National Aeronautics and Space Administration

NASA Heliophysics

Teacher-Created Lessons

By teachers for teachers

NASA Heliophysics Education Activation Team

Why Do We Have Seasons?
By Tanya Anderson

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Lesson Overview

Level: Grades 6-8 Time: 3-4 class periods

After completing a class KWL chart students will watch the video NASA Spotlight: What Causes The Seasons and answer questions. Students will then explore the concepts introduced in the video through exploration of several different websites. Next, students will show how light at different angles behaves. Then using hands-on materials, students will experiment with how Earth's 23.5 tilt causes different areas of Earth to receive different amounts of sunlight throughout the year and relate that to Earth's seasons. Students will also use hands-on materials to experiment what would happen on Earth if Earth's axis was not tilted. Finally, students will research the rotational tilt of *other planets in our solar system* and use the hands-on resources to form conclusions about whether or not other planets experience "seasons" during their revolution around the Sun.

Educator Background Knowledge

Educators need a basic knowledge of the Earth's revolution and rotation, and how the Earth's tilt during its revolution around the Sun causes the seasons in the Northern and Southern regions of the planet. Teachers can visit the teacher websites below for background knowledge of the seasons, and on the key vocabulary.

- Reasons for the Seasons (website): https://wardsworld.wardsci.com/geology-earth-science/reasons-for-the-seasons-earth-science-facts-to-make-their-day
- What Causes the Seasons (website): https://www.weather.gov/fsd/season

It will also be helpful for teachers to spend time with the student's digital resources (below) so they are familiar with how they work before students spend time exploring them.

Learning Goals
Using videos, NASA websites students, and hands-on activities students (in small groups) will investigate how the tilt of Earth along with its revolution around the Sun causes the seasons on Earth.

Learning Objectives

1. Using videos and hands-on exploration, students (in small groups) will investigate and be able to identify how the tilt of Earth's axis in relation to the Sun creates the seasons.

Framework for Heliophysics Education
NASA Question: What are the impacts of the Sun on humanity? Big Idea: The Sun is really big and its gravity influences all objects in the solar system.

NGSS Performance Expectations
MS-ESS1-1: Earth's Place in the Universe: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon and seasons.

Targeted STEM Skills

- Teamwork, Collaboration, Communication, Intellectual Curiosity, Planning, Presenting, Problem Solving, Decision Making, and Creativity

Materials

- Laptops/Tablets to watch videos and access websites
- Each small group will need the following materials:
    - Ruler
    - Protractor
- Each student will need access to the following:
    - Paper or notebook for students to record their data

- pen/pencil

For the **Sunlight Distribution Activity**, student groups will need:

- A flashlight, empty toilet paper roll, a protractor, and graph paper

For the **Modeling the Seasons Activity: F**or the whole group, you'll need:

- a 150–200 watt light bulb (not frosted) or a flashlight
- a lamp or socket for the bulb
- an extension cord
- a room that can be made dark

For each student group, you'll need:

- a Styrofoam ball
- a large straw
- a rubber band
- a flexible plastic cup (5.5 oz)
- scissors
- tape
- a thumbtack or sticky dot
- a protractor
- a ruler with centimeters

Handouts

- KWL Chart
- Sunlight Distribution Activity Worksheet
- Student Video Worksheet
- Modeling the Season Worksheet
- Diagram of the tilt of the axis of the planets in our solar system.

Links to Digital Resources for Students

- NASA What Causes The Seasons Video: https://nasaeclips.arc.nasa.gov/spotlite/seasons/seasons_nasa-spotlite--what-causes-seasons-july-2017

- NASA What Causes the Seasons (website): https://spaceplace.nasa.gov/seasons/en/#:~:text=Earth's%20tilted%20axis%20causes%20the,winter%20in%20the%20Northern%20Hemisphere
- Why Do We Have Seasons (Interactive website): https://illinois.pbslearningmedia.org/resource/npls13.sci.ess.seasons/why-seasons/
- Seasons Interactive (interactive website): https://sepuplhs.org/middle/iaes/students/simulations/sepup_seasons5.html
- All About That Tilt: Sun and Seasons (website): https://earthobservatory.nasa.gov/blogs/eokids/wp-content/uploads/sites/6/2019/04/16_SunSeasons-508.pdf

Key Vocabulary
Rotation, revolution, axis, tilt, orbit, season, solstice, equinox

Material Preparation
- Teachers will need to provide each student with a copy of the Student Video Worksheet and the Sunlight Distribution Activity Worksheet.

