Solar Insolation and Heat Transfer In The Earth

Earth Science/Geology **Mr. Traeger**

Name: _____ Period: ____ Date: _____

Background

The purpose of this lab is to investigate how heat transfer in the Earth affects temperature ranges in a particular area. The effects of sun angle will also be investigated.

Materials

- 1 beaker filled with sand
- 1 beaker filled with water
- 3 Celsius thermometers
- 1 beaker filled with soil
- heat lamp mounted on a stand
- stop watch

Part 1 Procedure: Heating of Water and Land Surfaces

Be safe! Exercise extreme caution when around electricity and water! The heat lamp is very hot! Do not get your hands near the bulb!

1. Move each beaker ***directly*** under the heat lamp, but *do not* turn on the lamp yet.
2. Place a thermometer in each beaker so the thermometer bulb is *just* below the surface. Tie the thermometer for the water to the ring on the stand. You may need to hold the thermometers in the sand and soil. *None* of the thermometers should be touching the side of the beaker.
3. Record the initial temperature of each substance in degrees Celsius. Put this reading under time = 0 in the table titled ***Heating*** below.
4. Turn on the lamp. Record the temperature of each substance in 1-minute intervals. Use the stopwatch to time these intervals. You will record temperature every minute until 10 minutes have passed.
5. Now turn off the lamp. Take the temperature of each substance in 1-minute intervals until another 10 minutes have passed.
6. Graph the data from the **Heating** and **Cooling** tables on the appropriate grid. Use a **triple-line** graph. You will have one line for each substance. On the horizontal axis, you should have time in minutes. On the vertical axis, you should have temperature in °C. Make sure to give a title to your graph, label both axes, *scale* your graph appropriately, and include a legend for what each line means.

Part 1 Analysis Questions

1. **Heating**: Which substance heated up the fastest? Which one heated the slowest?

Fastest?	Slowest?

2. **Geology**: Calculate the average slope (change in y/change in x) for heating of each substance in °C per minute.

Sand Soil Water

3. **Cooling**: Which substance cooled down the fastest? Which one cooled down the slowest?

Fastest?	Slowest?

4. **Geology**: Calculate the average slope (change in y/change in x) for cooling of each substance in °C per minute.

Sand Soil Water

5. **Geology: Calculate Energy Required to Heat a Substance:** The specific heat capacity of a material is the amount of heat (in Joules) required to raise the temperature of a one-gram mass by 1°C. The formula is:

Heat energy (q) = Mass (m) X Specific Heat (c_s) X Change in Temperature (ΔT)

Or

$q = mc_s\Delta T$

Calculate the amount of energy (in Joules) that is needed to heat 1 gram of each of the following substances by 10° Celsius:

Sand (SiO_2)
c_s = 0.739 J / °C X g

Water (H_2O)
c_s = 4.18 J / °C X g

6. Which substance requires more energy to heat it to the same temperature? Why?

7. From what you have seen in this lab, why do you think that it is generally cooler near the ocean during the day? Why is it generally warmer the farther you go inland ***during the day***?

8. Would coastal areas be warmer or colder than deserts ***at night***? Why?

9. What would happen to the temperature of the sand if it were black?

Part 2 Procedure: Intensity of Insolation

1. Put new water in your beaker. Make sure that the sand and soil have cooled back down to their original temperatures.
2. Move each beaker ***at an angle*** under the heat lamp, but *do not* turn on the lamp yet. Try to keep your lamp at the same distance from the beakers as in part 1.
3. Repeat the steps as outlined in Part 1 for recording and graphing data.

Part 2 Analysis Questions

1. Look at your second graph and compare it to your first. How did the temperatures change, if at all?

2. What would the length of the day do for the amount of heating of the earth?

3. What would the time of the day do for the amount of heating of the earth?

4. Based upon your observations, explain the reasons for our seasons? Draw a picture if needed!

5. Why are the Poles generally cold and the Equator is generally warm?

6. How would the presence or absence of clouds affect temperature in the day? How about at night?

Graph for Part 1: Light Source Directly Above Surface

Heating: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	0	1	2	3	4	5	6	7	8	9	10
Sand											
Water											
Soil											

Cooling: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	11	12	13	14	15	16	17	18	19	20	
Sand											
Water											
Soil											

Graph for Part 2: Light at an Angle to Surface

Heating: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	0	1	2	3	4	5	6	7	8	9	10
Sand											
Water											
Soil											

Cooling: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	11	12	13	14	15	16	17	18	19	20	
Sand											
Water											
Soil											

Error Analysis

Discuss some possible errors with this lab. Why is it not a perfect representation of the real world?