Seasons

Introduction: 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.

The seasons are caused by the Earth's axis tilt of 23.4° from the ecliptic plane. Earth is constantly tilted as it orbits around the sun. Because of this tilt, at different points in its orbit, different parts of the earth are tilted closer or further away from the Sun. This causes temperature changes which we see as the four seasons.

Materials:

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

Procedure:

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°. here's how you find this point on your balloon:

1. 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° latitude point. You'll need this to find the 23° mark.
2. Find the midway point between the 45° and the North Pole and make another mark, larger this time and label it with 23°. When this mark is pointing up, the Earth is tilted over the right amount.
3. 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° 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:
   1. Find the halfway point between the South Pole and the equator. Put one thermometer on this mark.
   2. Put the other thermometer on the northern hemisphere's 45° mark from above.
6. Make sure your lamp is facing the balloon as you stand on summer. Be sure to have the balloon's axis on the 23° mark, not straight up and down. Let the balloon be heated by the lamp for a couple of minutes and then record the temperature in the data table below.
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°, which includes the Earth, Mars, Saturn and Neptune.

Season	Temperature North Hemisphere (°F)	Temperature South Hemisphere (°F)
Summer		
Fall		
Winter		
Spring		

What do you notice about the temperatures in the different seasons? You should see the temperature is higher during summer compared to winter. You should also see that the southern hemisphere is the opposite, with the winter being the warmer of the two!

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° axis tilt) and Venus (2.7°) are very similar. The Moon's axis tilt is 6.7°, so you can approximate these four objects with a 0° axis tilt

Season	Temperature North Hemisphere (°F)	Temperature South Hemisphere (°F)
Summer		
Fall		
Winter		
Spring		

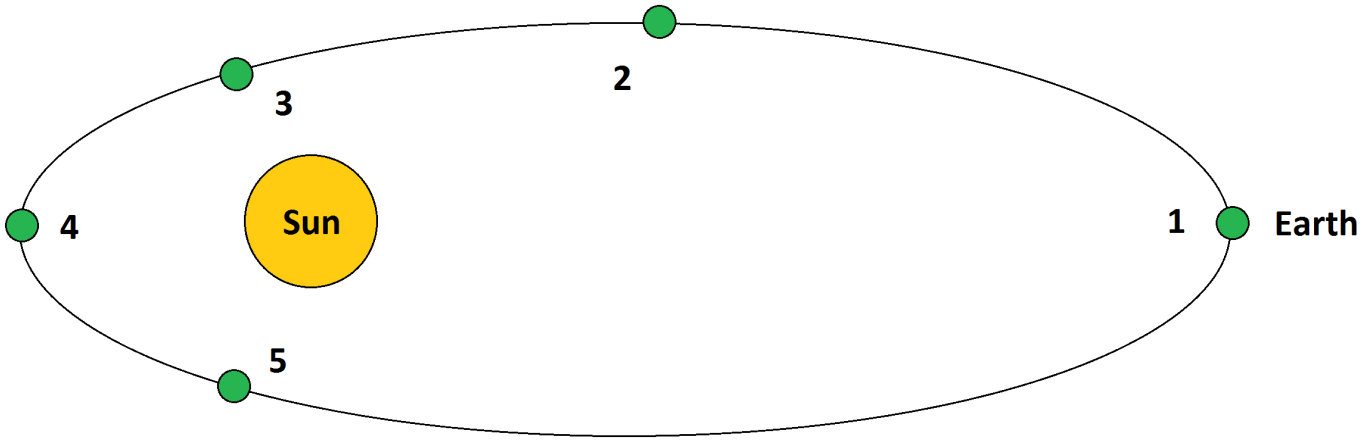
What do you notice with the temperatures of the different seasons with the 0° tilted planets? You should see no change in the temperatures from season to season!

Repeat steps 1-9 for Uranus. Since the axis tilt is 97.8°, you can approximate this by pointing the north pole straight at the Sun during summer (90° 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.

Season	Temperature North Hemisphere (°F)	Temperature South Hemisphere (°F)
Summer		
Fall		
Winter		
Spring		

Problems:

1. What would happen to temperatures on Earth if its orbital period was still one full year, but it went through a much more elliptical path (shown below). List in order the temperatures from hottest to coldest.



2. What would affect temperatures on Earth more, changing to this elliptical orbit, or changing to a 90° axis tilt like Uranus? Assume the distance form the Sun at position 1 is the normal average distance.

Answers:

1. 3 and 5 are the same, 4, 2, 1
2. The elliptical orbit will affect temperatures more than an axis tilt like Uranus. In fact, Uranus' temperatures range form -243 °F to -370 °F depending on the season. The temperature on Venus (the next closest planet to the Sun from the Earth) can get up to 480 °F! This is because it's much closer to the Sun.