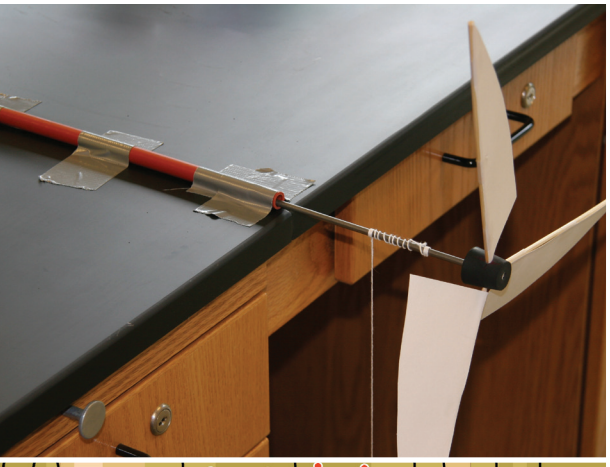
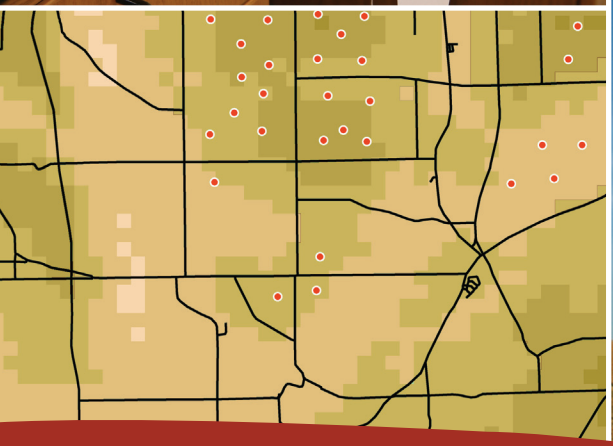
WindWise Education

Transforming the Energy of Wind into Powerful Minds





A Curriculum for Grades 6–12

2nd edition

windwise education

www.WindWiseEducation.org

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WHAT CAUSES WIND?

LESSON 4

KEY CONCEPT

Students learn about the forces that cause wind and how to measure these changes in the atmosphere.

TIME REQUIRED

3–4 class periods

GRADES

6–8

SUBJECTS

Physical Science
Social Studies
Earth Science

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BACKGROUND

The horizontal movement of air, also called wind, is driven by two primary factors: differences in pressure caused by the unequal heating of the Earth's surface and the rotation of the Earth. The factors that cause wind can be measured and are the basic elements of a daily weather forecast. Students also explore how measurements can be made with instruments such as barometers and thermometers.

OBJECTIVES

At the end of the lesson, students will:

- understand the relationship between temperature and pressure in the context of the gases in the atmosphere
- understand the forces that cause wind
- be able to explain how pressure of a fluid changes with speed

METHOD

Through observing a series of demonstrations and participating in hands-on activities, students learn about the relationship between temperature, pressure, and wind speed. On the molecular level, students describe what causes pressure, as well as, changes in pressure. Students then relate these concepts to topography and larger scale weather patterns.

MATERIALS

Hardboiled Egg Pushed into a Bottle

- ❑ Bottle with opening just smaller than the egg. (Iced coffee bottles work well.)
- ❑ Peeled hardboiled egg
- ❑ Matches
- ❑ Small piece of paper

Crushing a Soda Can

- ❑ Soda can
- ❑ Hot plate
- ❑ Tray
- ❑ Tongs

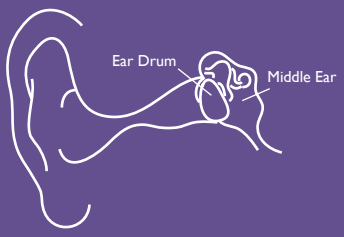
Moving a Table

- ❑ Table
- ❑ Large garbage bag
- ❑ Straws

Unequal Air Pressures

- ❑ 12–18" of clear plastic tubing
- ❑ Balloons that fit tightly over the tubing or over stoppers forced into tubing
- ❑ Clamp

EAR POPPING



Ears "pop" when there is an imbalance between the pressure inside and outside the ear. Airplanes are designed to maintain an air pressure in the cabin that is similar to that of the air on the ground. When the air pressure in the cabin changes, however, an internal blockage such as mucus can prevent equalization of pressure on each side of the ear drum. As a result, the ear drum is pushed in or out, creating a "popping" sensation.

