SEASONS DAY 1: SPACE-BASED PERSPECTIVES

Draw a space-based diagram that shows WHY we have day and night on Earth.

- ❏ Include all objects that you think are important for showing your reasoning.
- ❏ Label key parts of your diagram.
- ❏ Shade your diagram to show the unlit (nighttime) part.
- ❏ Draw a triangle on a location (city) that is experiencing daytime.
- ❏ Draw an x on a location (city) that is experiencing nighttime.
- ❏ **Think about how a city like Boston experiences a day-night cycle.** Add arrows to your diagram to show the movement that explains WHY Boston experiences these changes. Think carefully about *which direction* things should move in.

North

East

South

West

SEASONS DAY 2-3: APPARENT PATH OF THE SUN IN THE SKY

A) PREDICT:

I think the Sun's apparent path in the sky each day is ________________ throughout the year.
< the same / different >

If you think it is the same, explain *why*. If you think it is different, describe *how* it is different.

____

____

____

____

B) COLLECT DATA FOR BOSTON:

Season	Marker color on Suntracker	Sun angle at midday (degrees)	Length of day (hours)
Winter *(December 21)*	blue		
Spring *(March 21)*	green		
Summer *(June 21)*	red		
Fall *(September 21)*	black		

C) COMPARE AND ANALYZE DATA FOR BOSTON:

1. Which Season has the highest Sun angle at midday?______________________________

2. Which Season has the lowest Sun angle at midday?______________________________

3. Which Season has the longest day length?______________________________

4. Which Season has the shortest day length?______________________________

5. Which Seasons have the same day length and Sun angle at midday? ______________________________

6. Was the Sun ever directly overhead in Boston? ______________________________

D) RECORD YOUR IDEAS:

In what ways do you think the Sun's height in the sky and length of day affect temperature?

Ways I think the Sun's height in the sky affects temperature:

____

____

Ways I think the length of day affects temperature:

____

____

SEASONS DAY 4: SUN-ANGLE AND ENERGY

1. Modeling light from the Sun:

Using the flashlight + grid paper, model what happens when sunlight hits the ground at different angles.

Explore how Sun angle affects the amount of ground illuminated by the Sun, and therefore, the energy we receive from the Sun (and therefore, temperature).

A) PROCEDURE:

1. Place the graph paper on your desk. Use a protractor (or half-Sun tracker) to position the meter stick pointing straight up, at 90°. This represents a Sun angle of 90°.
2. Turn off the room lights and turn on the flashlight. Use a pencil to draw an outline of the illuminated part of the grid. Label the outline with the Sun angle.
3. Repeat step 2 at 60°, 30°, and 10°, using the protractor (or half-Sun tracker) to measure the angle. It will help to keep the tip of the meter stick near the top of the paper for each trial.
4. Turn on the lights when everyone is finished.
5. For each Sun angle, count the number of squares illuminated by the flashlight, estimating if some squares are only partially lit. Record data in the table. (To save time, you can calculate the area of a rectangle inside the lit up area and then add the count of additional squares around the rectangle.)
6. For each Sun angle, determine the fraction of light striking each square and record in the table. For example, if the flashlight illuminated 15 squares, then each square receives 1/15 of the light.

B) COLLECT DATA:

Complete this table with your group:

Sun Angle (in degrees - °)	Number of Squares Illuminated (Area in cm^2)	Fraction of Light Received By Each Square (units)
90°		
60°		
30°		
10°		

C) COMPARE AND ANALYZE:

a. At which Sun angle was the largest area of ground illuminated? ___________

b. At which Sun angle was the smallest area of ground illuminated? ___________

c. At which Sun angle did each square of ground receive the most amount of light (and therefore, the most intense light)? ___________

d. When sunlight is more intense, the temperature will be ______________ .
<warmer/cooler>

e. At which Sun angle did each square of ground receive the least amount of light (and therefore, the least intense light)? ___________

f. When sunlight is less intense, the temperature will be ______________ .
<warmer/cooler>

D) RECORD YOUR IDEAS:

Based on what we have learned so far, explain ***why*** you think it is warmer in the summer than in the winter.

