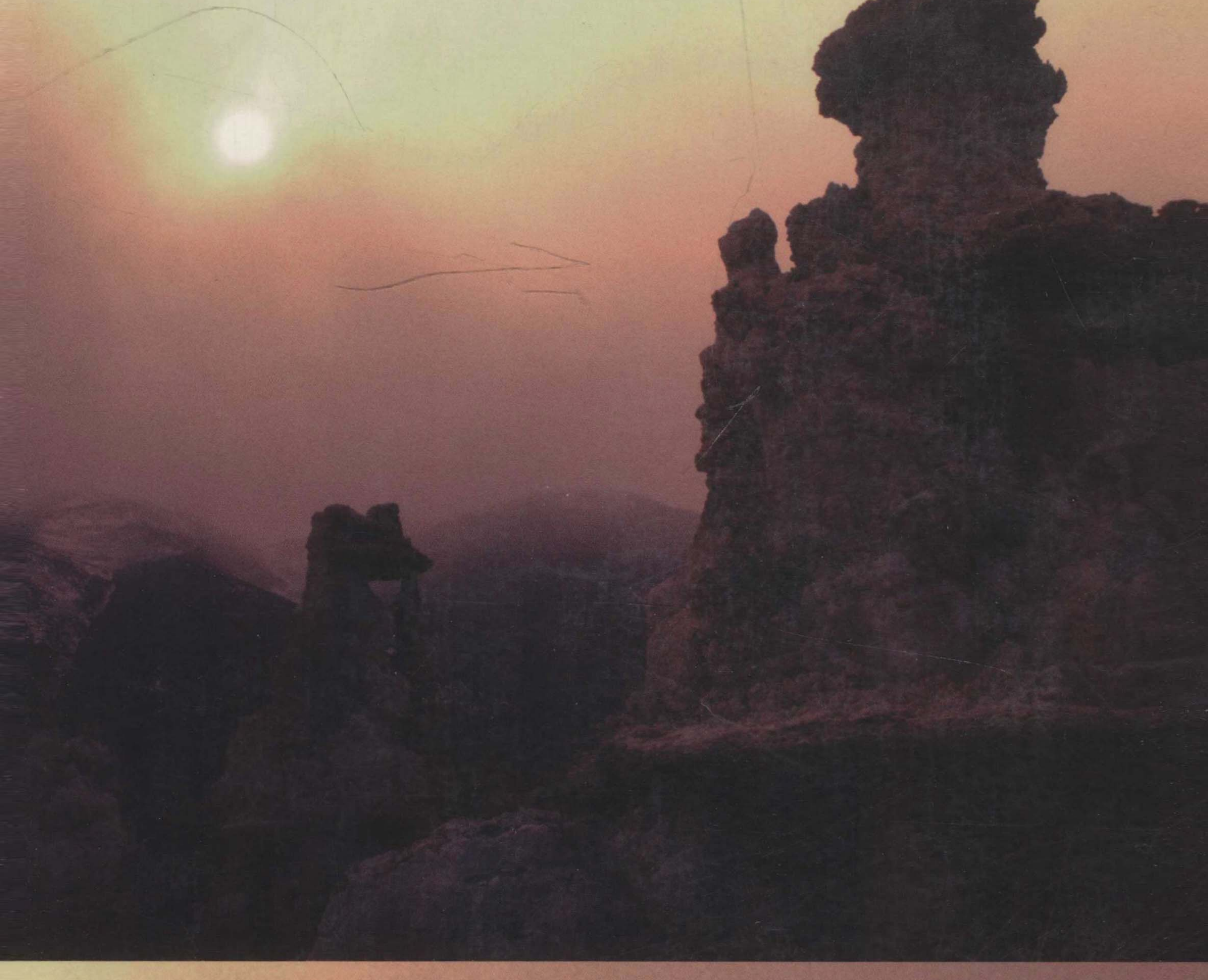
EXERCISES IN PHYSICAL GEOGRAPHY

THIRD EDITION



DON W. DUCKSON, JR.

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THIRD EDITION

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WCB McGraw-Hill

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2 3 4 5 6 7 8 9 0 QPD/QPD 9 3 2 1 0 9

ISBN 0–697–38493–4

Vice president and editorial director: *Kevin T. Kane*
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Compositor: *Shepherd, Inc.*
Typeface: *10/12 Times Roman*
Printer: *Quebecor Printing Book Group/Dubuque, IA*

Cover/interior design: *Kristyn Kalnes*
Cover photograph: *Digital Stock CD Rom*

The credits section for this book begins on page 1088 and is considered an extension of the copyright page.