Build a Barometer (1 set for each barometer)

- ❑ Straight sided glass jar (over 6" tall) with screw top lid
- ❑ Narrow plastic 6" ruler
- ❑ Clear tape
- ❑ 9" of clear plastic tubing
- ❑ Water
- ❑ Red food coloring
- ❑ Small clamp

Other Materials

- ❑ Paper
- ❑ Student Reading Passage & Worksheets*
- ❑ Soda Bottles
- ❑ Barometer (optional)

* included with this activity

GETTING READY

- Study the reading passage to become familiar with the relationship between temperature and pressure and how wind is generated.
- Collect materials for demonstrations.
- Try all demonstrations ahead of time to ensure they are working correctly.
- Make copies of the worksheets for each student.
- Assign the reading passage for homework if desired.

ACTIVITY

What are wind, air, and air pressure?
If students have not read the reading passage, ask them to do so at this time.

Start a discussion to see how much your students already know about these concepts. Here are some questions to get the conversation started:

- What is the fastest wind you have ever experienced?
- Has the wind pushed you around?
- What is air/wind comprised of?
- What do you think causes wind?
- Why does a hot air balloon rise and then drift with the wind?
- Why is it windy sometimes and calm at other times?
- Have you noticed wind is more likely to blow during the day and be calm during the night? Why is that?
- Have you ever had your ears pop? Why do you think this happens?
- What is air pressure?
- How do you measure changes in air pressure?
- Why does air pressure change?

Students will have had a variety of experiences with wind and air pressure. If possible, let them discuss their concepts among themselves for 10 minutes or longer. Once the conversation has concluded, you can begin performing the demonstrations. The demonstrations are designed to be confusing and to force students to think about what may be happening. It can be helpful to

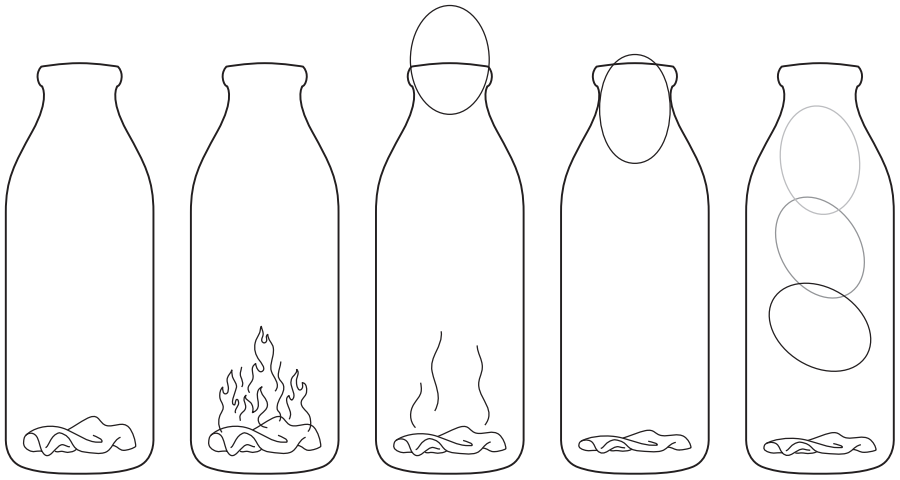
ask students to predict what will happen in each experiment before you do them. It is up to you how much you tell the students what is going on in each demonstration. It can help to ask students to draw each demonstration as it is happening and to ask them to explain what they think is occurring. Prompt them to focus on what is going on at the molecular level and what air is comprised of at the molecular level.

