

Due: Fri Oct 10 2014 12:00 PM EDT

Question 1

Instructions
Lab 2: Earth and the Seasons (Globe Version)

Read the lab before attending lab. You might find it easier to navigate if you expand only one or two sections at a time.

The following summary video is available to you in case you miss lab or want to review it when completing the lab:

Earth and the Seasons (Globe Version) (17:47)

You are permitted 100 submissions per question. Use some of these to save your work.

If you do not save your work periodically, you risk losing it when WebAssign times you out. WebAssign does this after a few hours for security reasons.

Do not open multiple copies of this assignment, or multiple WebAssign assignments, or you risk losing your answers upon saving or submitting.

Enter all calculated values to at least two significant digits.

Do not add units when entering numerical responses. WebAssign will not accept your response.

Do not use special characters when naming files. WebAssign will not accept your file.

IMPORTANT: Submit your observations for Lab 3 immediately. These observations take up to two weeks to complete, and you must have them to do Lab 3. Instructions for submitting these observations can be found in Lab 3, Procedure, Section A, Part 1.

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1. Question Details UNCAstro101L1 2.IL.001.globe. [2026856]

LAB 2 — EARTH AND THE SEASONS

GOALS

In this lab, you will:

- Determine which way Earth rotates.
- Determine how length of day changes with latitude and season.
- Determine how the height of the sun in the sky at midday varies with latitude and season.
- Measure Earth's diameter.

EQUIPMENT

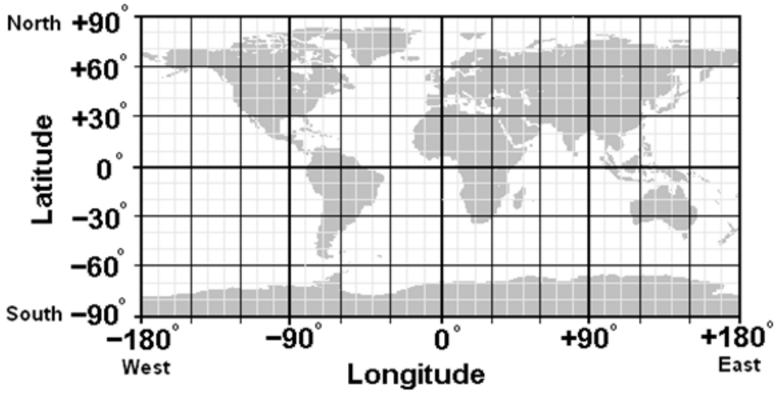
12-inch diameter globe with tilted rotation axis and hour circle
12-inch diameter ring light
Ring light stand and clamp
Dark-colored towel

Protractor with attached string
Computer with Internet connection

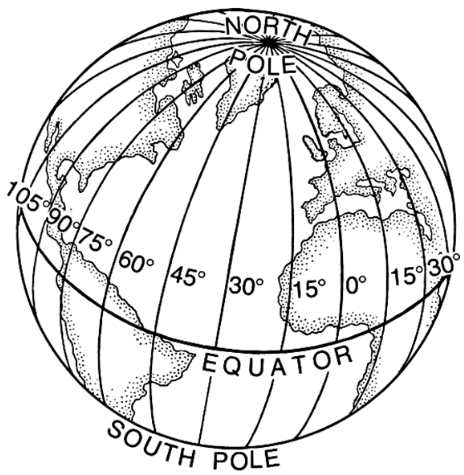
⊞ BACKGROUND: A. LONGITUDE AND LATITUDE

Longitude (or **lines of *changing* longitude**) run from −180° (or 180° W) to +180° (or 180° E) around Earth. By international agreement, 0° passes through the Royal Observatory in Greenwich, England.