Library of Congress Cataloging-in Publication Data

Duckson, Don W.
Exercises in physical geograpy / Don W. Duckson. — 3rd ed.
p. cm.
Includes index.
ISBN 0–697–38493–4
1. Title.
GB24.D83 1999
910'.02—dc21 98–6986
CIP

www.mhhe.com

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Preface

Geography is an often misunderstood discipline. Geography is a way of viewing the world by seeking to identify and understand patterns found over the earth's surface. Such *spatial* patterns are interrelated and interdependent, but frequently are discussed in the context of separate units, individual examples, or non-related issues. A large picture of the world is confusing when the parts are barely recognized. Frequently, introductory texts must describe the parts and do not always integrate them into the whole. Of necessity, this exercise manual provides an opportunity to explore only *some* of the topics in physical geography within a one-semester course. Insufficient time precludes covering some topics altogether, and links or connections will be inconsistent. The lab instructor thus plays a key role in the instructional process.

The approach of the manual and the sequence of exercises are traditional. Exercise length and coverage may vary with topic. Combinations of topics or partial exercises can be assigned, or skipped altogether, depending on time or the instructor's choice. Custom-published versions are also available from WCB/McGraw-Hill.

Minor changes in organization from the second edition were made in response to user surveys. These changes include the elimination of two exercises; the combination of three short exercises on earth-sun relationships, time, and the geographic grid; and attempts to better link content among exercises. Additional changes include 30 new graphics, already completed isoline maps for student analysis and interpretation, an El Niño event Pacific hurricane, shortening of three of the exercises on landforms, and substantially rewritten exercises on aerial photographic interpretation and glacial landscapes.

Reviewers of the first edition provided useful suggestions, many of which appeared in the second edition. Although no formal review was made of the second edition toward preparation of the third edition, users continued to send ideas, colleagues graciously continued to supply both ideas and criticisms, and my own second or third thoughts resulted in this product. Mistakes or errors remain solely my responsibility.

Finally, it should be noted that this manual is NOT a stand-alone publication. A text is required. This manual is intended to be collateral, and background information occasionally will be needed before students can work on their own. At Frostburg State University, I am fortunate to be able to lecture to students who have my wife as lab instructor. We talk to each other continually about individual students, student problems, "good" days and "bad" days, and assignments, approaches, or projects that could better convey the content of the course as a whole. I try to adjust to her labs, and she adjusts to my lecture. The students know that they benefit from such coordinating effort. The success of the text/manual is decidedly dependent on the effort given to the preparation and presentation of its content.

Should instructors or students have criticisms or ideas to better convey the content of this edition, please feel free to contact me.

Don W. Duckson, Jr.

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EXERCISE

Earth-Sun Relationships, the Geographic Grid, and Time

Name Section

THE EARTH IN SPACE

PURPOSE

Earth-sun relationships are important to understanding weather and climate. Variations in the amount of solar energy available at the earth's surface are a direct consequence of the earth's position in orbit. Variations in solar elevation, and the resulting differences in daylight and darkness, are responsible for seasons. This exercise portion examines how the earth's motion causes seasons.

Revolution

One of Kepler's Laws of Planetary Motion states that orbiting bodies have elliptical paths. Unlike circles, ellipses have two foci. In our solar system, the sun serves as the only focus for the earth's revolutionary plane of orbit (Figure 1.1).

