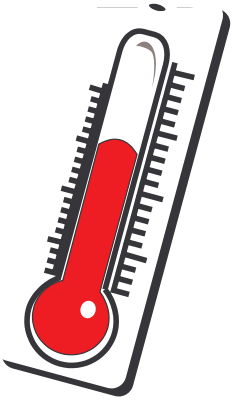
Cold Stuff



Cold Stuff

WHAT MATERIALS MAKE GOOD INSULATORS?

Problem

Which substance makes the best insulator: cotton, air or steel wool?

Research

Answer the following True or False questions about insulators:

True/False Insulators don't allow heat to pass through them easily.

True/False Most metals make good insulators.

True/False Conduction, convection and radiation are ways that heat can move around.

True/False A good insulator will make an object get warmer.

Hypothesis

I think that _____ will be the best insulator.

(cotton, air or steel wool)

Procedure

1. To do this experiment, your team will need:
    - 3 different materials to test
    - A thermometer
    - A stopwatch
    - A bowl filled with 500 milliliters of ice water
2. There are three jobs to do:
    - **Time Keeper** - tells the Temperature Reader when to read the temperature
    - **Temperature Reader** - tells the Data Recorder what the temperature is at that time
    - **Data Recorder** - writes the temperature in the data chart
3. Put the thermometer in one of the three insulators and measure its **Initial Temperature**. This should be somewhere near 20˚ Centigrade. It might take the thermometer a few minutes to read the correct temperature. Give it time to get used to its new home.
4. Record the Initial Temperature on the chart on the next page.
5. Put the insulator in the ice water and start the stopwatch. Hold the insulator in the ice water by the lid. Keep the insulator in the water for **5 minutes**.
6. Measure and record the insulator's temperature **every 30 seconds** for 5 minutes. **DO NOT STOP THE STOPWATCH UNTIL 5 MINUTES HAVE PASSED!!** If you stop the stopwatch early, you won't know how long the insulator has been in the ice water.
7. At the end of five minutes, get ready to test the next insulator. Your team will have to:
    - Reset the stopwatch
    - Get 500 milliliters of new ice water
    - Put the thermometer in the next insulator to measure its initial temperature (Remember: the initial temperature should be somewhere near **20˚ Centigrade**!)
    - Put the insulator in the ice water **after** you have recorded its initial temperature
8. Put the second insulator in the ice water and measure its temperature **every 30 seconds** for 5 minutes, just like you did with the first one. **Don't forget to record your data!**
9. Test the third insulator when you finish with the second one.
10. Make certain that everyone on your team has all of the temperatures written down.
11. Make a line graph for each insulator on the **Cold Stuff Results Graph**.

Cold Stuff Data Chart

For each insulator:
- **Record** the Initial Temperature (somewhere near 20˚ C)
- **Start** the stopwatch when you put the insulator in the ice water
- **Record** the temperature **EVERY 30 SECONDS**
- **Stop** the stopwatch when it reaches 5 minutes

INSULATOR	TEMPERATURE of insulator at TIME (minutes:seconds)										
	(initial temperature) 0:00	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00

