Student Exploration: Seasons Around the World

Vocabulary: Arctic Circle, axis, equator, equinox, North Pole, solar energy, solar intensity, solstice, Tropic of Cancer

[Note to teachers and students: This Gizmo was designed as a follow-up to the Seasons in 3D *Gizmo™. We recommend doing that activity before trying this one.]*

Prior Knowledge Question (Do these BEFORE using the Gizmo.)
On June 21, the summer **solstice**, the Sun rises at 5:50 A.M. and sets at 7:16 P.M. in Honolulu, Hawaii. On the same day in Anchorage, Alaska, the sun rises at 4:20 A.M. and sets at 11:43 P.M.

1. How does the length of a summer day differ in these two locations? _____

   _____

2. How do you think the length of daylight on June 21 changes as you travel north towards the **North Pole**?

   _____

Gizmo Warm-up
For most places on Earth's surface, the length and intensity of sunlight received varies by season. Just how much can it vary? You will use the *Seasons Around the World* Gizmo to find out.

To begin, set the **Latitude** on the DESCRIPTION pane to 89°, which is as close to the North Pole as the Gizmo allows. Move the **speed** slider all the way to the right. Click **Play** ( ) and observe on the top portion of the SIMULATION pane how much sunlight falls on the North Pole (marked by the red dot) over the course of the year.

1. What do you think it would be like to live near the North Pole in the winter? _____

   _____

2. What do you think it would be like to live near the North Pole in the summer? _____

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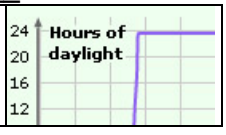
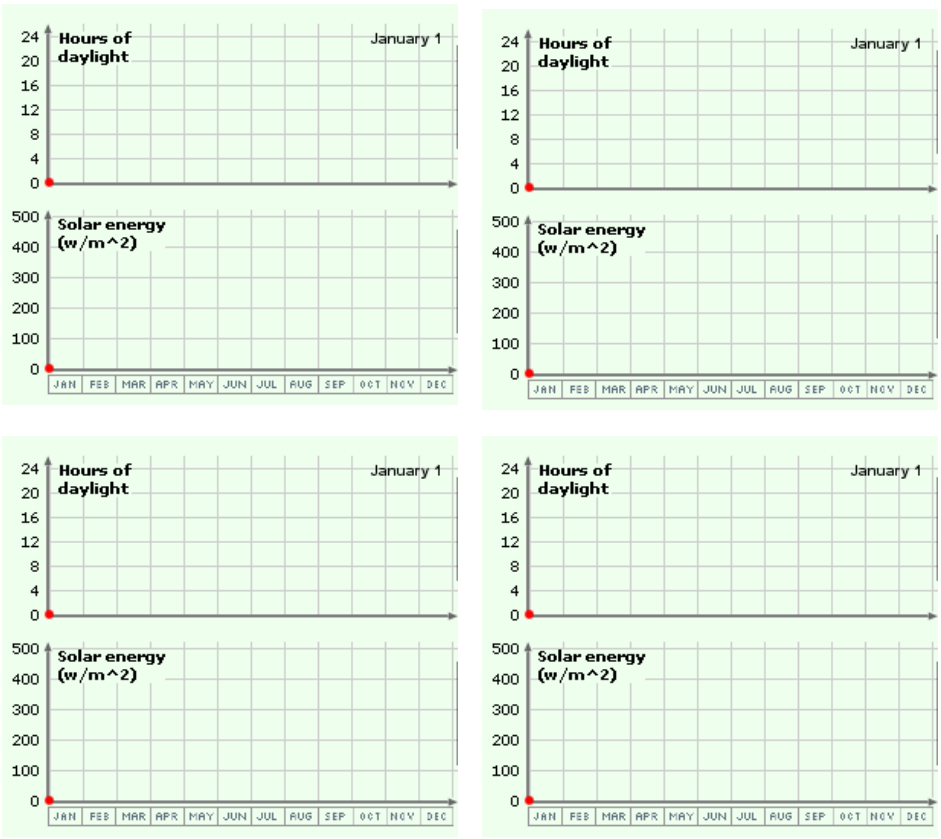
   _____

Activity A: **Seasons at different latitudes**	Get the Gizmo ready: • Click **Reset** ( ).	

