

Shadows, Angles, and the Seasons

If it's cold in winter, why is Earth closer to the Sun? This activity shows the relationship between Earth-Sun positions and the seasons.

From

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Shadows, Angles and the Seasons Notes for the Teacher

Objective:

To investigate the relationship between Earth-Sun positions and the seasons. Also, to investigate the nature of the shadows cast by the Sun.

Materials Needed:

chalk, meter stick, globe, modeling clay or silly putty, toothpick, overhead projector, unshaded table lamp (100 watt bulb), two identical thermometers, aluminum foil.

Suggestions:

1. This activity is best suited for small groups (2-3 people).
2. This activity requires the student to go outside three different times of the day - morning, around noon and in the afternoon. Please keep this in mind and plan accordingly.
3. Background information should include: The use of a globe and the students location on the globe relative to their position on Earth; the concepts of rotation (spinning about an axis through the Earth) and revolution (going about the Sun); and how to read a thermometer.
4. Remember the *Right Hand Rule*. Use your thumb as Earth's north pole - your fingers curve around to show you the direction of Earth's rotation on its axis *and* the direction that it revolves around the Sun in its orbit [see diagram].



ONLY THE SHADOW KNOWS

or

SHADOWS, ANGLES AND THE SEASONS

Why does the Earth have seasons? Are the shadows cast by objects always the same? Why is the Sun so low in the sky in the winter and high overhead in the summer? These are wonderful questions and each has the same answer. Because, Earth is spinning on an axis that is tilted as it goes around the Sun.

In this activity you will first investigate how the position of the Sun overhead affects your shadow. You will do this by going outside at three different times during the day and tracing out a shadow with chalk. Keep in mind that the Sun will appear to change position in the sky, but it is actually you on the spinning Earth that is changing position. The Earth spins from west to east so the Sun appears to go from east to west.

Next you will take a globe and an overhead projector to look at the Earth - Sun system in more detail. This will show what day and night are, why your shadow appears the way it does at certain times of the day and/or year, and why we have seasons.

And finally, you will make a temperature gauge to investigate why the seasons produce different temperatures here on Earth.

PROCEDURE

Me and My Shadow

In this part of the activity you will need to go outside to investigate the length and shape of your shadow at three different times during the day: the morning, around noon, and in the afternoon.

1. Go to a sidewalk or parking lot with a partner and trace each other's shadow with chalk. You will need to trace around each others feet so you can come back outside and stand in the exact same place.
2. Measure the length of the shadow with the meter stick and record this value in **Data Table A** on the data sheet.
3. Do this same procedure for the three times indicated above.
4. Answer the questions on the data sheet.

You and the Earth

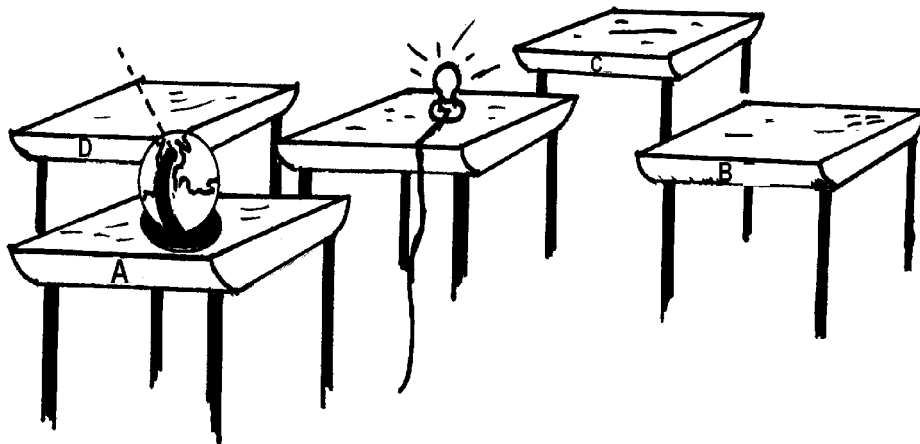
Now you will take a look at why the shadow changes on the Earth and what day and night are.

1. Take a globe and find your position on the globe where you live. Place a piece of modeling clay or silly putty on this spot.
2. Darken the room and turn the overhead projector on the globe. The projector is representing the Sun. Notice how much of the globe is lit up and how much is in shadow. The lit up part is day on Earth and the shadowed part is night.
3. Now slowly spin the globe and watch as the modeling clay goes from day to night to day and so on.
4. Now stick a toothpick in the clay and spin the globe slowly. Notice what happens to the shadow of the toothpick.
5. Answer the questions on the data sheet.

