centre de développement pédagogique
pour la formation générale en science et technologie

Working document

(THERMAL CONSTRAINTS IN A WORK ENVIRONMENT)

Adaptation to cold

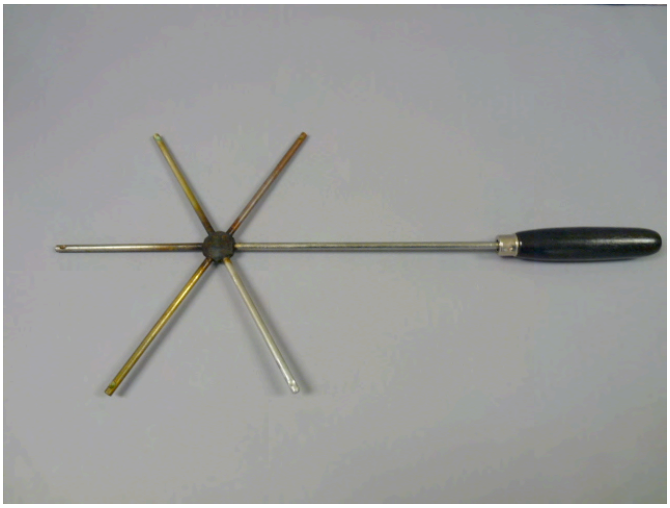
Materials preparation guide

May 2010

Center for pedagogical development

Demonstration of the methods of heat propagation:

1- Conduction:



Equipment required:

- "Star" conductivity meter for conduction test
- Drops of wax (candle)
- 5 necklace beads
- Alcohol burner
- Lighter or matches
- Cafeteria tray or aluminium foil

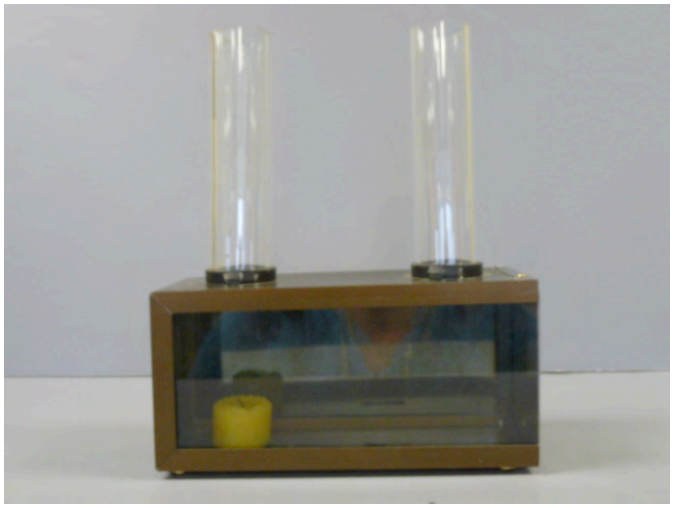
Preparation:

1. Light the candle and let a drop of wax fall into the cavity at the end of the first shaft.
2. Affix a bead using the wax.
3. Repeat these two operations on the four other shafts.

Protocol:

1. Place the alcohol burner on the tray or aluminium foil.
2. Light the alcohol burner.
3. Place the center of the conductivity meter on the flame of the burner, placing the beads towards the bottom.
4. Note which metal conducts the heat most quickly (the most conductive metal will be the first one to lose its bead: the heat will melt the wax holding the bead and the bead will fall into the tray).

2- Convection:



Equipment required:

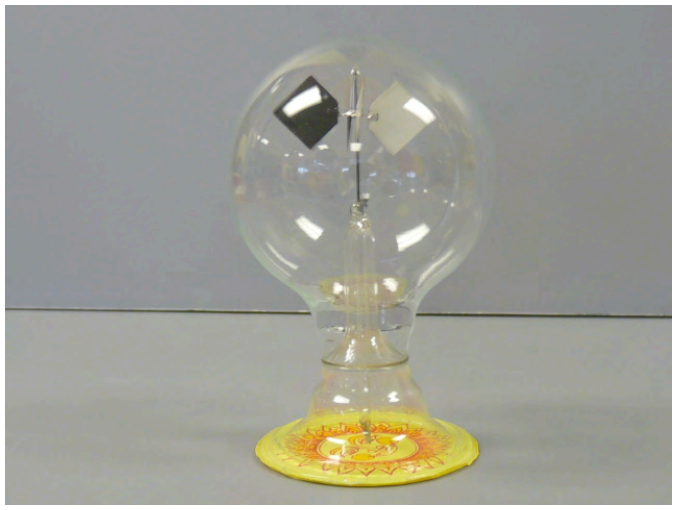
- ❑ Gas conduction model
- ❑ Tea light candle
- ❑ Smoke producing paper or wood chips
- ❑ Lighter or matches

Protocol:

1. Place the candle in the model, under a chimney.
2. Light the candle and close the window.
3. Light the smoke producing paper.
4. Insert and hold the smoke producing paper above the other chimney. (If using wood chips, you must blow out the flame in order to have an incandescent end that produces smoke).