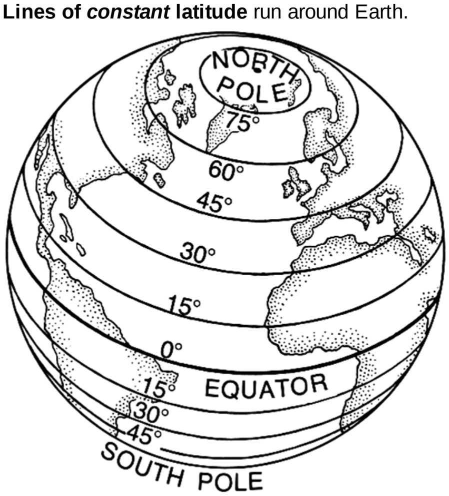
Latitude (or **lines of *changing* latitude**) run from −90° (or 90° S) to +90° (or 90° N) from pole to pole.



Lines of *constant* longitude run from pole to pole.



Lines of *constant* latitude run around Earth.



Question: Using your globe, estimate the longitude and latitude of Chapel Hill, North Carolina to the nearest degree. Use a negative sign for west longitudes or south latitudes. (2 points)

longitude		°
latitude		°

Question: Google the true longitude and latitude of Chapel Hill and record these values to the nearest degree. Use a negative sign for west longitudes or south latitudes. Use these values to calculate your percent errors. (4 points)

	True Value (°)	Percent Error (%)
Longitude		
Latitude		

Question: Discuss significant sources of error. (3 points)

BACKGROUND: B. SEASONS

The first day of summer is called the **summer solstice**.

The first day of winter is called the **winter solstice**.

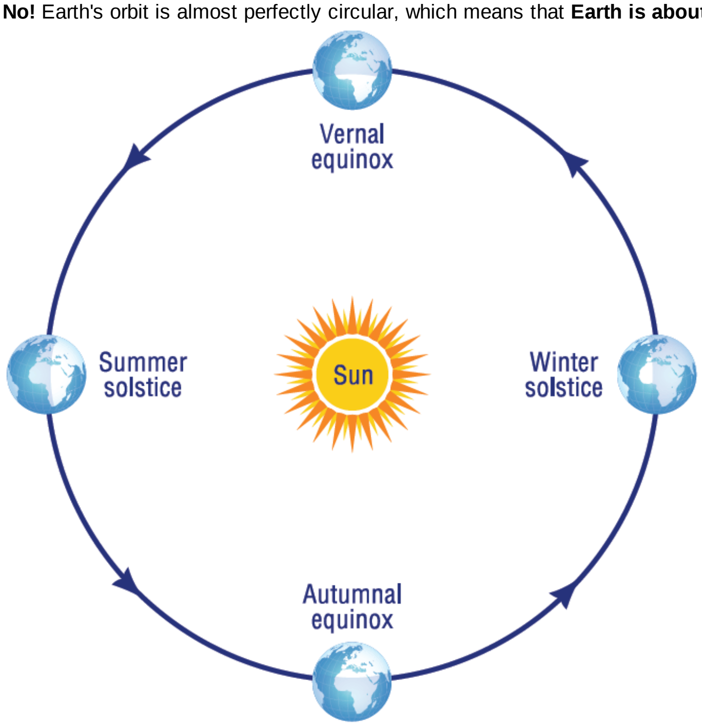
The first day of spring is called the **vernal equinox**.

The first day of fall is called the **autumnal equinox**.

Why is it hotter on the summer solstice and cooler on the winter solstice?

Is it because Earth is closer to the sun during the summer solstice and farther from the sun during the winter solstice?

No! Earth's orbit is almost perfectly circular, which means that **Earth is about as close to the sun in summer as it is in winter.**

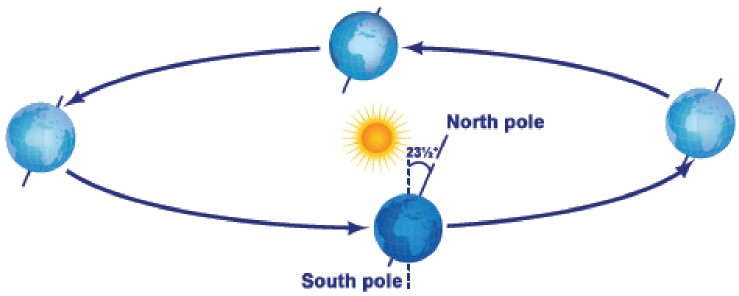


(Technically, Earth is slightly closer to the sun when it is the **winter** solstice in the northern hemisphere!)