The Changing Seasons

In this part of the activity you will be finding out why Earth has seasons.

1. In the middle of the room set up a bright, unshaded lamp. The lamp represents the Sun.
2. Set up four desks around the lamp each the same distance away from the lamp as shown below. And label the desks **A**, **B**, **C**, **D**.
3. Mark one of the walls "north" and always set the globe on its base so that the axis is pointing towards this wall.

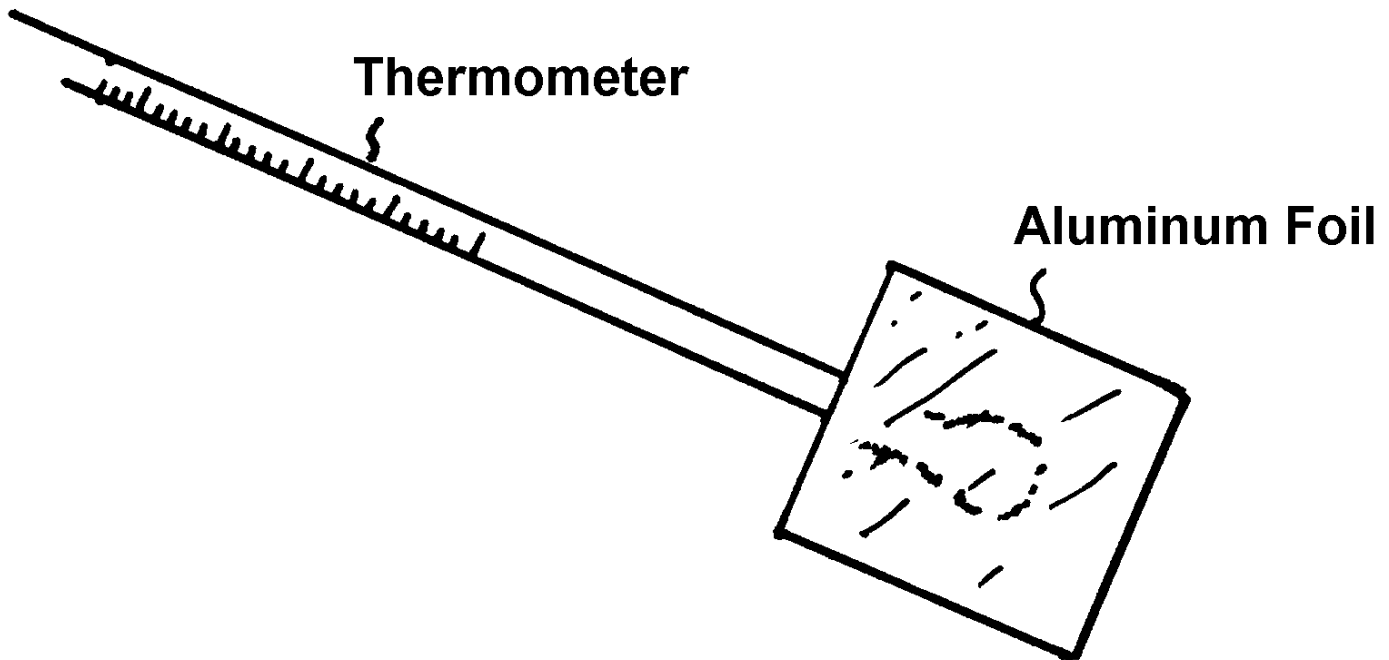


4. The four desks represent the four different seasons. Move the globe to each desk and notice the shadow of the toothpick at each desk and the amount of day and night for the toothpick.
5. Answer the questions on the data sheet.

The Seasons and Temperature

The temperature outside is different for different season, why? You will be investigating this question in this last part of the experiment.

1. Take two thermometers and fold a piece of aluminum foil around the bulb of each so as to make a 4 - 5 cm square as shown below.



2. Place both the thermometers on the overhead projector, one flat, and the other tilted up at an angle of about 45° . The flat one represents sunlight directly overhead and the tilted one represents sunlight striking Earth at an angle. Then turn the projector on for two minutes.
3. After two minutes quickly read the two thermometers.
4. Answer the question on the data sheet.

