4.E: Earth, Moon, and Sky (Exercise)

For Further Exploration

Articles

Bakich, M. “Your Twenty-Year Solar Eclipse Planner.” *Astronomy* (October 2008): 74. Describes the circumstances of upcoming total eclipses of the Sun.

Coco, M. “Not Just Another Pretty Phase.” *Astronomy* (July 1994): 76. Moon phases explained.

Espenak, F., & Anderson, J. “Get Ready for America’s Coast to Coast Experience.” *Sky & Telescope* (February 2016): 22.

Gingerich, O. “Notes on the Gregorian Calendar Reform.” *Sky & Telescope*(December 1982): 530.

Kluepfel, C. “How Accurate Is the Gregorian Calendar?” *Sky & Telescope*(November 1982): 417.

Krupp, E. “Calendar Worlds.” *Sky & Telescope* (January 2001): 103. On how the days of the week got their names.

Krupp, E. “Behind the Curve.” *Sky & Telescope* (September 2002): 68. On the reform of the calendar by Pope Gregory XIII.

MacRobert, A., & Sinnott, R. “Young Moon Hunting.” *Sky & Telescope*(February 2005): 75. Hints for finding the Moon as soon after its new phase as possible.

Pasachoff, J. “Solar Eclipse Science: Still Going Strong.” *Sky & Telescope*(February 2001): 40. On what we have learned and are still learning from eclipses.

Regas, D. “The Quest for Totality.” *Sky & Telescope* (July 2012): 36. On eclipse chasing as a hobby.

Schaefer, B. “Lunar Eclipses That Changed the World.” *Sky & Telescope*(December 1992): 639.

Schaefer, B. “Solar Eclipses That Changed the World.” *Sky & Telescope*(May 1994): 36.

Websites

Ancient Observatories, Timeless Knowledge (Stanford Solar Center): http://solar-center.stanford.edu/AO/. An introduction to ancient sites where the movements of celestial objects were tracked over the years (with a special focus on tracking the Sun).

Astronomical Data Services: aa.usno.navy.mil/data/index.php. This rich site from the U.S. Naval Observatory has information about Earth, the Moon, and the sky, with tables and online calculators.

Calendars through the Ages: http://www.webexhibits.org/calendars/index.html. Like a good museum exhibit on the Web.

Calendar Zone: http://www.calendarzone.com/. Everything you wanted to ask or know about calendars and timekeeping, with links from around the world.

Eclipse 2017 Information and Safe Viewing Instructions: www.nsta.org/publications/pre...enceInsert.pdf.

Eclipse Maps: http://www.eclipse-maps.com/Eclipse-Maps/Welcome.html. Michael Zeiler specializes in presenting helpful and interactive maps of where solar eclipses will be visible

Eclipse Predictions: astro.unl.edu/classaction/ani...ipsetable.html. This visual calendar provides dates for upcoming solar and lunar eclipses through 2029.EclipseWise: http://www.eclipsewise.com/intro.html. An introductory site on future eclipses and eclipse observing by NASA’s Fred Espenak.

History of the International Date Line: http://www.staff.science.uu.nl/~gent0113/idl/idl.htm. From R. H. van Gent at Utrecht University in the Netherlands.

Lunacy and the Full Moon: www.scientificamerican.com/ar...the-full-moon/. This *Scientific American* article explores whether the Moon’s phase is related to strange behavior.

Moon Phase Calculator: https://stardate.org/nightsky/moon. Keep track of the phases of the Moon with this calendar.

NASA Eclipse Website: http://eclipse.gsfc.nasa.gov/eclipse.html. This site, by NASA’s eclipse expert Fred Espenak, contains a wealth of information on lunar and solar eclipses, past and future, as well as observing and photography links.

Phases of the Moon Gallery and Information: http://astropixels.com/moon/phases/phasesgallery.html. Photographs and descriptions presented by NASA’s Fred Espenak.

Time and Date Website: http://www.timeanddate.com/. Comprehensive resource about how we keep time on Earth; has time zone converters and many other historical and mathematical tools.

Walk through Time: The Evolution of Time Measurement through the Ages (National Institute of Standards and Technology): http://www.nist.gov/pml/general/time/.

Videos

Bill Nye, the Science Guy, Explains the Seasons: https://www.youtube.com/watch?v=KUU7IyfR34o. For kids, but college students can enjoy the bad jokes, too (4:45).

Geography Lesson Idea: Time Zones: https://www.youtube.com/watch?v=-j-SWKtWEcU. (3:11).

How to View a Solar Eclipse: www.exploratorium.edu/eclipse...o-view-eclipse. (1:35).

Shadow of the Moon: https://www.youtube.com/watch?v=XNcfKUJwnjM. This NASA video explains eclipses of the Sun, with discussion and animation, focusing on a 2015 eclipse, and shows what an eclipse looks like from space (1:54).

