Name: _____ Date: _____ Period: _____

Have you ever wondered why we have seasons or even why there are places on Earth that rarely drop below 70 degrees Fahrenheit, while other places may struggle to reach a temperature above freezing? The amount of heat delivered to Earth from the sun varies due to the tilt of the Earth and Earth's positioning in its revolution around the sun. In this lab we will discover why we have seasons and what causes this unequal heating of the earth.

Essential Questions:

1. Why do we have seasons on Earth?
2. Why is the earth heated unequally?

Purpose of the lab: To determine the relationship between the angle of insolation and the concentration of energy delivered to Earth's surface during different points in Earth's revolution around the sun.

Observation/Research:

The Earth tilts _____ on its axis as it orbits the sun. This _____ is what causes seasons on our planet. The 23.5 degree tilt causes the sun to take different _____ across the sky during different seasons. During the summer the sun takes a _____ path across the sky than it does during the winter.

Heat is delivered to Earth's surface through a type of heat transfer called _____. Radiation is the direct _____ of heat by a specific type of electromagnetic waves called ultraviolet radiation. Incoming solar radiation is called _____ (**In**coming **Sol**ar Radia**tion**). The amount of insolation depends on two factors:

1. The _____ or how long the surface receives sunlight.
2. The _____ of the sunlight, which depends on the angle between the sun's rays and the surface, which is called the _____ of insolation. If the sun is directly overhead the angle of insolation is 90 degrees. If the sun is at the horizon the angle of insolation is 30 degrees.

Part I: Marshmallow Seasons

Procedure:

1. Put Seasons Placemat on top of the Styrofoam board.
2. Stick one toothpick in each position of the Earth's orbit indicated by circles. There are 8 circles and 8 toothpicks.
3. Stick a different toothpick in each of the 8 marshmallows at a 23.5-degree angle to represent the tilted axis of Earth.
4. Place one of marshmallow with the tilted axis on each of the 8 toothpicks set up in the Styrofoam board.
5. Observe the model that you have created. Use this model to answer the analysis questions.
6. When you are done with the questions from Part I, raise your hands to have the answers checked by the teacher. You may not move on to Part II until approved by the teacher.

Marshmallow Seasons Analysis Questions:

1. What day, in the northern hemisphere does the axis of Earth point....

towards the sun? _____

away from the sun? _____

Sideways to the sun? _____ & _____

2. What date, in the northern hemisphere, would the following occurrences take place?

Autumnal Equinox: _____

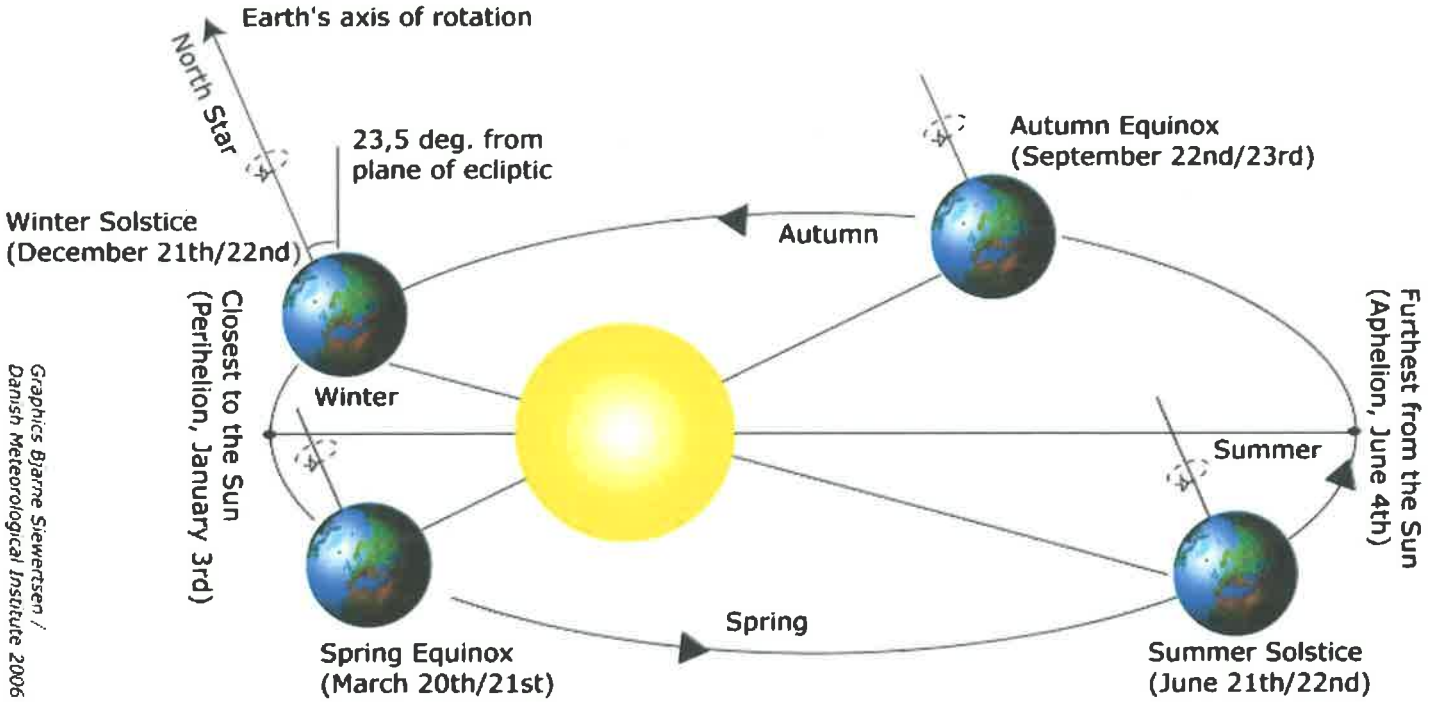
Winter Solstice: _____

Spring Equinox: _____

Summer Solstice: _____

Choices:
June 21st
December 21st
September 23rd
March 20th

3.



