

E X E R C I S E S I N

# PHYSICAL GEOGRAPHY

T H I R D E D I T I O N



D O N W . D U C K S O N , J R .

E X E R C I S E S I N  
**PHYSICAL GEOGRAPHY**

T H I R D E D I T I O N

**DON W. DUCKSON, JR.**

*Frostburg State University*



Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis  
Bangkok Bogotá Caracas Lisbon London Madrid  
Mexico City Milan New Delhi Seoul Singapore Sydney Taipei Toronto

# WCB/McGraw-Hill

A Division of The McGraw-Hill Companies

## EXERCISES IN PHYSICAL GEOGRAPHY, THIRD EDITION

Copyright © 1999 by The McGraw-Hill Companies, Inc. All rights reserved. Previous editions © 1992, 1995 by Wm. C. Brown Communications, Inc. All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher.



This book is printed on recycled paper containing 10% postconsumer waste.

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*

Publisher: *Edward E. Bartell*

Sponsoring editor: *Daryl Bruflodt*

Marketing manager: *Lisa L. Gottschalk*

Project manager: *Terry Routley*

Production supervisor: *Deborah Donner*

Designer: *K. Wayne Harms*

Photo research coordinator: *John C. Leland*

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 geography / 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

# Contents

## **Preface vi**

### **EXERCISE 1**

## **Earth-Sun Relationships, the Geographic Grid, and Time 1**

The Earth in Space 1

Purpose 1

Revolution 1

Rotation 1

Inclination and Parallelism 3

The Geographic Grid 4

Purpose 4

The Geographic Grid 4

Circles Great and Small 5

Direction and Distance 5

Time 6

Purpose 6

Solar Time (Local, or Sun Time) 6

Sample Problem 7

Time Problems 8

World Standard Time 8

### **EXERCISE 2**

## **Isolines and Profiles 11**

Purpose 11

Isolines 11

Construction 11

Elevations 13

Profiles 14

### **EXERCISE 3**

## **Energy and Sun Angles 17**

Purpose 17

Sun Angle 17

Intensity 19

Length of Day 20

### **EXERCISE 4**

## **Temperature 21**

Purpose 21

Temperature Scales 21

Spatial Distributions of Temperature 21

Vertical Changes in Temperature 24

Temporal Distributions of Temperature 25

Supplemental Problems 29

### **EXERCISE 5**

## **Atmospheric Pressure, Wind, and Ocean Currents 31**

Purpose 31

The Nature of Pressure 31

Surface Pressure Patterns 32

Wind Systems 33

Ocean Currents 35

### **EXERCISE 6**

## **Atmospheric Moisture 39**

Purpose 39

Humidity 39

The Saturation Curve 39

Dew Point, Condensation, and

Sublimation 40

Adiabatic Heating and Cooling 41

Sample Problem 41

Adiabatic Problems 41

Stability 42

Isohyetal Map 43

Distribution of Precipitation 43

### **EXERCISE 7**

## **Weather Maps 46**

Purpose 46

Air Masses 46

The Station Model 46

Hypothetical Weather Map Construction 55

## EXERCISE 8

### **Climatic Classification 59**

#### Purpose 59

The Nature of Climatic Data 59

Köppen Climatic Classification 60

## EXERCISE 9

### **Low Latitude and Dry Climates 65**

#### Purpose 65

A Summary of Climatic Controls 65

Tropical Climates 65

Anomaly 68

Dry Climates 68

## EXERCISE 10

### **Middle- and High-Latitude Climates 71**

#### Purpose 71

Mesothermal Climates 71

Microthermal Climates 74

Polar Climates 76

Variations 76

Climatic Traverse 77

## EXERCISE 11

### **Elements and Symbols on Topographic Maps 79**

#### Purpose 79

Location 79

Effingham, Illinois Quadrangle  
(Figure 11.1) 79

Public Land Survey System 81

Effingham, Illinois Quadrangle—  
