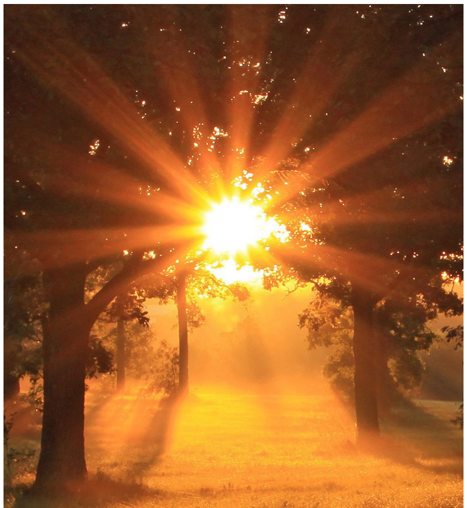
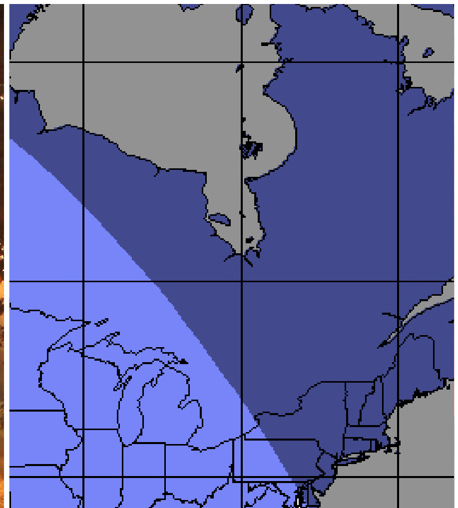
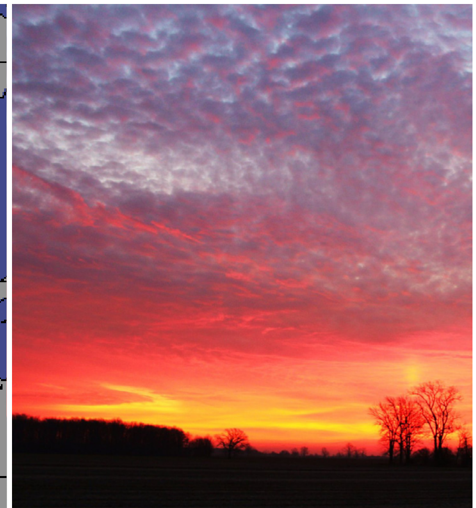






6 Clear as Night and Day: Calculating Sunrise and Sunset

By Steven Branting

Guiding Question

What is the length of a degree longitude and latitude in your geographic location, and how does it affect sunrise and sunset?

Project Duration

Two class periods

Grade Level

Grades 6–9 (ages 11-14)

Learning Objectives

Students will be able to:

- look for patterns in the passage of sunlight across the surface of the Earth
- calculate ground data from geographic observations
- calculate the distance from one point to another
- complete a distance-to-ground time calculation
- formulate a hypothesis concerning sunrise/sunset variability

Subjects

- Geography
- Mathematics

Clear as Night and Day

Calculating Sunrise and Sunset

By Steven Branting

What is the length of a degree longitude and latitude in your geographic location, and how does it affect sunrise and sunset?

Overview

The rising and setting of the sun mystified ancient man and led to many unusual explanations. The sun rose each day, but not at the same time or in the same place until a year's cycle was complete. It was not long before priest-astronomers in several cultures began to catalogue the sun and use the information to predict future events. In this investigation, students use the "Day/ Night" data set provided with My World to (1) calculate the daily sunrise and sunset for any place on the planet and (2) examine how sunrise and sunset times are a function of latitude.

Before beginning the activity, have students identify how daylight seems to change during the year in the area where they live. Have any of the students heard about or travelled to places where the sunrise and sunset pattern is different than in their area? Discuss the variations.