1. Label in Figure 1.1 the points in orbit known as:
   a. Aphelion
   b. Perihelion

2. When are those points achieved in earth's orbit and at what distance?
   a. Aphelion

   b. Perihelion

3. Explain why physical distance from the sun alone cannot cause the seasons.

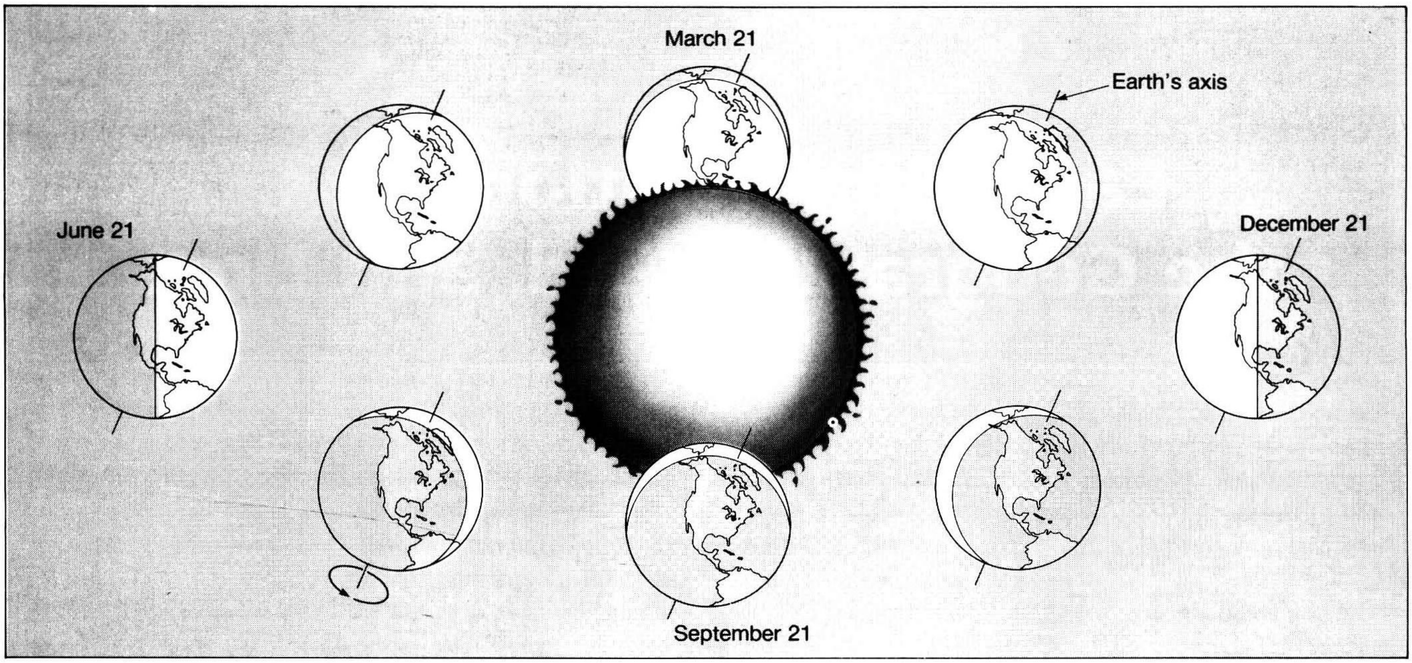
Rotation

The earth rotates about its axis in a counterclockwise direction if viewed from space above the North Pole. The speed at which the earth spins may be described in terms of either *angular velocity* or *linear velocity.*

4. Angular velocity is measured in degrees of arc per unit time and is a constant for all points on the earth's surface. To determine this rate, complete the following:
   a. Number of degrees in a circle (representing a spherical earth): ____________________

   b. divided by the number of hours in one day: __________

   c. equals angular velocity of __________ degrees per hour.



