Name: ______________________ Laboratory Section: ______________________

Date: ______________________ Score/Grade: ______________________

Video
Exercise 2
Pre-Lab Video

LAB EXERCISE

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2 The Geographic Grid and Time

In the previous exercise we studied latitude and longitude. In this exercise we will examine latitude and longitude together as they make the geographic grid that we use to locate places. As you complete your *Geography I.D.* in the Preface, you will determine the time zone you live in. A knowledge of longitude and Earth's rotation forms the basis of standard time and the world system of Coordinated Universal Time (UTC). We examine both this essential geographic location grid and time in this exercise. Lab Exercise 2 features three sections.

Key Terms and Concepts

antipode
Coordinated Universal Time (UTC)
daylight saving time
geographic grid
Greenwich Mean Time (GMT)
International Date Line
local Sun time

KEY LEARNING concepts

After completion of this lab you should be able to:

1. *Use* latitude and longitude to *locate* places on Earth's surface.
2. *Relate* the time where you are with world standard time and *calculate* differences in standard and Sun time.
3. *Contrast* the prime meridian with the International Date Line.

Materials/Sources Needed

protractor
world atlas

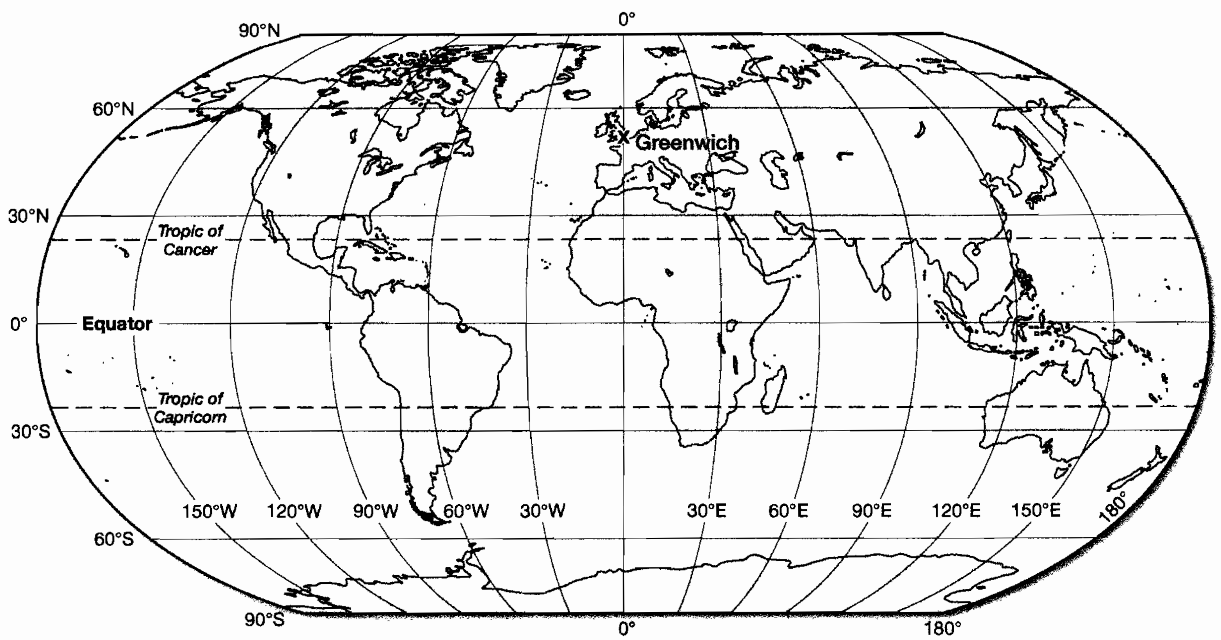
Earth's Geographic Grid

Latitude and longitude form Earth's **geographic grid**. Every location on our planet is described with this Cartesian coordinate system—where location is described on a plane by two intersecting lines. The *Geography I.D.* asks you to identify the general coordinates of your hometown and college campus. **Antipodes** are points on the globe that are diametrically opposite each other that would be at either end of a line drawn through the center of Earth—such as the North Pole and South Pole. Determine the following geographic grid coordinates and cities from an atlas, wall map, or large political world globe. While wall maps and globes will help you see points in relation to the rest of the world, you should use regional maps in an atlas to be more precise in your readings.