On the Student Instructions and Answer Sheet, you will see three parts to this activity:

- Part I is guided practice. Provide the latitude so students can gain proficiency with the mathematics involved with this lesson. If sources cite the latitude in degrees/minutes/seconds, convert to decimal degrees by dividing the number of minutes by 60, and round to 2 decimal places. Do an Internet search of "sunset" and your city or town to find out the sunrise time for the day of the lesson, as well as the sunset. Note: This lesson is most effective on days that are *not* near the equinox.
- Part II, independent practice, investigates sites along a meridian of longitude. This part will work best when students compare their own city or town with another city or town north or south of them. If there is no city/ town that meets that criterion, sites within a 1/10th of a degree are still good candidates, given the accuracy of this lesson.
- Part III enables students to replicate Part I and check the impact of the change in time on their results.

Background

The tilt of the Earth's axis (23.5° from the ecliptic plane) causes a number of anomalies, not the least of which is that cities directly north and south of each other will have different sunrises and sunsets for the same day. Old globes used to include a graphic that most people misinterpreted as a figure eight. In actuality, it was an analemma, which shows the position of the sun at different times during the year as seen from a single point at local noon.

My World will constantly update the "Day/Night" information being portrayed on the screen. This will allow different classes during the day to arrive at the same answer, plus or minus a few minutes depending on the accuracy they use to set the endpoints with the measurement tool.

The boundaries of the "Day/Night" data set represent sunrise and sunset. Students should be aware that before and after these times an event called *twilight* occurs. Twilight is divided into three categories: civil, nautical and astronomical. Civil twilight occurs after the sun has set and while it is less than 6° below the horizon. The term "nautical twilight" describes the time the sun is between

6° and 12° below the horizon. There is dim light, but still enough to distinguish your surroundings. Astronomical twilight begins when the sun is more than 12° below the horizon. For most people, astronomical twilight looks like night. The reverse of this order describes the twilight before sunrise.

Connections to National Standards

NATIONAL GEOGRAPHY STANDARDS

- Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.
- Standard 18: How to apply geography to interpret the present and plan for the future.

NCTM PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS, GRADES 6–8

- Number & Operations Standard 1: Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Algebra Standard 1: Understand patterns, relations, and functions
- Algebra Standard 4: Analyze change in various contexts
- Geometry Standard 2: Specify locations and describe spatial relationships using coordinate geometry and other representational systems
- Measurement Standard 2: Apply appropriate techniques, tools, and formulas to determine measurements

Vocabulary

- **degree,** *noun*—unit of measurement for latitude and longitude.
- **latitude,** *noun*—distance north or south of the Equator, measured in degrees.
- **longitude,** *noun*—distance east or west of the prime meridian, measured in degrees.
- **sunset,** *noun*— time when the sun descends behind the horizon.
- **twilight,** *noun*—the light from the sky between full night and sunrise, or between sunset and full night, produced by diffusion of sunlight through the atmosphere and its dust.

Extending the Learning

Students can repeat the steps in Part I, but measuring instead east to the boundary of the sunset curve to determine what time their sunset would take place.

When do the students think the sunrise and sunset for different towns on the same meridian will be the same?

Additional Resources

- National Geographic Education's encyclopedia and glossary entries for geographic terms and more: http://education.nationalgeographic.com/education/reference-and-news/
- Length of a Degree of Latitude and Longitude Calculator: www.csgnetwork.com/degreelenllavcalc.html

Clear as Night and Day

Calculating Sunrise and Sunset

By Steven Branting

What is the length of a degree longitude and latitude in your geographic location, and how does it affect sunrise and sunset?

In this activity, you will use My World to learn how your location on Earth—as described by longitude and latitude—is linked to the day and night cycle. You will build understanding of how the Earth's rotation and shape affect the 24-hour cycle of darkness and daylight. Specifically, you will be able to (1) determine how far the sun's image travels in one hour at your specific latitude, and (2) calculate sunrise and sunset at your location.

Use your student answer sheet to record answers for each question below.

Background

Latitude tells you how far north or south of the equator you are, while **longitude** provides the relative distance east or west of the prime meridian (0° longitude). The prime meridian runs through Greenwich, England.

For this activity, the boundaries of the data set represent **actual reported** sunrise and sunset. Before and after these times an event called *twilight* occurs. Twilight is divided into three categories: civil, nautical, and astronomical.