The candle heats the air in the box. This heated air is lighter and goes up the chimney. This creates a current that carries the smoke produced by the paper up the chimney in the box.

3- Radiation:



Equipment required:

- ❑ Radiometer
- ❑ Flashlight

Protocol:

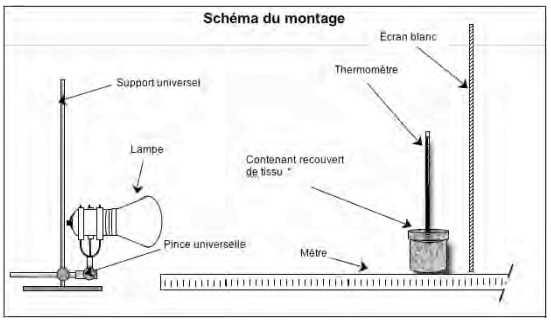
1. Place the radiometer on the teacher's desk.
2. Light the flashlight and point it on the radiometer.
3. Observe.

The black surface absorbs the radiation and heats up more quickly than the white surface. The gas molecules inside the radiometer heat up on the black side and acquire a greater speed. This creates kinetic pressure on the black plates and makes the black plates turn towards the white ones.

Directed laboratories

1. The black body effect

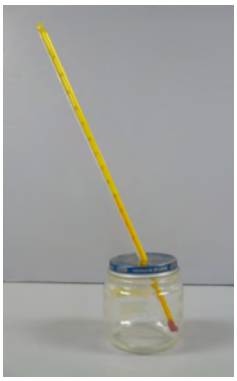
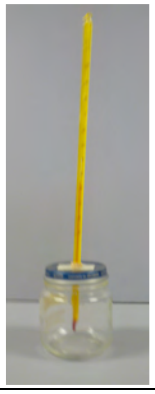
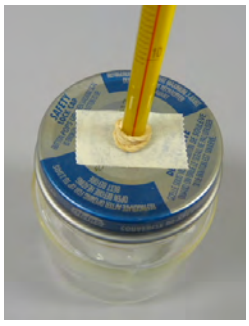
(Installation + manipulations + putting away = 50 min.)



- Universal support
- 3 pronged clamp
- Right angle nut (to affix the clamp)
- 250 W lamp + reflector + clamp
- 1 or 3 thermometers (depending on how you proceed)
- 3 containers with perforated covers (covered in black, white and metallic fabrics)
- Meter stick
- Timer or watch
- White screen (cardboard or foam board - approximate dimensions: 50 cm X 40 cm)
- Masking tape

<u>Preparing the containers:</u>

It is important that the containers be of the same size and that they be sealed. For our experiments, we used glass baby food jars. You need only drill the cover with a bit approximately the same diameter as the thermometer. Ideally, the thermometer should be inserted without being inclined or touching the bottom of the jar. An elastic can help keep the thermometer in place.

Thermometer (incorrect position)	Thermometer (correct position)
	  

Method for drilling the covers:

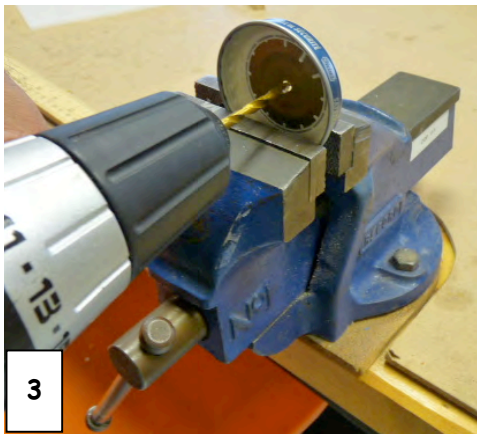
Equipment required:

- Punch or nail
- Hammer
- Martyr (old piece of wood to be placed under the lid while pointing it)
- Bit the same size as the tip of the biggest bit
- Bit the same diameter as the thermometer
- Hand held drill
- Workbench vice
- Sand paper

Manipulation:

1. Find and mark the center of the lid.
2. Punch the center.
3. Affix the lid in the vise and make the first hole using the smaller bit.
4. Drill again with the bit having the same diameter as the thermometer.
5. Sand the edges to avoid possible injury from metal shards.