Why then is it hotter on the summer solstice and cooler on the winter solstice?

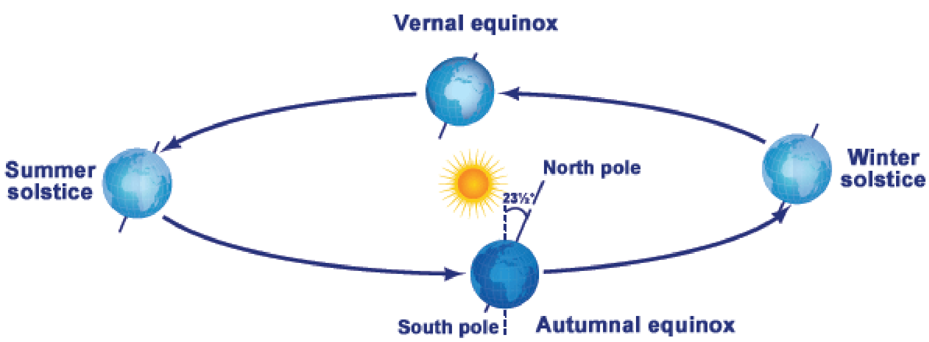
The answer has to do with Earth's rotation axis, which is tipped over from vertical by 23.5°.

Because Earth's rotation axis is tipped over, as Earth orbits the sun, sometimes the northern hemisphere points toward the sun, sometimes it points away from the sun, and sometimes it points neither toward nor away from the sun.



When a hemisphere points directly toward the sun, it is the summer solstice in that hemisphere. When a hemisphere points directly away from the sun, it is the winter solstice in that hemisphere. If a hemisphere points neither toward nor away from the sun, it is either the vernal or autumnal equinox in that hemisphere.

For example, in the **northern hemisphere**:



Question: If it is the summer solstice in the northern hemisphere, what is it in the southern hemisphere? (1 point) summer solstice

autumnal equinox

winter solstice

vernal equinox

In Sections B and C of the procedure, you will see that the degree to which a location on Earth is tipped toward or away from the sun affects both **length of day** (i.e., how long a location on Earth is heated by the sun) and **how high the sun is in the sky at midday** (i.e., how directly the sun's light strikes a location on Earth). Both of these affect how hot or cold a location on Earth becomes.

PROCEDURE: A. EARTH'S ROTATION

Place the globe, which represents Earth, a few inches away from the ring light, which represents the sun. Adjust the height of the ring light such that it **precisely** matches the height of the globe. Move the globe a few feet away from the ring light. Make sure that the globe is **precisely** centered on the ring light.

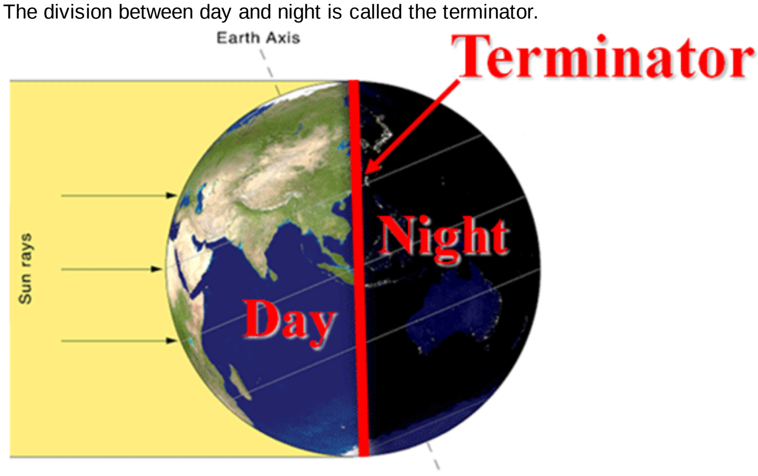
Northern hemisphere summer solstice configuration.