Strangest Time Zones in the World: https://www.youtube.com/watch?v=uW6QqcmCfm8. (8:38).

Understanding Lunar Eclipses: https://www.youtube.com/watch?v=lNi5UFpales. This NASA video explains why there isn't an eclipse every month, with good animation (1:58).

Collaborative Group Activities

1. Have your group brainstorm about other ways (besides the Foucault pendulum) you could prove that it is our Earth that is turning once a day, and not the sky turning around us. (Hint: How does the spinning of Earth affect the oceans and the atmosphere?)
2. What would the seasons on Earth be like if Earth's axis were not tilted? Discuss with your group how many things about life on Earth you think would be different.
3. After college and graduate training, members of your U.S. student group are asked to set up a school in New Zealand. Describe some ways your yearly school schedule in the Southern Hemisphere would differ from what students are used to in the Northern Hemisphere.
4. During the traditional U.S. Christmas vacation weeks, you are sent to the vicinity of the South Pole on a research expedition (depending on how well you did on your astronomy midterm, either as a research assistant or as a short-order cook!). Have your group discuss how the days and nights will be different there and how these differences might affect you during your stay.
5. Discuss with your group all the stories you have heard about the full moon and crazy behavior. Why do members of your group think people associate crazy behavior with the full moon? What other legends besides vampire stories are connected with the phases of the Moon? (Hint: Think Professor Lupin in the Harry Potter stories, for example.)
6. Your college town becomes the founding site for a strange new cult that worships the Moon. These true believers gather regularly around sunset and do a dance in which they must extend their arms in the direction of the Moon. Have your group discuss which way their arms will be pointing at sunset when the Moon is new, first quarter, full, and third quarter.
7. Changes of the seasons play a large part in our yearly plans and concerns. The seasons have inspired music, stories, poetry, art, and much groaning from students during snowstorms. Search online to come up with some examples of the seasons being celebrated or overcome in fields other than science.
8. Use the information in Appendix H and online to figure out when the next eclipse of the Sun or eclipse of the Moon will be visible from where your group is going to college or from where your group members live. What time of day will the eclipse be visible? Will it be a total or partial eclipse? What preparations can you make to have an enjoyable and safe eclipse experience? How do these preparations differ between a solar and lunar eclipse?
9. On Mars, a day (often called a sol) is 24 hours and 40 minutes. Since Mars takes longer to go around the Sun, a year is 668.6 sols. Mars has two tiny moons, Phobos and Deimos. Phobos, the inner moon, rises in the west and sets in the east, taking 11 hours from moonrise to the next moonrise. Using your calculators and imaginations, have your group members come up with a calendar for Mars. (After you do your own, and only after, you can search online for the many suggestions that have been made for a martian calendar over the years.)

Review Questions

1. Discuss how latitude and longitude on Earth are similar to declination and right ascension in the sky.
2. What is the latitude of the North Pole? The South Pole? Why does longitude have no meaning at the North and South Poles?

3. Make a list of each main phase of the Moon, describing roughly when the Moon rises and sets for each phase. During which phase can you see the Moon in the middle of the morning? In the middle of the afternoon?
4. What are advantages and disadvantages of apparent solar time? How is the situation improved by introducing mean solar time and standard time?
5. What are the two ways that the tilt of Earth's axis causes the summers in the United States to be warmer than the winters?
6. Why is it difficult to construct a practical calendar based on the Moon's cycle of phases?
7. Explain why there are two high tides and two low tides each day. Strictly speaking, should the period during which there are two high tides be 24 hours? If not, what should the interval be?
8. What is the phase of the Moon during a total solar eclipse? During a total lunar eclipse?
9. On a globe or world map, find the nearest marked latitude line to your location. Is this an example of a great circle? Explain.
10. Explain three lines of evidence that indicate that the seasons in North America are not caused by the changing Earth-Sun distance as a result of Earth's elliptical orbit around the Sun.
11. What is the origin of the terms "a.m." and "p.m." in our timekeeping?
12. Explain the origin of the leap year. Why is it necessary?
13. Explain why the year 1800 was not a leap year, even though years divisible by four are normally considered to be leap years.
14. What fraction of the Moon's visible face is illuminated during first quarter phase? Why is this phase called first quarter?
15. Why don't lunar eclipses happen during every full moon?
16. Why does the Moon create tidal bulges on both sides of Earth instead of only on the side of Earth closest to the Moon?
17. Why do the heights of the tides change over the course of a month?
18. Explain how tidal forces are causing Earth to slow down.
19. Explain how tidal forces are causing the Moon to slowly recede from Earth.
20. Explain why the Gregorian calendar modified the nature of the leap year from its original definition in the Julian calendar.
21. The term *equinox* translates as "equal night." Explain why this translation makes sense from an astronomical point of view.
22. The term *solstice* translates as "Sun stop." Explain why this translation makes sense from an astronomical point of view.
23. Why is the warmest day of the year in the United States (or in the Northern Hemisphere temperate zone) usually in August rather than on the day of the summer solstice, in late June?

