PARENT / INSTRUCTOR NOTES

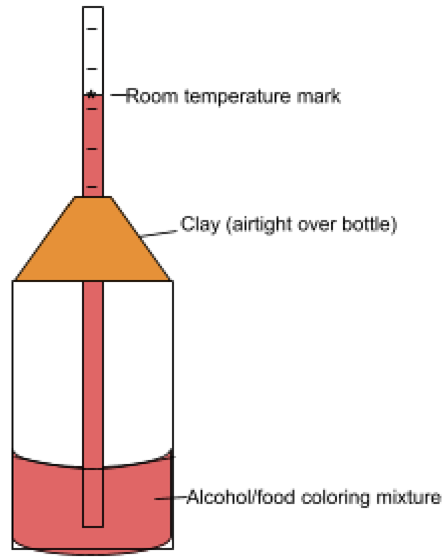
Homemade Weather Instruments

Recommended for ages 13+ (or with adult supervision)

Objective:

Many of the weather instruments that are used to record weather observations can be recreated (in simplified versions) using materials commonly found at home. The objective of this activity is to build simple weather observation instruments to record weather data at your location.

Part I. Building a Thermometer



Materials:

- Clear Plastic Straw
- Ruler
- Fine-tipped permanent marker
- Narrow-necked plastic bottle with lid

  (small bottles used for food-coloring or vanilla extract work best)
- Water
- Rubbing Alcohol

  (Be sure your work area is well-ventilated. Cover alcohol when not in use)
- Food coloring (just a few drops)
- Modeling Clay or Play-Doh
- Medicine dropper or syringe

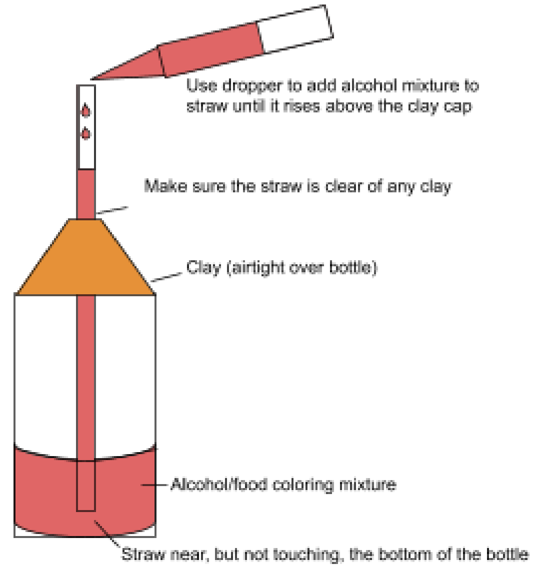
Directions:

1. Empty and wash the small, plastic bottle.

2. The clear plastic straw will become the narrow tube of your thermometer. Use the marker to make small marks on the straw, from the top down, at half-centimeter intervals. These marks will serve as level marks on your thermometer.

3. Your modeling clay will seal the bottle's neck and hold the straw in place. Mold the clay until it feels soft and elastic, then form a ball and push it flat. This round flat piece of clay should be bigger than the neck of your bottle. Use your straw to punch a hole in the middle of this round piece of clay, just big enough to allow the straw to go through. Remove any clay clogging the straw (toothpicks work great for this). Don’t put the clay cap on the bottle until Step 5.

Fill the bottle about halfway with rubbing alcohol and a few drops of food coloring, put the lid on the bottle, and shake well.



4. Take the lid back off of the bottle and place your clay cap over the opening. The straw should be immersed in the liquid, but NOT touching the bottom of the bottle. The jar should be closed off to any outside air.

air should not be able to enter bottle through the straw as the straw is immersed in liquid

5. Use the medicine dropper to drip the colored alcohol solution into straw until the liquid reaches about halfway up the straw.

6. This is now your ***Room Temperature***. Draw a symbol on your straw to indicate room temperature.

   Make note of the actual temperature using another thermometer if you can!