Try to connect what you have learned about how the sun appears to move in the sky during different seasons; how the Earth's axis affects the mid-day Sun angle; and how the Sun's angle in the sky affects the intensity of light we receive.

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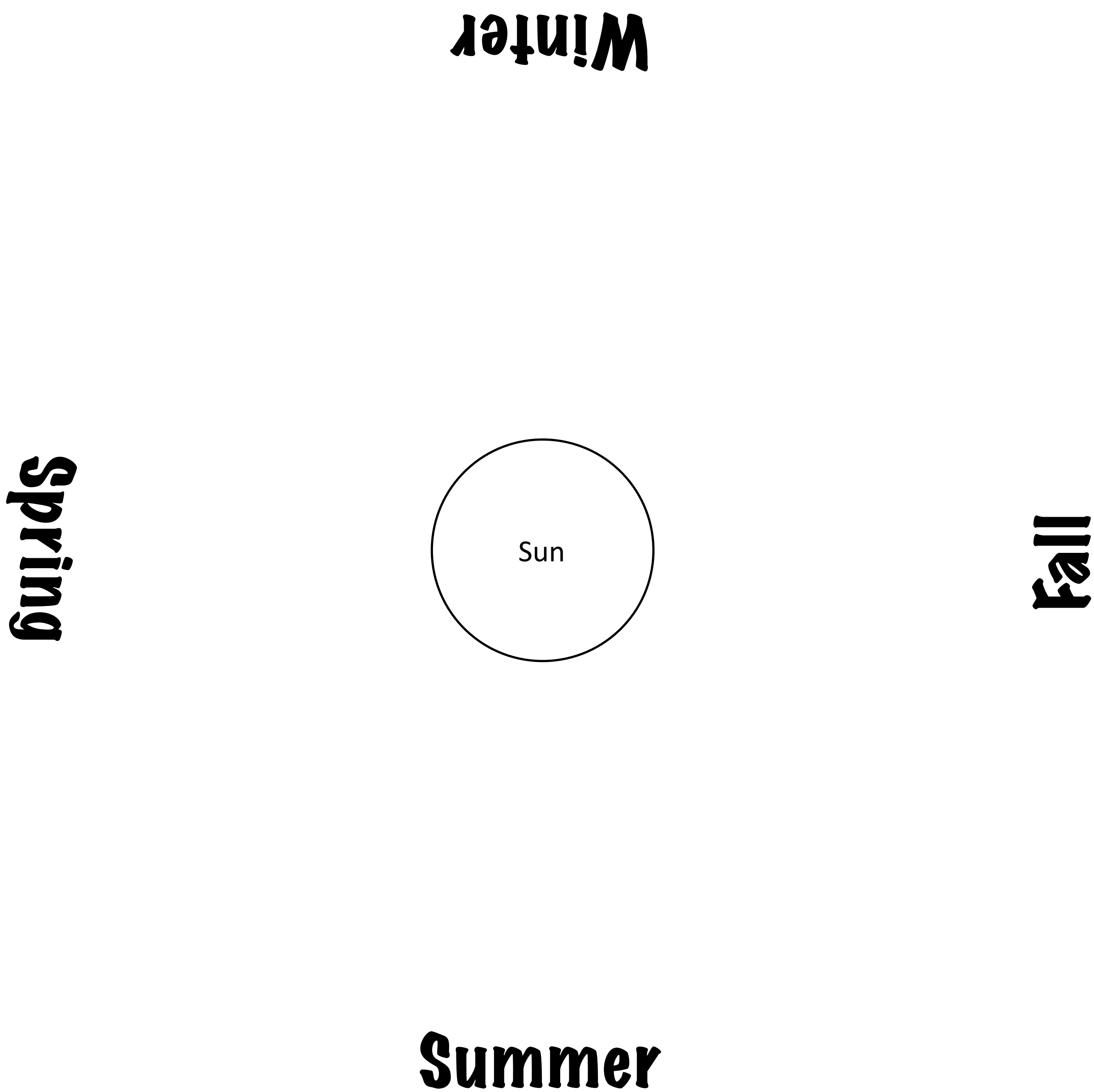
____

