on an axis. If Earth did not rotate we could define the ecliptic and the poles of the ecliptic, but there would not be a separate set of celestial poles and celestial equator. Under such a circumstance, we would have difficulty defining a geographic

equator and geographic poles. The geographic equator would most likely be defined as the intersection between the ecliptic and Earth's surface and the geographic poles would be 90° from this equator.

10. Where would you go on Earth if you wanted to be able to see both the north celestial pole and the south celestial pole at the same time?

To see the north and south celestial poles at the same time, one needs to be at Earth's equator. Due to the refraction of light by the atmosphere, an observer on the equator would observe the north celestial pole approximately 0.5° above the northern horizon and the south celestial pole about 0.5° above the southern horizon. An observer at latitudes between 0.5° S and 0.5° N could see both celestial poles above their horizon.

11. Where would you go on Earth to see a celestial pole at your zenith?

A celestial pole will be on your zenith if you are at latitude of 90° N, the north geographic pole, or at 90° S, the south geographic pole.

12. Explain how to make a simple astronomical observation that would determine your latitude.

Your latitude can be determined by observing the angle between your northern horizon and the north celestial pole. Since Polaris, the North Star, is within 1° of the north celestial pole, Polaris can be used as a fairly accurate marker of the north celestial pole. Determining latitudes in the southern hemisphere is more difficult because there is no bright star within a few degrees of the south celestial pole.

13. Why does the number of circumpolar constellations depend on the latitude of the observer?

Circumpolar constellations are those constellations close enough to the celestial pole so that they never pass below an observer's horizon, but instead pass directly between the observer's celestial pole and northern or southern horizon at their lowest points in the sky. At different latitudes the celestial pole will be at different distance above an observer's horizon. If the observer is at latitude of 60° N, then all constellations within 60° of the north celestial pole will be circumpolar. However, if an observer is at a latitude of only 30° N, then only those constellations within 30° of the north celestial pole will be circumpolar.



RECOMMENDED READING

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EDUCATIONAL RESOURCES



Videos and Films

The Sky, 1994, (28 minutes) Produced by Coast Telecourse. Part of the *Universe: The Infinite Frontier* video series. This program describes how the motions of Earth determine the length of the day and year and the cause of the seasons. Additionally, it describes how different cultures viewed the sky.

Cycles of the Sky, 1994 (28 minutes) Produced by Coast Telecourse. Part of *Universe: The Infinite Frontier*. This video describes the phases of the moon and eclipses.



Computer Software and CD-ROMs

There are several planetarium programs that simulate the night sky. These include *RedShift College Edition* and *TheSky Student Edition*.

A few internet sites related to this material:

<http://skytonight.com/>
<http://domeofthesky.com/>
http://aa.usno.navy.mil/data/docs/RS_OneDay.html
<http://www.space.com/spacewatch/>
<http://www.nightskyinfo.com/>
<http://nightsky.jpl.nasa.gov/planner.cfm>

Lists events in the night sky
Online night sky with constellations
Sun and moon location data
Current observational events
Night sky events for the week
Planning tools for night sky observations.