5E Steps

Engage
Ask students what they know about seasons and what causes them. Create a class KWL using a graphic organizer or on the board. List what they think they know about why we have seasons, and additional questions they have about them.

Pass out the Student Video Worksheet with questions and give the students a moment to look through the questions so they have an idea of what they are listening for as they watch the video. Show the video to introduce the basic facts about why Earth has seasons. NASA Spotlight: What Causes The Seasons: https://nasaeclips.arc.nasa.gov/spotlite/seasons/seasons_nasa-spotlite--what-causes-seasons-july-2017

After viewing the video, lead a discussion with students to identify the misconception addressed in the video. 1. Misconception: Seasons are caused by Earth's distance

from the Sun. 2. Identify key vocabulary words and phrases in the video: Rotation, revolution, axis, tilt, orbit, season, solstice, equinox. Have students answer the questions on their worksheet.

Explore

Part A: Students should use some or all of the following websites to learn about what causes the seasons.

- What Causes the Seasons (website)
- Why Do We Have Seasons (Interactive website)
- Seasons Interactive (interactive website)
- All About That Tilt: Sun and Seasons (website)

Part B: Place students in small groups and guide them through completing the Sunlight Distribution Activity (see Handouts).

Part C: Place students in small groups and guide them through completing the Modeling the Seasons Activity (see Handouts).

Part D: Place students in small groups and guide them through completing the Modeling the Seasons activity a second time but this time they will change the tilt of Earth's axis to 0°instead of 23.5°.

Students should again record their observations during the summer and winter solstice and the spring and autumnal equinoxes.

Explain

Students in their teams should compare and contrast their observations from the 23.5° activity and the 0° activity. This will help students understand that without the tilt of Earth's axis we would not have seasons here on Earth as we know them. Instead, seasons would be latitude dependent with endless summer at equator, and endless winter in the northern latitudes, in between, spring/fall type conditions. For plants, this would be a 24-hour diurnal pattern.

Extend

Students can explore and experiment the tilt of the axis of other planets in our solar system and hypothesize if seasons occur on these planets and how the seasons would be similar or different from the seasons on Earth.

The image of the tilt of the planets from the NASA Jet Propulsion Laboratory is in the Handouts. The link to the diagram and a video and information about the tilt of Uranus, **Dancing Uranus** is here: https://www.jpl.nasa.gov/edu/learn/video/dancing-uranus/

Evaluate

Refer back to the KWL and fill in what students have learned about Earth's seasons, and how they are related to the tilt of Earth's axis. Do a check to see if all of their questions have been answered.

Educators should evaluate the individual answers to the discussion question answers where students compared their results from the 23.5° tilted axis and the 0° tilted axis.

Resources

- KWL Chart
- Student Video Questions Worksheet
- Sunlight Distribution Activity Worksheet
- Modeling the Seasons Activity: https://www.exploratorium.edu/ancientobs/chaco/HTML/TG-seasons.html
- Diagram of the Tilt of the axis of the planets in our solar system.
- NASA What Causes The Seasons Video: https://www.youtube.com/watch?v=nKTB9hFH6nc
- What Causes the Seasons (website)
- Why Do We Have Seasons (Interactive website)
- Seasons Interactive (interactive website)
- All About That Tilt: Sun and Seasons (website)

Handouts

These begin on the next page.

