6A Earth's Seasons

What causes the seasons?

In this Investigation, you will use a solar cell and a digital meter to measure the intensity of light emitted by a light source that represents the Sun. You will first measure the intensity of light from the bulb at different distances from it—like Earth at different distances from the Sun. Then you will measure the intensity of light at various latitudes on the globe. By performing these two kinds of measurements, you will determine which factors cause the seasons.

Materials

- Globe
- Velcro® tabs
- 100-watt light source
- Solar (PV) cell
- Digital meter
- Tape measure or meter stick

1 Setting up

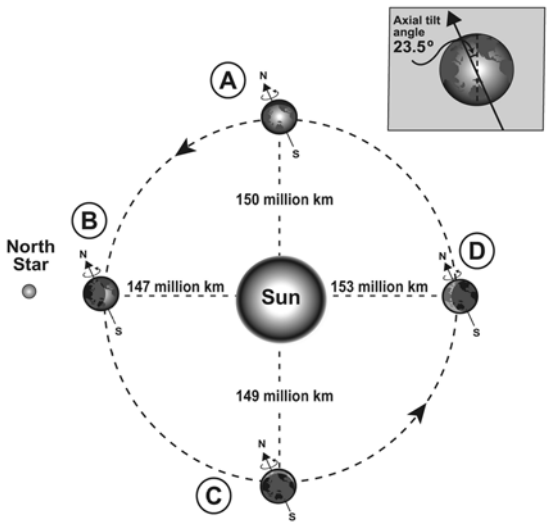
1. A light source representing the Sun will be placed in the center of your classroom. It is important that the light source emit light equally in all directions like the Sun does.
2. The globe will be used to represent Earth. Put the Velcro® dots on Earth so that the solar cell will adhere to the dots. Put the tabs at the equator, Tropic of Cancer (23.5 degrees north), and Tropic of Capricorn (23.5 degrees south).
3. With your class, choose a wall in your classroom that will represent the position of the North Star (Polaris) in the night sky. Tape a sign to this wall that says "North Star."

Safety tip: If your light source is a light bulb, do not touch it. Light bulbs can get very hot!

2 Stop and think

Earth's orbit around the Sun is slightly elliptical. At certain times during the year, Earth is a little closer to or farther from the Sun than at other times. Also, Earth is tilted as it moves around the Sun.

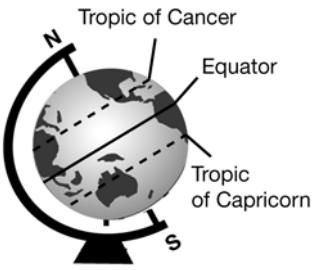
a. Come up with a hypothesis stating why you think the seasons occur.
Do you think they are caused by changes in Earth's distance from the Sun?
Do you think Earth's tilt causes the seasons?
Do you think both of these factors play a role? Or do you think other factors cause the seasons?

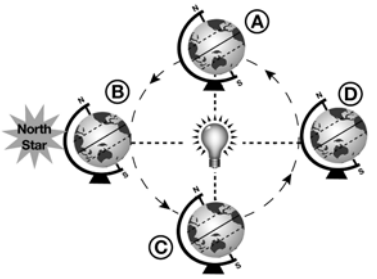


b. Which quarter of the diagram (A to B, B to C, C to D, or D to A) do you think represents summer in the Northern Hemisphere? Explain why you think this is so.

3 Doing the experiment, part A (complete with your class)

1. One student will move the globe, in a circle, to each position (A-D) in a counterclockwise direction around the light source (the "Sun"). This movement simulates one revolution around the Sun (or one year).
2. As the globe is moved from point to point, the axial tilt at the north pole of the globe should always point toward the "North Star."
3. As Earth revolves around the Sun, it also spins on its axis. Note that the globe can also be spun on its axis.
4. Now, answer these questions. Use the globe and the diagram at right to help you.





Questions:

a. Although the axis of Earth is always pointing in the same direction, what is happening to Earth itself as it revolves around the Sun?

b. What does the side of the globe that faces the Sun represent? What does the side of the globe that faces away from the Sun represent?