For each of the following demonstrations, students should make a drawing to use in answering the questions in Step 1. Each of the demonstrations illustrates one of three important points. Make sure that students think about these as you perform each one:

- When air is heated it expands, causing a drop in air pressure
- Unequal pressures exert forces (Force = Pressure × Area)
- Areas of high pressure push toward areas of low pressure

DEMONSTRATION 1: EGG IN A BOTTLE

Where is this air pressure? I don't see it or feel it!
Light the small piece of paper with a match and drop it into the glass bottle. If the paper stays lit for a few seconds, immediately place the narrow end of a peeled hard-boiled egg over the mouth of the bottle so that it seals the opening.



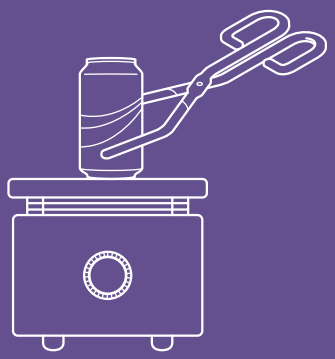
Observe what happens and discuss this with the students.

Discussion: As the air is heated, it begins to "expand," increasing the space between the air molecules. This happens because air molecules become energized when heated and move around faster, taking up more space. This expansion causes some air to escape from the bottle, which may make the egg wobble when it is first put on top of the bottle. As the air inside the bottle cools, the air "contracts" or the space between the air molecules decreases. The egg creates a temporary seal over the top of the bottle. There is less air inside the bottle (remember some of the air escaped when the air expanded), causing unequal pressures to occur between the air in the bottle and the air

ALTERNATIVE EGG DEMO

If you can't use fire for some reason, you can also do the demonstration with the bottle and egg using hot water. Add hot water into the glass bottle and leave for a few seconds to thoroughly warm up the glass, then discard the hot water. Immediately place the narrow end of a peeled hard-boiled egg over the mouth of the bottle so that it seals the opening. Observe what happens and discuss this with the students.

CRUSH A CAN WITH AIR PRESSURE



outside the bottle. The greater air pressure on the outside pushes the egg into the bottle, equalizing air pressure inside and outside the bottle.

Challenge: How can you remove the egg from the bottle without breaking it? Hint: Invert the bottle with the narrow end of the egg in the throat of the bottle, bring the bottle up to your lips, and blow hard. The egg will be forced into your mouth.

DEMONSTRATION 2: CRUSH A CAN WITH AIR PRESSURE

Pour a small amount of water into a soda can and place the soda can on a hot plate. After the water boils for a few minutes, invert the can into a tray of water, using a pair of tongs or some wet paper towels. Instantly, the can will be crushed by the air pressure in the room.

Discussion: As in the egg experiment, when we heat the water in the soda can, the space between the air molecules increases, forcing some of the air molecules out of the container. Newly formed water vapor molecules also push some of the air molecules out. When the heated air and water vapor molecules are quickly cooled, the pressure inside the can is lower than the pressure outside. This pressure difference causes the can to be crushed very quickly. Try to record with a video camera so you can replay and watch in slow motion. You will need a high-speed camera as this happens very quickly.

DEMONSTRATION 3: MOVING A TABLE

You can use a resealable zipper bag, a straw, and a large book to show students that air can move heavy objects. Place a large book on a zipper bag that has been sealed and that has a straw coming out of it. Ask students to move the book with air by blowing into the bag.

For a larger demo, tie off a large trash bag so that is it airtight and place it on a table. Invert a second table and place it on top of the trash bag. Poke a number of small holes in the bag just large enough so a straw can be inserted into each hole. Ask for volunteers to try to move the second table by blowing air into the bag.

Discussion: The students will be able to force some air molecules into the bags because the air pressure in their lungs is greater than in the classroom and bag. After many puffs, their higher air pressure will exert a force on the bag great enough to lift the book or the table.