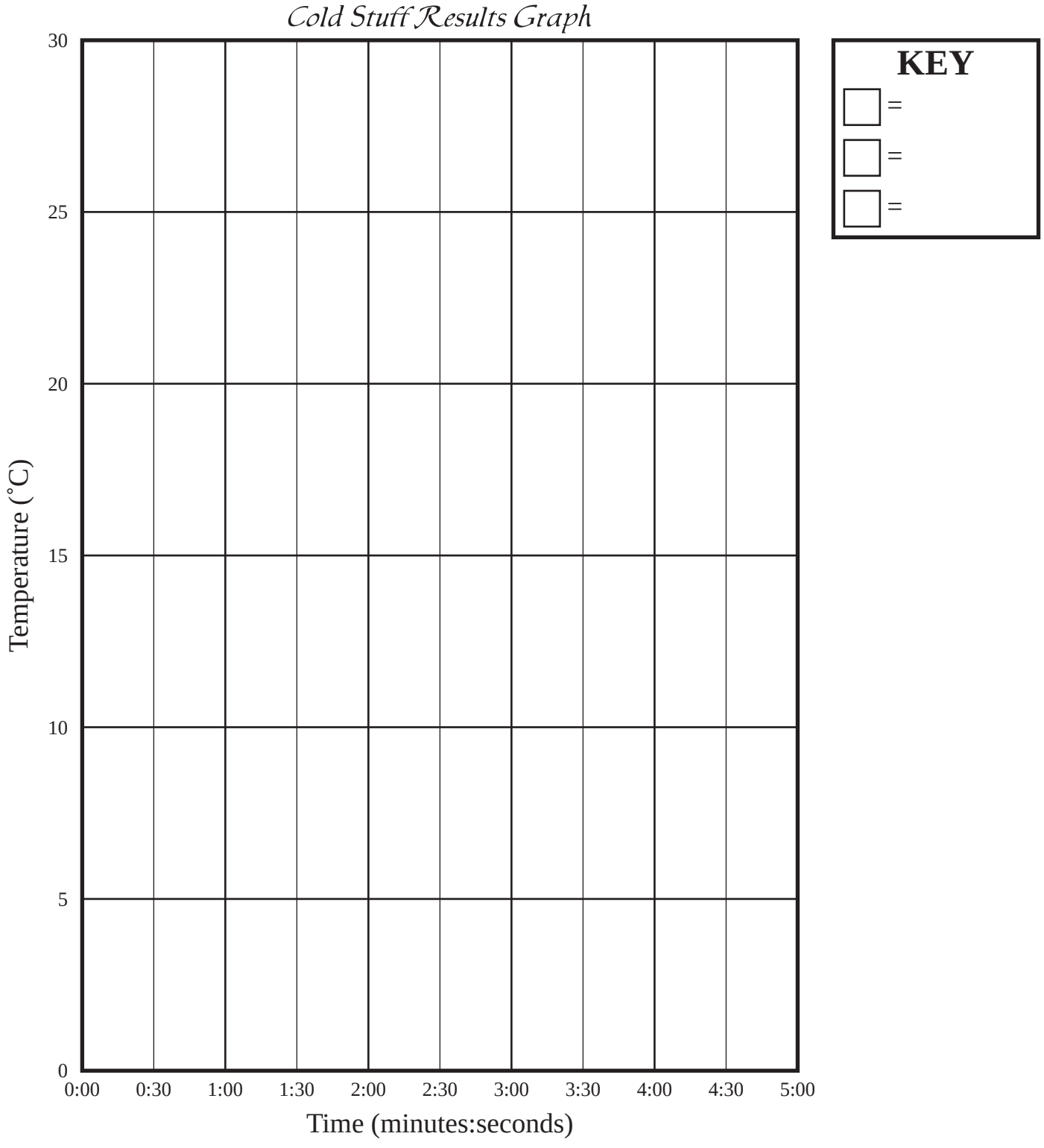
NAME THAT VARIABLE!!

Directions: Identifiy the **Independent Variable**, **Dependent Variable**, **Constants** and **Control** of this experiment.

Independent Variable	
Dependent Variable	
Constants	
Control	

LET'S MAKE A GRAPH!

Directions: Make a **line graph** for each of the three insulators you tested. Graph one insulator at a time. Start by plotting the insulator's initial temperature. Then plot the insulator's temperature at 30 seconds, one minute, one and a half minutes, all the way to 5 minutes. Plot the other two insulators on the graph in the same way. You will have to make different symbols for each insulator so that you can tell them apart.



Conclusion

THE BEST INSULATOR APPEARS TO BE _____

QUESTIONS TO THINK ABOUT

1. Which container cooled the fastest?

2. Which container took the longest to cool?

3. Where did the heat inside the containers go as they were cooling?

4. Which material that your team tested is the best insulator? How can you tell?

5. What other materials do you think might make good insulators?

6. What materials would make poor insulators?

Reading About Heat Transfer

THE COLD STUFF ACTIVITY YOU DID AT JEFFERSON LAB WAS AN EXPERIMENT IN THE TRANSFER OF HEAT.