K-W-L Chart

TOPIC:_____

What I **K**now	What I **W**ant to Know	What I **L**earned

Student Video Worksheet

Name_____**Date**_____

1. What causes the seasons on Earth?

2. What role does the tilt of Earth play in the changing seasons?

3. What are solstices and equinoxes? How are they related to the seasons?

4. How are the amounts of heat and light received on Earth related to the angle of the Sun's rays?

Sunlight Distribution Activity Worksheet

You will need a flashlight, empty toilet paper roll, a protractor, and graph paper. Put the toilet paper roll over the end of the flashlight – tape it if you need to so it doesn't fall off. This will focus the light. Use the protractor to establish four different angles of 90°, 60°, 30°, and 0°. You will hold the flashlight in one spot (centered above the graph paper), varying the angle. Outline the area the light covers for each angle. Label each outline by the angle.



Count the number of squares for each angle and record your data. The area indicates the dispersal of light which is a model of sunlight and the amount of solar energy which falls on Earth.

Angle of Light	# full squares	# partial squares
0°		
30°		
60°		
90°		

Discussion Questions:

1. Compare the total areas. What do you think the data means?

2. Together, talk about the amount of solar energy that falls on a given area. What happens when light is not spread out?

3. What happens when the light is more spread out?

4. How does this idea relate to the Sun's energy on Earth?

5. How does the above data relate to different places on Earth's surface like the North Pole, the equator, mid-latitudes, and the equator?

Modeling the Seasons Activity From the Exploratorium

by Lori Lambertson

https://www.exploratorium.edu/ancientobs/chaco/HTML/TG-seasons.html

Students model the seasons with their own Earth globes.

Materials

For the whole group, you'll need:

- a 150–200 watt light bulb (not frosted) or a flashlight
- a lamp or socket for the bulb
- an extension cord
- a room that can be made dark



For each student or pair of students, you'll need:

- a styrofoam ball
- a large straw
- a rubber band
- a flexible plastic cup (5.5 oz)
- scissors
- tape
- a thumbtack or sticky dot
- a protractor
- a ruler with centimeters

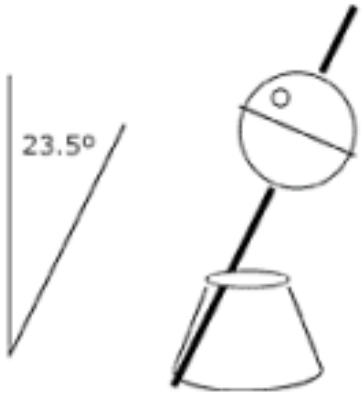
Making a Model of the Earth

Push the straw through the center of the Styrofoam ball. This represents the axis about which Earth rotates. One end is north and the other end is south. Place a rubber band around the center of the ball (Earth's equator). Looking at a globe or a

map, find your approximate latitude, and place the tack or dot there. (For example, San Francisco is at 37.75° north, so placing the tack not quite halfway between the equator and the North Pole is an acceptable approximation.)

Use the scissors to make a hole in the bottom of the plastic cup, near the side, as shown above. It should be just large enough to accommodate the diameter of the straw. Take an 8-cm piece of tape and stick a 2-cm piece to the center of the 8-cm piece (sticky sides together). Place the straw into the hole in the cup, and use the modified tape to hold the straw against the side of the cup, yet still allowing the straw to rotate in the hole.

Your model should look something like the picture on the left. Use a protractor to check the angle of Earth's tilt. It should be 23.5 degrees.



Setting up the Room

Use one bright lamp for the whole group or flashlights for small groups. Designate some visual reference as Polaris, the North Star. All straws should point to Polaris throughout the activity. Set up the light in the center of the group or flashlights in the center of each small group. Before darkening the room, make sure all Earth models are oriented correctly toward polaris. Darken the room.

To Do and Notice: Model a "Day" on Earth

Each student should turn the straw so that Earth spins counterclockwise (when viewed from the north) for one rotation. They should notice that the dot is in light (day) for about half of the rotation and is in shadow (night) for about half of the rotation.