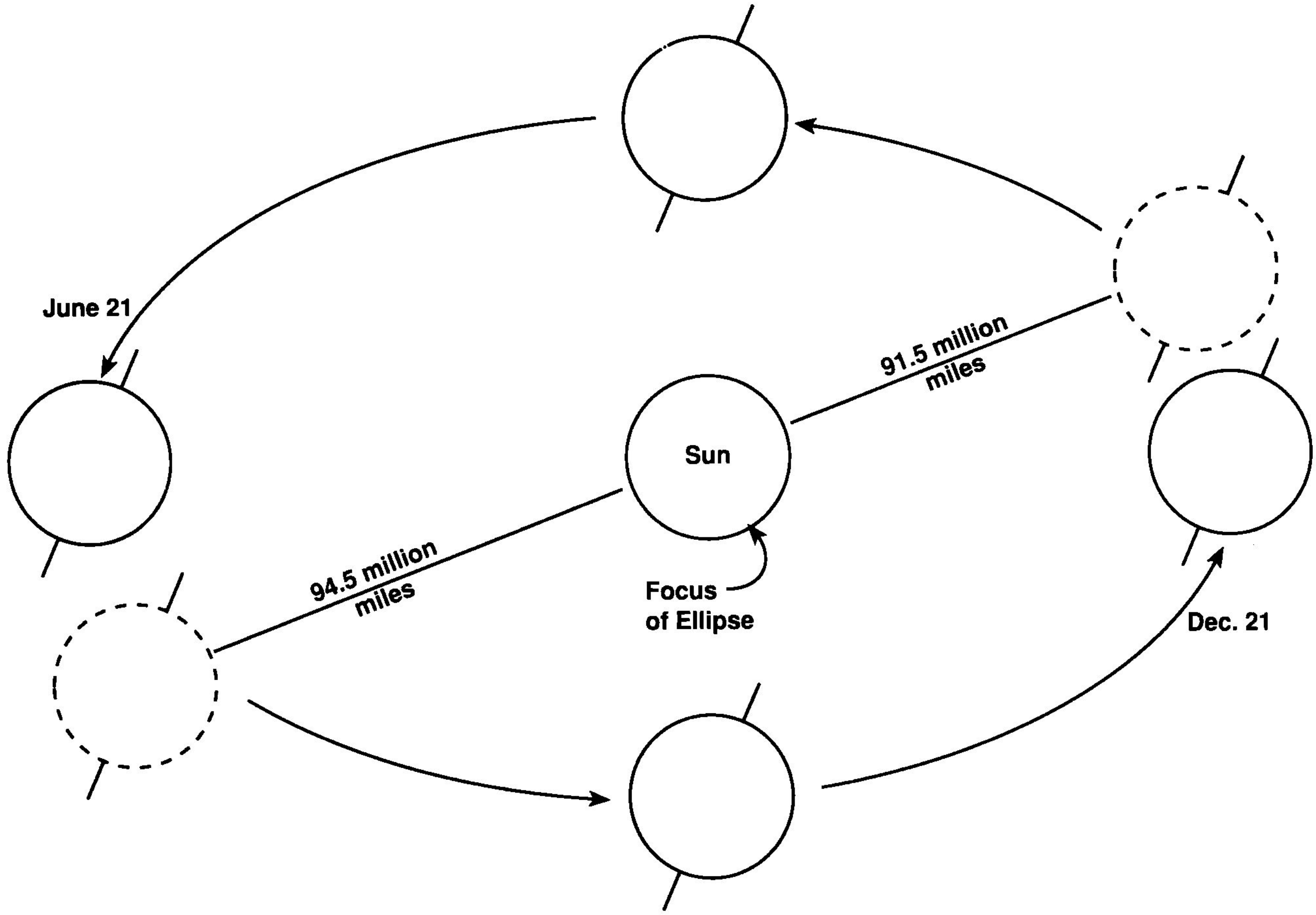


Figure 1.1 *Earth's orbital plane.*

(top) From Arthur Getis, Judith Getis, and Jerome Fellmann, *Introduction to Geography,* 4th ed.

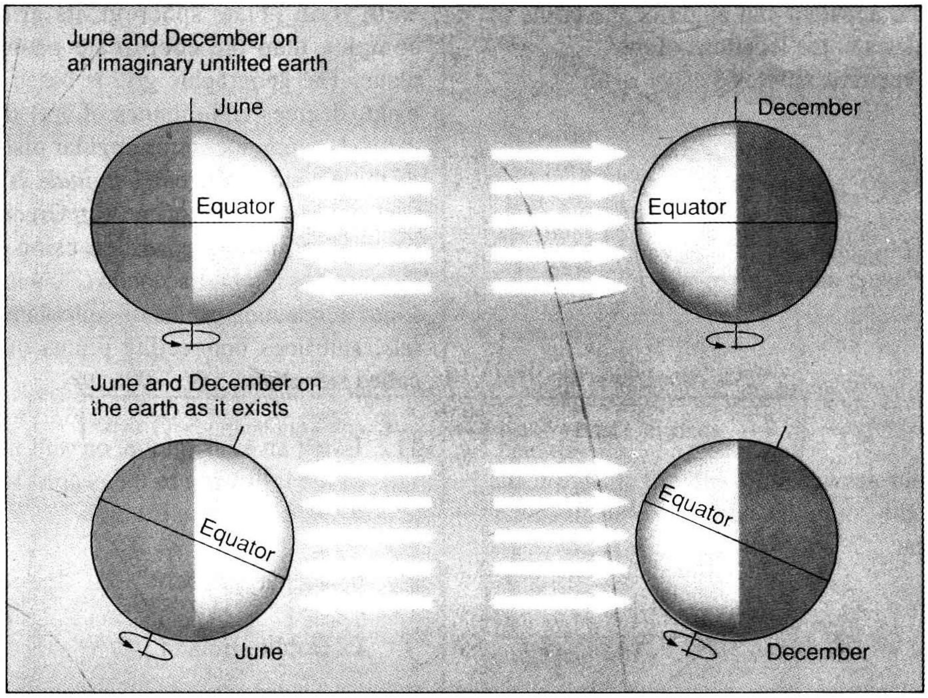


Figure 1.2 *Illumination in orbit.*

From Arthur Getis, Judith Getis, and Jerome Fellmann, *Introduction to Geography,* 4th ed. Copyright ©1994 Wm. C. Brown Communications, Inc., Dubuque, Iowa. All Rights Reserved. Reprinted by permission.