____

____


Winter
Spring
Sun
Fall
Summer

Summer

Fall

Winter

Spring

SEASONS DAY 5 - EARTH'S TILTED AXIS

1. Model a Year

Model the Earth orbiting the Sun, using the Seasons sheet on your table as a guide. ***Be sure to always point your Earth's axis in the direction given by the instructor***.

☐ Place your team's Seasons sheet on the table, matching the orientation with the signs around the room. Place your Sun on the Seasons sheet.

☐ Each team member should stand around your table at the Seasons positions marked.

☐ Summer team member: hold Earth on the side of the Sun that represents Summer, keeping the Earth's axis oriented correctly.

☐ Pass the Earth to the Fall team member, always keeping the axis pointed in the correct direction.

☐ Complete a Year by passing the Earth to the Winter and Spring team members, and back to Summer.

2. Model a Day at Different Times of Year

☐ Summer: Rotate Earth at the Summer position, so your Lego person experiences both night and day. Teammates should check that the axis orientation remains correct.

☐ Pass Earth to the Fall team member. Spin the globe on its axis to make your Lego person experience Day and Night during this season. Teammates should check that the axis orientation remains correct.

☐ Repeat for the other 2 seasons.

3. Observe from the Model

When Earth experiences SUMMER in the Northern Hemisphere,

- the Northern axis is tilted ______________ the Sun
  <towards/away from>
- the Southern axis is tilted _______________ the Sun
  <towards/away from>
- To see the Sun at midday, Lego person has to look ____________ , ________ in the sky.
  <up / ahead> <high/low>

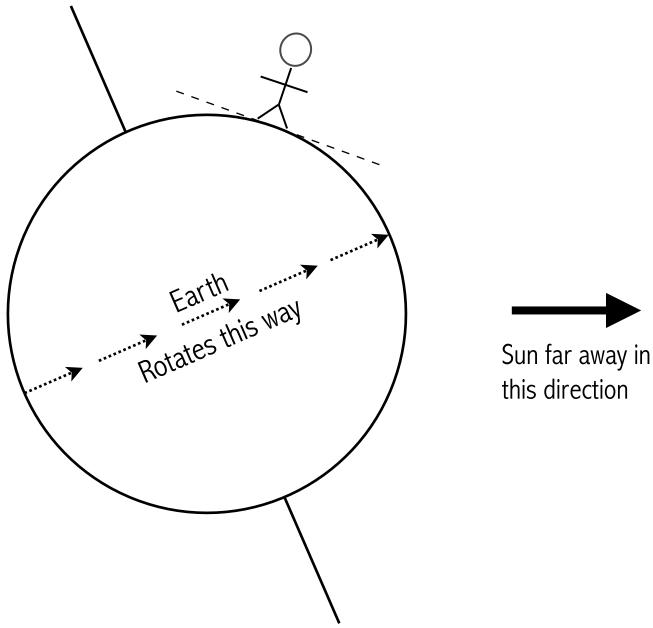
When Earth experiences WINTER in the Northern Hemisphere,

- the Northern axis is tilted ______________ the Sun
  <towards/away from>
- the Southern axis is tilted _______________ the Sun
  <towards/away from>
- To see the Sun at midday, Lego person has to look ____________ , ________ in the sky.
  <up / ahead> <high/low>