Modeling the Seasons

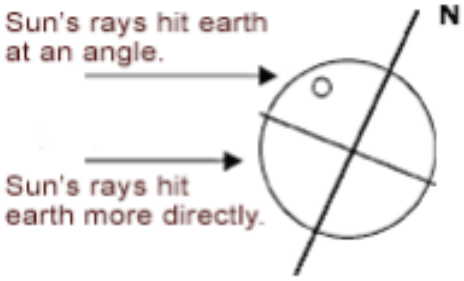
Divide the class into four groups. Have each group move to one of the four seasonal positions around the lamp (or one student at each position around a flashlight if using small groups): December 21, March 21, June 21, and September 21. It should look like the image below, if seen from above:



Have each group model a day at each position. At each position, they should notice:

- For what fraction of the day is the dot in the light? More than half? Less than half? About half?
- For what fraction of the day is the North Pole in the light?
- How is the light from the Sun striking the dot? Is it direct or at an angle?

For example, on December 21:
Angle at or above equator, direct below equator



Modeling a Year

After students have been to each of the four dates: December 21, March 21, June 21, and September 21, they'll have modeled a year: one Earth revolution around the Sun.

What's Going On?

Many people think the seasons are caused by variations in our distance from the Sun. While Earth's orbit is slightly elliptical, it's very close to circular, and the variation in distance between Earth and Sun is not enough to account for our seasons. The seasons are caused by the tilt of Earth. Earth holds its rotation axis (tilt) fixed in space as it moves around the Sun. In the summer, the Northern Hemisphere tilts toward the Sun. It's warmer because: (1) there are more hours of daylight, providing us with more heat energy, and (2) the midday Sun shines more directly, increasing the amount of solar energy Earth receives. In the winter, when the Northern Hemisphere tilts away from the Sun, the Sun's rays strike Earth at a lower angle, and the energy from the sunlight is spread out over a larger area, which reduces its effectiveness at heating the ground. Combined with shorter daylight hours, the temperatures are cooler in winter. The seasons in the Northern and Southern Hemispheres are opposite.

Teacher Tips for Modeling the Seasons

Grade Level
5-8

National Standards Addressed
Grades 5-8:
Earth and Space Science: Earth in the Solar System
Science as Inquiry: Design & Conduct Investigation, Analyze & Interpret Data, Develop Explanations, Think Critically

Key Concepts
Seasons, rotation of Earth, Earth's axis, day and night, Earth's orbit around the sun.

Background Science
Seasons of the year
http://www-istp.gsfc.nasa.gov/stargaze/Sseason.htm

NASA Now: Reasons for Seasons
https://www.youtube.com/watch?v=M4BbW8AwJ0o

Ideas for Discussion
The Sun dagger petroglyph (see link below) was a way for the Chacoans to know when the seasons were changing. Why would this be important for them?

Sun dagger petroglyph:
http://www.exploratorium.edu/chaco/HTML/sundagger.html

How do you know when the seasons are changing? Do you use signs that the Chacoans may have used? What modern signs tell you that the seasons are changing?

How does the change of the seasons affect you?

Related Media
Our Seasons has a description of how sunlight is affected by the Earth's tilt and orbit: http://www.exploratorium.edu/chaco/HTML/seasons.html

See an animation showing how the Sun moves across the horizon throughout the

year (requires the Flash Plugin):
http://www.exploratorium.edu/chaco/HTML/TT-seasons.html

See an animation showing how the area of the globe that is in sunlight changes throughout the year (requires the Flash Plugin):
http://www.exploratorium.edu/chaco/HTML/seasons.html

What Time Is It on Mars? The Mars24 software displays a Mars sunclock, a graphical representation of the planet Mars showing its current sun- and nightsides, along with a numerical readout of the "standard" Mars time as well lander and other local times.
https://www.giss.nasa.gov/tools/mars24/

Going Further

Revisit the year stations. Notice the angle at which the Sun strikes your dot during the summer versus during the winter. In which season are you the most likely to get sunburned? Why?

• Imagine you're living on the equator. How would you describe the change of seasons?