5. Linear velocity varies with latitude and is calculated by dividing the length of a parallel of latitude by the number of hours in a day. Calculate the linear velocity for the following latitudes:

Latitude	Approximate Length (mi.)	Linear Velocity (mph)
0	24,900	________
15	24,060	________
30	21,645	________
45	17,640	________
60	12,480	________
75	6,465	________
90	0	________

Does the speed of rotation have any bearing on seasonality?

Inclination and Parallelism

The earth's rotational axis extends from the North Pole to the South Pole, through the center of the planet. This axis is 66.5° away from the plane of earth's orbit and 23.5° away from the perpendicular to that plane (Figure 1.2). The axis is maintained in a parallel fashion everywhere in orbit.

The following problems pertain to Figures 1.1 and 1.2.

6. Label for each solstice and equinox the following:
   a. North and South Poles
   b. Arctic and Antarctic Circles
   c. Equator
   d. Tropics of Cancer and Capricorn
   e. Circle of Illumination.

7. Explain why parallelism is necessary for seasons to occur.

8. Explain how the apparent sun angle or the circle of illumination relates to the locations of the:
   a. Arctic and Antarctic Circles

   b. Tropics of Cancer and Capricorn.

9. How would your answer in Problem 8 change if the inclination of the rotational axis were at 30° away from the vertical?

10. Why is there always equal daylight and darkness at the equator?

THE GEOGRAPHIC GRID

PURPOSE

The geographic grid is an artificial device that permits specific ground locations to be identified in terms of a grid system of latitude and longitude. Knowledge of latitude and longitude is important, because the former relates to sun angles and energy, and the latter to the world system of Coordinated Universal Time.

After completing this portion of the exercise, students should be able to distinguish between a great circle and a small circle, use latitude and longitude to identify specific places, calculate differences in solar time and distances between places, and determine directions using azimuths and bearings.

The Geographic Grid

Students in mathematics are familiar with graphing along an x–y grid, and similar planar relationships can be expressed for the earth's surface. However, because the earth is an oblate spheroid, its grid is somewhat more complex than the coordinate geometry of a Cartesian plane. The geographic grid is based on angular measurement (degrees and minutes of arc) from the center of the earth. *Latitude* measures angular distance north and south of the equator, whereas *longitude* is the angular distance east or west of the prime (or Greenwich) meridian. By convention, both are written using symbols for degrees (°), minutes (′), and seconds (″), with latitude given first. Lines connecting points of equal latitude are called *parallels,* and lines connecting points of equal longitude are called *meridians.*

11. Using an atlas, globe, or wall map, give the location of the following to the nearest whole degree:
   a. Addis Ababa, Ethiopia
   b. Calgary, Alberta
   c. Dublin, Ireland
   d. Guadalajara, Mexico
   e. Harare, Zimbabwe
   f. Paris, France
   g. Point Barrow, Alaska
   h. Punta Arenas, Chile
   i. Quito, Ecuador
   j. South Pole
   k. Tokyo, Japan
   l. Washington, D.C.