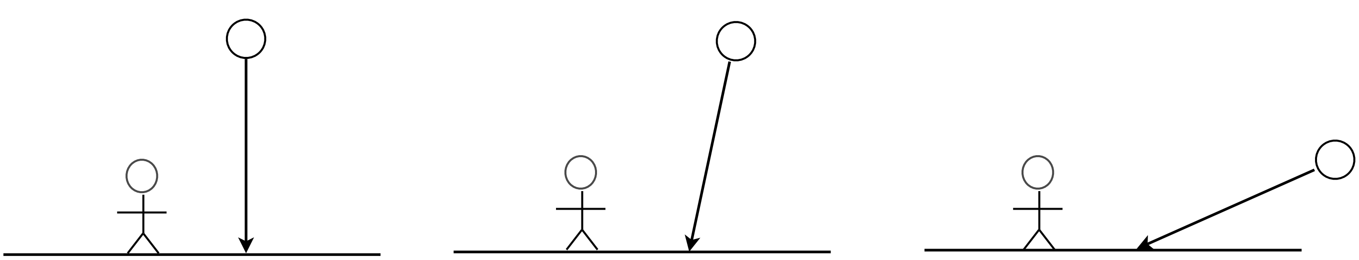
SEASONS DAY 6: TILTED AXIS AND SUN ANGLE

A. Interpret this diagram:

Diagram NOT to scale.



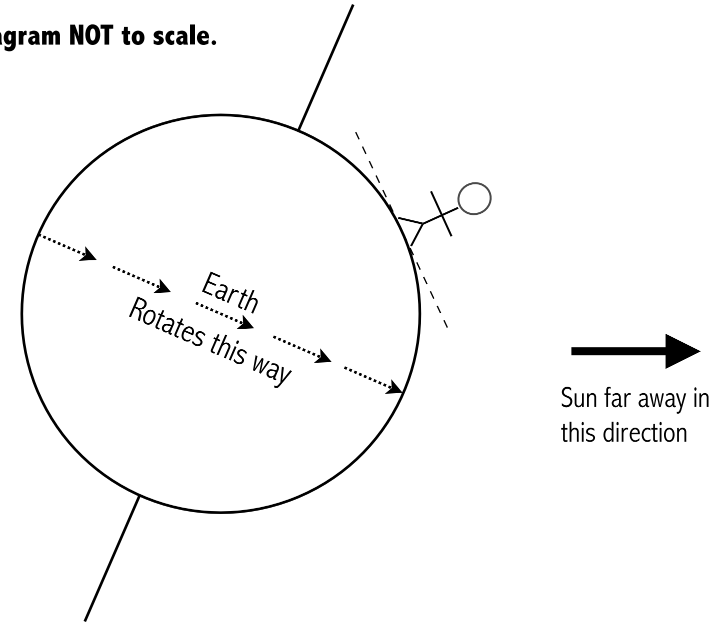
1. The northern hemisphere is tilted ___________________ the Sun.
   <towards/away from>
2. Sketch in five light rays from the Sun, to show how you think Sunlight reaches the Earth.
3. Shade the diagram to show which part of the Earth is dark.
4. What time of day do you think it is for the stick person in the diagram? ___________________
   <sunrise/midday/sunset/midnight>
5. Circle the figure that you think best represents the angle of sunlight hitting the person's ground (and therefore, the Sun in the person's sky) at the moment shown above.



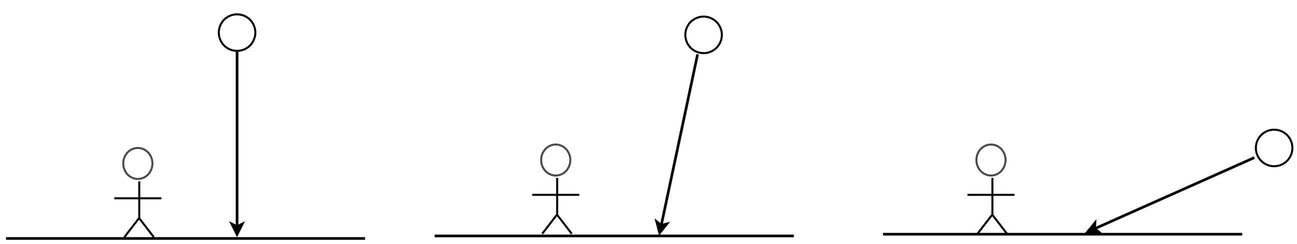
6. What season do you think it is for the person? ___________________________
   <summer/winter>

B. Interpret this diagram:

Diagram NOT to scale.