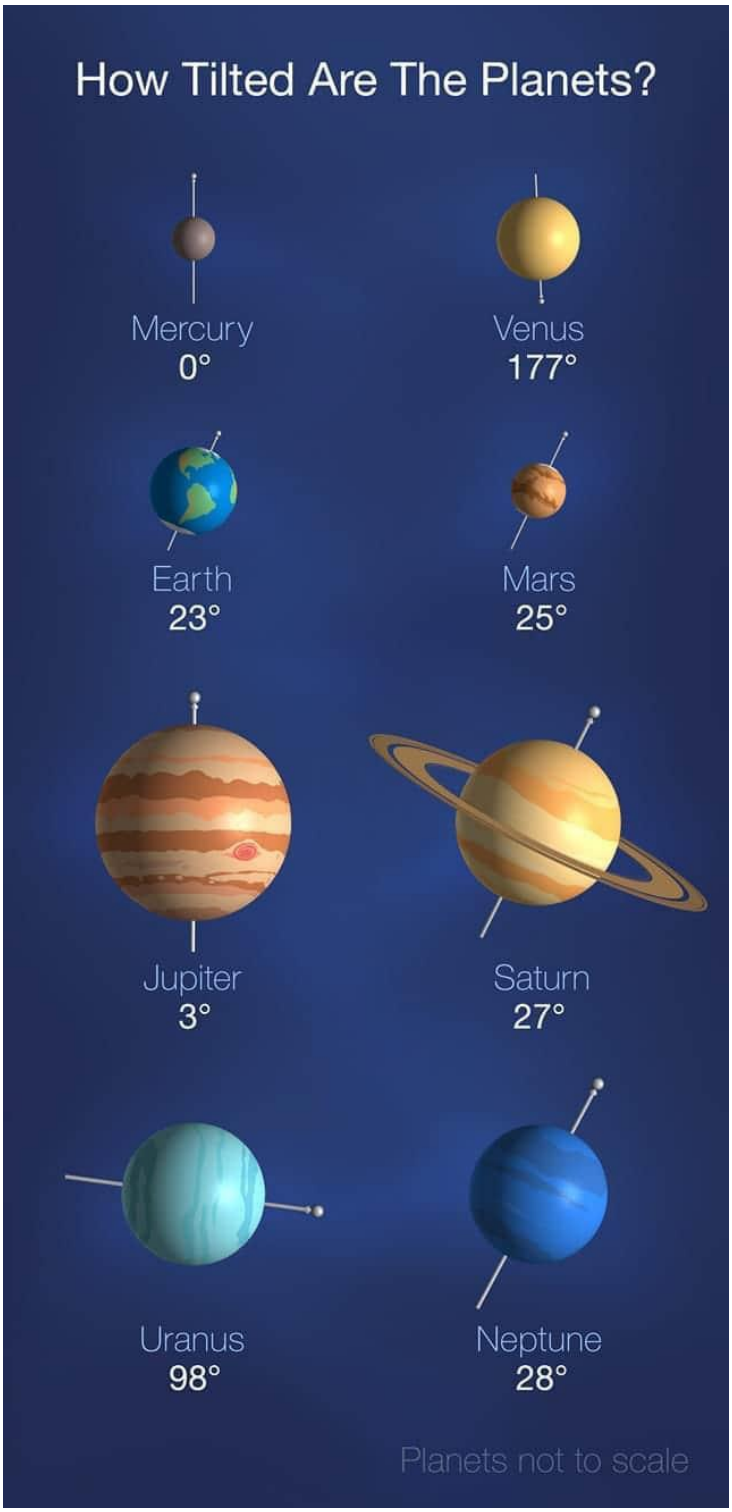
• Now imagine that you're at the North Pole in the summer. What path does the Sun take across the sky?

Check for Understanding

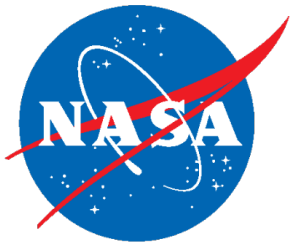
What special aspect of the sun's position or movement do we mark with the solstices and the equinoxes? What would seasons on Earth be like if the axis was not tilted?

Credit: Lori Lambertson for The Exploratorium.
https://www.exploratorium.edu/ancientobs/chaco/HTML/TG-seasons.html

Tilt of axis of the planets in our solar system


How Tilted Are The Planets?
Mercury
0°
Venus
177°
Earth
23°
Mars
25°
Jupiter
3°
Saturn
27°
Uranus
98°
Neptune
28°
Planets not to scale

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