Heat can be transferred by three different means:

- **Conduction** - the transfer of heat through two or more materials that are touching
- **Convection** - the transfer of heat by the movement of a gas, like air, or a liquid, like water
- **Radiation** - the transfer of heat by means of rays

Which method of heat transfer best defines each scenario: conduction, convection or radiation?

1. You wake up on a Saturday morning and are glad you don't have to go to school. You sit outside in the sun because you don't really feel like doing anything at all. The heat from the sun is starting to make you sweat. _____

2. Last night you went to the store and bought fruit punch, so you have a big glass of it to help cool you off. _____

3. The news is on and the forecast calls for hot and muggy weather. The temperature in the house is rising too so you turn on the air conditioner. _____

4. It's boring sitting in the house on your day off, so you go to the pool to meet your friends. You jump in and the water is freezing but you don't want to look like a wimp so you try to get used to it. Your lips are turning blue and your skin now feels cold. _____

5. You climb out of the pool and lie on the warm concrete to warm your body back up. _____

6. You're beginning to feel comfortable again but don't want to get too warm, so you move to a place in the shade. It's getting hotter and hotter now and you're starting to sweat again, even though you are in the shade. _____

7. You decide that it wasn't so bad at home after all and you're getting hungry anyway so you go back home and cool off in the air conditioning, on the sofa, with a good book. _____

Cold Stuff

WHAT MATERIALS MAKE GOOD INSULATORS?

Problem

Which substance makes the best insulator: cotton, air or steel wool?

Research

Answer the following True or False questions about insulators:

***True*/False** Insulators don't allow heat to pass through them easily.

True/*False* Most metals make good insulators.

***True*/False** Conduction, convection and radiation are ways that heat can move around.

True/*False* A good insulator will make an object get warmer.

Hypothesis

I think that _____ will be the best insulator.
(cotton, air or steel wool)

Cold Stuff Data Chart

For each insulator:
- **Record** the Initial Temperature (somewhere near 20˚ C)
- **Start** the stopwatch when you put the insulator in the ice water
- **Record** the temperature **EVERY 30 SECONDS**
- **Stop** the stopwatch when it reaches 5 minutes

INSULATOR	*(initial temperature)*	TEMPERATURE of insulator at TIME (minutes:seconds)									
	0:00	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00
Cotton	***21***	***21***	***20***	***20***	***19***	***19***	***19***	***18***	***18***	***18***	***18***
Air	***20***	***19***	***17***	***15***	***14***	***13***	***12***	***11***	***10***	***9***	***8***
Steel Wool	***22***	***22***	***21***	***21***	***20***	***18***	***17***	***16***	***14***	***13***	***11***