2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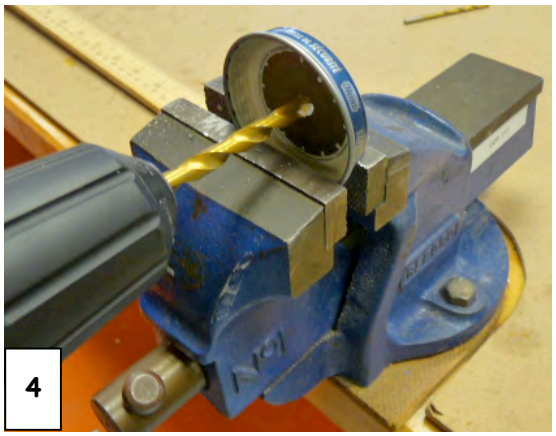

4

It may be necessary to use masking tape if the hole in the lid is greater than the diameter of the thermometer.

To find the ideal size bit for drilling, simply insert the thermometer in the place of the bit and see if it fits well.

Method for covering the lids

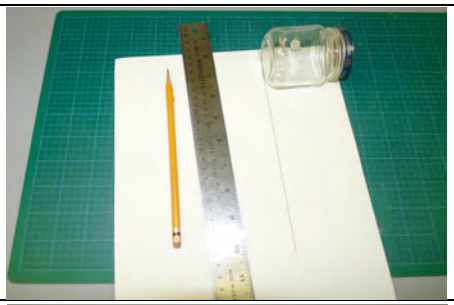
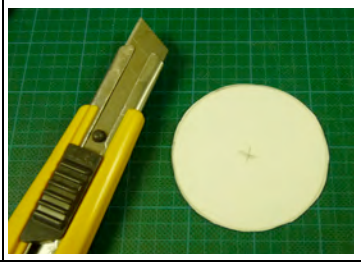
To cover the lids, we used white and black foam rubber. The metallic fabric is a strip of survival blanket. These materials are available at dollar stores or art stores. You may also procure containers painted either black or white at laboratory equipment suppliers.

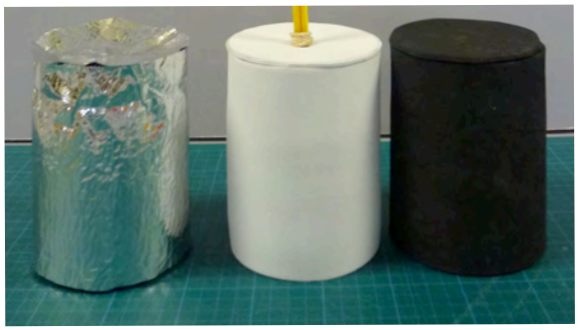
Equipment required for covering jars and lids:

- ❑ Sheets of white foam rubber *
- ❑ Sheets of black foam rubber *
- ❑ Metallic fabric (survival blanket, lunch box liner or aluminium foil)
- ❑ Ruler
- ❑ Scissors or knife with retractable blade (utility knife)
- ❑ Pencil
- ❑ Compass
- ❑ Hot glue gun + glue stick

*(depending on the number of containers to be covered)

Preparation for covering jars and lids:

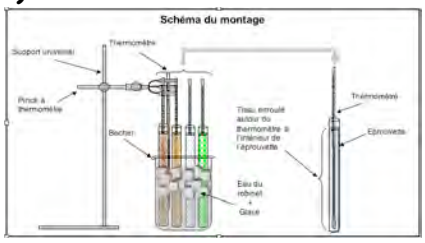
	Operation or manipulation	Photo
1	Measure the amount of foam rubber necessary for covering the surface of the chosen container.	
2	Using scissors or utility knife, cut out this section.	
3	Glue the strip onto the container using the hot glue or other glue.	
4	Trace the outline of the lid using a compass or place the lid on the foam rubber and trace around it.	
5	Cut out this section. Cut an X in the center (to insert the thermometer into the container) Glue this section onto the lid.	 

6	Repeat the same operations for the two other containers.	

White screen: The screen used for our experiments is 4mm thick styrene. Its dimensions are 500 mm X 400 mm. Dimensions may vary, but it is important to have a fairly large surface. The nature of the screen may also be different: (white poster board, foam, etc.) It must, however, be white, so as not to absorb the light.

2. Insulating power

(Installation + manipulations + putting away = 35 min.)



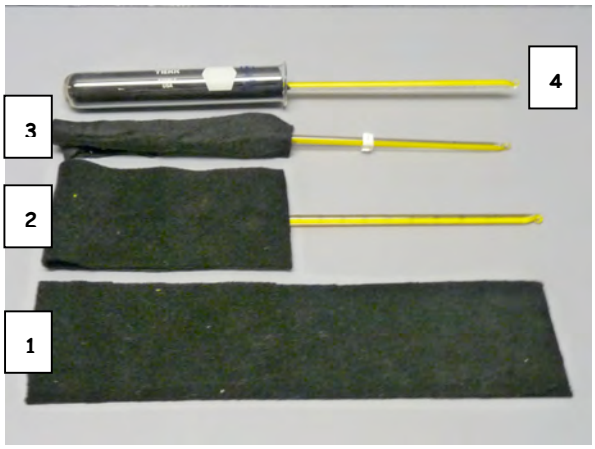
- ❑ Universal support
- ❑ Thermometer clamp
- ❑ Universal clamp (or three pronged clamp + right angle nut)
- ❑ 1000 mL beaker or plastic bucket
- ❑ 5 thermometers
- ❑ 4 - 25 X 150 mm test tubes
- ❑ Test tube holder
- ❑ Timer or watch
- ❑ Tap water
- ❑ Ice
- ❑ Pieces of fabric of the same dimensions (acrylic, cotton, wool, nylon and bubble wrap)