Additional Problems 82

Scale 82

Scale Conversion Problems 82

Other Symbols and Additional Information 83

## EXERCISE 12

### **Aerial Photographs 87**

#### Purpose 87

Nature of Aerial Photographs 87

Photographic Interpretation Keys 87

(1) Size 87

(2) Shape 88

(3) Pattern 88

(4) Tone 88

(5) Texture 88

(6) Shadow 88

(7) Location or Context 88

Stereogram 105, Mount Capulin  
(Figure 12.1) 88

Folsom, New Mexico (Figure 12.2) 89

## EXERCISE 13

### **Structural Landforms 93**

#### Purpose 93

Aerial Photographs 93

Stereogram 104, The Loop  
(Figure 13.1) 93

Stereogram 112, Thacker Creek  
(Figure 13.3; Scale 1:20,700) 95

Stereogram 124, Rattlesnake Ridge  
(Figure 13.4; Scale 1:29,100) 95

Stereogram 129, Ouachita Fold  
(Figure 13.6; Scale 1:21,500) 98

Topographic Maps 100

Maverick Springs, Wyoming  
(Figure 13.7) 100

Mount Dome, California-Oregon  
(Figure 13.8) 100

Cumberland, Maryland  
(Figure 13.10) 103

## EXERCISE 14

### **Drainage Basin Morphology 105**

#### Purpose 105

The Basin 105

Laws of Drainage Composition 105

Law of Stream Numbers 105

Law of Stream Lengths 107

Related Form Properties 107

Channel Slope 107

Drainage Density 108

Comparative Data 108

## EXERCISE 15

### **The Fluvial Landscape 111**

#### Purpose 111

Patterns and Controls 111

Erosional Landscapes 112

Bray, California 1:62,500  
(Figure 15.2) 112

Waldron, Arkansas 1:62,500  
(Figure 15.6) 116

Gratz, Kentucky 1:24,000  
(Figure 15.7) 118

- Depositional Landscapes 118
  - Stereogram 507, Spotted Valley (Figure 15.8; 1:31,400) 118
  - Crowder, Mississippi 1:62,500 (Figure 15.3) 121
- Supplemental Problems 121
  - Sioux City North, Iowa-South Dakota-Nebraska 1:100,000 (Figure 15.9) 121
  - Fairbanks (C-3), Alaska 1:63,360 (Figure 15.4) 121

#### EXERCISE 16

### Ground Water 123

- Purpose 123
  - Monticello, Kentucky 1:24,000 (Figure 16.1) 123
  - Lake Wales, Florida 1:24,000 (Figure 16.2) 125
  - Stereogram 133, Sink (Figure 16.3) 125
  - Lakeside, Nebraska 1:24,000 (Figure 16.4) 128

#### EXERCISE 17

### Desert Landforms, Wind, and Dunes 131

- Purpose 131
  - Stereogram 125, Stovepipe Wells 1:65,000 (Figure 17.1) 131
  - Ennis, Montana 1:62,500 (Figure 17.2) 133
  - Sacaton Mountains, Arizona 1:24,000 (Figure 17.3) 135
  - Stereogram 196, Moencopi Plateau 1:20,000 (Figure 17.4) 135
  - Stereogram 509, Tularosa Basin 1:34,600 (Figure 17.5) 135
  - Seiler, Washington 1:24,000 (Figure 17.6) 139

#### EXERCISE 18

### Glacial Landscapes 141

- Purpose 141
  - Alpine Glacial Environments 141
    - Mount Rainier, Washington 1:100,000 (Figure 18.1) 141
    - Glacier National Park, Montana 1:100,000 (Figure 18.2) 143
    - Mount Darwin, California 1:24,000 (Figure 18.3) 143
    - Stereogram 179, La Perouse Glacier 1:46,600 (Figure 18.4) 146
  - Continental Glaciation 149
    - Whitewater, Wisconsin 1:24,000 (Figure 18.5) 149
    - Rome, Wisconsin 1:24,000 (Figure 18.7) 150
  - Supplemental Problems 152
    - Effingham, Illinois 1:62,500 (Figure 11.1) 152
    - Columbia, Missouri 1:62,500 (Figure 18.8) 152

#### EXERCISE 19

### Coastal Landforms 155

- Purpose 155
  - Kingston, Rhode Island 1:24,000 (Figure 19.1) 155
  - Cayucos, California 1:62,500 (Figure 19.2) 157
  - Stereogram 539, Johnson Pass 1:33,000 (Figure 19.3) 159
  - Point Reyes, California 1:62,500 (Figure 19.4) 159
  - San Luis Rey, California 1:24,000 (Figure 19.5) 163