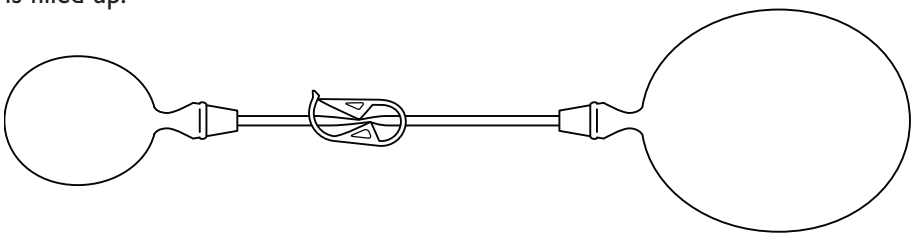
UNEQUAL AIR PRESSURE

Step 1. Why does air move?
Attach one balloon to the plastic tubing or rubber stopper. Blow up the balloon to about ¾ of its volume. Clamp the middle of the tubing or fold it over a few times and squeeze hard so the balloon maintains it volume. Blow up the second identical balloon to a very small size and attach it to the other

end of the tubing. After asking the students to predict what will happen to the balloons, release the clamp and observe the results.

Discussion: What should happen when you release the clamp is the small balloon inflates the large balloon. Not what you expected, right!? All of us remember that it is much harder to start blowing up a balloon when it is new. We also when know that when we add an extra puff of air to a balloon that is full, many times it pops!

The plastic balloon material is relatively thick when you start to blow it up and becomes thinner as the balloon inflates. This material can eventually become so thin that the inside air pressure eventually pops the membrane. In this demo, the air in a small balloon is under higher pressure than the balloon that is filled up.



Step 2: How does moving air affect pressure?
Quick definition—Bernoulli's principle states that an increase in the speed of the fluid (liquid or gas) occurs simultaneously with a decrease in pressure.

Hold a sheet of 8½ × 11 piece of paper by two corners. Ask the students what will happen when air from your lungs is blown across the bottom of a piece of paper. The usual answer is that the "paper should rise".

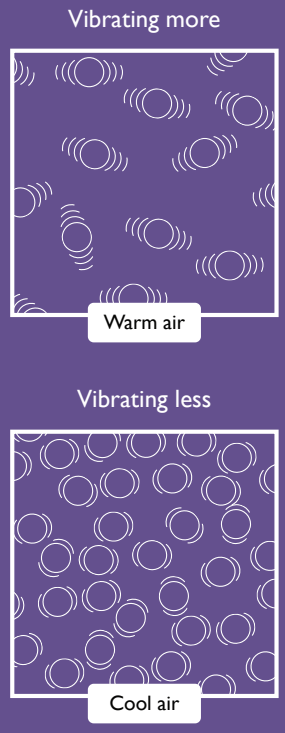
Follow up with a similar question, but this time tell the class that the air is blown across the top of the paper. When you do this the paper should also rise. Strange right?

When the air moves faster across the top side of the paper, it exerts less pressure on that side of the page. On the bottom side of the paper, the normal air pressure is still 14.7 pounds per square inch; hence the pressure difference will force the paper up. Again the direction is from high pressure to areas of low pressure.

Place two large plastic soda bottles (2 or 3 liter size) on the lecture table about an inch apart and ask the students to predict what will happen when air is blown through a straw between the two bottles. The bottles should roll together because you have created a low-pressure space in between the bottles i.e., Bernoulli's principle.

Step 3: Build a barometer (demonstration or hands-on activity)
Now that students understand that air exerts a force caused by differences in pressure, which can be caused by changes in temperature, have them build a simple barometer to show how pressure is measured. Show students a real barometer or download an image from the Internet (see Additional Resources).

AIR MOLECULES



Tape the tube to the ruler and then tape the ruler to the inside of the glass container.

Position the ruler and tube so that the bottom of the tube is clear of the bottom of the container, the top of the tube is above the top of the container, and the top of the ruler is inside the container. Cut the top off the ruler if necessary (see Figure 1).