For this manipulation, it is not necessary to affix the test tubes with a clamp, since we are working with ice water. There is no danger if the test tubes touch the bottom of the beaker.

<u>Equipment required for set up:</u>

- ❑ Pieces of fabric of the same dimensions (acrylic, cotton, wool, nylon and bubble wrap)
- ❑ Ruler
- ❑ Scissors
- ❑ Pencil

<u>Fabric preparation:</u>



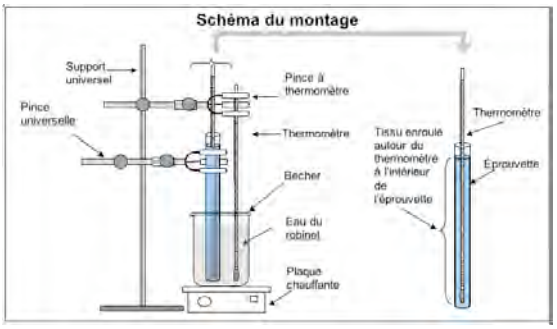
1. Measure and cut out a strip 30 X 8 cm in the first fabric sample*.
2. Place the thermometer in the middle of the fabric and fold it in half.
3. Roll the fabric strip around the thermometer.
4. Insert this "sausage" into the test tube.
5. Repeat the same operations for the other pieces of fabric.

***To save time when preparing the fabrics, you may make a template of the correct dimensions out of plastic or cardboard.**

3. Resistance to heat

(Installation + manipulations + putting away = 45 min.)

- ❑ Universal support
- ❑ Thermometer clamp
- ❑ 2 universal clamps (or 3 pronged clamp + right angle nut)
- ❑ Hot plate
- ❑ 5 thermometers
- ❑ 1000 mL beaker
- ❑ Beaker clamp
- ❑ 4 - 25 X 150 mm test tubes
- ❑ Test tube holder
- ❑ Timer or watch



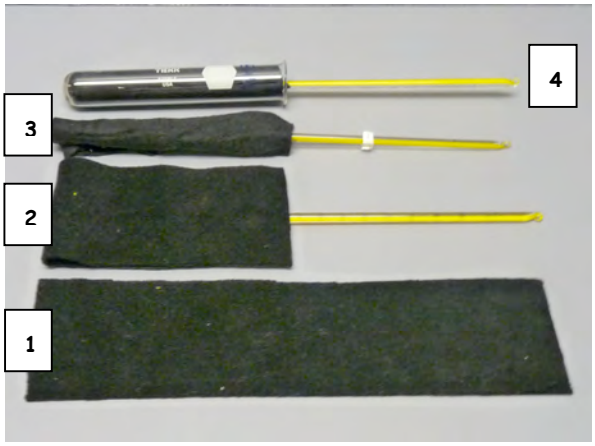
- ❑ Tap water
- ❑ Pieces of different fabrics of the same dimensions (acrylic, cotton, wool, nylon, metallic plastic, etc.)

For this operation, it is necessary to affix the test tubes with a clamp, since we are working with boiling water. The clamp can prevent burns from steam or from the hot plate. It is also better to not let the test tubes rest on the bottom of the beaker, since it is on the hot plate.

<u>Equipment required for set up:</u>

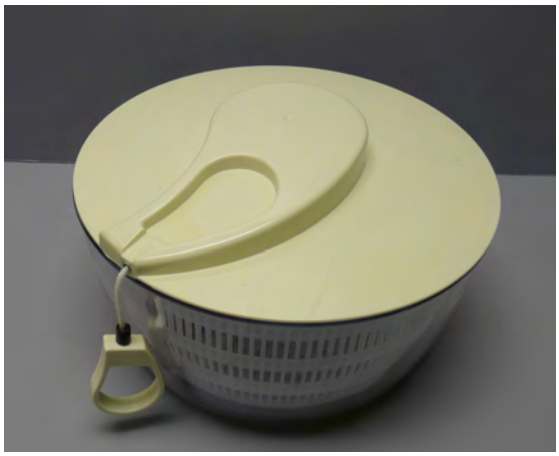
- ❑ Pieces of different fabrics of the same dimensions (acrylic, cotton, wool, nylon and bubble wrap)
- ❑ Ruler
- ❑ Scissors
- ❑ Pencil

<u>Fabric preparation:</u>



1. Measure and cut out a strip 30 X 8 cm in the first fabric sample (use of template possible).
2. Place the thermometer in the middle of the fabric and fold it in half.
3. Roll the fabric strip around the thermometer.
4. Insert this "sausage" into the test tube.
5. Repeat the same operations for the other pieces of fabric.