12. Name the places located at the coordinates given below:

   a. 23° S, 14° E   b. 40° N, 105° W

   c. 64° N, 22° W   d. 1° N, 104° E

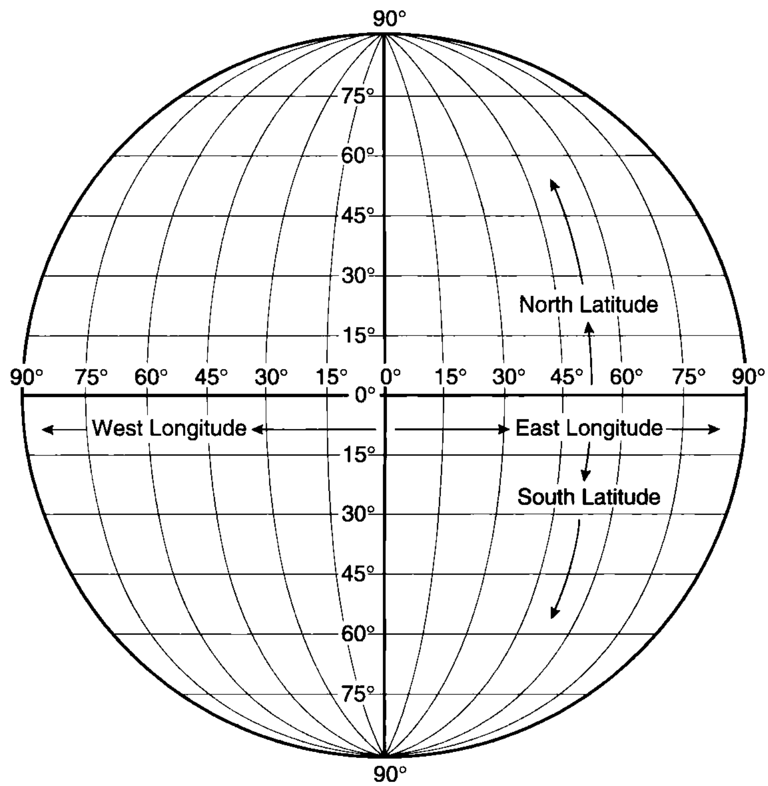


Figure 1.3 *Latitude and longitude.*

13. *Antipodes* are places diametrically opposite each other on the globe. For example, the North and South Poles are antipodes. Determine the antipode of each of the places identified in 12, on page 4.
    a. b.

    c. d.

Circles Great and Small

The geographic grid employs two types of circles. *Great circles* are equal to the maximum circumference of the earth. A plane inscribed by any great circle will pass through the center of the earth. The shortest distance between any two points on a sphere is along the arc of the great circle that connects those two points. All meridians, the equator, and the circle of illumination are great circles. Note that on a globe (or on Figure 1.3), two meridians of different labeling or value are required to form one great circle of longitude. Any circle of smaller dimension is a *small circle.* The plane of a small circle does not pass through the center of the earth. Thus, all parallels other than the equator are small circles.

The geographic grid uses both kinds of circles, resulting in a major departure from a true Cartesian grid: scale is constant in a north-south direction, but varies in an east-west direction. For example, rounded to the nearest mile:

1° of longitude along the equator	=	69 miles
1° of longitude along the 30th parallel	=	60 miles
1° of longitude along the 40th parallel	=	53 miles
1° of longitude along the 50th parallel	=	45 miles
1° of longitude along the 60th parallel	=	35 miles
1° of longitude along the 90th parallel	=	0 miles
1° of latitude along any meridian	=	69 miles

14. Calculate angular and linear distances in Table 1.1.

Direction and Distance

Not all great circles are aligned into an x–y grid; the number of great circles possible for the earth is infinite. The directional orientation of any line can be determined using either *bearings* or *azimuths.* Bearings assess departure from a heading of either true north or true south. Northeast expressed as a bearing is valued at N 45° E, southeast

Table 1.1 LOCATIONS FOR PROBLEM 14

From	To	Distance Angular	Distance Linear
Seward, Alaska 60° N, 149° W	St. Petersburg, Russia 60° N, 30° E	179°	6265
New Orleans, Louisiana 30° N, 90° W	Cairo, Egypt 30° N, 31° E		
Frostburg, Maryland 40° N, 79° W	Quito, Ecuador 0°, 79° W		
Quito, Ecuador 0°, 79° W	Singapore 1° N, 104° E		

Table 1.2 COMPARISON OF BEARINGS AND AZIMUTHS

Bearings	Azimuths
Values vary from 0 to 90°	Values vary from 0 to 360°
Require two letters and a numerical value	Require only a numerical value
Measured clockwise or counterclockwise	Measured clockwise only
Referenced from north or south	Referenced only from north

at S 45° E, southwest at S 45° W, and northwest at N 45° W. East may be a 90° departure from north or south, usually the former, written as N 90° E or S 90° E. Azimuths represent clockwise rotation from north. Northeast is simply 45°; southwest is 225°. Divisions smaller than whole degrees (usually minutes, but not seconds) are possible with both bearings and azimuths.

Figure 1.4 illustrates how directions are determined by both methods, and Table 1.2 briefly explains each method. Note in Figure 1.4 that a line has been drawn to represent an azimuth of 123° 25′ (from north). That line also has a bearing of S 56° 35′ E. Both notations apply correctly to the same line.

15. Convert the values below (degrees and minutes, not decimals):

Bearing	**Azimuth**
	18° 18′
S 49° 30′ E	
	268° 12′
N 16° 21′ W	

Parallels of latitude are everywhere equidistant. Meridians, however, converge toward the poles. A line that depicts constant direction, a *loxodrome* or *rhumb line*, will be a straight line on a globe, because such a line is also a great circle. Some map projections distort direction (see Appendix B), so loxodromes are not always straight lines.

16. To illustrate the nature of rhumb lines, use a piece of string or the edge of a sheet of paper to measure the distance on a globe between Los Angeles and Honolulu. Use the globe's scale to convert to miles.

TIME

PURPOSE

This portion of the exercise demonstrates functional relationships between longitude and solar time, allows the student to determine the differences in time between places of known longitude, and discusses world time zones.