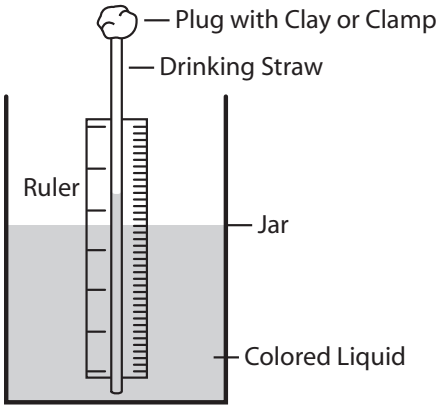


Figure 1: A Simple Barometer

Fill the container halfway with water and add some food coloring to make observation easier. Draw some water up the tube by inhaling on the straw, seal the top first with your finger, and then quickly seal the top with clay (or a clamp) so that the column of water in the tube is clearly higher than the level in the container.

If air pressure increases, the level of the fluid in the tube will go up. If the air pressure decreases, the level will fall. The change can be measured against the ruler in inches.

Discussion: Inches, centimeters, and millimeters of water or mercury are some of the many units that can be used to measure pressure. A standard barometer is a thin tube over 30 inches long. Normal air pressure, at sea level, is 29.92 inches of mercury or 760 mm of mercury. Normal air pressure can also be expressed as 14.7 pounds per square inch (14.7 psi). For example, a strong hurricane may have pressure as low as 27 inches of mercury.

Tell students to observe their homemade barometer each class period during the next week or two to see what changes take place. Relate the changes to the type of weather outside and see if you can find any patterns. What is the weather or wind speed like when the barometer is "low" or when it is "high"? Typically, low-pressure readings indicate unsettled weather of some kind, while high-pressure readings will be present with nice weather. Tell students to watch the local weather report, or head to the Internet and record barometric pressure for your area and say how it relates to their barometer.

Step 4: Volume, molecules, equilibrium, and pressure

As you do each demonstration, you should make sure that students create a drawing in their notes. Spend a few minutes using these drawings to explore the following concepts:

- Temperature can cause a pressure change at the molecular level.
- Air moves from regions of high pressure to regions of low pressure.
- Pressure differences generate a force which caused the air to move
- Moving air can cause a change in pressure

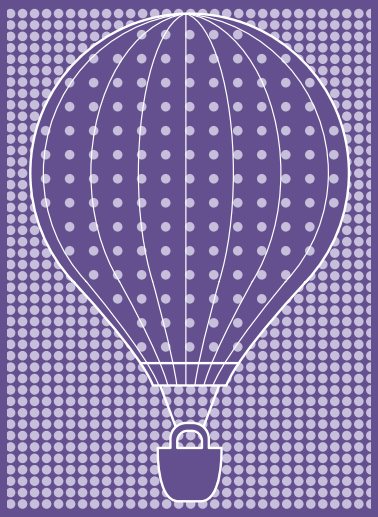
Step 5: How do these demos apply to wind and weather?
Refocus on the air pressure/air temperature egg demonstration for a minute. An increase in temperature adds kinetic energy to gas molecules in the air, which causes them to move about faster. This action creates more collisions, which cause molecules of gases in the air to move farther apart (expansion). In the confines of a bottle, the only way out is up and out through the mouth of the bottle.

When air warms in the atmosphere, similar principles apply. When the air is heated by the sun, molecules move farther apart, creating a less dense fluid and an area of low pressure. Air from higher-pressure areas will move towards areas of lower pressure to replace the rising air. This is known as wind. Areas with more intense heating will more actively rise, creating stronger winds.

Ask students to study worksheet diagrams 1 and 2 and complete the questions.

EXTENSION: HOW DOES A HOT AIR BALLOON WORK?

A hot air balloon has gas heaters to heat the air inside the balloon. As the air is heated, the air molecules begin to move faster which causes them to move farther apart. As they move farther apart, the overall density of the air in the balloon becomes less than the density of the air outside the balloon. The balloon begins to rise because the less dense hot air lifts the balloon and "floats" on top of the denser, cooler air around it. To bring the balloon down, some of the hot air is let out in openings at the top and cooler air is brought in through the bottom (the heat is turned off). This increases the density of the balloon and causes it to descend.



Heating air causes it to expand and become less dense.

Make your own hot air balloon
This project can be effective in helping students understand heat, air displacement, buoyancy and causes of wind. It works best indoors, but do this in a room without smoke detectors and with cement or tile floors.