1. The northern hemisphere is tilted _________________ the Sun.
   <towards/away from>
2. Sketch in five light rays from the Sun, to show how you think Sunlight reaches the Earth.
3. Shade the diagram to show which part of the Earth is dark.
4. What time of day do you think it is for the stick person in the diagram? ___________________
   <sunrise/midday/sunset/midnight>
5. Circle the figure that you think best represents the angle of sunlight hitting the person's ground (and therefore, the Sun in the person's sky) at the moment shown above.



6. What season do you think it is for the person? ________________________
   <summer/winter>

C. Compare:

When the Northern Hemisphere is tilted **towards** the Sun, the Sun is

_____________ in the sky at midday. This is _____________ .
<high/low> <summer/winter>

When the Northern Hemisphere is tilted **away from** the Sun, the Sun is

______________ in the sky at midday. This is ______________ .
<high/low> <summer/winter>

SEASONS DAY 6 - Bonus Questions

Figure 1

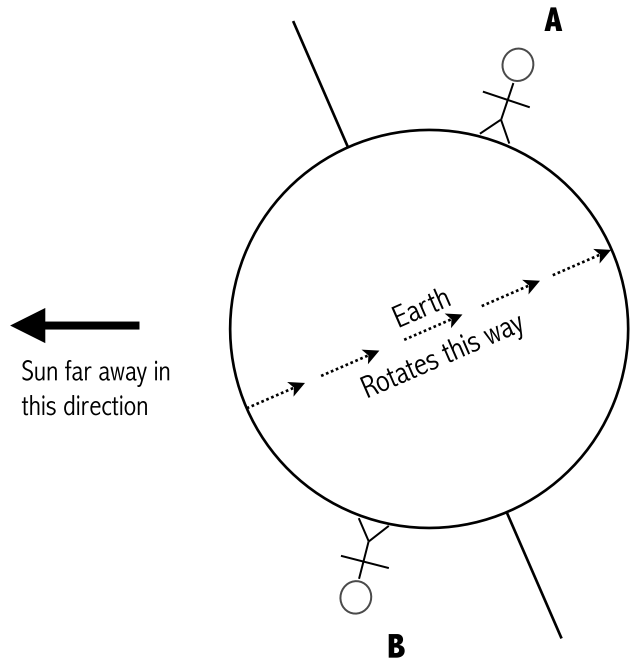


Diagram NOT to scale.

- Sketch in rays from the Sun
- Shade the dark part of Earth
- What time of day is it for Person A? __________
- What season is it for Person A? ___________
  Explain why you think so:

- What time of day is it for Person B? __________
- What season is it for Person B? ____________
  Explain why you think so:

Figure 2

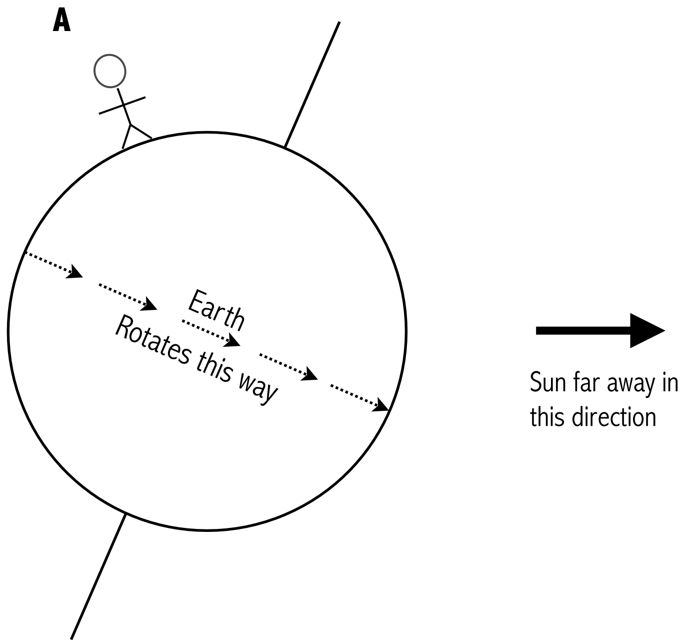


Diagram NOT to scale.