Solar Time (Local, or Sun Time)

Solar time is based on the position of the earth's surface relative to the sun. An infinite number of the sun's rays strike the surface of the earth at any one time. Only one ray can strike the earth's surface vertically. The meridian along which that vertical ray occurs will experience the highest (largest) sun angle of the day. Solar time assesses time differences based on longitude.

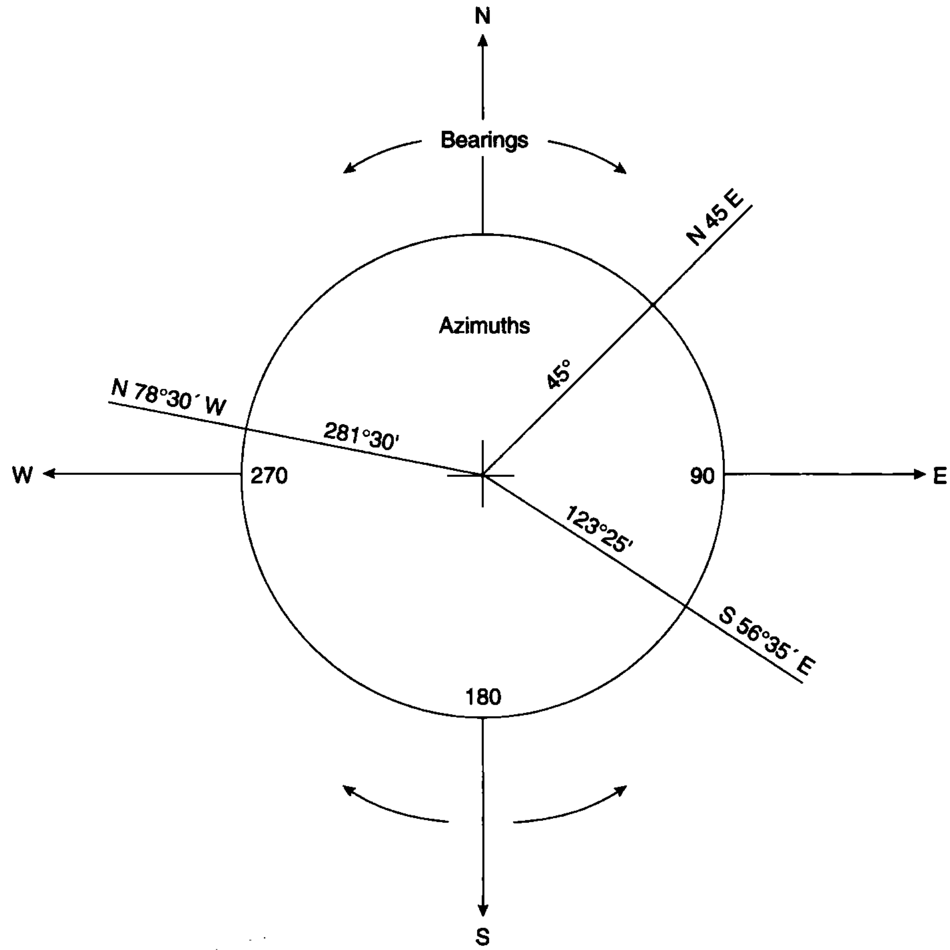


Figure 1.4 *Bearings and azimuths.*

The earth is described as a spheroid; a 360° circumference, divided by 24 hours in a day, equals 15° of arc per hour. Smaller divisions are also possible.

17. Calculate the following conversions, which are basic to the interrelationships between longitude and solar time.

Time	**Arc**
1 hr	15°
	1°
1 min	
	1′

Sample Problem

If it is 11:00 P.M. Saturday in Baltimore, Maryland, what is the solar time in Rome, Italy? The first step is to determine the longitude of each place. From an atlas, Baltimore is at 76° 40′ W, and Rome is located at 13° E. The angular difference in longitudinal degrees is 89° 40′ (76° 40′ plus 13° E). Longitudinal difference (89° 40′) divided by 15°/hr equals a time difference of 5:58. The 58 minutes results from a time base-60, not decimals; 40′ of longitudinal arc is two-thirds of one degree, not 40 minutes of time. From west to east, solar time is later (add hours), so the solar time in Rome must be 4:58 A.M. on Sunday.

As a general rule, going west means subtracting hours; going east means adding hours. If the International Date Line is crossed, days change in the opposite direction. For example, going from west longitude across the International Date Line to east longitude means entering the following day.