Note: Be very careful with the ring light. It is breakable!

If the surface on which you are working is light-colored or shiny, light will reflect onto the globe from below. To prevent this, cover the surface between the ring light and the globe with something darker and not shiny, like a dark-colored towel.

Turn off all other lights in the room. If it is daytime, block light from coming through windows (or wait until nighttime).

The division between day and night is called the terminator.



No, not this terminator.

To best view the terminator, stand directly in front of it and take a few steps back. Do not focus on the reflection of the ring light.

If the globe is properly centered on the ring light, the terminator will be coincident with the line that extends up from the center of the base of the globe. If you are having a difficult time seeing the terminator, you can use this line for reference.

There is one terminator on either side of the globe: One for sunrise and one for sunset.

Consider New York City (NYC) and Los Angeles (LA). Sunrise occurs first in NYC. A few hours later it occurs in LA. Later sunset occurs in NYC. Then it occurs in LA.

Move these cities through each terminator reproducing (1) sunrise in NYC, (2) sunrise in LA, (3) sunset in NYC, and (4) sunset in LA.

Question: As viewed from the top down, is Earth rotating clockwise or counterclockwise? (1 point)

- ○ clockwise
- ○ counterclockwise

Question: As viewed from the bottom up, is Earth rotating clockwise or counterclockwise? (1 point)

- ○ clockwise
- ○ counterclockwise

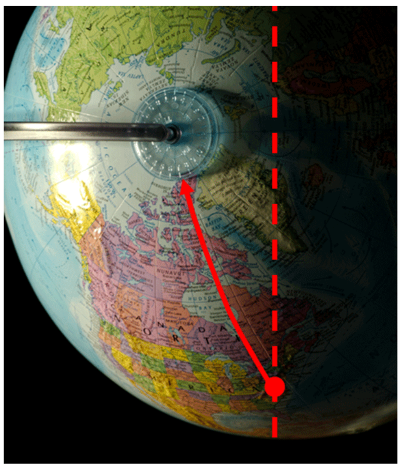
⊞ PROCEDURE: B. LENGTH OF DAY - 1. How Long is the Day in Chapel Hill During the Summer Solstice?

Position the globe such that it is **precisely** the summer solstice in the northern hemisphere.

Move Chapel Hill to the terminator nearest to you (sunrise or sunset).

Adjust the hour circle on the top of the globe such that noon points to the ring light.

Follow the line of **constant** longitude from Chapel Hill to the hour circle. This line will intersect the hour circle at the time of sunrise or sunset.



Question: If the ring light is to the right of the globe, you are measuring the time of sunrise. If the ring light is to the left of the globe, you are measuring the time of sunset. Which are you measuring? (1 point)

- sunrise
- sunset

Question: Estimate this time to the nearest 0.5 hours. (Enter time in decimal hours in the first box and specify AM or PM in the second box. 1 point)

Note: This is the time that it would be without daylight savings time and without time zones.

If sunrise: **12 hours − this AM time = half length of day**
If sunset: **this PM time = half length of day**.
Question: Using your estimate of the sunrise or sunset time above, calculate the half length of day. (1 point)

hr

2 × half length of day = length of day
Question: Calculate the length of day. (1 point)