- Appendix A** Topographic Map Symbols 165
- Appendix B** Map Projections 167





# 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.**

## EXERCISE

# Earth-Sun Relationships, the Geographic Grid, and Time

Name \_\_\_\_\_

Section \_\_\_\_\_

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

## 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).

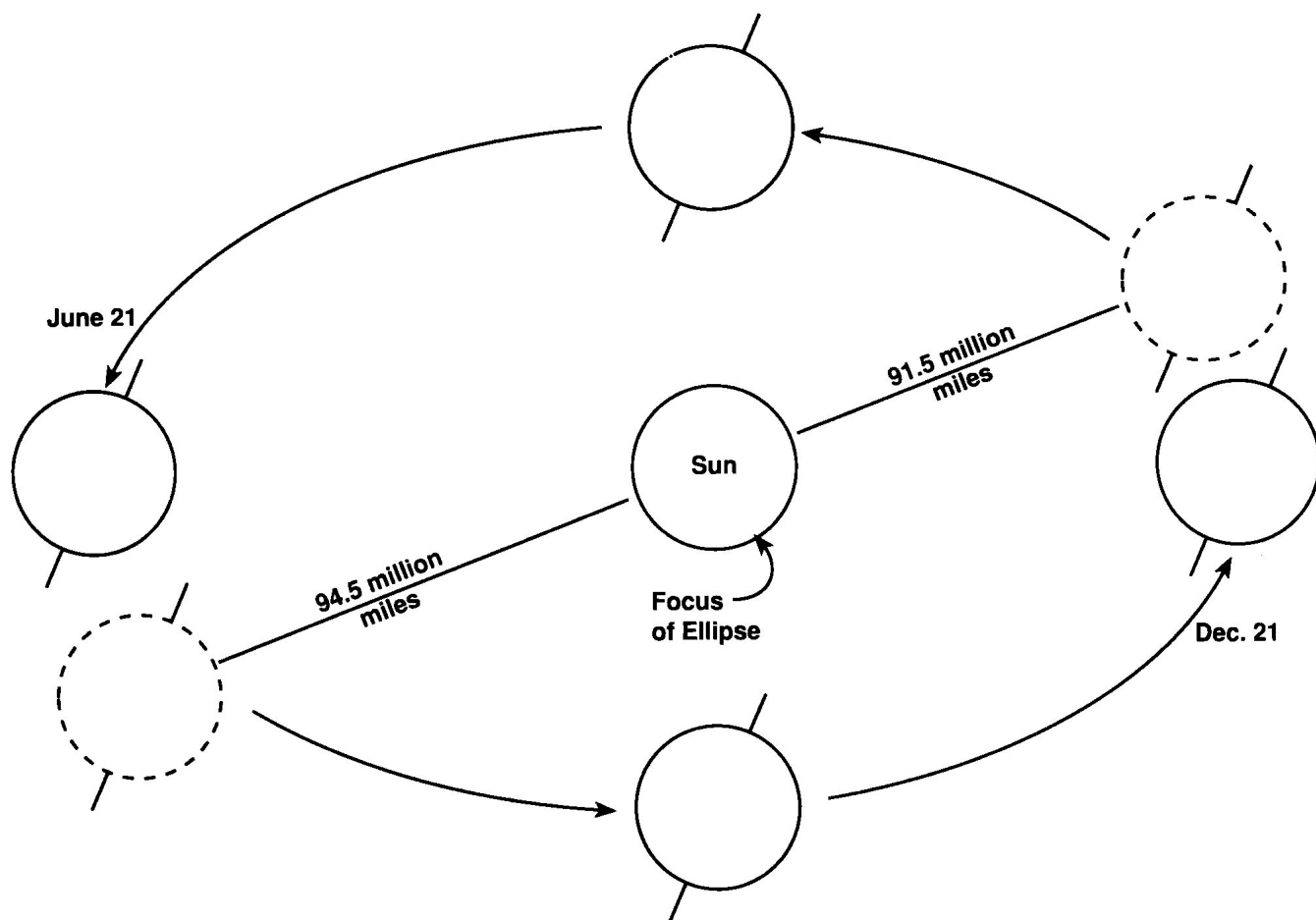
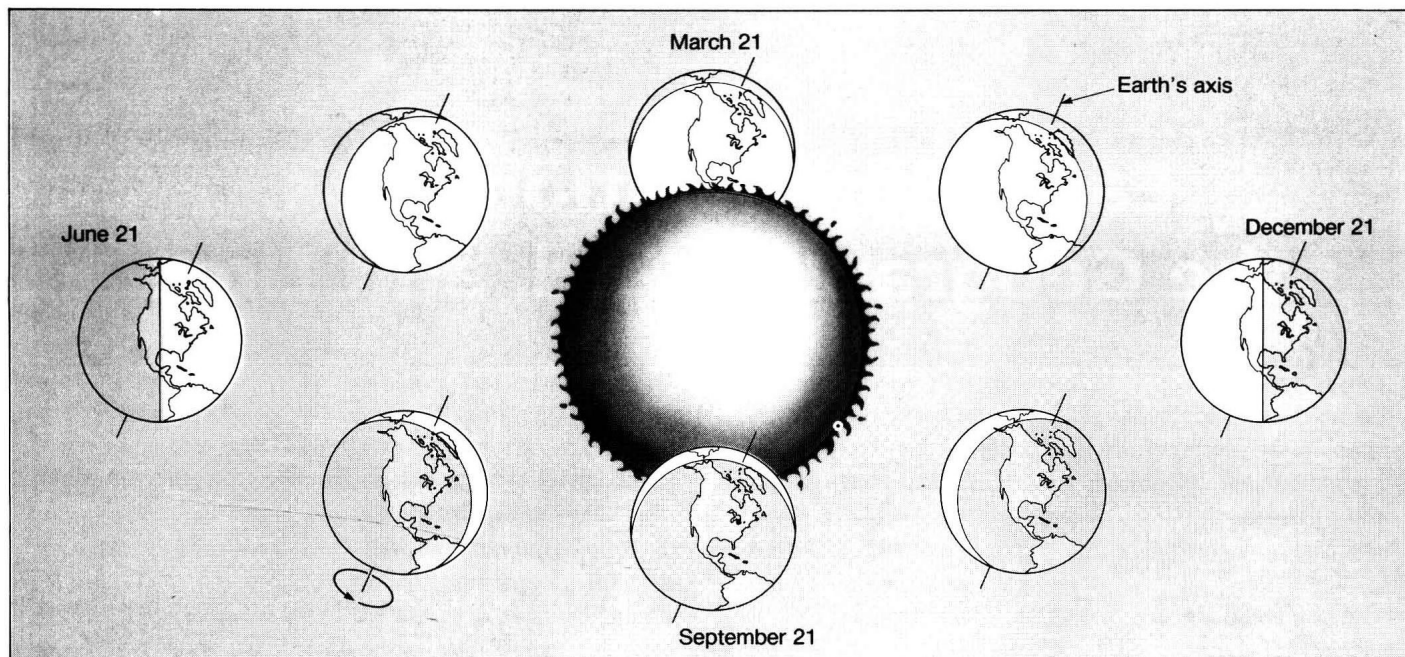
1. Label in Figure 1.1 the points in orbit known as:
  - a. Aphelion
  - b. Perihelion
2. When are those points achieved in earth's orbit and at what distance?
  - a. Aphelion
  - b. Perihelion