Name _____ Date _____

SHADOWS

DATA SHEET & QUESTIONS

DATA TABLE A

ME AND MY SHADOW

TIME OF DAY	LENGTH OF SHADOW (cm)

1. What time of day is your shadow the longest?

2. What time of day is your shadow the shortest?

3. What causes your shadow to change?

4. If the Sun were directly overhead:

A) What time of day would it be?

B) What would your shadow look like?

YOU AND THE EARTH

5. How much of Earth (the globe) is lit up by the projector at any given time?
6. What happens to the shadow of the toothpick as the globe spins?
7. Why does the Sun "rise" in the east and "set" in the west?

THE CHANGING SEASONS

8. Why does the Earth have seasons?
9. Starting with the desk closest to the "North" wall and going counterclockwise as in the diagram, name each season that the desk represents.

DESK	SEASON
A	
B	
C	
D	

10. During which season do you see the longest shadow?
11. During which season do you see the shortest shadow?
12. When is the shortest period of daylight for the toothpick?
13. When is the longest period of daylight for the toothpick?
14. During which season or seasons will the length of day and night be just about the same?
15. Where on the globe and during what season or seasons is it possible to see 24 hours of daylight?

THE SEASONS AND TEMPERATURE

16. Which thermometer has the highest temperature after two minutes, the flat or tilted one?
17. Explain how the tilt of the Earth's axis and the temperature of the seasons are related.

Teacher's Edition
SHADOWS
DATA SHEET & QUESTIONS

DATA TABLE A

ME AND MY SHADOW

TIME OF DAY	LENGTH OF SHADOW (cm)
<i>Morning 9:07 am</i>	<i>(example) 157.5 cm</i>
<i>Noon 12:15 pm</i>	<i>(example) 48.6 cm</i>
<i>Afternoon 2:38 pm</i>	<i>(example) 69.9 cm</i>

1. What time of day is your shadow the longest?

In the morning when the Sun is close to the horizon.

2. What time of day is your shadow the shortest?

Around noon when the Sun is high overhead.

3. What causes your shadow to change?

The position of the Sun with respect to the horizon. If the Sun is low to the horizon the shadow will be long. If the Sun is high overhead the shadow will be short.

4. If the Sun were directly overhead:

- A) What time of day would it be?

Noon.

- B) What would your shadow look like?

You wouldn't be able to see your shadow if the Sun were directly overhead because, you would be standing on your shadow.

YOU AND THE EARTH

5. How much of Earth (the globe) is lit up by the projector at any given time?

Half of the globe is always lit.

6. What happens to the shadow of the toothpick as the globe spins?

The shadow goes from very long when the toothpick is near to the unlit side of the globe (this corresponds to morning and evening) to very short when the toothpick points toward the projector (this corresponds to noon).

7. Why does the Sun "rise" in the east and "set" in the west?

Because, Earth rotates from west to east. The Sun becomes visible as Earth rotates so that you start to face the Sun and disappears when you rotate away from the Sun.

THE CHANGING SEASONS

8. Why does the Earth have seasons?

Because, the angle the rays from the Sun strike Earth change during the course of the year. The tilt of Earth's axis accounts for this change in angle.

9. Starting with the desk closest to the "North" wall and going counterclockwise as in the diagram, name each season that the desk represents.

DESK	SEASON
A	<i>Winter</i>
B	<i>Spring</i>
C	<i>Summer</i>
D	<i>Fall</i>

10. During which season do you see the longest shadow?

During winter when the Sun is closer to the southern horizon.

11. During which season do you see the shortest shadow?

During summer when the Sun is high overhead.

12. When is the shortest period of daylight for the toothpick?

In the middle of winter. This is called the winter solstice.

13. When is the longest period of daylight for the toothpick?

In the middle of summer. This is called the summer solstice.

14. During which season or seasons will the length of day and night be just about the same?

In the middle of both spring and fall. These are called the equinox.

15. Where on the globe and during what season or seasons is it possible to see 24 hours of daylight?

During the winter it is possible to see 24 hours of sunlight from the south pole. And during summer it is possible to see 24 hours of sunlight from the north pole.

THE SEASONS AND TEMPERATURE

16. Which thermometer has the highest temperature after two minutes, the flat or tilted one?

The one that was flat. The rays from the projector strike more directly over its surface and heat it up quicker just like the rays in summer heat the northern latitudes better.

17. Explain how the tilt of the Earth's axis and the temperature of the seasons are related.

The tilt of the axis determines the angle of the Sun's rays and therefore the temperature on Earth.