hr

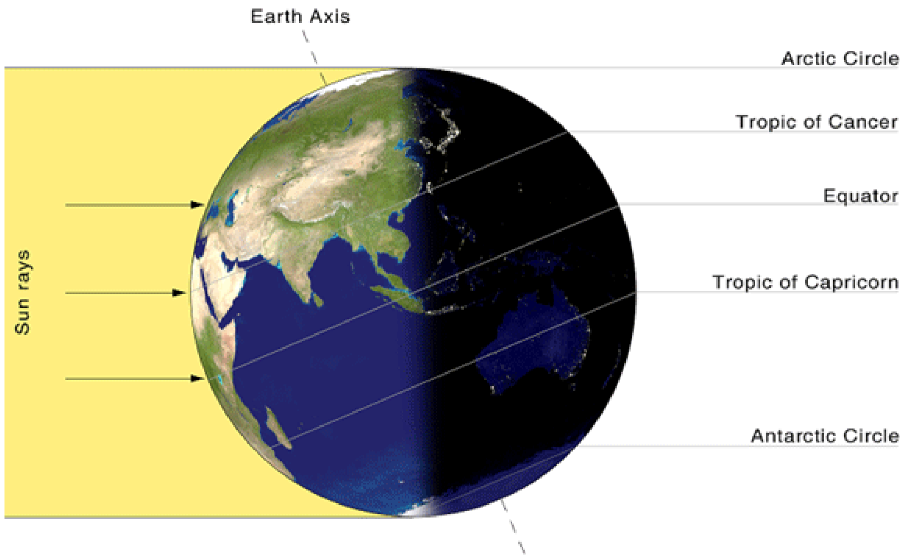
Question: The true value is 14.6 hours. Calculate your percent error. (1 point)

%

Question: Discuss significant sources of error. (3 points)

PROCEDURE: B. LENGTH OF DAY - 2. How Does Length of Day Vary with Latitude and Season?

Pick five cities: #1 near but at least a few degrees south of the Arctic circle (<66.6°), #2 in the middle of the northern hemisphere (e.g., Chapel Hill), #3 near the equator, #4 in the middle of the southern hemisphere, and #5 near but at least a few degrees north of the Antarctic circle (>−66.6°). Record them in Data Table 1 below.



For each city, estimate its latitude to the nearest degree and record it in Data Table 1 below. Record southern-hemisphere latitudes as **negative** numbers.

For each city, estimate the sunrise or sunset time during the summer solstice in the northern hemisphere and record it to the nearest 0.5 hours in Data Table 1 below. After the lab, calculate the length of day for each city.

Reposition the globe such that it is **precisely** the winter solstice in the northern hemisphere and re-measure the length of day for the same cities.

Reposition the globe such that it is **precisely** the vernal equinox in the northern hemisphere and re-measure the length of day for the same cities.

Reposition the globe such that it is **precisely** the autumnal equinox in the northern hemisphere and re-measure the length of day for the same cities.

Data Table 1: Length of Day (12 points)

Note 1: List cities from north to south!

City	Name	Latitude (degrees) (N = positive, S = negative)
1		°
2		°
3		°
4		°
5		°

Question: If the ring light is to the right of the globe, you are measuring sunrise times. If the ring light is to the left of the globe, you are measuring sunset times. Which are you measuring? (1 point)

- sunrise
- sunset

Note 2: All measurements must be either sunrise times or sunset times, as you have specified above. Do not go back and forth.
Note 3: Report sunrise or sunset times in decimal hours. Specify AM or PM.
Note 4: Vernal and autumnal equinox results must be measured and calculated, not assumed.

City	Sunrise or Sunset Time (first box = decimal hours) (second box = AM or PM)		Half Length of Day (hours)	Length of Day (hours)
Northern Hemisphere Summer Solstice (Southern Hemisphere Winter Solstice)				
1				
2				
3				
4				
5				
Northern Hemisphere Winter Solstice (Southern Hemisphere Summer Solstice)				
1				
2				
3				
4				
5				
Northern Hemisphere Vernal Equinox (Southern Hemisphere Autumnal Equinox)				
1				
2				
3				
4				
5				
Northern Hemisphere Autumnal Equinox (Southern Hemisphere Vernal Equinox)				
1				
2				
3				
4				
5				

Sign your name to attest to the fact that you collected these data yourself.

After the lab, go to this website.

In this tutorial, you will learn how to graph your data.