4. Power of humidity retention (according to the students' protocol)



- ❑ Scale
- ❑ Salad spinner with pull string, pump, or any other mechanism that allows you to control of the number of turns.
- ❑ 1000 mL beaker
- ❑ Tap water
- ❑ Pieces of fabric of the same dimension.

Equipment required for set up:

- ❑ Pieces of fabric of the same dimension (acrylic, cotton, wool, nylon and bubble wrap)
- ❑ Ruler
- ❑ Scissors
- ❑ Pencil

Fabric preparation:

1. Measure and cut out a 8 cm X 8 cm square in the first fabric*.
2. Repeat the same operations for the other fabrics.

*** To save time when preparing the fabrics, you may make a template of the correct dimensions out of plastic or cardboard.**

If the teacher decides not to guide the students, various equipment will need to be foreseen for other protocols.

Here is a cursory list of equipment you may want to have available:

- ❑ Universal support
- ❑ Universal clamp (or 3 pronged clamp + right angle nut)
- ❑ 1000 mL beaker
- ❑ 25 X 150 mm test tubes
- ❑ Test tube holder
- ❑ 10 mL graduated cylinder
- ❑ 25 mL graduated cylinder
- ❑ Eye dropper
- ❑ Others…

5. Demonstration: The effect of humidity on temperature

(Installation + demonstration + putting away = 10 to 15 min.)

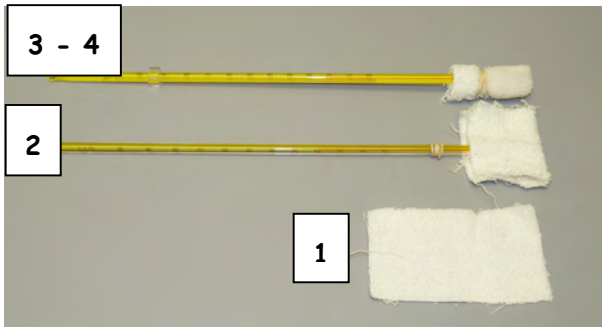
- ❑ Universal support
- ❑ 2 thermometer clamps
- ❑ 2 thermometers
- ❑ 2 pieces of cotton fabric (facecloth or towel)
- ❑ Beaker with room temperature water
- ❑ 2 elastic bands
- ❑ Watch or timer
- ❑ Fan (hand or electric)

All this equipment may be replaced with an instrument called a hygrometer. It is an instrument of measurement used in meteorology. It may be available in your establishment.
http://galileo.cyberscol.qc.ca/intermet/instrument/psychrometre.htm

Equipment required for set up of assembly:

- ❑ Pieces of cotton
- ❑ Elastic bands
- ❑ Rulers
- ❑ Scissors
- ❑ Pencil

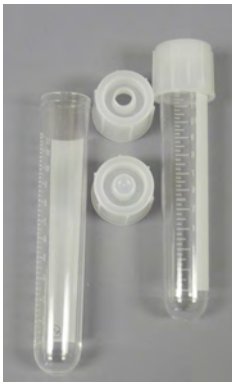
Fabric preparation:



1. Measure and cut out two 10 cm X 5 cm sections in the cotton.
2. Place the thermometer in the middle of the fabric and fold it in half.
3. Roll the fabric strip around the thermometer.
4. Affix the fabric using the elastic band.
5. Repeat operations 2 to 4 for the other thermometer.

6. Glove design:

- Plastic test tube with cap, with a hole the diameter of the thermometer (sterile culture test tube with polystyrene cap, 17 mm X 100 mm) or similar sized tube from a florist.
- Finger template
- Scissors
- Sewing needle*
- Thread*
- Pieces of fabric (pre-cut, to avoid waste)



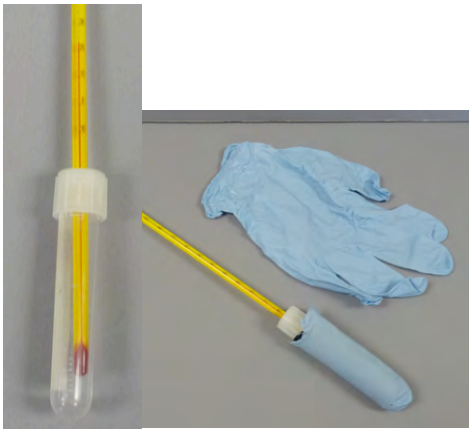
* Could be replaced by a stapler, fabric glue, strip of heat sealing fabric + iron, or any other method allowing fabric to be assembled.