Graphics Bjarne Siewertsen / Danish Meteorological Institute 2006

Look at the position of the marshmallow during the Winter Solstice. Which hemisphere would receive the most direct sunlight (northern or southern)? Explain and describe the seasons of the northern and southern hemispheres when Earth is in this position.

_____

_____

_____

_____

4. Look at the position of the marshmallow during the Autumnal Equinox. Imagine where the sunlight would fall on the marshmallow in this position and compare the amount of sunlight the northern and southern hemispheres would receive.

_____

_____

_____

_____

5. What latitude on Earth receives the most amount of direct sunlight all year long? Why is this true?

6. During the Summer Solstice at the North Pole, the sun never sets. What do you think is happening at the South Pole when the Earth is in this position?

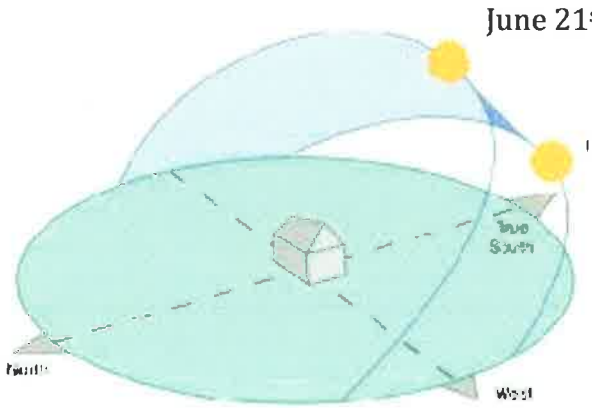
7. Describe how the length of daylight changes from the Equator to the North Pole on December 21st and explain the reasoning for your answer.

8. Looking at the model, imagine the position of the Earth in its revolution around the sun today. Describe and explain the seasonal changes that are getting ready to take place in Ohio.

Part II: Angle of Insolation

Procedure:

1. Place the flashlight in the clamp on the ring stand so that it is 10 centimeters above the grid paper.
2. Shine the flashlight straight down to create a 90-degree angle of insolation.
3. Have a group member trace the outline of the bright circle of light on your grid paper.
4. Lightly shade this area in with a pencil and label it as 90°.



5. You will now try to estimate the number of squares shaded in for the 90° angle of insolation. Count each fully shaded square and record the number in the data table in the Full Squares column. Then count the squares that are more than ½ shaded and record this number in the data table. Next count all of your half squares and record this number in the data table. Ignore all squares that are less than ½ shaded. Total all of the numbers for a 90° angle of insolation and record under total squares.

6. Now move to a different spot on your grid paper. Use the protractor to determine a 60° angle of insolation and repeat the same steps you did to estimate the area for the 90° angle of insolation. Record your data in the data table.
7. Follow this same procedure for a 30° angle of insolation.

Angle of Insolation Data Table

Angle of Insolation	Full Squares	> Half Squares	Half Squares # ½ = # whole		Total Square Cm
90°					
60°					
30°					

8. You should now have three different shapes on your paper and three different areas in square centimeters. Now you will have to figure out how much light is landing on each square centimeter in each case. This can be figured out since we know your flashlight produces **8 lumens** (unit to measure the amount of light emitted from a source- brightness).
9. Take the number of lumens and divide it by the number of square centimeters for each case. Place your answers in the space provided below.

_____ lumens/ 90° angle had _____ sq. cm = _____ lumens per square centimeter

_____ lumens/ 60° angle had _____ sq. cm = _____ lumens per square centimeter

_____ lumens/ 30° angle had _____ sq. cm = _____ lumens per square centimeter

Angle of Insolation Analysis Questions:

1. In which case is all of the light concentrated into the smallest area? _____
2. What happens to the illuminated area as the angle of insolation decreases? _____

_____

3. In which case is the intensity of light the greatest? Why?

4. Determine which angle of insolation would best match each season.

90° angle of insolation equates best to what season(s)? _____

60° angle of insolation equates best to what season(s)? _____

30° angle of insolation equates best to what season(s)? _____

5. Does the distance between the sun and Earth cause the seasons? Explain.

6. Why do you think noontime shadows are longer in the winter than in the summer?

7. As Earth revolves around the sun, it is actually about 5 million miles closer in January than it is in July. Despite being closer, Ohio weather is much colder in January than in July. Why?

   a. (Think of Earth's tilt and revolution)

   b. (Think of angle of insolation/intensity of light)

   c. (Think of the length of time exposed to sunlight)

5. What latitude on Earth receives the most amount of direct sunlight all year long? Why is this true?

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