Question: Make a graph of length of day vs. latitude for all four seasons. Save it as a png file. Upload your png graph here. (Submit a file with a maximum size of 1 MB.) (5 points)

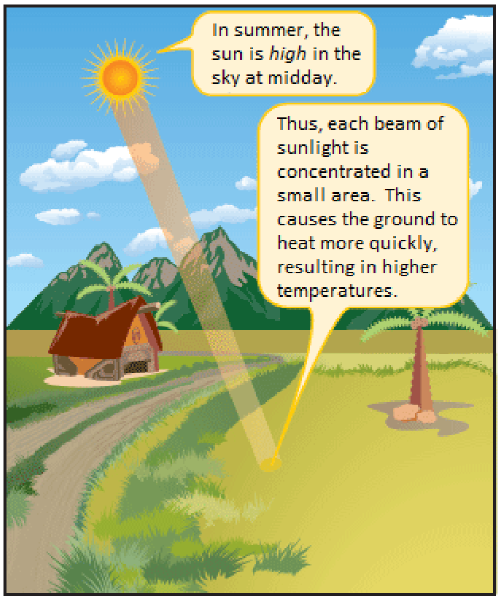
Choose File No file chosen

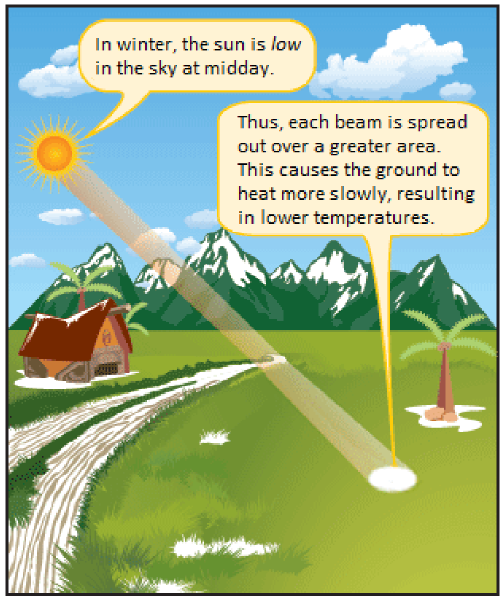
Question: Discuss how length of day varies with latitude for each of the four seasons in your graph. (4 points)

The longer the day, the longer that that location on Earth is heated by the sun, and consequently the warmer that that location becomes.

PROCEDURE: C. SUN'S ANGLE ABOVE HORIZON AT MIDDAY

A location's temperature is also a function of how high the sun is in the sky, and consequently of how directly the sun's light strikes that location.



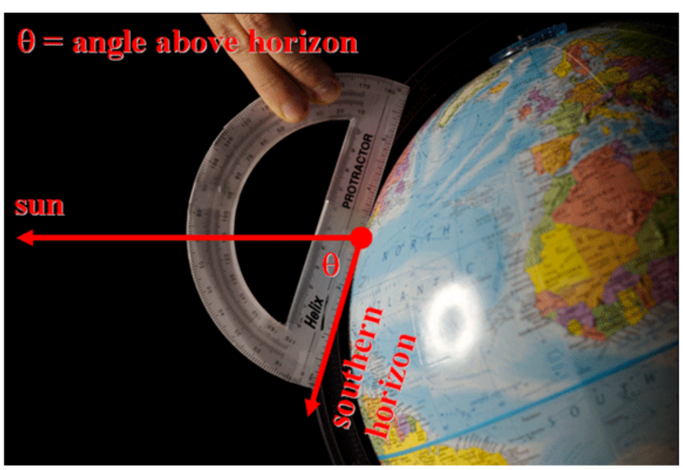


PROCEDURE: C. SUN'S ANGLE ABOVE HORIZON AT MIDDAY - 1. How High is the Sun in the Sky at Midday in Chapel Hill During the Summer Solstice?

We can measure how high an object is in the sky by measuring its **angle above horizon**.