Part I: Determining Sunrise at Your Location

1. Navigate to the following website: **www.csgnetwork.com/degreelenllavcalc.html** Find the length of one degree of longitude at your latitude by entering your latitude in decimal degrees into the calculator. The distance will display in the Calculated Results sections. Note and record the **Length of A Degree of Longitude in Statue Miles** as **Variable A.**

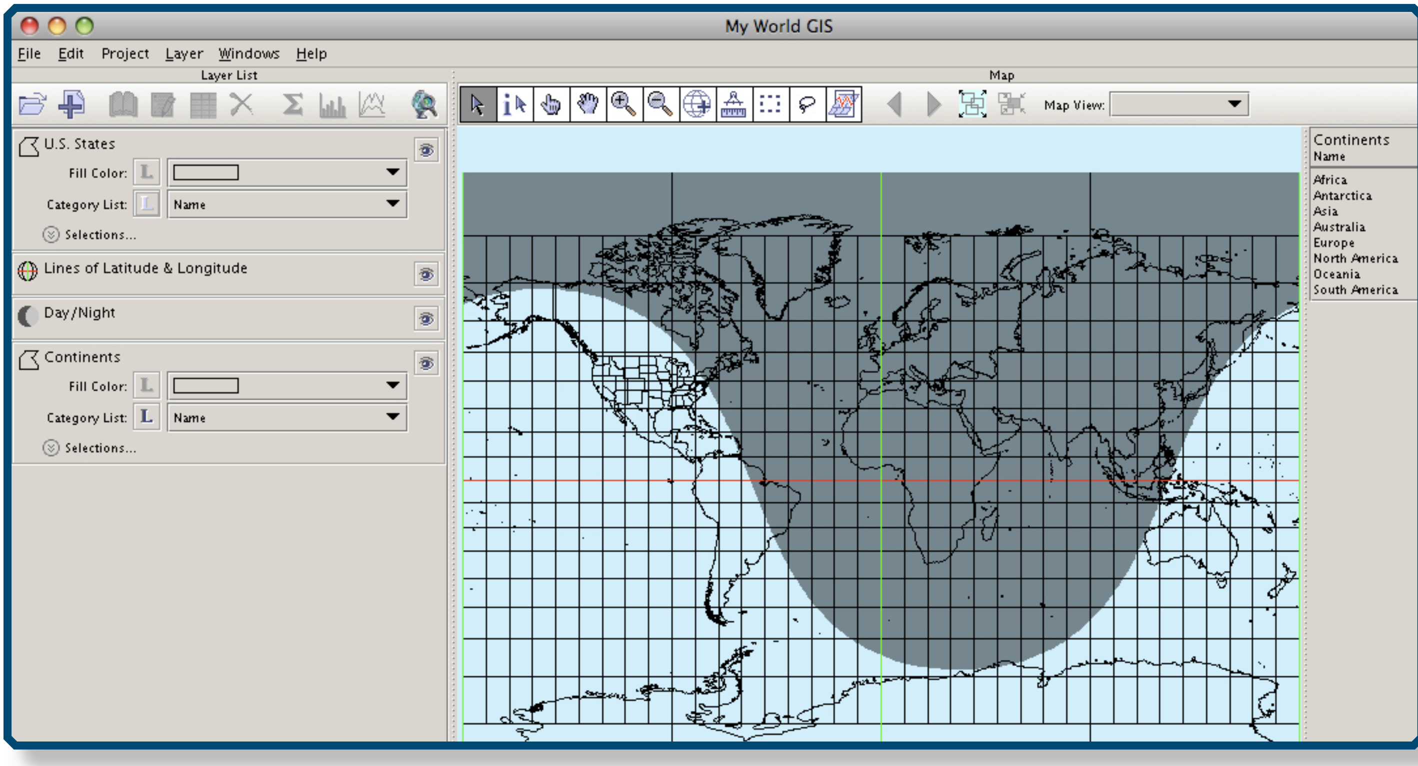
QUESTION 1: How far does the sun travel in one hour at your latitude?

