Solar Insolation and Heat Transfer In The Earth

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
- Vernier Probes with thermometers
- 1 beaker filled with soil
- heat lamp (150W) 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 or temperature probes near the bulb!

1. Move each beaker ***directly*** under the heat lamp, but *do not* turn on the lamp yet. Each beaker should be a distance of 10 cm from the lamp. Be careful that the cords are not near the lamp!
2. Place a thermometer in each beaker so the thermometer tip is *just* below the surface. Clamp the thermometer for the water to the clamp 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 or the light.
3. Set up the Vernier probes and turn on the calculator. Make sure all of the probes are plugged in and that the cable from the calculator to the Lab Pro is plugged in. Select **Apps** and then select **Datamate**. You should then hit the **clear** button. You should now see your three temperatures. Ch.1 = Sand, Ch. 2 = Soil, Ch. 3 = Water
4. Record the initial temperature of each substance in degrees Celsius. Put this reading under time = 0 in the table titled ***Heating*** below.
5. 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.
6. Now turn off the lamp. Take the temperature of each substance in 1-minute intervals until another 10 minutes have passed.
7. 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. 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. Calculate the average slope (change in y/change in x) for cooling of each substance in °C per minute.

Sand Soil Water

5. **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?

10. Why are oceans such good transporters of heat throughout the planet?

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 a 45° 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 diagram below!

5. Why are the Poles cooler and the Equator is warmer?

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 (1)											
Soil (2)											
Water(3)											

Cooling: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	11	12	13	14	15	16	17	18	19	20	
Sand (1)											
Soil (2)											
Water(3)											

Graph for Part 2: Light at a 45° Angle to Surface

Heating: Record Temperature in Degrees Celsius

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

Cooling: Record Temperature in Degrees Celsius

Beaker	Time (minutes)										
	11	12	13	14	15	16	17	18	19	20	
Sand (1)											
Soil (2)											
Water(3)											

Error Analysis

Discuss some possible errors with this lab. In what ways is it a good representation of heat transfer in the Earth? In what ways is it not a good representation of heat transfer in the Earth?