Materials needed (each balloon):
- ❑ 28" long, lightweight garbage bags (the kind custodians place in classroom garbage cans). 24" inch long bags tend to melt too easily.
- ❑ 3 small birthday candles
- ❑ 5" square piece of aluminum foil
- ❑ 4–6 soda straws (straight kind)
- ❑ Lightweight string

Procedure
See student sheet (page 102).

⚠ CAUTION!

Students will be using plastic bags and small candles. They must be very careful *not* to let the candle burn the plastic bags they are using as the hot air balloon.

VOCABULARY

barometer – An instrument used to measure atmospheric pressure.

pressure (in the atmosphere) – The weight of air pushing down on each square inch of the Earth's surface.

thermometer – An instrument used to measure temperature.

topography – The study and mapping of the shape of surface features of the Earth such as mountains, valleys, rivers and lakes

RELATED ACTIVITIES

- Lesson 5: Where Is It Windy?

ADDITIONAL RESOURCES

ABOUT.COM— http://kwind.me/c3d—Search for "barometer" on this site.

BRASSBINNACLE.COM—http://kwind.me/v5p—Search for "barometer" and then click on the code number for an illustration.

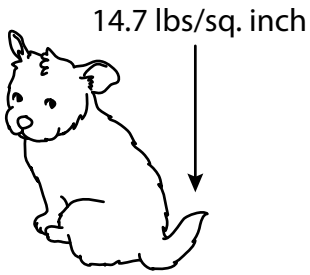
NATIONAL WEATHER SERVICE—http://kwind.me/p04—Type in your zip code to see your current and recent barometric pressure.

UNIVERSITY OF WYOMING— http://kwind.me/u8e—Get maps of current barometric pressure and wind.

WEATHER UNDERGROUND— http://kwind.me/f0n—Type in your zip code to get current and recent weather data.

READING PASSAGE

The common definition of wind is that it is air flowing from high pressure to low pressure.



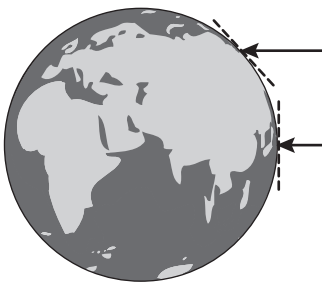
A column of air, one square inch in cross section, measured from sea level to the top of the atmosphere would weigh approximately 14.7 pounds. If you think about how many square inches your body has, that is a lot of weight! Why don't we feel it?

What causes differences in pressure? The closer air is to the ground, the more pressure it is under because air above pushes down on air below. Air is made of gas molecules, which have weight, and it is this weight that causes pressure. A 1 square inch column of atmospheric air pushing down creates approximately 14.7 lbs of pressure at sea level. At higher altitudes, the pressure is less simply due to the fact that there are fewer air molecules above.

Pressure varies in different places and at different times of the day because of the way energy from the sun is distributed. As the Sun's rays hit the Earth, land, water, and vegetation absorb the energy, some of which is given off as heat, which then heats the surrounding air. When air molecules heat up, they vibrate more and move farther apart as they collide with each other more often. This causes them to increase the amount of space (volume) they take up. When air molecules cool down, they come closer together, taking up less space (volume). As the volume of the air molecules increases, the density decreases. Conversely, as the volume of the air molecules decreases, the density increases. This change in the air density causes it to move. Denser, cooled air will fall, and less dense, heated air will rise. As air rises and falls in different places, it creates differences in pressure. Air moves from areas of higher pressure to areas of lower pressure and creates wind.

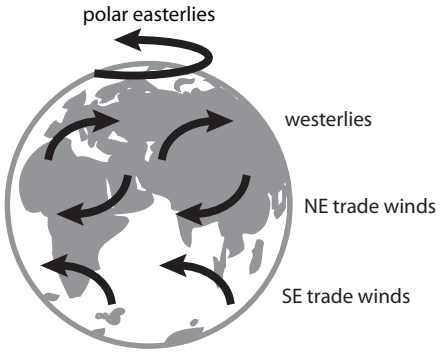
The Earth's spherical shape, topography, vegetation, and water bodies all ensure that every part of the Earth receives different amounts of energy. There will be differences in air pressure due to different temperatures, causing variation in the amount of air rising and falling and therefore variation in wind velocity and direction. For example, sea water heats more slowly than land, creating a major difference in pressure between land masses and oceans. Friction with the ground surface is also a factor, especially where mountain ranges create barriers to wind.