Position the globe such that it is **precisely** the summer solstice in the northern hemisphere.

Move Chapel Hill such that it faces the ring light (midday).



Place your protractor on Chapel Hill and with the attached string measure the sun's angle above horizon to the nearest degree.

Note 1: As indicated in the picture, the line to the sun should be horizontal. It should not point to the center of the ring light! The farther out that you hold the string, the better that you will be able to judge whether or not it is horizontal.

Note 2: Your protractor has two scales on it. The outside scale runs from 0° on the left to 180° on the right. The inside scale runs from 180° on the left to 0° on the right. Use the scale with 0° on the southern horizon.

Question: Record the angle above horizon you measured. (1 point)

[ ]°

Question: The true value is 78°. Calculate your percent error. (1 point)

[ ]%

Question: Discuss significant sources of error. (3 points)

[ ]

PROCEDURE: C. SUN'S ANGLE ABOVE HORIZON AT MIDDAY - 2. How Does the Height of the Sun in the Sky at Midday Vary with Latitude and Season?

Pick the North Pole (#1) and three northern hemisphere cities: #2 near the Arctic circle, #3 between the Arctic circle and the Tropic of Cancer (e.g., Chapel Hill), and #4 near the Tropic of Cancer. (You can reuse cities from Section B.2.) Record them in Data Table 2 below.

For each location, estimate its latitude to the nearest degree and record it in Data Table 2 below.

For each location, estimate the sun's angle above horizon at midday during the summer solstice in the northern hemisphere and record it to the nearest degree in Data Table 2 below.

Reposition the globe such that it is **precisely** the winter solstice in the northern hemisphere and re-measure the sun's angle above horizon at midday for the same locations.

Reposition the globe such that it is **precisely** the vernal equinox in the northern hemisphere and re-measure the sun's angle above horizon at midday for the same locations.

Reposition the globe such that it is **precisely** the autumnal equinox in the northern hemisphere and re-measure the sun's angle above horizon at midday for the same locations.

Data Table 2: Angle Above Horizon (12 points)

Note 1: List cities from north to south!

City	Name	Latitude (degrees)
1	North Pole	[ ]
2	[ ]	[ ]
3	[ ]	[ ]
4	[ ]	[ ]

Note 2: Vernal and autumnal equinox results must be measured independently.

City	Angle Above Horizon (degrees)
Northern Hemisphere Summer Solstice	
1	[ ]
2	[ ]
3	[ ]
4	[ ]

Northern Hemisphere Winter Solstice	
1	Sun below horizon all day (use −23)
2	
3	
4	
Northern Hemisphere Vernal Equinox	
1	
2	
3	
4	
Northern Hemisphere Autumnal Equinox	
1	
2	
3	
4	

Sign your name to attest to the fact that you collected these data yourself.

After the lab, go to this website.

Question: Make a graph of the sun's angle above horizon at midday vs. latitude for all four seasons. Save it as a png file. Upload your png graph here. (5 points)

Choose File No file chosen

Question: Discuss how the height of the sun in the sky at midday varies with latitude and with season. (4 points)

The higher the sun is in the sky, the more directly and consequently the more efficiently that that location on Earth is heated by the sun, and consequently the warmer that that location becomes.

Question: How would these results differ if we chose southern hemisphere locations and measured the sun's angle above the northern horizon at midday? (1 point)

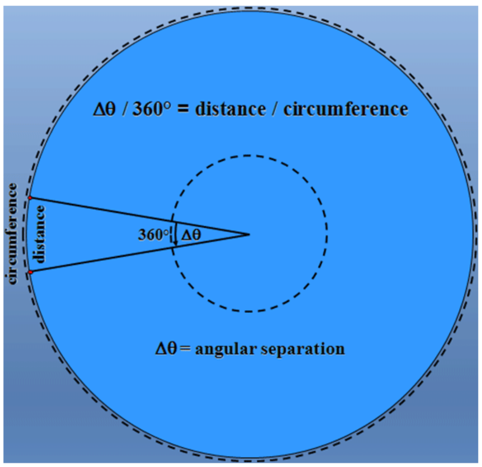
PROCEDURE: D. EARTH'S DIAMETER

In this part of the lab, you will learn how to measure Earth's circumference and consequently Earth's diameter. Knowing Earth's diameter will allow us to measure distances to solar system objects in Lab 4.