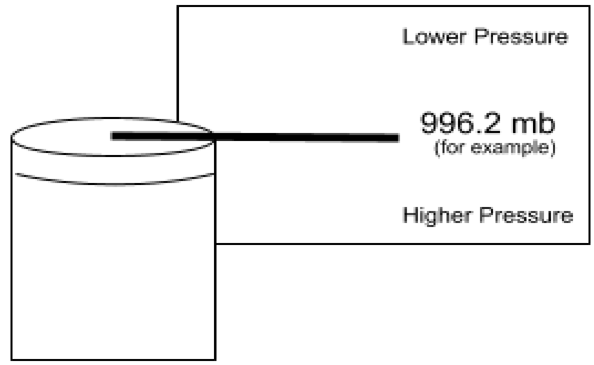
Try it out! Hold your thermometer tightly in your hands and observe the liquid in the straw!

Try setting your thermometer in warm water and cold water baths and compare your results!

Part II. Building a Barometer

Materials:

- Small coffee can or empty food can
- Plastic wrap
- Scissors
- Tape
- Drinking straw
- Index Card or sturdy piece of paper
- Rubber band



Directions:

1. Using the plastic wrap, cover the top of the can and secure it using the rubber band. The plastic wrap should form an airtight seal over the can.

2. Place the straw horizontally on the top of the can. Make sure it is centered (looking down, the straw should split the top of the can into two half circles). Tape the straw in place.

3. Tape the index card to the can behind the straw (you may need to trim the straw for this).

4. Record the location of the straw on the index card with a pencil. Find the ECONet station nearest to you (at http://climate.ncsu.edu) and label your index card with the true pressure (ex. 996.2 mb)

5. Continue recording the location of the straw as often as you want. Does the location of the straw change? For a particular straw reading, you can look up the current pressure at a nearby station and make note of it on your card.

You've now built your very own barometer!

Questions and Discussion

1. Record a few observations, do you see any changes in the location of the straw?

Could be yes or no. During the allotted time for the lab, it is unlikely any significant changes will be observed. Since your barometers will be at home, you will have the opportunity to observe changes over longer periods of time.

2. Describe how your homemade barometer works.

The homemade barometer measures the differences in pressure between the air inside the can/jar and the air outside of it. When the atmospheric pressure is low, the air inside the can will have a higher pressure than the air outside the can, causing the plastic wrap to 'bubble out' and the straw to move up on the index card. The opposite happens when the atmospheric pressure is high.

3. If the straw moves up on the card, what kind of pressure would you expect? Why?

Low Pressure. When the atmospheric pressure is low, the air in the can will have a higher pressure than the air outside the can and the air in the can will push outward.

4. Do you think your homemade barometer is more or less accurate than the ones that are used on our ECONet weather towers?

The homemade barometer is probably much less sensitive to variations in atmospheric pressure than the sensor used on the tower, so the homemade barometer is less accurate.

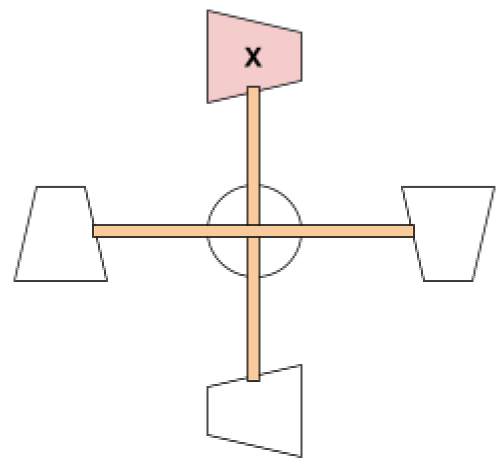
5. What are some advantages the *digital* barometer on the ECONet tower has over your barometer?

Since the barometer on the tower can record its own measurements, we don't need someone to physically go to the tower and record what the pressure is. This makes having hourly observations during all types of weather possible. Additionally, it is more difficult to capture the accuracy of the homemade barometer because there may be imperfections in the can, card, airtightness of the plastic wrap, or even errors when recording the location of the straw.

Part III. Building an Anemometer

Materials:

- Scissors
- 5 cups (such as dixie or solo cups), one should be of a different color or easily discernible
- Pen
- 2 strips of stiff cardboard
- Ruler
- Stapler
- Push pin
- Pencil with an eraser on the end
- Watch with a second hand or a timer.
- Small fan (optional).
- Calculator



Directions:

1. Cross the cardboard strips so they make a plus sign and staple them together.

2. Using the ruler and pencil, find the center of the two pieces of cardboard by drawing lines down the center of each piece and finding where they intersect.

3. Staple 4 of the cups, including the cup with the different color, to the ends of each cardboard piece. Make sure all the cups are facing the same direction relative to the cardboard pieces.