- Sketch in rays from the Sun
- Shade the dark part of Earth
- True or False? Figure 1 and Figure 2 show the same time of day and the same season for Person A.
- Sketch in a person for whom the Sun is directly overhead on this day. Label this Person B.
- Sketch in a person who will never see the Sun on this day. Label this Person C.
- Sketch in a person who will never experience darkness on this day. Label this Person D.

SEASONS DAY 7 - Tilt & Day Length

1. Collect Data: Length of Day around the World

On June 21:

A. The northern hemisphere is tilted ______________ the Sun.
<toward/away from>

B. A place that spends this ENTIRE day in darkness (and never sees the Sun) is ________________.

This place is in the __________________ hemisphere, close to the __________________.
<Northern/Southern> <equator/pole>

C. A place that spends less time in daylight than darkness is ____________________.

This place is in the __________________ hemisphere, which is tilted ________________ the Sun.
<Northern/Southern> <toward/away from>

On December 21:

D. The northern hemisphere is tilted ______________ the Sun.
<toward/away from>

E. A place that spends more time in daylight than darkness is ____________________.

This place is in the __________________ hemisphere, which is tilted ________________ the Sun.
<Northern/Southern> <toward/away from>

F. A place that spends the same amount of time in daylight as darkness is ____________________.

This place is located near the ____________________.
<North Pole/South Pole/Equator>

G. A place that spends the ENTIRE day in daylight (and never sees the Sun set) is ________________.

September 21:

H. Barrow, Alaska spends ________________ time in daylight than darkness.
<more/the same amount of/less>

I. Puerto Montt, Chile spends ________________ time in daylight than darkness.
<more/the same amount of/less>

2. Compare

A. When the Northern Hemisphere is tilted toward the Sun, the Southern Hemisphere is tilted

_____________________ the Sun.
<toward/away from>

B. Cities in the hemisphere that is tilted **toward** the Sun, have _____________________ hours
<more/the same amount of/fewer>

of daylight than darkness.

C. Cities in the hemisphere that is tilted **away from** the Sun, have _____________________
<more/the same amount of/fewer>

hours of daylight than darkness.

D. Some places on Earth have roughly equal amounts of daylight and darkness every day.

These places are close to the ____________________________.
<equator/poles>

E. There are places on Earth where the Sun never rises or never sets for an entire day. These

places are close to the _____________________.
<equator/poles>

F. On September 21 and March 21, there are _____________________ hours of daylight than
<more/the same amount of/fewer>

darkness every where on Earth. These dates are known as the ______________________.

SEASONS DAY 8: EARTH'S ORBIT

What shape is Earth's Orbit?

A. Draw a diagram of Earth's orbit around the Sun from an **overhead** perspective.
B. Label key parts of your diagram.
C. Label where you think Earth is in September, December, March, and June.

Distance from Earth to Sun:

Predict: At what time of year (if any) do you think Earth is closest to the Sun? ________________________.

Date	Collect Data distance from Earth to Sun (in kilometers)
December 21 *(Boston winter)*	
March 21 *(Boston spring)*	
June 21 *(Boston summer)*	
September 21 *(Boston fall)*	

Compare and Analyze:

Use the data in your table to answer these questions:

Earth is closest to the Sun in the Northern Hemisphere's ____________________.
<Fall/Winter/Spring/Summer>

Earth is farthest from the Sun in the Northern Hemisphere's ____________________.
<Fall/Winter/Spring/Summer>

Reflect:

A common explanation for why we experience Seasons is that Earth is closer to the Sun in the summer, and farther away in the winter. Do you agree or disagree with this? ______________
<agree/disagree>