Differences in pressure represent part of the explanation of what causes wind. The second part is related to the Earth's rotation. As the world turns from west to east, the atmosphere turns, too, and in the same general direction. It is for this reason that the prevailing winds in most places blow from a westerly direction generally toward the east. Different levels of air in the atmosphere are affected differently by the Earth's rotation. Air high up in the atmosphere is not affected as much as air below, setting up a situation where air can flow in opposite directions at different altitudes. (You may have seen clouds moving in different directions at different heights.)



The Sun hits the Earth at different angles in different places. This creates uneven heating.

Latitude affects how much solar radiation is received each day. Tropical latitudes receive direct warming from the sun, whereas "high latitudes" (toward either pole) receive solar energy at an oblique angle due to the curvature of the Earth. Tropical latitudes, therefore, warm more easily than high latitudes and so there is a fairly constant rising of air away from the tropics (low pressure), which causes air from surrounding areas to move toward the tropics. Sailors call this constant air flow the "trade winds," which are very reliable.



Trade Winds

Land, water, topography, and the types of vegetation affect how much sunlight is absorbed and reflected. Snow cover plays a major role by reflecting back into space most of the solar radiation it receives. This creates cool air over the extreme northern and southern latitudes as well as over extensive mountain ranges. Cool air is denser than warm air and sinks to the surface, creating large areas of high pressure. This sets up many of the winter storms experienced in northern states such as New York when cold arctic air spreads south due to this high pressure.

Another concept related to wind formation is the Coriolis effect. Large masses of moving air, such as those described above, are pulled into circular rotation due to the Earth's rotation. Instead of air moving in direct lines from high pressure areas to low pressure areas, it is bent into curves. In the northern hemisphere, this causes air to flow clockwise around high pressure areas (anti-cyclones) and counter-clockwise around low pressure areas (cyclones). Severe storms are cyclones with very low pressure. These flows are reversed in the southern hemisphere.


Coriolis Effect

Since differential temperature is the major factor that affects pressure, it is common for large areas of warm air (originating from closer to the equator) to come into close proximity with large areas of cooler air (usually originating closer to the poles). Warm and cold air masses do not readily mix, and where they meet the cold air will push under the warm air, forming a "front." A front can create windy and rainy weather, sometimes with thunderstorms and tornadoes.

This reading passage was adapted from material found on two websites:

- "Exploring What Causes Wind." Robert Leverton. http://kwind.me/b8x
- "Weather Dudes." http://kwind.me/k2m

CAREER PROFILE: BILL QUINLAN, METEOROLOGIST

I joined the WCJB TV20 Weather Team in Gainesville, Florida, in 1996. I present the weather at 5:30, 6:00, and 11:00 pm weeknights and oversee the WCJB TV20 weather staff and severe weather coverage for the station. I love weather and am happy that I have a career that allows me to study the weather every day. I love to explain complex weather phenomena to television audiences.

To become a meteorologist, you need to study weather in college. To present weather forecasts on television, it also helps to study mass media. My qualifications include a bachelor's degree in meteorology from the University of Massachusetts and also a Certificate in Broadcast Meteorology from Mississippi State University.

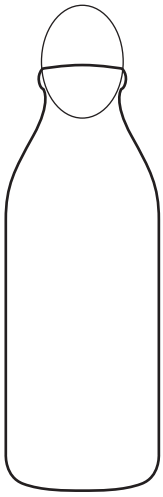
I have been awarded Seals of Approval by both the National Weather Association and the American Meteorological Society. I also present lectures to numerous organizations, including civic groups, schools, and retirement communities in North Florida, where I live with my wife and son.

Name_____ Date_____ Class_____

WHAT CAUSES WIND?