Time Problems

18. If it is 3:00 A.M. Friday in New Orleans (90° W), what is the solar time in Tokyo (135° E)?

19. If it is 10:00 P.M. Wednesday in Nome, Alaska (165° 20′ W), what is the solar time and day in Cairo (31° 17′ E)? Go the long way around the earth.

20. Repeat Problem 3 but go the short way around and cross the International Date Line.

21. What is the solar time difference between Adelaide, Australia (139° 08′ E), and Niigata, Japan (139° 04′ E)?

World Standard Time

Confusion that arose because each locality used its own solar time was greatly reduced with agreement on a consistent counting scheme for meridians (prime or Greenwich meridian equals zero) and the adoption of standardized time zones. Each time zone theoretically spans 7.5° on either side of a standard meridian. Thus, the Greenwich meridian controls a zone from 7° 30′ W to 7° 30′ E. Figure 1.5 shows that each zone is roughly centered on a standard meridian that is a multiple of 15° of arc. Not all political units conform with so-called standard times. Note that China could potentially span five time zones; in reality, all China uses Beijing time.

22. How many time zones does the United States occupy?

23. How many time zones are found in Russia?

24. Why does the International Date Line not align with a single meridian as the Greenwich meridian does?

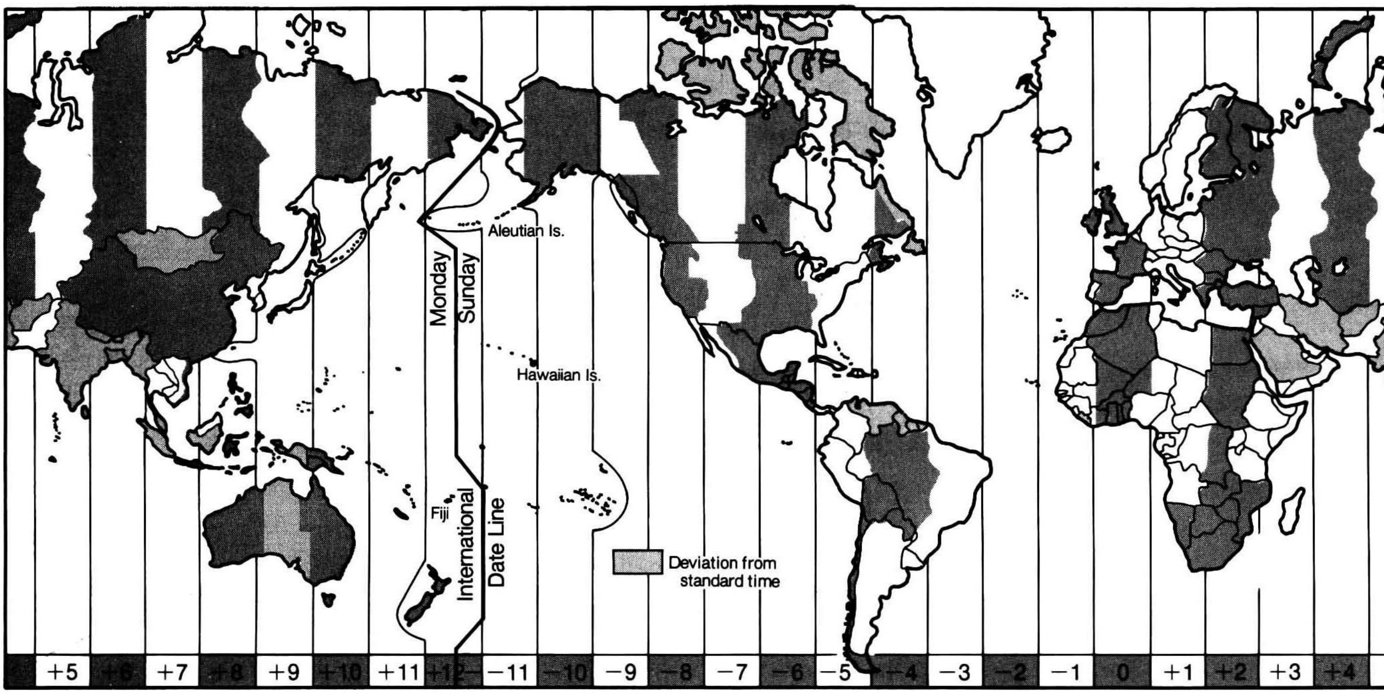


Figure 1.5 *World time zones.*

Source: Arthur Getis, Judith Getis, and Jerome Fellmann, *Introduction to Geography,* 4th ed. Copyright © 1994 Wm. C. Brown Communications, Inc., Dubuque, Iowa.