Explain your reasoning. If you disagree, please tell us why you think we experience Seasons:

____

____

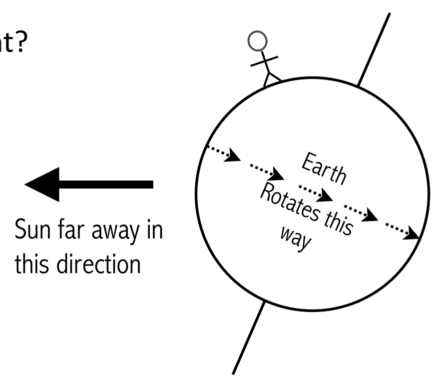
____

____

Recap:

1. What season is it for the person in the diagram to the right?

____
<Fall/Winter/Spring/Summer>

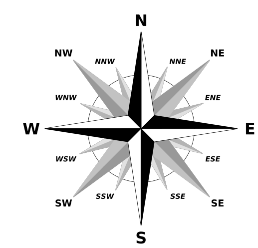


2. The person in the diagram will experience:
   A. A longer day and shorter night.
   B. Roughly equal day and night
   C. A longer night and shorter day

3. Sketch a side-view of the Earth and Sun when the southern hemisphere is experiencing winter:

SEASONS KEY TERMS

Rotation:	turning or spinning on an axis; Earth's **rotation** is the reason we experience **night/day.**
Revolution/ Orbit:	movement or path around another object; Earth's **revolution** around the sun takes one Earth **year** (365 days).
Axis:	an imaginary line around which the Earth spins or rotates
Sunrise:	when a given point on Earth rotates from the unlit half to the lit half; "daytime" begins.
Sunset:	when a given point on Earth rotates from the lit half to the unlit half; "nighttime" begins.
Cardinal Directions:	Directions of north, east, south, and west. *(See diagram to right).*
Horizon:	An imaginary line where the sky and the ground appear to meet. (Has a sky angle of 0 degrees.)
Directly Overhead:	The point in the sky that is straight above. (Has a sky angle of 90 degrees.) Unless you live within 23.5° latitude of the equator, the sun is NEVER directly overhead.
Sky Angle:	Measure (in degrees) of how high above the horizon an object is in the sky.
Sun Angle:	Sky angle of the Sun.
Equinox:	2 days of the year when we experience equal hours of daylight and night time (12 hours each) - March 21 and Sept 21
Tilted Axis:	Earth's axis is tilted at 23.5 degrees and is always pointed toward the North Star, Polaris. 

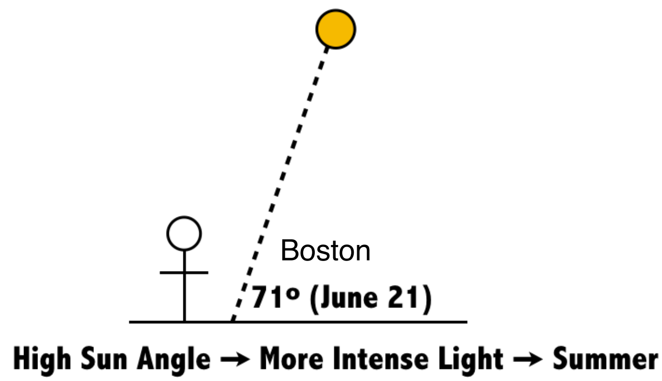


Cardinal Directions

SEASONS KEY IDEAS

Summer - Hot

- Higher sun angle at midday
  - Light concentrated over a small area -> more intense -> warmer
- Longer sun path -> Longer hours of daylight
  - More time to heat up the ground



Fall/Spring - In between

- Medium height sun angle at midday
- Medium length sun path -> medium hours of daylight
- Equinoxes: September 21/March 21 - Equal hours of day/night - 12 hours each

Winter - Cold

- Lower sun angle at midday
  - Light spread out over a larger area -> less intense -> cooler
- Shorter sun path -> Fewer hours of daylight
  - Less time to heat up the ground