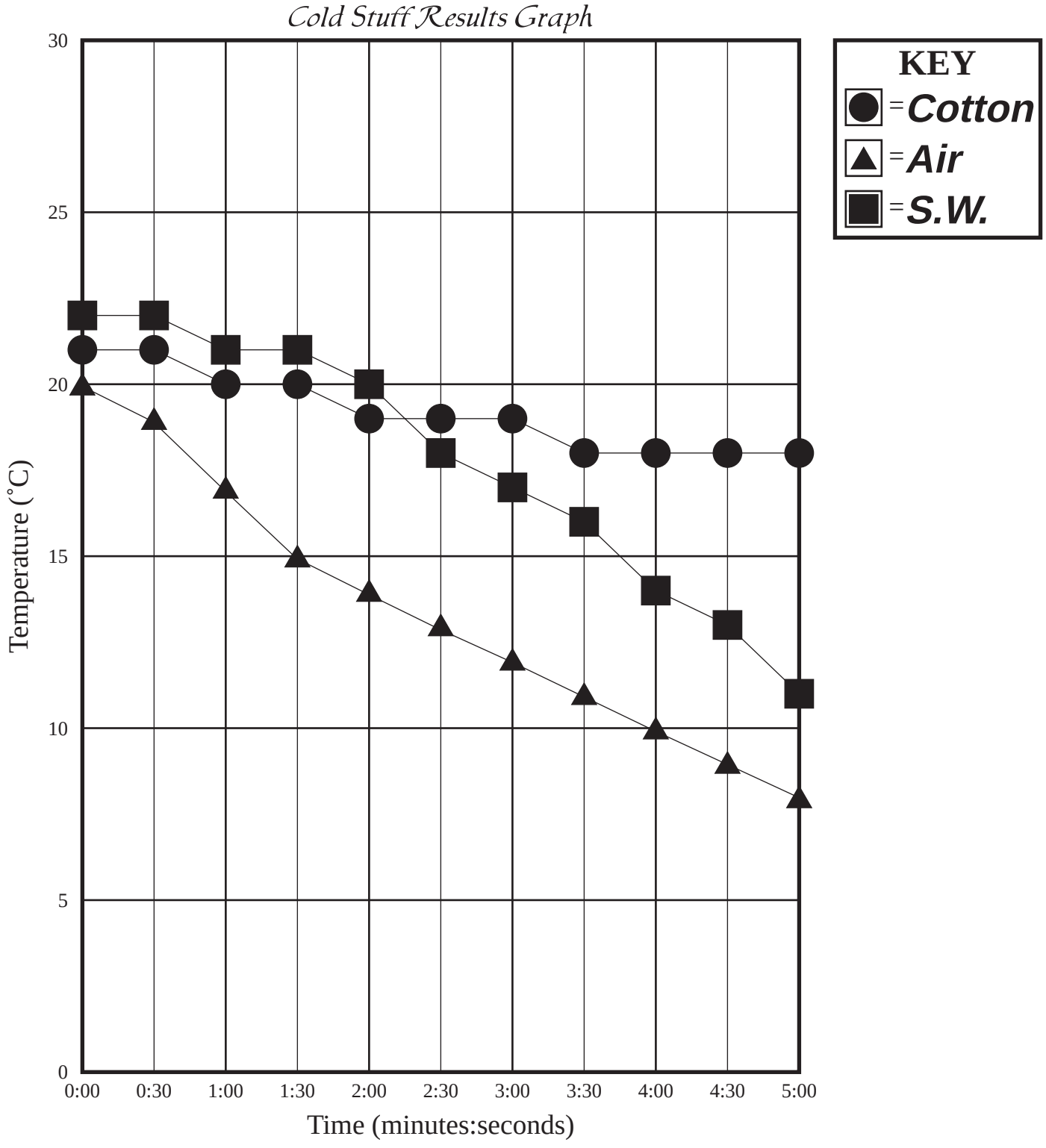
NAME THAT VARIABLE!!

Directions: Identifiy the **Independent Variable**, **Dependent Variable**, **Constants** and **Control** of this experiment.

Independent Variable	***choice of insulator***
Dependent Variable	***temperature inside insulator***
Constants	***water in bath, temp of water, time, etc***
Control	***air filled container***

LET'S MAKE A GRAPH!

Directions: Make a **line graph** for each of the three insulators you tested. Graph one insulator at a time. Start by plotting the insulator's initial temperature. Then plot the insulator's temperature at 30 seconds, one minute, one and a half minutes, all the way to 5 minutes. Plot the other two insulators on the graph in the same way. You will have to make different symbols for each insulator so that you can tell them apart.



Conclusion

THE BEST INSULATOR APPEARS TO BE _____

QUESTIONS TO THINK ABOUT

1. Which container cooled the fastest?

Usually air, but steel wool can come very close.

2. Which container took the longest to cool?

Cotton

3. Where did the heat inside the containers go as they were cooling?

Into the ice and water.

4. Which material that your team tested is the best insulator? How can you tell?

Cotton, since it didn't change temperature quickly.

5. What other materials do you think might make good insulators?

Answers vary. Wool, polyester, fur, etc...

6. What materials would make poor insulators?

Answers vary. Copper, steel, iron, etc...