Equipment required for the "finger" preparation:

- Plastic test tube
- Thermometer
- Room temperature water

} "Testing" test tube

- Universal support
- Universal clamp (or three pronged clamp + right angle nut)
- Finger cut from a rubber glove



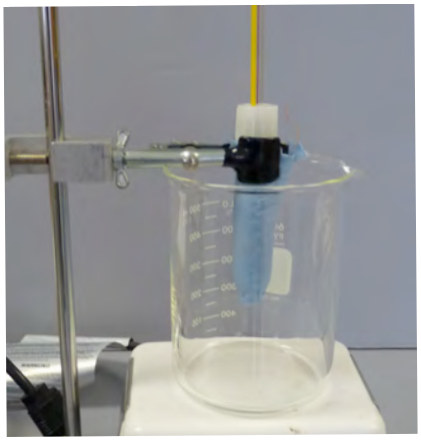
There are two possible ways to do the protection test:

The first consists of filling the "testing" test tube with room temperature water. It is imperative to ensure that the initial water temperature be identical for all the students.

For the second method, fill the "testing" test tube with water at normal human body temperature, that is ± 37°C. To do so, this test tube must be immersed in a double boiler set to the correct temperature. This necessitates additional equipment: a 1000 mL beaker, hot plate, thermometer clamp and a beaker clamp.

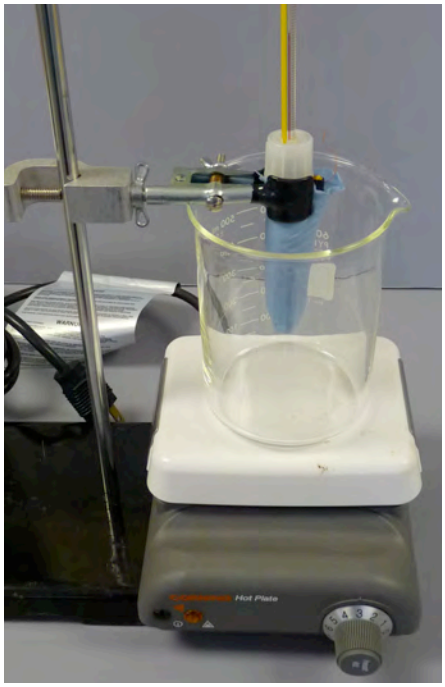
Equipment required for the protection test assembly (cold test):

- Universal support
- Universal clamp (or three pronged clamp + right angle nut)
- "Testing" test tube
- 25 mL graduated cylinder
- Finger from rubber glove
- 1000 mL beaker or plastic bucket
- Thermometer clamp
- Thermometer
- Ice
- Cold water
- Chronometer



Equipment required for the protection test assembly (heat test):

- Universal support
- Universal clamp (or three pronged clamp + right angle nut)
- "Testing" test tube
- 25 mL graduated cylinder
- Finger from rubber glove
- Hot plate
- 1000 mL beaker
- Thermometer clamp
- Thermometer
- Beaker clamp
- Chronometer
- Water

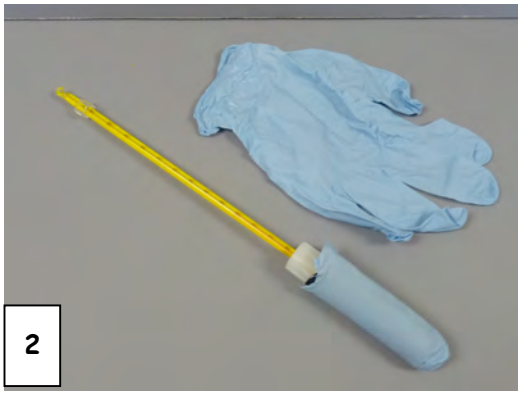


Note: on the two photos, there should be a thermometer and clamp in order to verify the temperature of the beaker in which the tests are carried out. It is imperative to maintain the same temperature of water for all the students.

Protocol for the protection test:

1. Measure 11 mL of warm water or water at 37°C.
2. Pour it into the "testing" test tube and recap.
3. Insert the thermometer in the hole in the cap.
4. Insert the glove designed by the student onto the "testing" test tube.
5. Slide the rubber finger over the student glove (the rubber finger protects the fabrics and prevents them from becoming soaked).
6. Note the initial temperature of the "testing" test tube.
7. Affix this set onto the universal support using a universal clamp.
8. Place the set into the beaker corresponding to the constraint (heat or cold) for which the glove was designed.
9. Leave it in this environment for 15 minutes.
10. Note the final temperature.