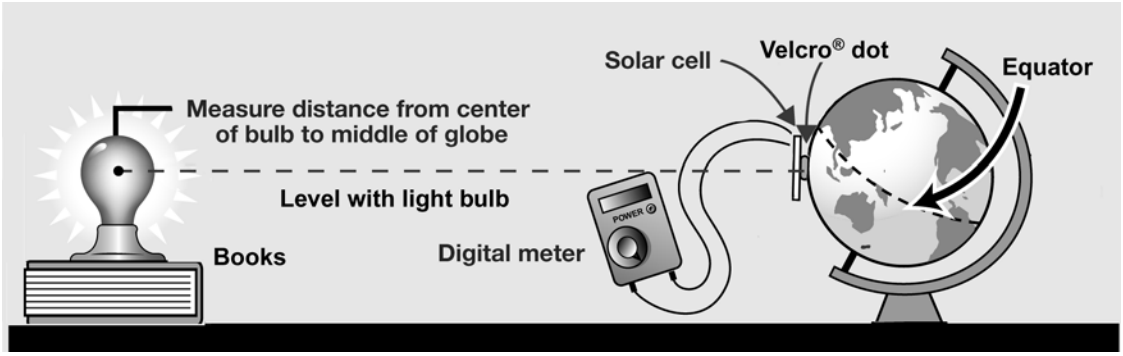
c. Diagram the following parts of the globe: equator, northern hemisphere, southern hemisphere, and latitude lines. At what latitude are you located right now?

d. In which position in the diagram is the northern hemisphere pointing towards the Sun? In which position is the southern hemisphere pointing towards the Sun?

4 Doing the experiment, part B

Now, you will model the distance of Earth from the Sun using a scale distance. You will observe the amount of energy (light intensity) produced by a light source at each scale distance. Remember, Earth does not stay the same distance away from the Sun all year long.

It is impossible to measure millions of kilometers in your classroom, but you can use a scale distance of 1 centimeter to represent 1 million kilometers. Therefore, a distance of 150 million kilometers would be represented by 150 centimeters. Using the scale distance of 1 centimeter equals 1 million kilometers, determine the scale distance for positions B, C, and D. Write the scale distance in the third column of Table 1 below.



1. Attach the solar cell to the Velcro® dots found on the equator of the globe.
2. Place the globe so the face of the globe is exactly 150 centimeters from the center of the light source. The light source should be level with the center of the globe. One student can hold the end of the tape measure at center of the globe closest to the light and another directly over the center of the light.
3. Measure the light intensity on the globe using the digital multimeter. Keep the solar cell at the center of the globe so you are only changing the distance of the globe to the light, not the angle of the solar cell. Your readings will be in milliamps. Record your readings in Table 1.
4. Repeat this for the other scale distances, being careful to set the globe at the correct distance for each position A-D. NOTE: Do not move the globe to simulate Earth's orbit for each position. Vary only the distance from the light source.

5. Now answer these questions. Use Table 1 to help you.

Table 1: Light intensity at scale distances

Position	Distance from the Sun (km)	Scale distance from the Sun (cm)	Light intensity (mA)
A	150,000,000	150	
B	147,000,000		
C	149,000,000		
D	153,000,000		

Questions:

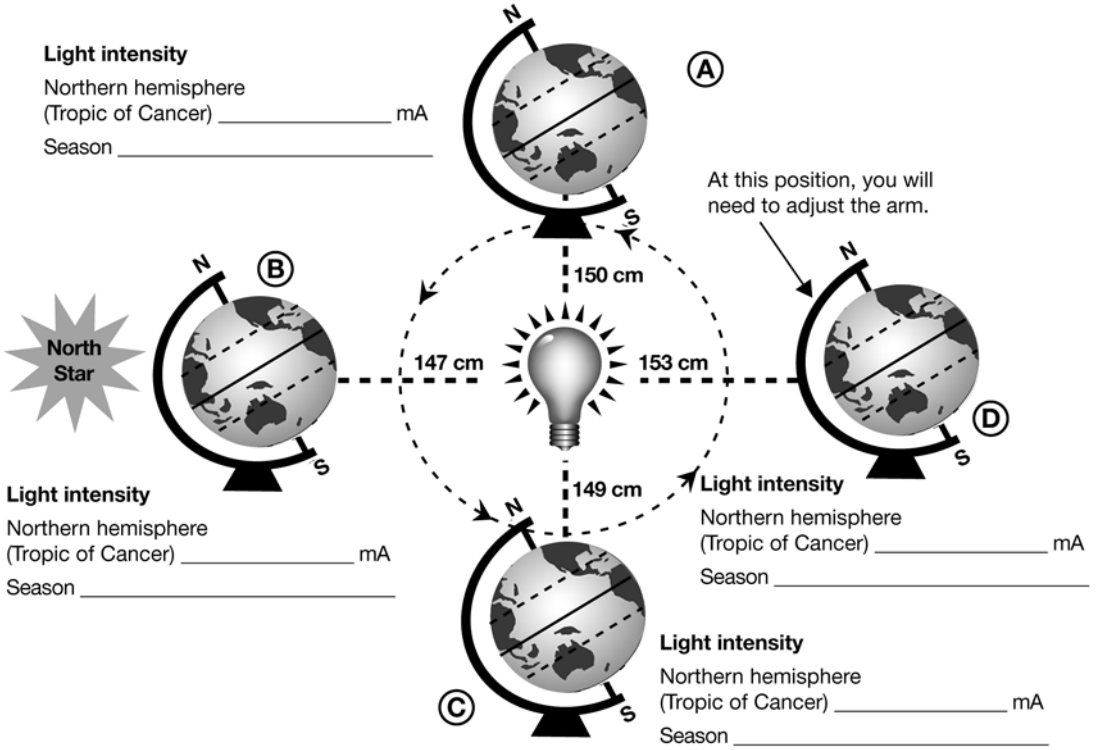
a. Are there big or small differences in distances as Earth revolves around the Sun?

b. Based on your data, how does the light intensity change as these distances change?