1. Locate and give the geographic coordinates for the following cities (to a tenth of a degree if your atlas maps are detailed enough) or identify the cities from the given coordinates. The answers to a) and d) are provided for you in bracketed italics.

	City	Latitude and Longitude
a)	Greenwich, London, England	*[51.5°N 0°]*
b)	Rio de Janeiro, Brazil	
c)	Your state's/province's capital city	
d)	*[Tokyo, Japan]*	35.7°N 139.7°E
e)		8.8°S 13.2°E
f)		21.3°N, 157.8°W

On the map grid in Figure 2.1, plot the coordinates in items 1 (a) through (f) above, and label the city names.



▲ Figure 2.1 Plotting coordinates

2. Using your knowledge of latitude and longitude, find and circle the errors in the following geographic grid coordinates. Rewrite the coordinates correctly in the space to the right. You do not have to locate these on a map. The first error is identified with a box.

   a) DMS format Lat. 57° [86′] 24″ S, Long. 149°02′63″ N ________ *[minutes cannot exceed 60′]* ________

   b) DD format Lat. 105.03° W, Long. 93.99° E ____

3. If you were halfway between the equator and the South Pole and one-quarter of the way around Earth to the west of the Prime Meridian, what would be your latitude and longitude?

4. You are at 10°N and 30°E; you move to a new location that is 25° south and 40° west of your present location. What is your new latitudinal/longitudinal position?

5. You are at 20°S and 165°E; you move to a new location that is 45° north and 50° east from your present location. What is your new latitudinal/longitudinal position?

The antipode is the point on the opposite side of Earth from another point. You may have heard that if you dig straight down, you'll eventually reach China. Setting aside the difficulties of digging through the molten iron outer core of Earth, you wouldn't end up in China if you started digging from the United States.

To find the antipode of a location, you'll need to find both the latitude and longitude of the antipode. To find the antipodean latitude, convert the location's latitude to the opposite hemisphere. If the latitude is 50°N, it's antipodean latitude is 50°S. With longitude, the antipode is always 180° away. To find the antipodean latitude, simply subtract the location's latitude from 180 and change it to the other hemisphere. To find the antipodean longitude of 120°W, subtract 120° from 180°, and change it to the Eastern Hemisphere to find 60°E.

6. What is the antipode of your current location?

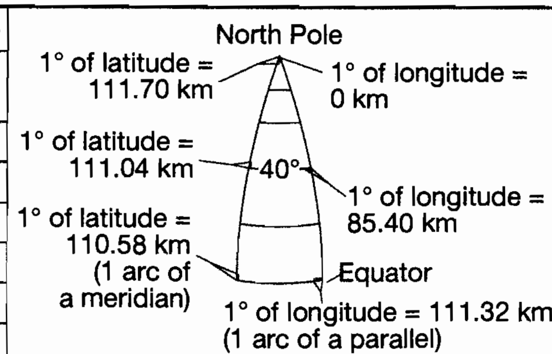
7. If you wanted to dig through the center of the Earth and come up in Beijing, China, where should you start digging?

SECTION 2

Latitude and Longitude Values

Because meridians of longitude converge toward the poles, the actual distance on the ground (linear distance) spanned by a degree of longitude is greatest at the equator (where meridians separate to their widest distance apart) and diminishes to zero at the poles (where they converge). The linear distance covered by a degree of latitude, however, varies only slightly, due to the oblateness of Earth's shape. Table 2.1 compares the linear or physical distance of a degree of latitude and longitude at selected latitudinal locations. It also shows the similarity of ground distance for a degree of latitude and a degree of longitude at the equator.