The sun moves approximately 15 degrees in longitude in the course of an hour. Calculate the distance in statute miles the Sun's image (viewable daylight) travels in one hour at your latitude: (Variable A x 15.) The numeric result provides the Sun's change in position in statute miles in one hour (Variable B.)

Variable B = Variable A x 15

2. Launch My World GIS, and choose **File > New Project.** Add the following built-in data sets to your project:
   - Continents
   - Day/Night
   - Lines of Latitude & Longitude
   - U.S. States

These can be added by selecting **File > Add Data to Map.** Next, choose **Add Data From: Data Library > All Data Files,** and select the appropriate files.



3. Adjust the appearance of your map.

   Change the background color of your map by selecting **Project > Settings > Edit Project Settings.** Change the **Map Background Color** to white. Click **Apply** and **Close.** (Note: This change will take effect on reopening My World.)

   Next, **Edit the Appearance** of your Continents layer. Change the **Fill Color** to the **Colorscheme** of blue. Click **Apply** and **Close.**

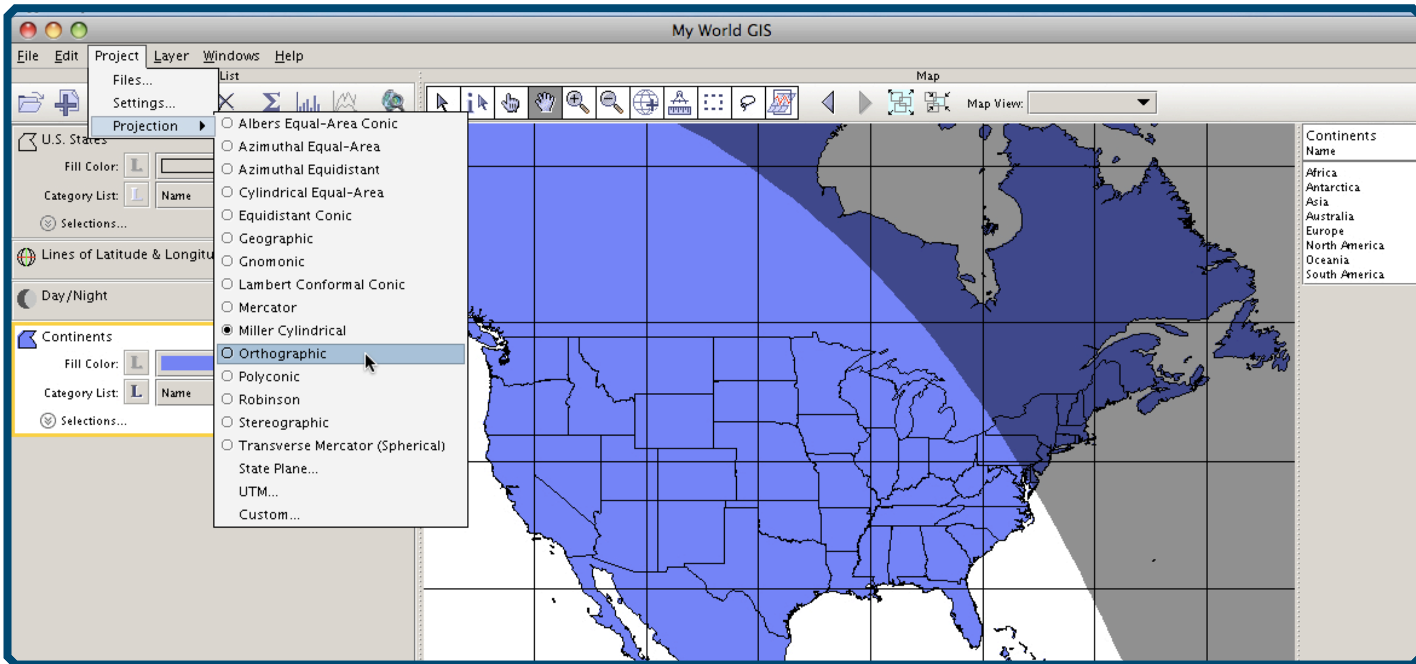
   Set your unit of measurement to Miles by selecting **Edit > Preferences.** In the **Measurement Units:** drop-down menu, select **international mi (Mile).**

4. Zoom in on the map by using the magnifying glass so that you can easily find your current geographical location on the map. Start by finding your home state. If needed, add the U.S. Cities layer and do a search for a city near yours.