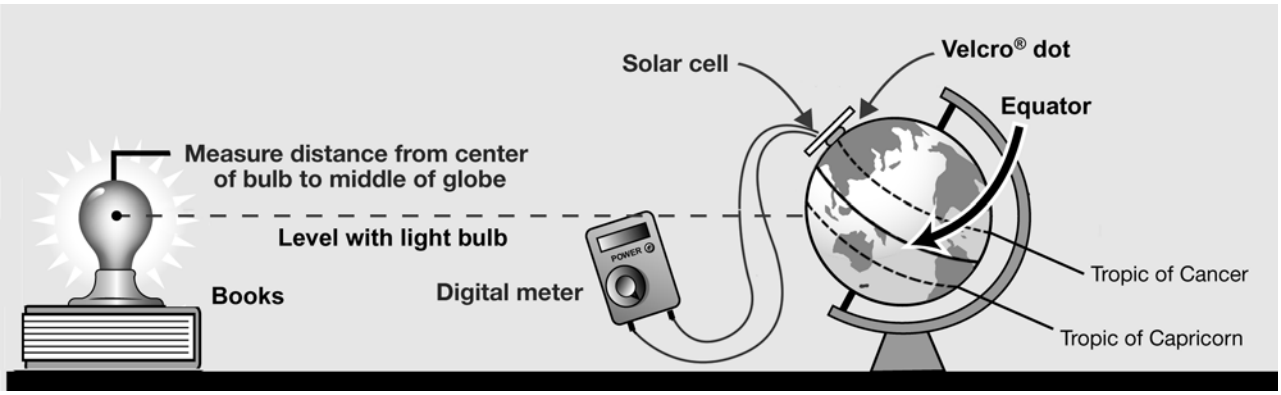
c. Based on your results from this experiment, do you think Earth's changes in distance from the Sun over a year causes the seasons? Why or why not?

5 Doing the experiment, part C

Now, you will simulate the effect that Earth's axial tilt has on the intensity of the Sun's light. You will model Earth's orbit around the Sun, in addition to its distance at the four positions shown below. Notice how the Sun's direct light never shines further south than the Tropic of Capricorn or further north than the Tropic of Cancer.



1. Since you live in the northern hemisphere, you will place the solar cell on the Tropic of Cancer (23.5 degrees north).



2. At each position, make sure the north pole of the globe always points toward the North Star. Measure each distance from the center of the light bulb to the surface of the globe. You will not move the solar cell this time. The Sun's direct rays will strike the parts of Earth shown by the diagram and you will be able to measure the energy that the Tropic of Cancer receives each time.

- For Position A, the bulb should be level with the equator and the solar cell will be on the Tropic of Cancer. At this time of year, the Sun's direct rays don't hit the Tropic of Cancer—they hit the equator. The north pole should be pointed at the North Star. The distance should be 150 cm from the center of the bulb to the globe surface.
- For Position B, the bulb should be level with the Tropic of Capricorn, since during this time of year, the Sun's direct rays hit here. Still leave the solar cell where it is.
- For Position C, the bulb should be level again with the equator. This is where the direct rays of the Sun shine at this time of year.
- See if you can figure out Position D on your own. If not, ask a partner or your teacher for help.

1. Write the light intensity values at each position on the graphic. At position D, you will need to move the arm of the globe slightly to the left or right in order to line up the bulb and solar cell nicely.
2. Answer the questions below and then complete the questions for part 6.

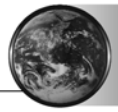
Questions:

a. What role does axial tilt play in the intensity of light on Earth?

b. At which position (A, B, C, or D) does the Tropic of Cancer receive the most light? What season do you think that represents?

6 Thinking about what you observed

a. Of the two factors—distance from the light source and axial tilt – which plays the most significant role in causing the seasons? Was your hypothesis supported by your results?



b. Based on your results, which position (A-D) represents the first day of summer in the northern hemisphere? Which position represents the first day of winter in the northern hemisphere?

c. Which quarter of earth's orbit represents summer in the northern hemisphere (from A to B, B to C, C to D, or D to A)? Explain your answer based on your results from the investigation.

d. Now go back to the diagram and write in all the northern hemisphere seasons at the appropriate positions. In the space below, write what would be happening at the same time in the southern hemisphere.