4. Push the pushpin through the center of the cardboard pieces. Take the pencil and push the eraser onto the pin sticking out of the cardboard pieces.

5. Using the scissors, poke a small hole in the center of the bottom of the remaining cup. Insert the pencil into this cup.

6. If you have a small fan available, set it up several feet away from the anemometer and turn it on to a low speed. Using the stopwatch, count the number of rotations in 15 seconds and multiply this number by 4 to get the number of rotations per minute (rpm). If you do not have a fan, take the anemometer outside to a bench or table and repeat the exercise.

Questions and Discussion

1. What is the actual wind speed measured by your anemometer? To determine this, you will need to find the circumference of the circle made by the two cardboard pieces and multiply this number by the recorded rpm (rotations per minute).

<u>**Example**</u>:
***rpm**: 20*
***Length of cardboard piece**: 20 inches (this is the diameter of the circle)*
***π** = 3.14159*

Circumference *(π * diameter)* = π * 20in = 62.83 in

Speed *(circumference * rpm)* = **62.83in * 20 = 1256.6 in/minute**
[Divide 1256.6 in/minute by 63360 to get miles/minute]
= 0.0198 miles/minute
[Multiply by 60 to get miles/hour]
= 1.19 miles/hour

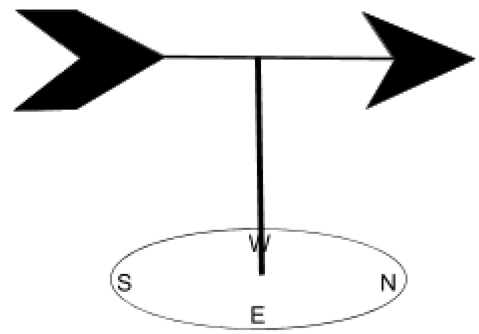
> *In order to solve, replace the length of your cardboard pieces and rotations per minute (rpm) in the example with the ones that you measured using your new anemometer.*

2. The speeds you calculated in question 2 are likely slightly different than the actual wind speeds. What are some possible reasons?

> *Both drag and friction are being ignored in this calculation. Additionally sources of error may include: differences in the lengths of the cardboard pieces, the cups may be stapled at slightly different positions on each of the cardboard legs, or the anemometer itself may not be exactly vertical either because of the surface it is resting on. Despite all of these, the homemade anemometer can provide a good estimate of the wind speed.*
>
> *It may also be beneficial to discuss why automated sensors have an advantage over your homemade anemometer (less human error).*

Part IV. Building a Wind Vane

Materials:



- A manila folder
- A pin
- Scissors
- Glue
- Pencil with eraser
- A straw
- Modeling clay
- A paper plate

Directions:

1. Using the manila folder, cut out an arrow point that is 5cm long and 5cm wide. Then, cut out a tail for the arrow that is 7cm long and 7cm wide.

2. Take your straw and make 1cm cuts on each end, parallel to the length of the straw. Create your arrow by sliding the arrow point and tail into either end of the straw *(result should look like image above)*

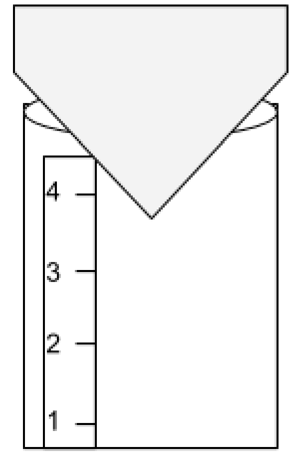
3. Take your arrow, your pencil, and your pin and push your pin through the middle of the straw and into the pencil's eraser. Push the sharp end of the pencil into a small lump of clay to form the base of your wind vane.

4. On your paper plate, write the four cardinal directions (North, South, East, West) and place your clay base and arrow at the center of the paper plate.

5. Try out your wind vane! Make sure your paper plate is facing the correct orientation (using a compass or your phone - there's an app for that!) and observe the wind direction!