5. Orient the map so that you can see both your current location and the end of the sunrise boundary. You can re-center the map by clicking on the **Re-center Projection** tool on the tool bar. The button displays a map projection with a (+) sign.

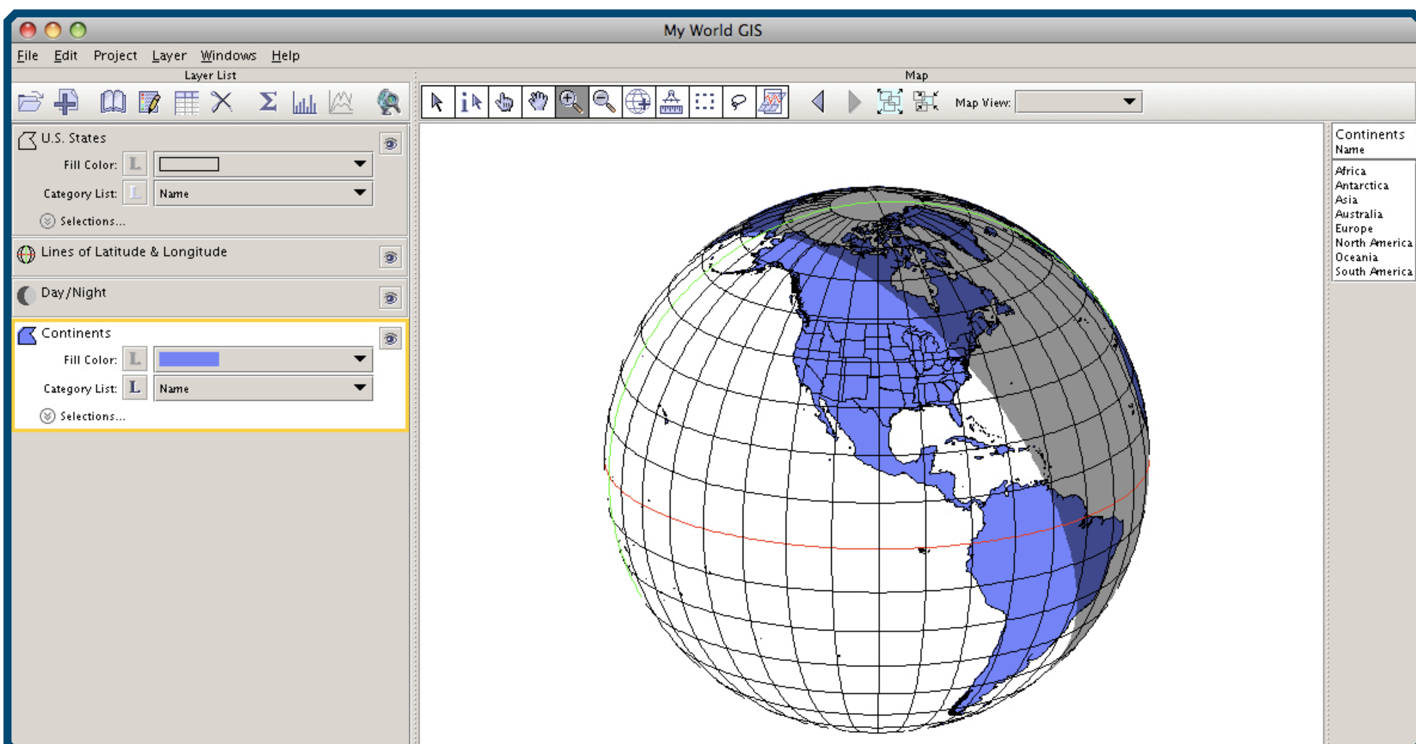
   In My World, the default projection is *Miller Cylindrical.* The "Day/Night" data set is a long curved shape across the map. In this activity, you will utilize a different projection to analyze the relationship between latitude, longitude, and sunrise.