Question: Which latitudes experience the greatest seasonal variations?

1. Graph: Select the YEAR GRAPH tab. Click **Play**. The top graph shows the hours of daylight near the North Pole over the course of the year. The bottom graph shows the amount of **solar energy** received by that location over the course of the year. Copy the data to a graph below. Label the graph '89°N'.



2. Gather data: Look at the **Hours of daylight** graph for the North Pole.

   A. How many hours of daylight are there from October to March? _____

   B. How many hours of daylight are there from April to September? _____

3. Identify: What is the maximum solar energy on the North Pole? _____
   (Note: Drag the **Solar energy** graph on the Gizmo down to see the top of the graph.)

4. Graph: Create graphs for the following latitudes: 66.5° N (**Arctic Circle**), 23.5° N (**Tropic of Cancer**), and 0° N (**equator**). Copy the data to a graph above and label the graphs appropriately.

5. Analyze: Compare the graphs for the four different latitudes.

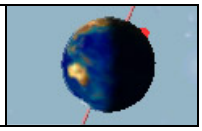
   A. Which latitude experiences the most extreme seasonal changes? _____

   B. Why do you think this is? _____

   _____

   C. People who live in the tropics usually don't refer to their seasons as "winter" or "summer." Why do you think this is? _____

   D. Notice that the solar energy curve for the equator has two small peaks at the spring **equinox** (March 21) and the fall equinox (September 23). What do you think causes this? (Hint: Think of the directness of the Sun's rays.)
   _____

Activity B: **Summer vs. winter**	Get the Gizmo ready: • Click **Reset**. • Move the **speed** slider all the way to the left.	

Question: How do temperatures at different latitudes compare during the summer versus during the winter?

1. Compare: The chart below shows average temperatures for January and July in three cities.

City	Latitude	Average January Temp.	Average July Temperature
Fairbanks, Alaska	65° N	-28 °C (-19 °F)	17 °C (62 °F)
New York City, New York	43° N	1 °C (33 °F)	25 °C (77 °F)
Honolulu, Hawaii	21° N	23 °C (73 °F)	27 °C (81°F)

   A. What is the temperature difference between Fairbanks and Honolulu in the winter?

   _____

   B. What is the temperature difference between Fairbanks and Honolulu in the summer?

   _____

   C. During which time of the year are the climates of Fairbanks, New York City, and Honolulu most similar? _____

2. Form hypothesis: Why do you think the temperature difference between high latitudes and low latitudes is so small during the summer? _____

   _____

3. Think about it: Solar energy is a measure of how much heat from the Sun an area receives in a day. How do you think the following two factors would affect the amount of solar energy a location receives?

   Hours of daylight: _____

   Angle of Sun's rays: _____

4. Gather data: **Solar intensity** is a measure of the amount of solar energy striking a place in one hour. The more direct the sun's rays are, the greater the solar intensity will be. Set the **Latitude** to 65°. Select the DAY GRAPH. Click **Play**, and then click **Pause** ( ) at noon.

   Record the noon solar intensity for this latitude in the table below. Then, select the YEAR GRAPH tab and record the hours of daylight and solar energy for this day. Repeat this for July 1. Then, use the Gizmo to fill in the rest of the table.

Date	Latitude	Noon solar intensity (W/m^2h)	Hours of daylight	Solar energy (W/m^2)
January 1	65° N			
	43° N			
	21° N			
July 1	65° N			
	43° N			
	21° N			

5. Analyze: Look at the data you collected in the table.

A. On January 1, which latitude has the lowest solar intensity? The highest? _____

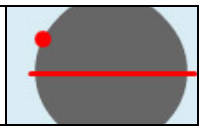
B. On January 1, which latitude has the fewest hours of sunlight? The most? _____

C. On July 1, which latitude has the lowest solar intensity? The highest? _____

D. On July 1, which latitude has the fewest hours of sunlight? The most? _____

6. Explain: Why is the climate of Fairbanks more similar to Honolulu in the summer than in the winter?

_____

Activity C: **Tilt of Earth's axis**	Get the Gizmo ready: • Click **Reset**. On the DESCRIPTION tab, set the **Latitude** to your town's latitude.	

