

Teacher Information

This lesson is tiered by readiness and degree of support. You can use the prelab assessment at the end of the document to assess students readiness with math skills - particularly analyzing graphs. You can also group students based on your prior knowledge of their skills and prior performance on lab investigations.

Tiering:

Task 1 is for students who have difficulty analyzing graphs for meaning, they are “not yet ready”. This task, as written, offers more support to students for the procedure of the investigation with step by step instructions. These students would be able to look at a graph and give rudimentary information from their analysis. In Task 1, students are asked to collect and graph data and then make observations and comparisons about what the graphs tell them qualitatively.

Task 2 is for students who are “just ready” to go at grade level skills in analyzing graphs. The analysis asks students to calculate initial slope - taught in 8th grade math. The lab is described with “procedural guidelines”, as opposed to step by step instructions. These students would be able to look at a graph and describe the information given, they may use “slope” and make interpretations. In task 2, students are asked to collect and graph data and then calculate the initial slope of the line of each set of data. They make comparisons between these slopes and link this to the rate of cooling. Students in Physics 1 have worked with slopes of lines in 8th grade math.

Task 3 is for students who are “ready to go” and are in a math course Algebra 2 and beyond. These students know how to look at a graph and determine the type of mathematical function the graph is displaying. They also know how to carry out an investigation given a question and procedural guidelines. In task 3, these students will use the LabQuest 2 devices and thermometers to collect data. They are asked to analyze the graph of the data using the LabQuest 2 to get an equation to fit the line. The equation that matches is $T = Ae^{-Ct} + B$, where A is the difference between t_0 and t_f , C is a constant, B is the final room temperature. This equation is beyond Physics 1, but appropriate for students in Algebra 2 and beyond.

Considerations:

ALL tasks focus on the same learning target, but from different “angles”. The lesson is launched as a whole group, with the same focus question (it can be - how do I get my coffee to cool quicker?) Then students are sent to their task stations where the task handouts are. **Task 1** looks at whether substances heat and cool at the same rate - do the graphs of heating and cooling mirror one another? **Task 2** looks at the initial rate (slope) of cooling for water at different starting temperatures. **Task 3** looks at the mathematical model to describe the rate of cooling for water at different temperatures. **Each group will have important information to contribute to a class discussion about the investigations.** It is important to follow up the investigations with a class discussion to give students an opportunity to share their learnings.

Learning Target 3.3: I can compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.

**** A scientific explanation involving a claim and evidence is appropriate here. Reasoning for this is beyond grade level.

The **preassessment** is intended to help you sort students by readiness. Your prior knowledge of students' math level and abilities, as well as their background knowledge in science and interpreting graphs can also inform your grouping.

1 A. is a logarithmic function B. is a quadratic function

2. This is a graph of radioactive decay, showing that the half-life occurs every 25 years, an exponential decay process. The key, though, is for students to identify that the slope is changing (decreasing) over time and to attempt to link the graph to an equation that describes it. (needn't be the correct equation, just that they are trying to fit an equation - they know equations can describe graphs and know there is more than just a linear equation to describe a graph)

3. Look for students content knowledge about heating and specific heat.

Feel free to modify for your students.

Task 1: Heat Transfer of Different Substances

Question: Do substances absorb and lose heat at the same rate?

Learning Target 3.3: I can compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.

Materials:

- three pie pans
- Dark potting soil
- Light-colored sand or perlite
- Water
- Electronic balance
- Three thermometers
- Reflector lamp with a 200-watt bulb
- Graph paper
- Watch with a second hand

Procedure:

1. Measure out 100 g of each of the substances, potting soil, sand, and water. Place each substance in its own pie pan.
2. Place a thermometer in each of the substances just under the surface and record the initial temperature, time = 0 min.
3. Set the lamp about 30 cm above the pans.
4. Turn on the lamp and record the temperature for each of the substances every minute for 10 minutes.
5. At the end of ten minutes, turn off the lamp.
6. Continue to record the temperatures for each substance every minute for 10 minutes.