Thought Questions

1. When Earth's Northern Hemisphere is tilted toward the Sun during June, some would argue that the cause of our seasons is that the Northern Hemisphere is physically closer to the Sun than the Southern Hemisphere, and this is the primary reason the Northern Hemisphere is warmer. What argument or line of evidence could contradict this idea?
2. Where are you on Earth if you experience each of the following? (Refer to the discussion in Observing the Sky: The Birth of Astronomy as well as this chapter.)
    1. The stars rise and set perpendicular to the horizon.
    2. The stars circle the sky parallel to the horizon.
    3. The celestial equator passes through the zenith.
    4. In the course of a year, all stars are visible.
    5. The Sun rises on March 21 and does not set until September 21 (ideally).
3. In countries at far northern latitudes, the winter months tend to be so cloudy that astronomical observations are nearly impossible. Why can't good observations of the stars be made at those places during the summer months?
4. What is the phase of the Moon if it . . .
    1. rises at 3:00 p.m.?
    2. is highest in the sky at sunrise?
    3. sets at 10:00 a.m.?
5. A car accident occurs around midnight on the night of a full moon. The driver at fault claims he was blinded momentarily by the Moon rising on the eastern horizon. Should the police believe him?
6. The secret recipe to the ever-popular veggie burgers in the college cafeteria is hidden in a drawer in the director's office. Two students decide to break in to get their hands on it, but they want to do it a few hours before dawn on a night when there is no Moon, so they are less likely to be caught. What phases of the Moon would suit their plans?
7. Your great-great-grandfather, who often exaggerated events in his own life, once told your relatives about a terrific adventure he had on February 29, 1900. Why would this story make you suspicious?

8. One year in the future, when money is no object, you enjoy your birthday so much that you want to have another one right away. You get into your supersonic jet. Where should you and the people celebrating with you travel? From what direction should you approach? Explain.
9. Suppose you lived in the crater Copernicus on the side of the Moon facing Earth.
    1. How often would the Sun rise?
    2. How often would Earth set?
    3. During what fraction of the time would you be able to see the stars?
10. In a lunar eclipse, does the Moon enter the shadow of Earth from the east or west side? Explain.
11. Describe what an observer at the crater Copernicus would see while the Moon is eclipsed on Earth. What would the same observer see during what would be a total solar eclipse as viewed from Earth?
12. The day on Mars is 1.026 Earth-days long. The martian year lasts 686.98 Earth-days. The two moons of Mars take 0.32 Earth-day (for Phobos) and 1.26 Earth-days (for Deimos) to circle the planet. You are given the task of coming up with a martian calendar for a new Mars colony. Would a solar or lunar calendar be better for tracking the seasons?
13. What is the right ascension and declination of the vernal equinox?
14. What is the right ascension and declination of the autumnal equinox?
15. What is the right ascension and declination of the Sun at noon on the summer solstice in the Northern Hemisphere?
16. During summer in the Northern Hemisphere, the North Pole is illuminated by the Sun 24 hours per day. During this time, the temperature often does not rise above the freezing point of water. Explain why.
17. On the day of the vernal equinox, the day length for all places on Earth is actually slightly longer than 12 hours. Explain why.
18. Regions north of the Arctic Circle are known as the “land of the midnight Sun.” Explain what this means from an astronomical perspective.
19. In a part of Earth’s orbit where Earth is moving faster than usual around the Sun, would the length of the sidereal day change? If so, how? Explain.
20. In a part of Earth’s orbit where Earth is moving faster than usual around the Sun, would the length of the solar day change? If so, how? Explain.
21. If Sirius rises at 8:00 p.m. tonight, at what time will it rise tomorrow night, to the nearest minute? Explain.
22. What are three lines of evidence you could use to indicate that the phases of the Moon are not caused by the shadow of Earth falling on the Moon?
23. If the Moon rises at a given location at 6:00 p.m. today, about what time will it rise tomorrow night?
24. Explain why some solar eclipses are total and some are annular.
25. Why do lunar eclipses typically last much longer than solar eclipses?

Figuring for Yourself

1. Suppose Earth took exactly 300.0 days to go around the Sun, and everything else (the day, the month) was the same. What kind of calendar would we have? How would this affect the seasons?
2. Consider a calendar based entirely on the day and the month (the Moon’s period from full phase to full phase). How many days are there in a month? Can you figure out a scheme analogous to leap year to make this calendar work?
3. If a star rises at 8:30 p.m. tonight, approximately what time will it rise two months from now?
4. What is the altitude of the Sun at noon on December 22, as seen from a place on the Tropic of Cancer?
5. Show that the Gregorian calendar will be in error by 1 day in about 3300 years.