### 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*.

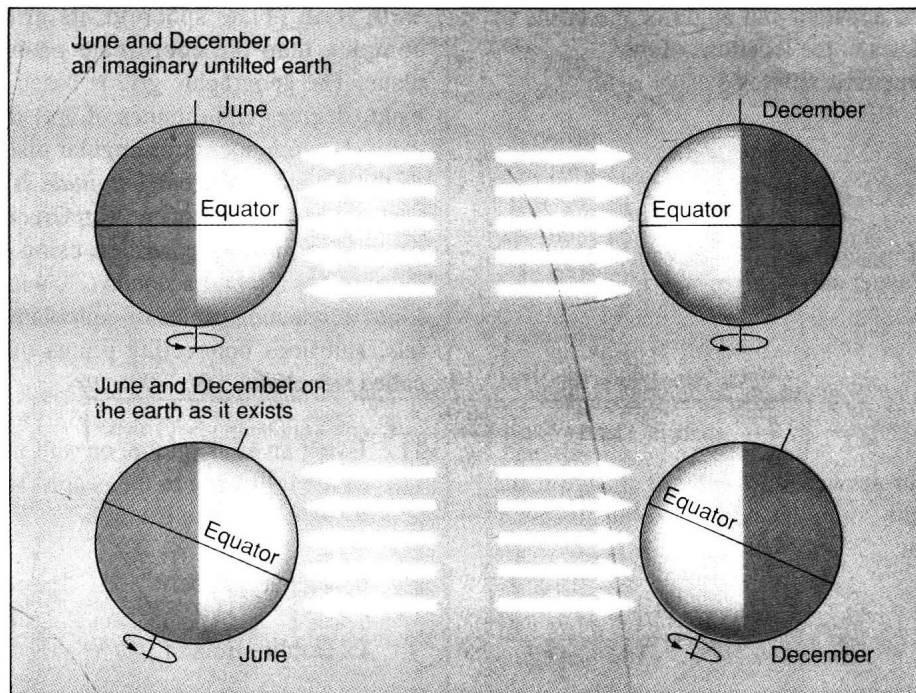
4. Angular velocity is measured in degrees of arc per unit time and is a constant for all points on the earth's surface. To determine this rate, complete the following:
  - a. Number of degrees in a circle (representing a spherical earth): \_\_\_\_\_
  - b. divided by the number of hours in one day: \_\_\_\_\_
  - 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. Copyright © 1994 Wm. C. Brown Communications, Inc., Dubuque, Iowa. All Rights Reserved. Reprinted by permission.