Note: Your vane will show the direction that the wind is coming from. If your wind vane points West, the wind is coming from the West

Part V. Building a Rain Gauge



Materials:

- Clear cylindrical jar (like a pickle jar)
- Plastic Ruler (preferably clear)
- Rubber bands
- Plastic funnel
- Clear tape

Directions:

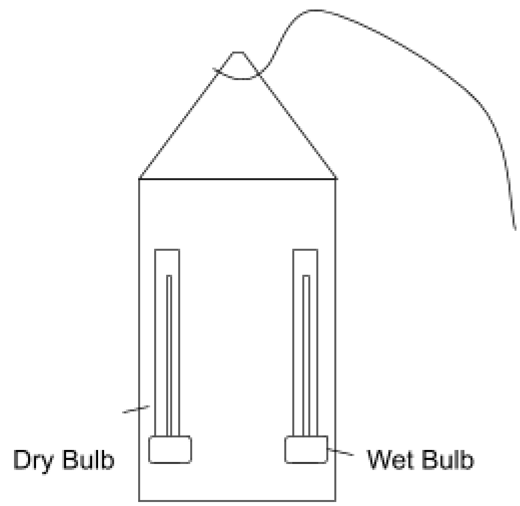
1. Attach your ruler to the outside of your jar using tape or rubber bands (you can attach the ruler to the inside of the jar if you prefer)

2. Put your funnel in the jar. The funnel should cover the entire mouth of the jar so rain can enter only through the funnel. For the best results, the diameter of the funnel should be about the same as the diameter of your jar.

3. Test your rain gauge using the faucet! If there is rain in the forecast, find a place outside that is not covered by trees or other obstructions that could block the rain.

4. Be sure to empty your gauge after each rain event to ensure accuracy!

Part VI. Building a Sling Psychrometer



Materials:

- Cotton gauze (gauze is preferable to cotton balls)
- Scissors
- Small rubber band
- Empty plastic water/soda bottle (20oz or ½ liter)
- Clear Tape
- 2 red alcohol thermometers (with °C)
- Water
- 18 inches of string

Directions:

1. Wet a double layer of cotton gauze. The gauze should be saturated, but not dripping.

2. Cover one bulb of the thermometers with the wet gauze using a rubber band.

3. Take the ‘wet bulb thermometer’ and tape it to one side of the bottle. Tape the other thermometer (‘dry bulb’) to the other side of the bottle. Make sure you can still read the numbers of the thermometer.

4. Tie the string to the top of the bottle. Make sure it is well-secured as you will be swinging the bottle around.

5. Find an outdoor open space to sling around your psychrometer!

6. Sling the psychrometer around your head for about 1 minute.

7. Record the temperatures on each thermometer.

8. Subtract the Wet Bulb temperature from the Dry Bulb Temperature. The difference between the two thermometers will allow you to measure how much water evaporated from the Wet Bulb thermometer.

9. On the next page, use your Dry Bulb and Wet Bulb measurements to determine the **Relative Humidity %**.

Relative Humidity %

Dry Bulb Temperature (Celsius)	Difference Between Wet-bulb and Dry-bulb Temperatures (ºC)															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
-20	100	28														
-18	100	40														
-16	100	48														
-14	100	55	11													
-12	100	61	23													
-10	100	66	33													
-8	100	71	41	13												
-6	100	73	48	20												
-4	100	77	54	32	11											
-2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Example)

Dry Bulb = 14 °C
Wet Bulb = 12 °C

Dry Bulb - Wet Bulb = 2 °C

using the chart, triangulate the Relative Humidity

Relative Humidity = 79%

Record your Observations

First, find the ECONet Station that is nearest to you. Go to *climate.ncsu.edu* to find your **Home Station** and the current conditions.

If you allow the website to use your location, your home station will automatically populate.

What is your **Home Station**? ____________________
(Ex. the State Climate Office's ***Home Station*** *is LAKE [Lake Wheeler Road Field Lab])*

Complete the data table!

Instrument (unit)	What does it measure?	Your Measurement *(don't forget units!)*	ECONet Station Measurement
Thermometer (°F)	*Temperature / heat*		
Barometer (mb)	*[Atmospheric] pressure*	*Students may indicate* ***High*** *or* ***Low***	
Anemometer (mph)	*Wind Speed*		
Wind Vane (direction)	*Wind Direction*		
Rain Gauge (in)	*Amount of precipitation*		
Sling Psychrometer (%)	*[Relative] Humidity*		

1) Which of **Your Measurements** has the *closest* value to the ECONet Measurement?

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2) Which of **Your Measurements** is the furthest from the value of the ECONet Measurement?

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3) Do you think **Your Measurements** are more accurate, or the **ECONet Measurements** are more accurate? Why?

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