	Latitude Degree		Longitude Degree	
Latitudinal Location	**Length km**	**(mi)**	**Length km**	**(mi)**
90° (poles)	111.70	(69.41)	0	(0)
60°	111.42	(69.23)	55.80	(34.67)
50°	111.23	(69.12)	71.70	(44.55)
40°	111.04	(69.00)	85.40	(53.07)
30°	110.86	(68.89)	96.49	(59.96)
0° (equator)	110.58	(68.71)	111.32	(69.17)



▲**Table 2.1 Physical Distances Represented by Degrees of Latitude and Longitude**

1. From the table, you can see that latitude lines are evenly spaced, approximately 111 km (69 miles) apart at any latitude. Using these values as the linear distance separating each degree of latitude, the distance between any given pair of parallels can be calculated. (*Note: Locations must be due north-south of each other.*) For example, Denver is approximately 40° north of the equator (arc distance). The linear distance between Denver and the equator can be calculated as follows:

   40° N to 0° = 40° × 111 km/1° = 4440 km

   or

   40° N to 0° = 40° × 69 miles/1° = 2760 miles

   Using these same values for a degree of latitude and an atlas for city location, calculate the linear distance in km and miles between the following sets of points (along a meridian):

   a) Mumbai, India, and the equator ______________________

   b) Miami, Florida, and 10° south latitude ______________________

   c) Edinburgh, Scotland, and the 5th parallel north ______________________

   d) Your location and the equator ______________________

2. The table also shows that the linear distance separating each 1° of longitude decreases toward the poles. For example, at 30° latitude each degree of longitude is separated by slightly more than 96 km (nearly 60 miles), and at 60° latitude, the linear distance is reduced to approximately half that at the equator. For each of the following latitudes, determine the linear distance in km and in miles for 15° of longitudinal arc (along a parallel): The first answer is provided for you in bracketed italics.

	km	miles
a) 30° latitude:	*[15° × 96.49 km = 1447 km]*	*[15° × 59.96 mi = 899 mi]*
b) 40° latitude:		
c) 50° latitude:		
d) 60° latitude:		

3. Again using Table 2.1, what is the linear distance in km and miles along the parallel at your latitude from your location to the prime meridian?

4. What is the approximate linear distance of the following angular distances, at your present latitude?

	km	miles
One degree		
One minute of longitude		
One second of longitude		
A tenth of a degree		
One hundredth of a degree		

5. John Harrison's chronometer (a clock giving Coordinated Universal Time), lost 5 seconds during the 81-day voyage from England to Jamaica. Given that Earth rotates through 15° in 1 hour, how many degrees of longitude would the ship be off, with an error of 5 seconds? How many kilometers and miles would that be, assuming 111 km per degree of longitude?

Precision and accuracy are two related concepts regarding measurements. *Precision* refers to the number of significant digits in a measurement, while *accuracy* refers to how close a measurement is to the actual figure. Giving a distance measurement as 2 km is less precise than giving it as 2.0 km or 2.00 km. If you were going to meet a friend in the Lake Nakuru National Park in Kenya, and that person's location were 0°, 36°E, how many square kilometers would you have to look through? Your friend's location is precise to 1°, so you would have to look for the person in an area 1° by 1°. At this location, 1° of both longitude and latitude are approximately 111 km (69 mi), so you would have to look for your friend in 12,321 km^2 (4761 mi^2).

6. How large an area would you have to look through if your friend's location were given 10 times as precisely, as 0.0°, 36.0°E?

7. Write your friend's location with sufficient precision so that you would only have to look in an area 111 m by 111 m.

SECTION 3

Time, Time Zones, and the International Date Line

Today we take for granted international standard time zones and an agreed-upon prime meridian. If you live in Oklahoma City and it is 3:00 P.M., you know that it is 4:00 P.M. in Baltimore and Toronto, 2:00 P.M. in Salt Lake City, and 1:00 P.M. in Seattle and Los Angeles. You also probably realize that it is 9:00 P.M. in London and midnight in Riyadh, Saudi Arabia. (The designation A.M. is for *ante meridiem*, for "before midday/noon," whereas P.M. is for *post meridiem*, meaning "after midday/noon.") Coordination of international trade, airline schedules, business activities, and daily living depends on a common time system.