**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  $66.5^\circ$  away from the plane of earth's orbit and  $23.5^\circ$  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:
- North and South Poles
  - Arctic and Antarctic Circles
  - Equator
  - Tropics of Cancer and Capricorn
  - 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  $30^\circ$  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.

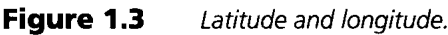
### The Geographic Grid

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 ( $^\circ$ ), 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. $23^\circ$ S, $14^\circ$ E	b. $40^\circ$ N, $105^\circ$ W
c. $64^\circ$ N, $22^\circ$ W	d. $1^\circ$ N, $104^\circ$ E



- a. 
- b. 
- c. 
- d. 

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.

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

- 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. North-east expressed as a bearing is valued at N 45° E, southeast

**Table 1.1 LOCATIONS FOR PROBLEM 14**

From	To	Distance	
		Angular	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		

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

**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

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.

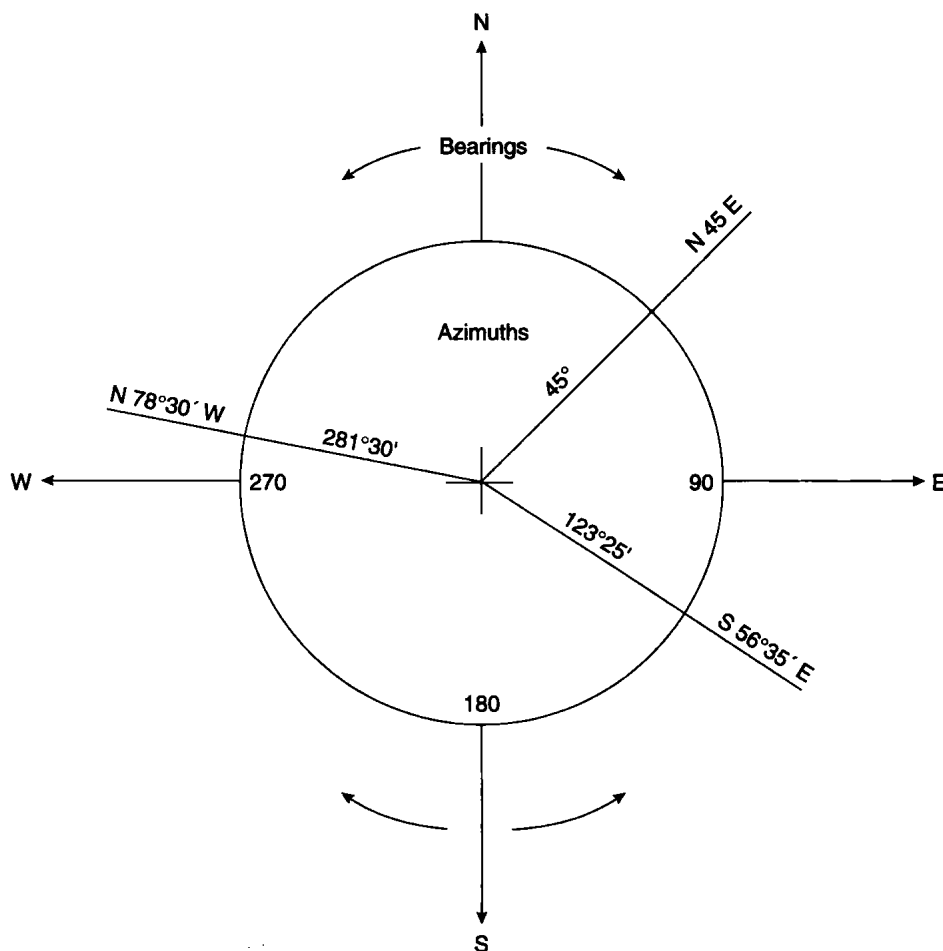
## TIME

### 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

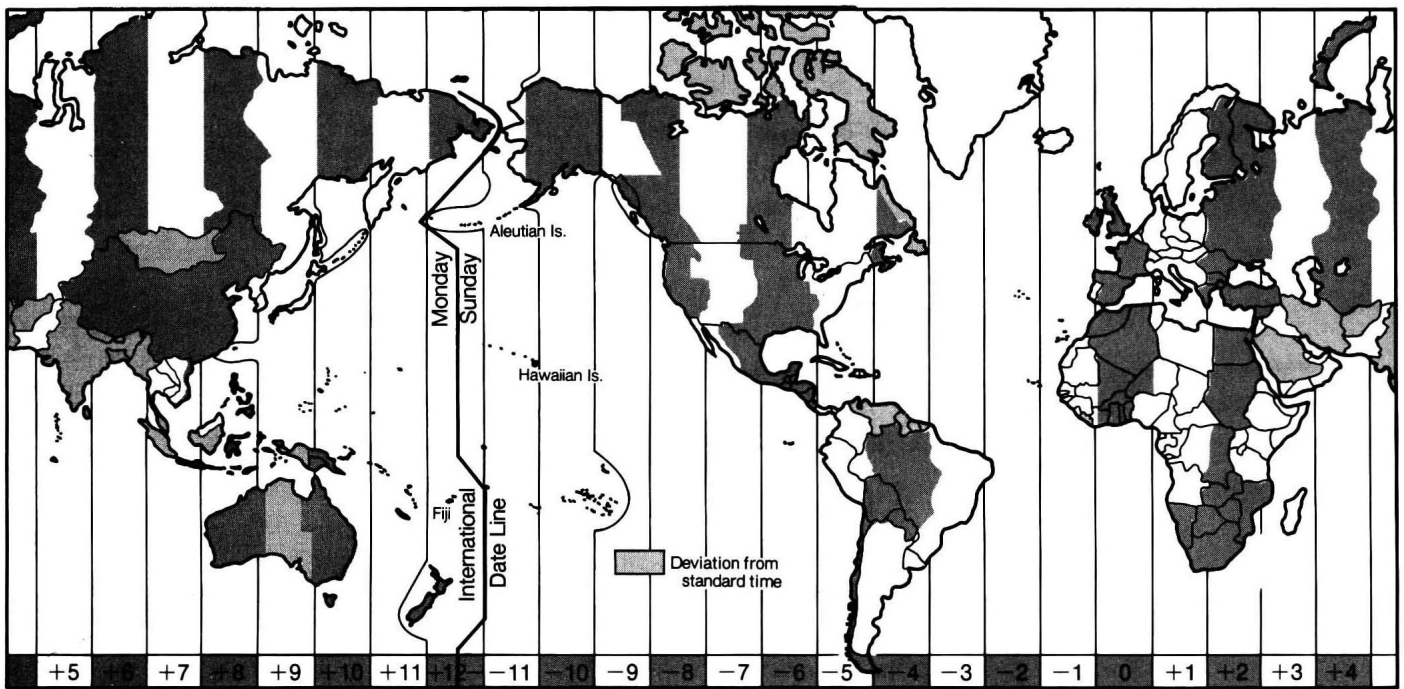
18. If it is 3:00 A.M. Friday in New Orleans ( $90^{\circ}$  W), what is the solar time in Tokyo ( $135^{\circ}$  E)?
19. If it is 10:00 P.M. Wednesday in Nome, Alaska ( $165^{\circ} 20'$  W), what is the solar time and day in Cairo ( $31^{\circ} 17'$  E)? Go the long way around the earth.
20. Repeat Problem 3 but go the short way around and cross the International Date Line.
21. What is the solar time difference between Adelaide, Australia ( $139^{\circ} 08'$  E), and Niigata, Japan ( $139^{\circ} 04'$  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  $7.5^{\circ}$  on either side of a standard meridian. Thus, the Greenwich meridian controls a zone from  $7^{\circ} 30'$  W to  $7^{\circ} 30'$  E. Figure 1.5 shows that each zone is roughly centered on a standard meridian that is a multiple of  $15^{\circ}$  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.