Analysis:

On the same graph, plot the temperature vs time data for all three substances. Use a different colored pencil for each substance.

Scientific Explanation:

Answer the question with a claim and evidence.

To help guide your thinking consider the following:

Compare the initial (time = 0 min) and final (time = 20 minutes) temperature for each substance.

How do the graphs compare for each of the substances? Do the substances have the same rate of heating and cooling? For a substance, do the heating and cooling phase “mirror” one another?

Be prepared to: Share your graph and scientific explanation with your class.

Task 2: Rate of Heat Loss

Question: How does the starting temperature of a material relate to the rate of heat loss?

Learning Target 3.3: I can compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.

Materials:

- Water
- Test tube
- Test tube rack
- beaker
- Graduated cylinder
- Hot pot or hot plate
- Thermometers or Vernier temperature sensors and LabQuest 2 device

Procedural Guidelines:

Heat the water in a hot pot or in a beaker on the hot plate. Conduct your experiment multiple times (or share data with classmates), using water that has been heated to different temperatures. Be sure to measure out the same amount of water each time with a graduated cylinder and place into a test tube at room temperature. Immediately begin recording the temperature, time = 0 min. Record the temperature of the water every minute for 10 minutes.

Analysis:

Graph your data of temperature vs time for each of the different starting temperatures. Compare the different sets of data and their graphs. Calculate the initial slope of the line for each of the different starting temperatures. How does the slope of this line compare to the rate of cooling?

Scientific Explanation:

Answer the question with a claim and evidence.

To help guide your thinking consider the following: What happens to the slope of the line over time? How do the rates of cooling compare for the different starting temperatures?

Be prepared to: Share your graph and scientific explanation with your class.

Task 3: Rate of Heat Loss

Question: How does the starting temperature of a material relate to the rate of heat loss?

Materials:

- Water

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Analysis:

Graph your data of temperature vs time for each of the different starting temperatures. Compare the different sets of data and their graphs.

Use the LabQuest 2 device/ LoggerPro 3 or a graphing calculator to perform a curve fit (try a variety of mathematical models). Once you have the equation that fits the graph, be sure to identify the variables of this mathematical model for cooling. Reference this in your explanation.

Scientific Explanation:

Answer the question with a claim and evidence.

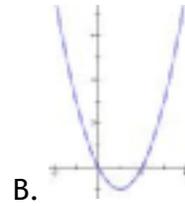
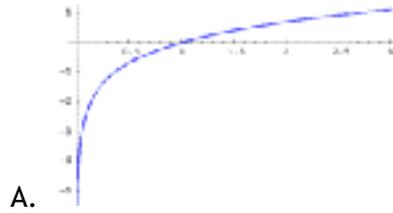
To help guide your thinking consider the following: What happens to the slope of the line over time? How do the rates of cooling compare for the different starting temperatures? What does the mathematical model tell you about rates of cooling?

Be prepared to: Share your graph and scientific explanation with your class.

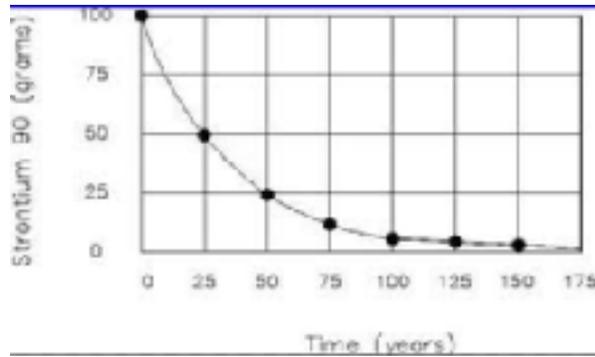
PreLab

1. What kind of math function is expressed by each of these graphs?

Learning Target 3.3: I can compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.



2. What information does the graph below tell us? Give as much information as you can.



3. A block of wood and a block of aluminum metal are placed in the same oven and heated for 3 minutes. How will the temperature of each of the blocks compare after the three minutes? Explain your thinking.