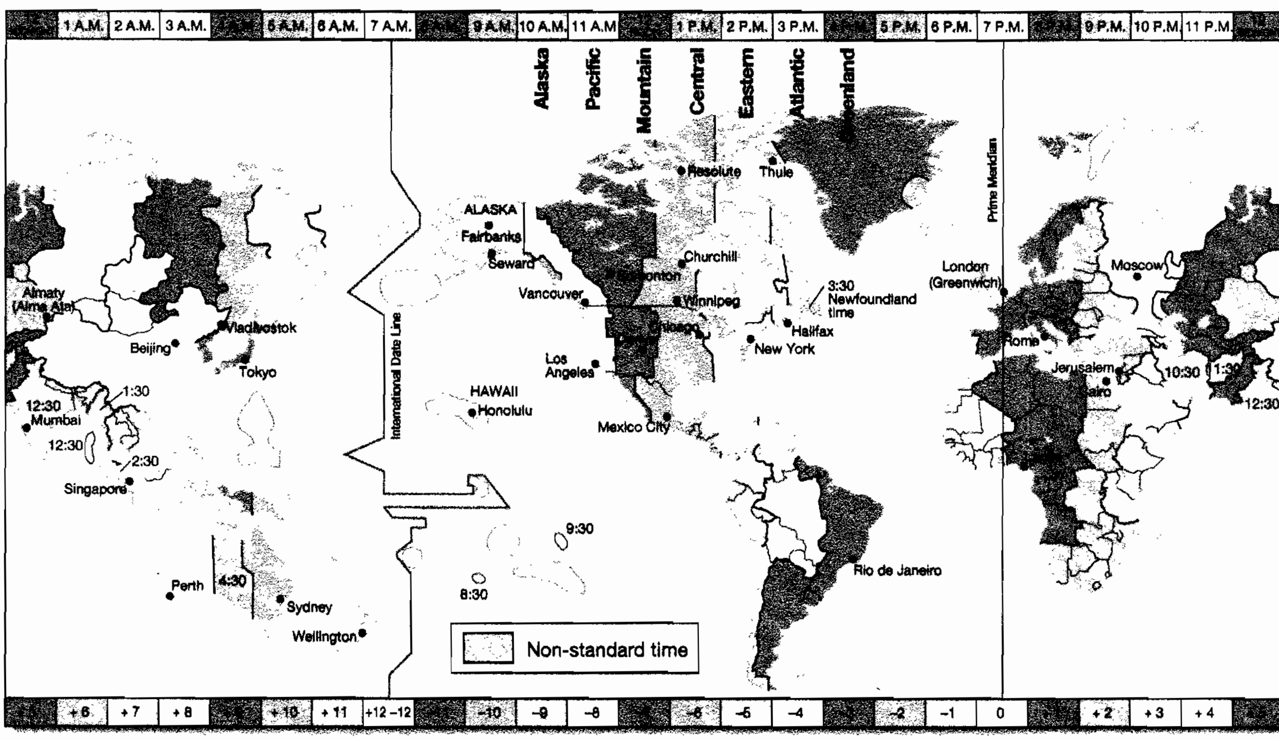
In 1884 at the International Meridian Conference in Washington, DC, the prime meridian was set as the official standard for the world time zone system—**Greenwich Mean Time (GMT)** (see http://wwp.greenwich-meantime.com/). Coordinated Universal Time For decades, GMT was determined using the Royal Observatory's astronomical clocks and was the world's standard for accuracy. In 1972, the **Coordinated Universal Time (UTC)** time-signal system replaced GMT and became the legal reference for official time in all countries. UTC is based on average time calculations from atomic clocks collected worldwide. You might still see official UTC referred to as GMT or Zulu time.

Because Earth revolves 360° every 24 hours, or 15° per hour (360° ÷ 24 = 15°), a time zone of 1 hour is established for each 15° of longitude. Each time zone theoretically covers 7.5° on either side of a controlling (standard) meridian (0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, etc.) and represents 1 hour. Traveling eastward, one would set the clock 1 hour later, and going westward, 1 hour earlier for each time zone.

Local Sun time, or solar time, is based on the actual longitudinal arc distance (in degree, minutes, and seconds) between a location and the prime

Figure
Modern International Time Zones

http://goo.gl/YvJmY9



▲ **Figure 2.2 Modern international standard time zones.**
The numbers at the bottom indicate how many hours each zone is earlier (plus sign) or later (minus sign) than Greenwich Mean Time, today known as Coordinated Universal Time (UTC) or Zulu Time.

meridian. There could be as much as 30 minutes' difference in time (or more, depending on the actual time zone boundaries) between local Sun time and standard time.