Question: Earth's axis is a line connecting the North and South Poles. How would changing the tilt of Earth's axis affect the seasons?

1. Graph: Set the **speed** to maximum and click **Play**. Select the YEAR GRAPH tab. After a year, click the camera and paste the snapshot in a blank document. Label this graph "Normal axis angle (23.5°)."

   A. What is the highest solar energy in this graph, and when does it occur? _____

   B. What is the lowest solar energy in the graph, and when does it occur? _____

2. Observe: On the DESCRIPTION tab, move the **Earth axis angle** slider back and forth. As you move the slider, watch the image of Earth at the bottom of the SIMULATION tab. How does Earth's orientation to the Sun change as you move the slider?

   _____

   _____

3. Form hypothesis: Set the **Earth axis angle** to -23.5°, the opposite direction of Earth's current axial tilt. How might this change affect seasons in the Northern Hemisphere?

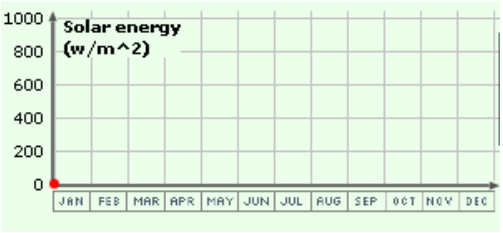
   _____

4. Graph: Click **Reset**. Select the YEAR GRAPH tab and click **Play**. Observe the data.

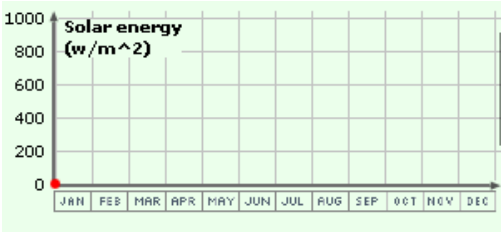
5. Analyze: Study the graph you just observed. What was the effect of changing Earth's axial tilt to -23.5° and why do you think this happened? _____

_____

6. Explore: For each axial angle listed below, sketch what you think the **Solar energy** graph will look like. Run the Gizmo with that angle and sketch the result. Explain each graph.



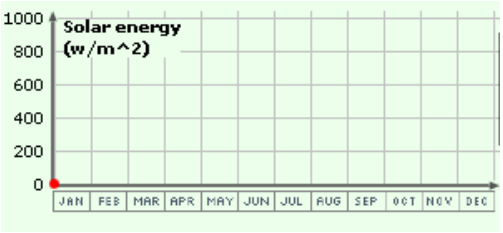
90° Predicted



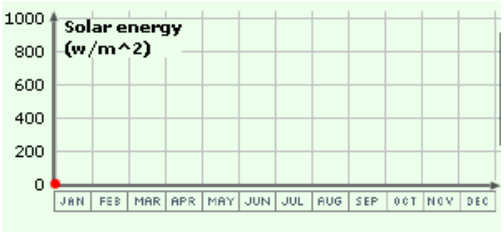
90° Actual

Explanation: _____

_____



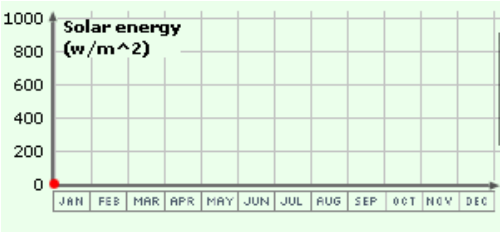
45° Predicted



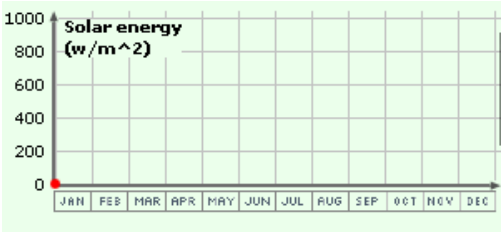
45° Actual

Explanation: _____

_____



0° Predicted



0° Actual

Explanation: _____

_____

_____