6. Change the projection of the map to see the sunlight patterns slightly differently. Select **Project > Projection > Orthographic.**



QUESTION 2: What changes are visible using the new projection?

7. Use the **Re-Center Projection** tool to place the boundary between day and night in the center of the map.



QUESTION 3: How far is it from your location to the boundary of day and night at your latitude?

8. Use the **Measurement Tool** on the tool bar to determine the distance between your location and the boundary of day and night. The Measurement Tool looks like a ruler with a compass. Click once on your location at the correct latitude. Follow the latitude as you draw the line west to the boundary and double-click to end it (look at the bottom of the screen and make sure the latitude of your final point is the same as your initial point.) If you are not satisfied with your result, simply re-do it. The measurement in miles will display at the bottom of the window as the Segment Length and should be given in miles. Record this number as **Variable C.**

   Note: This measuring should be done during daylight hours with your measurement occurring in a westerly direction to the beginning of the sunrise boundary.

QUESTION 4: What time is sunrise in your location?
To calculate your sunrise, divide the distance to the boundary (Variable C) by the sun's change in position (Variable B.) The result is the number of hours since sunrise. Convert the decimal to the number of hours and minutes. This will give you **Variable D.**

Variable D = Variable C/Variable B

Subtract **Variable D** from the current time at your location to determine the approximate time of sunrise. Your teacher can provide you with the exact time of sunrise to see how close you were.

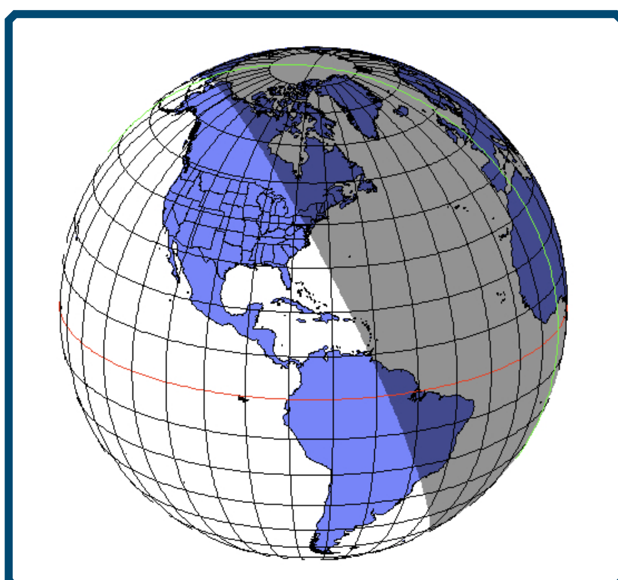
Part II: Determining How Sunrise and Longitude are Related

1. If necessary, launch My World GIS and, choose **File > Open Project...**

2. Navigate to your project file, and select **Open Project.** You can also double-click the project name to open the project (make sure the projection is set to Orthographic.)

3. Choose a major meridian somewhere in the world where, at this moment, the sunrise boundary is crossing. Use the **Re-Center Projection** tool to center the map on the Equator and the meridian you have chosen. See an example pictured below. Note: This part of the exercise works best on days that are not near the time of the spring and fall equinox.

4. Using the Re-Center Projection tool, position your cursor to find the data for each longitude noted in the table below (for each latitude noted, record the Longitude at Which Sunrise Occurs.)



QUESTION 5: Complete the table on your answer sheet, and see if a pattern emerges as you record the data and move northward. Record your longitudes to the nearest whole degree.

5. After you have recorded the **Longitude at Which Sunrise Occurs** for each latitude listed on the table, complete the **Degrees Difference** column by recording the change in degrees from the previous value. For example, how many degrees different is the 20° N value from the one for 10° N. Describe any pattern that you see.

QUESTION 6: You will notice that the sunrise (daylight) boundary extends only so far north. What is the farthest north that it will extend?

This information will change depending upon what time of year you are completing this activity. If time allows, repeat this activity during a different season to see how it changes. The closer you are to a seasonal equinox, the less dramatic your differences will be.

