Seasons

Overview: One common misconception is that the seasons are caused by how close the Earth is to the Sun. Today you get to do an experiment that shows how seasons are affected by axis tilt, not by distance from the Sun. And you also find out which planet doesn't have sunlight for 42 years.

What to Learn The seasons are caused by the Earth's axis tilt of 23.4^{o} from the ecliptic plane.

Materials

- Bright light source (not fluorescent)
- Balloon
- Protractor
- Masking tape
- 2 liquid crystal thermometers
- Ruler, yardstick or meter stick
- Marker

Experiment

1. For a light source, try lamps with 100W bulbs (without lamp shades). Make sure there's room to walk all the way around it. You'll want to circle the lamp at a distance of about 2 feet away.
2. Mark on the floor with tape and label the four positions: winter, spring, summer, and fall. They should be at the 12, 3, 6, and 9 o'clock positions. Winter is directly across from summer. The Earth rotates counterclockwise around the Sun when viewed from above.
3. Blow up your balloon so it's roughly round-shaped (don't blow it up all the way). Mark and label the north and south poles with your marker. Draw an equator around the middle circumference.
4. The Earth doesn't point its north pole straight up as it goes around the Sun. It's tilted over 23.4^{o}. here's how you find this point on your balloon:
    a. Put the South Pole mark on the table, with north pointing straight up. Find the midway point between the equator and the North Pole and make a tiny mark. This is the 45^{o} latitude point. You'll need this to find the 23^{o} mark.
    b. Find the midway point between the 45^{o} and the North Pole and make another mark, larger this time and label it with 23^{o}. When this mark is pointing up, the Earth is tilted over the right amount.
    c. You'll need to do this three more times so you can draw a line connecting the dots. You want to draw the latitude line at 23^{o} so you can rotate the balloon as you move around to the different seasons. The line will always be pointed up.
5. Place the thermometers on the balloon at these locations:
    a. Find the halfway point between the South Pole and the equator. Put one thermometer on this mark.
    b. Put the other thermometer on the northern hemisphere's 45^{o} mark from above.
6. Make sure your lamp is facing the balloon as you stand on summer. Let the balloon be heated by the lamp for a couple of minutes and then record the temperature in the data table.
7. Rotate the lamp to point to fall. Move your balloon to fall, rotating the balloon so that the thermometers are facing the lamp. Wait a few more minutes and take another reading.
8. Rotate the lamp to point to winter. Move your balloon to winter, rotating the balloon so that the thermometers are facing the lamp. Wait a few more minutes and take another reading.

9. Rotate the lamp to point to spring. Move your balloon to spring, rotating the balloon so that the thermometers are facing the lamp. Wait a few more minutes and take another reading. You've completed a data set for planets with an axis tilt of about 23^{o}, which includes the Earth, Mars, Saturn and Neptune.
10. Repeat steps 1-9 for Mercury. Note that Mercury does not have an axis tilt, so the North Pole really points straight up. Jupiter (3.1^{o} axis tilt) and Venus (2.7^{o}) are very similar. The Moon's axis tilt is 6.7^{o}, so you can approximate these four objects with a 0^{o} axis tilt.
11. Repeat steps 1-9 for Uranus. Since the axis tilt is 97.8^{o}, you can approximate this by pointing the north pole straight at the Sun during summer (90^{o} axis tilt). The orbit for Uranus is 84 years, which means 21 years passes between each season. The north pole will experience continued sunlight for 42 years from spring through fall, then darkness for 42 years.

Seasons Data Table

Don't forget to circle or label your units!
Note that Uranus's axis tilt is approximated by 90^{o} and Venus, Jupiter, and Mercury's axis tilt are approximated by 0^{o}

Axis Tilt	Season	Northern Hemisphere Temperature (^{o}C / ^{o}F)	Southern Hemisphere Temperature (^{o}C / ^{o}F)
23^{o}	*Summer*		
23^{o}	*Fall*		
23^{o}	*Winter*		
23^{o}	*Spring*		
0^{o}	*Summer*		
0^{o}	*Fall*		
0^{o}	*Winter*		
0^{o}	*Spring*		
90^{o}	*Summer*		
90^{o}	*Fall*		
90^{o}	*Winter*		
90^{o}	*Spring*		

Reading

The north and south poles only experience two seasons: winter and summer. During a South Pole winter, the Sun will not rise for several months, and also the Sun does not set for several months in the summer. We go into more detail about how this works in a later lesson entitled: *Star Trails and Planet Patterns*.

At the equator, there's a wet season and a dry season due to the tropical rain belt. Since the equator is always oriented at the same position to the Sun, it receives the same amount of sunlight and always feels like summer.

The changing of the seasons is caused by the angle of the Sun. For example, in June during summer solstice, the Sun is high in the sky for longer periods of time, which makes warmer temperatures for the Northern Hemisphere. During the December winter solstice, the Sun spends less time in the sky and is positioned much lower. This makes

the winters colder. (Don't forget that seasons are also affected by oceans and winds, though this is out of the scope of this particular activity.)

Exercises

1. What is the main reason we have seasons on Earth?
2. Why are there no sunsets on Uranus for decades?
3. Are there seasons on Venus?

Answers to Exercises: Seasons

1. What is the main reason we have seasons on Earth? (Because the axis is tilted 23.4^{o}, exposing one hemisphere to more sunlight each day and warming the planet.)

2. Why are there no sunsets on Uranus for decades? (The orbit for Uranus is 84 years, which means 21 years pass between each season. The north pole will experience continued sunlight for 42 years from spring through fall, then darkness for 42 years.)

3. Are there seasons on Venus? (No. It's the same temperature (460^{o}C) everywhere you go on the planet for two reasons: first the axis tilt makes almost difference between summer and winter. Second, the thick atmosphere traps the heat, which flows around the planet.)