Opposite the globe from the prime meridian is the **International Date Line**, the starting point for each new day. Since the Date Line is the standard (controlling) meridian for a time zone, no change in time occurs when crossing the line, only the date. When traveling westward, one will set the calendar 1 day ahead, and when crossing the line heading eastward, the calendar will be reset 1 day back.

1. From the map of global time zones in Figure 2.2, determine the present time in the following cities: (For your time, use the starting time of the lab.)

Moscow ______________	Los Angeles ______________
London ______________	Honolulu ______________
Chicago ______________	Mumbai ______________

2. You may not always have a time zone map available, but by remembering the relationship of 1 hour for every 15° of longitude, you can easily calculate the difference in time between places. Indicating and using the standard meridians to determine time zones, solve the following problems. The first answer is provided for you in bracketed italics. Show your work:

   a) If it is 3 A.M. Wednesday in Vladivostok, Russia (132°E), what day and time is it in Moscow (37°E)? [*The controlling meridian for Moscow is 105° away from Vladivostok's controlling meridian of 135°E* (135° – 30° = 105° *difference*). *Since Earth rotates 15° per hour, Moscow is 7 hours earlier than Vladivostok (105° difference / 15° rotation per hour = 7 hours time difference), therefore if it is 3* A.M. *Wednesday in Vladivostock it is 8* P.M. *Tuesday in Moscow.*]

   b) If it is 7:30 P.M. Thursday in Winnipeg, Manitoba, Canada (97°W), what day and time is it in Harare, Zimbabwe (31°E)?

   ____

   c) If you depart from San Francisco International Airport at 10:00 P.M. on Tuesday, what day and time will you arrive in Auckland, New Zealand (175°E), assuming a flight time of 14 hours?

   ____

3. If there is a difference of 15° of longitude for each hour of time, how much difference in time is there for 1° of longitude? for 1′ of longitude?

4. What is the standard (controlling) meridian for your time zone (75°—Eastern, 90°—Central, 105°—Mountain, 120°—Pacific, 135°—Alaska, other)?

   How many degrees of longitude separate you from this standard controlling meridian?

   How does your distance from the standard meridian affect the difference between the time on your clocks and actual Sun (solar) time? (Calculate the difference between standard and Sun time using the answer you determined in #3 above).

Knowing your standard meridian is useful because it will tell you how many minutes off (fast or slow) your watch is in your time zone from the actual position of the Sun in the sky.

Just as you can use longitudinal distance to calculate time, you can also use time difference to calculate your longitude. This is the method that was often used to determine longitudinal location when sailing (if they didn't happen to have a GPS unit on board!). Again, the relationship between time and longitude (15° = 1 hour of time) is the key. If you know the difference in time between two places, and you know the longitude of one place, you can calculate the longitude of the other. For example: Your watch (kept on your hometown standard time) reads 10:30 A.M., and you see that a clock in the town you are visiting reads 7:30 P.M. Your home near St. Paul, Minnesota, uses 90°W as its standard meridian. Therefore:

- Time difference between 10:30 A.M. and 7:30 P.M. = 9 hours
- 9 hours × 15°/hour = 135° of longitude separating the two locations
- Since you are at a place later in time than home, you must be east of home
- 135° east of your hometown at 90° W would be 45° E longitude

5. Assume the time on your watch, showing local standard time, is 4:15 P.M. A chronometer reads 2:15 A.M. What is your longitude?

Daylight saving time is the practice of setting time ahead 1 hour in the spring and back 1 hour in the fall in the Northern Hemisphere. Clocks in the United States were left advanced an hour continuously from 1942 to 1945 during World War II, and again from January 1974 to October 1975, in order to conserve energy during an oil embargo. Daylight saving time increased in length in the United States and Canada in 1986. Under the Energy Policy Act of 2005, Daylight saving time begins 3 weeks earlier than previously, at 2 A.M. on the second Sunday in March. DST has been extended by 1 week and now lasts until 2 A.M. on the first Sunday of November.

6. Does your community adopt daylight saving time? What are the dates for adjusting clocks in the spring and fall?

7. What time does your physical geography lab start

a) according to standard time? ____________________

b) according to daylight saving time? ____________________

c) in UTC? ____________________
(24-hour clock time in Greenwich, England; e.g., 3:00 P.M. = 15:00 hours)