Reading About Heat Transfer

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2. Last night you went to the store and bought fruit punch, so you have a big glass of it to help cool you off. ***Conduction***

3. The news is on and the forecast calls for hot and muggy weather. The temperature in the house is rising too so you turn on the air conditioner. ***Convection***

4. It's boring sitting in the house on your day off, so you go to the pool to meet your friends. You jump in and the water is freezing but you don't want to look like a wimp so you try to get used to it. Your lips are turning blue and your skin now feels cold. ***Conduction***

5. You climb out of the pool and lie on the warm concrete to warm your body back up. ***Conduction***

6. You're beginning to feel comfortable again but don't want to get too warm, so you move to a place in the shade. It's getting hotter and hotter now and you're starting to sweat again, even though you are in the shade. ***Conduction****

7. You decide that it wasn't so bad at home after all and you're getting hungry anyway so you go back home and cool off in the air conditioning, on the sofa, with a good book. ***Conduction****

**** Conduction if there is no movement of air, convection if hot/cold air is moving.***

Cold Stuff

This is an activity in which students investigate different materials to determine which makes the best insulator.

Objectives:

In this activity students will:

- work in groups
- be responsible for specific tasks within their groups
- measure liquid
- measure time using a stopwatch
- measure temperature change over time
- record data
- test and compare the effectiveness of different insulators
- create a line graph to depict the temperatures recorded at 30 second intervals using each insulator

Questions to Ask:

1. How could the way you hold the container affect the data?
2. What is different about the insulators that may have caused them to retain heat differently?
3. What are some other materials frequently used as insulators?
4. How are insulators useful? When might you use one? When might you not?

Travel Book Activities:

- Reading About Heat Transfer

Virginia State Standards of Learning

Math 6.2 Number and Number Sense

- by comparing the temperature within containers filled with various insulators

Math 6.18 Probability and Statistics

- by interpreting data using graphical methods (line graph and chart)

Science 6.1 Plan and Conduct Investigations

- by making observations involving fine discrimination between similar objects
- by developing a multiple attributes classification system
- by identifying differences in descriptions and the construction of working definitions
- by recording precise and approximate measurements
- by stating hypotheses in a way that identifies the independent and dependent variables
- by devising methods to test the validity of predictions and inferences
- by manipulating one variable over time with repeated trials
- by collecting, recording and analyzing data using appropriate metric measures
- by organizing and communicating data through graphical representations

Science 6.2 Demonstrate Scientific Reasoning and Logic

- by investigating ideas by asking for and actively seeking information
- by analyzing alternative scientific explanations

LS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials and means
- by defining variables
- by using SI (metric) units
- by establishing criteria for evaluating a prediction
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test the hypotheses
- by constructing, interpreting and using continuous line graphs to make predictions
- by evaluating and defending interpretations from the same set of data

PS.1 Plan and Conduct Investigations

- by accurately measuring and reporting data using SI (metric) units
- by using thermometers to gather data
- by recording and interpreting data from line graphs
- by identifying independent and dependent variables, constants, controls and repeated trials
- by making valid conclusions after analyzing data

C/T8.1 Communicate Through Application Software

- by communicating through application software with spreadsheets by entering and analyzing data, and creating graphs and charts to visually represent data

Cold Stuff
Teacher Overview and Materials List

Background:

Jefferson Lab's accelerator uses niobium cavities to accelerate electrons. In order for the cavities to operate correctly, they must be cooled to very low temperatures. The cavities are bathed in liquid helium, which keeps them at a temperature of 2 K (-456˚F), inside large thermos bottles called cryomodules. Cryomodules are designed to stop the three ways heat moves: conduction, convection and radiation.

Insulators are materials that prevent the flow of heat. In this experiment, three different materials are tested to see how well they insulate.

Minimum Materials Needed for Each Student Group:

Long stem Celsius thermometer capable of reading temperatures from room temperature (~25˚C) to 0˚C

Stopwatch

A 1 pint container (with lid) filled with air

A 1 pint container (with lid) filled with cotton

A 1 pint container (with lid) filled with steel wool

Bowl with a capacity of 750 milliliters

500 milliliters of ice water

Optional Materials:

A marked container to measure the ice water

Pre-Activity Preparations:

<u>The Pint Containers</u>

1. Remove all labels.
2. Drill a hole near the center of the lid just large enough for the thermometer to fit into.
3. Fill each container with the desired insulator.

Notes:

- Wrap a piece of tape around the stem of the thermometer to prevent it from touching the bottom of the container.

Materials for Cold Stuff