Although you can measure the circumference of a globe by wrapping a tape measure completely around it, you cannot wrap a tape measure completely around Earth. However, you can measure the distance between two points on Earth, sometimes relatively easily. For example, if they are connected by a straight shot of road, you could drive it and then read the distance off of the trip odometer.

Odometer (above) and trip odometer (below).

Then all you would need to measure Earth's circumference is the angular separation between the two points.



For any two points on a circle, their angular separation as a fraction of 360° is the same as the distance between them as a fraction of the circumference of the circle.

$$\frac{\textbf{angular separation}}{\textbf{360°}} = \frac{\textbf{distance}}{\textbf{circumference}}$$

Solving for circumference yields the following equation.

$$\textbf{circumference} = \textbf{distance} \times \left(\frac{\textbf{360°}}{\textbf{angular separation}}\right)$$

Question: Consider a road trip from Winnipeg, Manitoba, Canada to Omaha, Nebraska, United States, which are approximately on the same line of constant longitude. Use Google Maps to confirm that there is a relatively straight shot of road connecting them and to estimate the distance between them in kilometers (not miles!). (1 point)

[ ] km

The angular separation between two cities on the same line of **constant** longitude is simply their difference in latitude. However, in ancient times GPS's were not readily available. Instead, they used the sun's angle above horizon at midday to measure this.

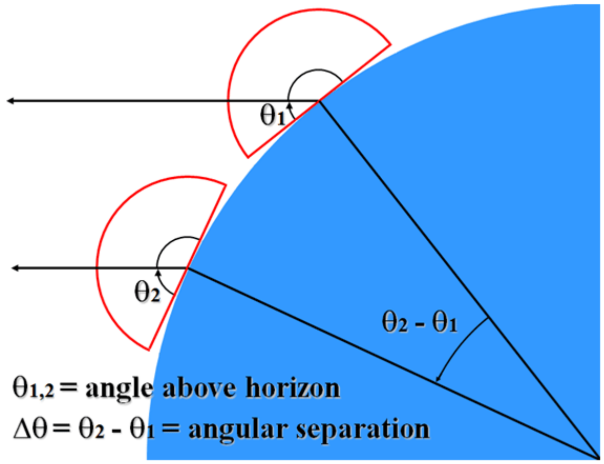
Position the globe any way you like; season does not matter.

Move your two cities such that they face the ring light (midday).

Question: For each city, measure the sun's angle above horizon at midday to the nearest 0.5 degrees. (2 points)

Winnipeg	[ ] °
Omaha	[ ] °

The positive value of the difference between these measurements is the angular separation between the two cities.



angular separation = Omaha's angle above horizon − Winnipeg's angle above horizon

Question: Calculate the angular separation between Omaha and Winnipeg. (1 point)

[ ] °

Question: Calculate Earth's circumference in kilometers. (3 points)

[ ] km

Show your work.

Question: Given that diameter = circumference /π, calculate Earth's diameter in kilometers. (1 point)

[ ] km

Question: The true value of Earth's diameter is 12,742 km. Calculate your percent error. (1 point)

[ ] %

Question: Discuss significant sources of error. (3 points)

Question: Discuss how you could measure Earth's diameter using nothing but a shadow-casting stick, a protractor, and a car's trip odometer if on a road trip between two cities that are approximately on the same line of constant longitude with a relatively straight shot of road connecting them. (3 points)

Assignment Details

Name (AID): **Lab 2G: Earth and the Seasons (T) (2504749)**
Submissions Allowed: **100**
Category: **Homework**
Code:

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