Part III: Determine If Your Computer Keeps Track of Earth's Rotation

QUESTION 7: If you are completing this activity over the length of a class period, or if you have the chance to repeat at another time, repeat the calculations from Part I to determine if My World keeps track of the rotation of Earth. Can you do this activity over and over again with the same degree of accuracy? Explain.

Name ______________________________ Date ______________________________

Clear as Night and Day

Directions: Use the Student Instructions pages to launch My World GIS and complete the activity. Fill in your answers on these pages.

Part I: Determining Sunrise at Your Location

1. How far does the sun travel in one hour at your latitude? ______________________________

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2. What changes are visible using the new projection? ______________________________

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3. How far is it from your location to the boundary of day and night at your latitude?

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4. What time is sunrise in your location? ______________________________

____

Name ______________________________ Date ______________________________

Clear as Night and Day

Part II: Determining How Sunrise and Longitude are Related

5. Complete this table and see if a pattern emerges as you record the data as you move northward. Record your longitudes to the nearest whole degree.

Latitude	Longitude at Which Sunrise Occurs	Degrees Difference From Previous Latitude
0° N		
10° N		
20° N		
30° N		
40° N		
50° N		
60° N		

Describe any pattern that you see. ______________________________

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6. You will notice that the sunrise (daylight) boundary extends only so far north. What is the farthest north that it will extend? ______________________________

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Name ______________________________________ Date ___________________________

Clear as Night and Day

Part III: Determine If Your Computer Keeps Track of Earth's Rotation

7. If you are completing this activity over the length of a class period, or if you have the chance to repeat at another time, repeat the calculations from Part I to determine if My World keeps track of the rotation of Earth. Can you do this activity over and over again with the same degree of accuracy? Explain.

ANSWER KEY

Name ______________________________ Date ______________________________

Clear as Night and Day Answer Key

Directions: Use the Student Instructions pages to launch My World GIS and complete the activity. Fill in your answers on these pages.

Part I: Determining Sunrise at Your Location

1. How far does the sun travel in one hour at your latitude? Answers will vary

   Sample answer: A = 50.09 miles at the following location and date/time

   Latitude in decimal Degrees: 43.692384 Longitude in decimal Degrees: -114.335933

   (9:00 am) 9/23/11

   Multiply Variable A x 15 = Variable B Record your results: B = 751.35

2. What changes are visible using the new projection? The Earth is round, and the day/night boundary line becomes a straight line.

3. How far is it from your location to the boundary of day and night at your latitude?

   Answers will vary.

4. What time is sunrise in your location? Answers will vary.

   Sample Answer: 7:25 am Sunset is at 7:32

Name ______________________ Date ______________________

Clear as Night and Day Answer Key

Part II. Determining How Sunrise and Longitude are Related

5. Complete this table and see if a pattern emerges as you record the data as you move northward. Record your longitudes to the nearest whole degree.

Latitude	Longitude at Which Sunrise Occurs	Degrees Difference From Previous Latitude
0° N		N/A
10° N		
20° N		
30° N		
40° N		
50° N		
60° N		

Describe any pattern that you see. As latitude increases, sunrises occur later. The pattern of the chart shows that as one goes north, the delay become greater and greater. For example, the difference between 30° and 40° is about 7° longitude. The difference between 40° and 50° is about 9° longitude.

6. You will notice that the sunrise (daylight) boundary extends only so far north. What is the farthest north that it will extend? The boundary is a Great Circle; The Arctic Circle is the farthest south the sunrise boundary will extend.

Name ______________________________ Date ______________________

Clear as Night and Day Answer Key

Part III. Determine If Your Computer Keeps Track of Earth's Rotation

7. If you are completing this activity over the length of a class period, or if you have the chance to repeat at another time, repeat the calculations from Part I to determine if My World keeps track of the rotation of Earth. Can you do this activity over and over again with the same degree of accuracy? Explain.

My World keeps track of the Earth's rotation. Students will find that they can calculate their sunrise exactly the same as in part 1. If part III is completed in the same class period or the same day as part I, students will find the same sunrise time (± 1-2 minutes, depending on the students' measurement accuracy.)