1


2


5

Compilation of laboratory equipment required

The following pages will serve as a guide for the preparation of laboratory equipment. **The quantities mentioned are for a single work station**. The quantities will have to be adjusted to take into account the number of work stations required for all the students or according to the scenario chosen by the teacher. Here are two examples of possible scenarios:

Scenario 1:
30 students in the class (working in teams of two).
Each team does all the directed laboratories.
You will have to plan for 15 work stations for each of the directed laboratories.
So, the quantities mentioned X 15.

Scenario 2:
(It is possible to do labs 1, 2 and 3 together and to rotate for each period).
30 students in the class (working in teams of two).
The directed laboratories are performed per station.
Yon will have to plan for 5 work stations for each of the directed laboratories.
So, the quantities mentioned X 5.

Equipment required for the demonstrations

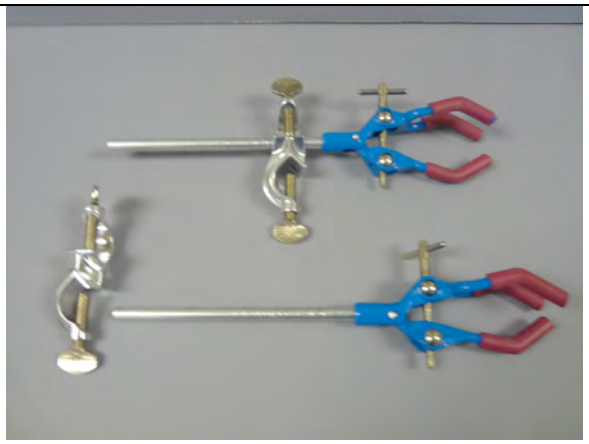
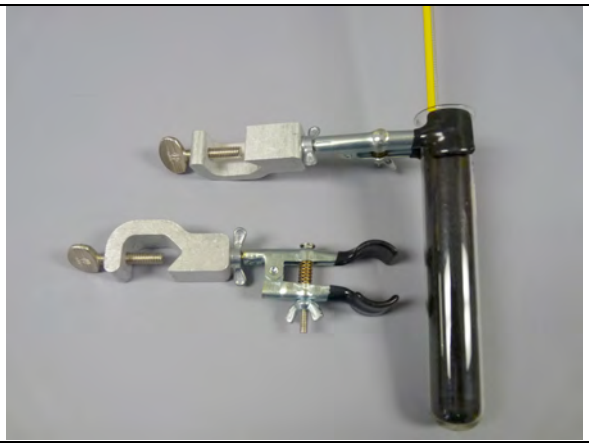
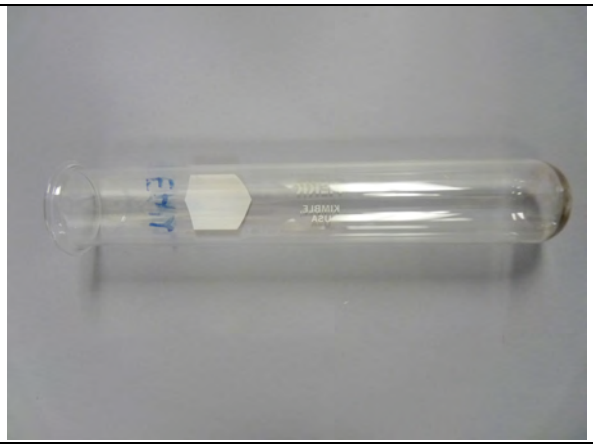
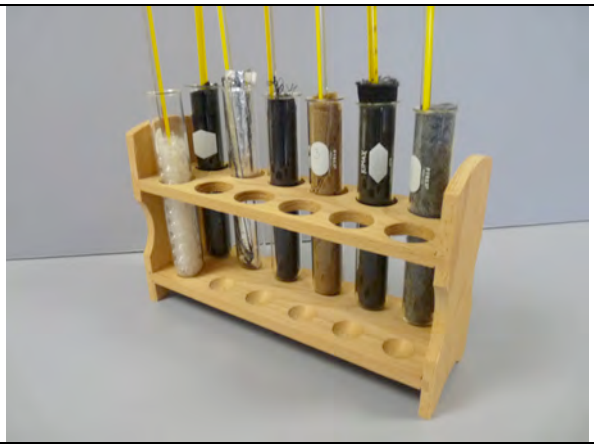
Compilation	Conduction demonstration	Convection demonstration	Radiation demonstration	Effect of humidity demonstration	Total
Conductivity meter	1				1
Gas conduction model		1			1
Radiometer			1		1
Universal support				1	1
Thermometer clamp				2	2
Thermometer				2	2
50 mL beaker				1	1
Chronometer				1	1
Tap water				1	1
Candle (drops of wax)	1				1
Necklace beads	5				5
Alcohol burner	1				1
Tea light candle		1			1
Smoke producing paper or wood chips		1			1
Lighter or matches	1	1			2
Cafeteria tray or aluminium foil	1				1
Flashlight			1		1
Pieces of cotton fabric (10 cm x 5 cm)				2	2
Elastic band				2	2
Fan (hand or electric)				1	1

