Earth Science   Name:

<p style="text-align:center">Four Special days – The Equinoxes and Solstices</p>

Introduction

For thousands of years, people noticed changes in the apparent path of the Sun across the sky. . For us here on Earth, it appears that the sky is a huge **celestial hemisphere**, with the Sun moving across it. It's easy to see that the Sun rises always on one side of your home (**"east"**), then seems to move to its highest point (but not directly overhead) in the middle of the day (**"south"**), and then sets on the opposite side of your home (**"west"**). If you are in places like Brazil or Australia, most of the time the Sun is to your **north** at midday when it is highest in the sky.

It took a very long time before people realized that it is actually the Earth that moves/spins/ rotates, which makes the Sun seem to move. For most people, this is a very difficult concept to understand. If you watch the Sun set below the horizon, it's hard to think that what you see is caused by the Earth turning you away from where the Sun can be seen. But understanding the apparent motions of the Sun, the Moon, planets, and stars are important parts of Earth Science.

People also noticed that there are four special days during the annual cycle of solar movement. On one of these days, the Sun is as high in the sky as it ever gets, and we have the longest day length and shortest night length. We call this the **summer solstice**. Six months later, the Sun is at its lowest point above the horizon at midday; this is the **winter solstice**. On two days of the year, the Sun seems to rise exactly in the east and set exactly in the west, and we have almost exactly 12 hours of day length and 12 hours of night. These are the **equinoxes.**

In this activity, you will learn more about these important concepts by making simple models of the Sun's apparent path on these dates. Please try to read and carry out the directions carefully and on your own—following instructions is VERY IMPORTANT IN SCIENCE AND MOST OTHER ACTIVITIES!

Part 1 – Modeling the Sun's Path During the Equinoxes

Obtain a **plastic hemisphere, external protractor, masking tape, paper marked off with N-S-E-W,** and a pen.

Place the hemisphere so kits highest point is directly over the intersection of the N-S and E-W lines on the paper. The highest point is called the **zenith**, and this is what you would see if you looked straight above your head—at a 90° angle from the horizon. Looking in all other directions appears to be going downward from the top of this celestial dome.

Take a long piece of masking tape and place it so it goes from the "South" mark over the zenith to the "North" mark. Then take two short pieces of the masking tape and mark the east and west points.

If you were on the equator at an equinox date, the Sun would be at zenith, directly over your head at **solar noon**. (This is different from clock noon, but we'll discuss this in another activity.) But we

here in Englewood at located at 40° North latitude, so the Sun is not at our zenith. It is at a 90 – 40 = 50° angle above the horizon. Place the protractor so the 90° mark is at the zenith and the 0° mark is on the south. Then mark on the masking tape where 50° lies.

Next, take a long piece of masking tape and place it so it starts at the east mark, passes through 50° mark on the south-zenith-north tape, and comes down to the west mark. This represents the apparent path of the Sun at the time of the equinox.

Using your protractor, how many degrees does the Sun seem to move through going from the east mark on the horizon to the center of the south-zenith-north line? _____
From that line to the west mark on the horizon? _____

If you measured 90° on each side, you marked the tape correctly. If you did not, try to figure out what caused your error.

Part 2 – Modeling the Sun's Paths at the Solstices

At the time of the Summer Solstice, the Sun is at zenith at 23-1/2° North—the Tropic of Cancer. This name comes from observations made thousands of years ago by Greek astronomers who noticed the Sun's path seemed to change ("Tropic") during the month dedicated to the sky constellation Cancer the Crab, equivalent to our month of June. This is when the Sun gets to its highest point above the horizon. At the Summer Solstice, the Sun would be 50° + 23-1/2° = 73-1/2° above the southern horizon.

Mark this point on the south-zenith-north tape. Then find the point which would be 23-1/2° toward the north of your east mark on the horizon. Take a long piece of masking tape and place it from that point through the 73-1/2° mark to a point 23-1/2° north of your west mark. This tape should be more or less parallel to the equinox tape your placed previously.

Using your protractor, how many degrees does the Sun seem to move through going from the east mark on the horizon to the center of the south-zenith-north line? _____
From that line to the west mark on the horizon? _____

You should have measured angles greater than 90° on each side. If you did not, try to figure out what caused your error.

Now make a mark on the south-zenith-north tape which is 50° - 23-1/2° = 26-1/2° above the southern horizon. Find the points which are 23-1/2° south of the east and west marks on the horizon. Place a piece of masking tape from these points through your 26-1/2° mark.

Again, using your protractor, how many degrees does the Sun seem to move through going from the east mark on the horizon to the center of the south-zenith-north line? _____
From that line to the west mark on the horizon? _____

You should have measured angles less than 90° on each side. If you did not, try to figure out what caused your error.

You probably already know that Earth makes one rotation (spin/turn) of 360 ^{o} in one day or 24 hours. This motion is what causes us here on the Earth to see the Sun as crossing the sky from east to west—we are really turning west to east.

How many degrees does the Sun appear to move in one hour. Show how to calculate this in the space below. (Hint—you want an answer in units of "degrees per hour" or " ^{o}/hr ").

Check with your teacher or classmates to be sure you found the correct answer.

Now, using this value and the number of degrees you measured along the paths for the equinoxes and solstices on your model, figure out how long the day would be at each of these important dates. Do the calculations as "degrees" / "degrees per hour" = "hours."

Equinoxes:

Summer Solstice:

Winter Solstice:

<u>Checking your answers</u>

Find out how accurate you were by going to the US Naval Observatory "Sun and Moon Data for One Day" website (*aa.usno.**navy**.mil/data/docs/RS_OneDay.php)* for Englewood NJ.

<u>Equinox</u> – Use Sep 20 or Mar 20, and record the times for sunrise _____ and sunset _____. Figure out the total day length—show your work below, and put your answer inside a box.

How close were you to the day length your worked out from the model? What might produce differences?

<u>Summer Solstice</u> – Use Jun 20, and record the times for sunrise _____ and sunset _____. Figure out the total day length—show your work below, and put your answer inside a box.

How close were you to the day length you worked out from the model? What might produce differences?

<u>Winter Solstice</u> – Use Dec 20, and record the times for sunrise _____ and sunset _____. Figure out the total day length—show your work below, and put your answer inside a box.

How close were you to the day length you worked out from the model? What might produce differences?