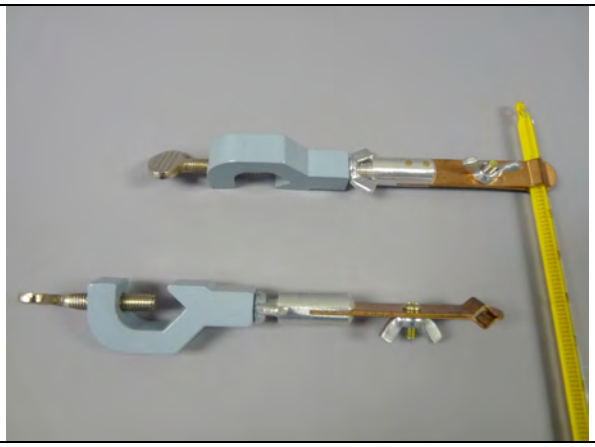
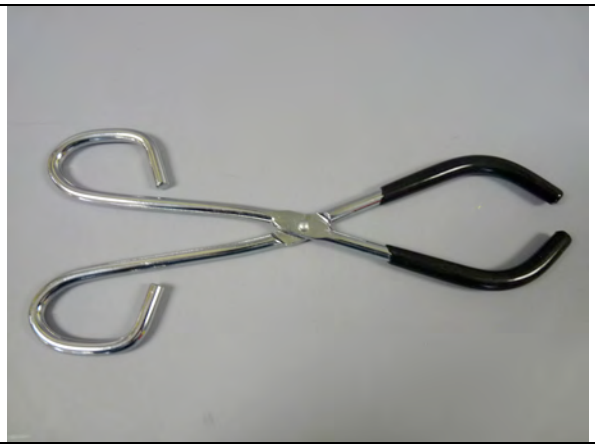
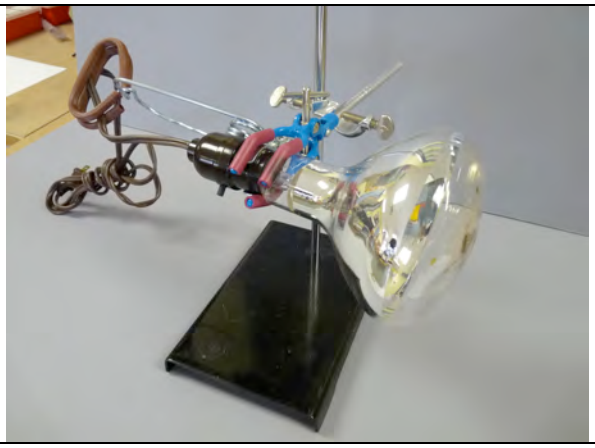
Equipment required for directed laboratories

Compilation	Black body effect	Insulating power	Heat resistance	Power of humidity retention	Glove protection test		Total
					Cold	Heat	
Universal support	1	1	1		1	1	5
Universal clamp		1*	2*		1*	1*	5*
3 pronged clamp	1	1*	2*		1*	1*	1 or 6*
Right angle nut	1	1*	2*		1*	1*	1 or 6*
Thermometer clamp		1	1		1	1	4
Thermometer	1 or 3	5	5		2	2	15 or 17
1000 mL beaker		1	1	1	1	1	5
25 x 150 mm test tubes		4	4				8
"Testing" test tube + rubber glove finger					1	1	2
Test tube holder		1	1				2
25 mL graduated cylinder					1	1	2
Hot plate			1			1	2
Beaker clamp			1			1	2
Scale				1			1
Salad spinner				1			1
250W infrared light	1						1
Container with perforated cover	3						3
Wooden or metal meter stick	1						1
Chronometer	1	1	1		1	1	5
White screen	1						1
Tap water		1	1	1	1	1	5
Ice		1			1		2
Masking tape	1						1
Pieces of fabric of the same dimensions		1	1	1	1	1	5

*** The universal clamp may be replaced by the 3 pronged clamp and the right angle nut.**

Purchasing or borrowing guide (laboratory equipment):

Universal support (stand)	3 pronged clamp + right angle nut
	
Universal clamp (for burette)	**Beaker**
	
Test tube 25 x 150 mm	**Test tube holder**
	

Hot plate	Thermometer clamp
	
Beaker clamp	**250 W infrared light**
	
Scale	
 	
Salad spinner	
  	

Fabric identification:

It is essential to have a system for identifying the fabrics. Here is an example of a poster allowing for the identification of the types of fabrics used during the experiments. You need only glue your samples in the appropriate box.

ACRYLIC	COTTON	WOOL	NYLON

METALLIC FILM	POLYESTER	BUBBLE WRAP