Relationship between temperature and pressure

1. What happened to the egg on top of the bottle you were observing?



2. Why did this happen?

3. On the drawing, label pressure areas just before the egg moves into the bottle.

Bag Experiment

4. Could you blow the bag up when it was under the book?

5. Why or why not?

Two Balloon Experiment

6. Why is it hard to blow up a new balloon?

7. When a balloon breaks, do you think the balloon material is very thin or thick?

8. Why does a small balloon always blow up an identical large balloon?

Build a Barometer Experiment

9. In terms of differences in air pressure, explain what happens to the barometer from one day to the next day.

10. A column of air, one square inch in cross section, measured from sea level to the top of the atmosphere would weigh approximately 14.7 pounds. If you think about how many square inches your body has, that is a lot of weight! Why don't we feel it?

Bernoulli's Principle Experiments

11. Why did the paper rise when air was blown across the top of it?

12. State Bernoulli's principle in your own words.

Air Can Exert a Force

13. Land and water heat and cool at different rates. Land heats and cools much faster than water. In coastal areas and areas near large lakes, this phenomenon causes the direction of winds to change at different times of the day and night. Based on what you now know about the relationship between temperature and pressure and how this creates conditions for wind, *circle the correct word in the sentences below and then draw arrows on the diagrams to show which ways the wind will blow.*

    a. On sunny days, in the morning, the Sun heats the land more quickly than it heats the nearby ocean. Because of this, the air over the land will **rise / fall** and the pressure over the land will **increase / decrease**. Because of this, the wind will blow **toward / away from** the ocean and **toward / away from** the land.

On Diagram 1 below, draw in arrows to show where air is rising and falling and in which direction the wind will flow.

INDICATE THE WIND DIRECTION
Label high & low pressure areas

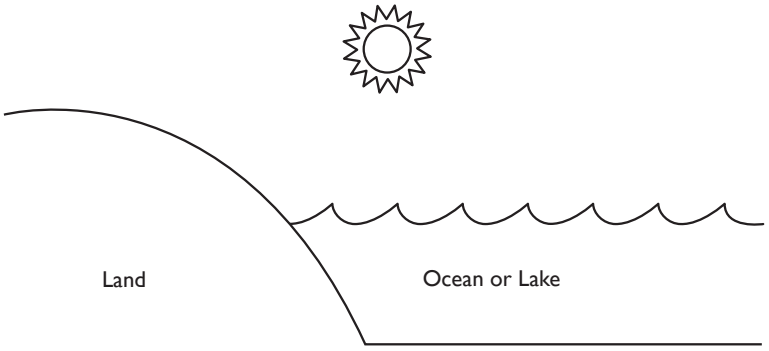


Diagram 1: 11am on a sunny day

    b. In the evening, when the sun goes down, the land will cool down, which cools the air above it. Because of this, the air over the land will **rise / fall** and the pressure over the land will **increase / decrease**. Because of this, the wind will blow **toward / away from** the ocean and **toward / away from** the land.

On Diagram 2 below, draw in arrows to show where air is rising and falling and in which direction the wind will flow.

INDICATE THE WIND DIRECTION
Label high & low pressure areas

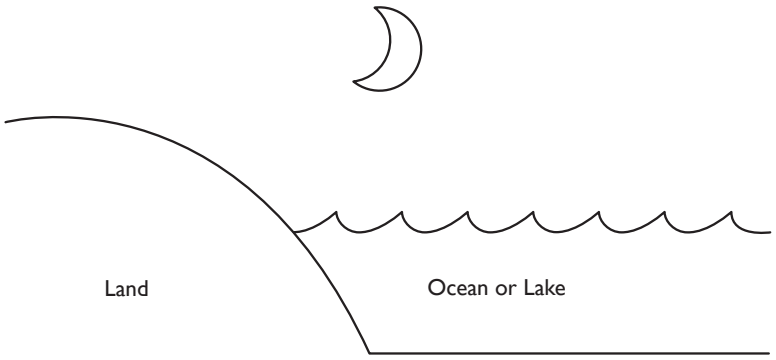
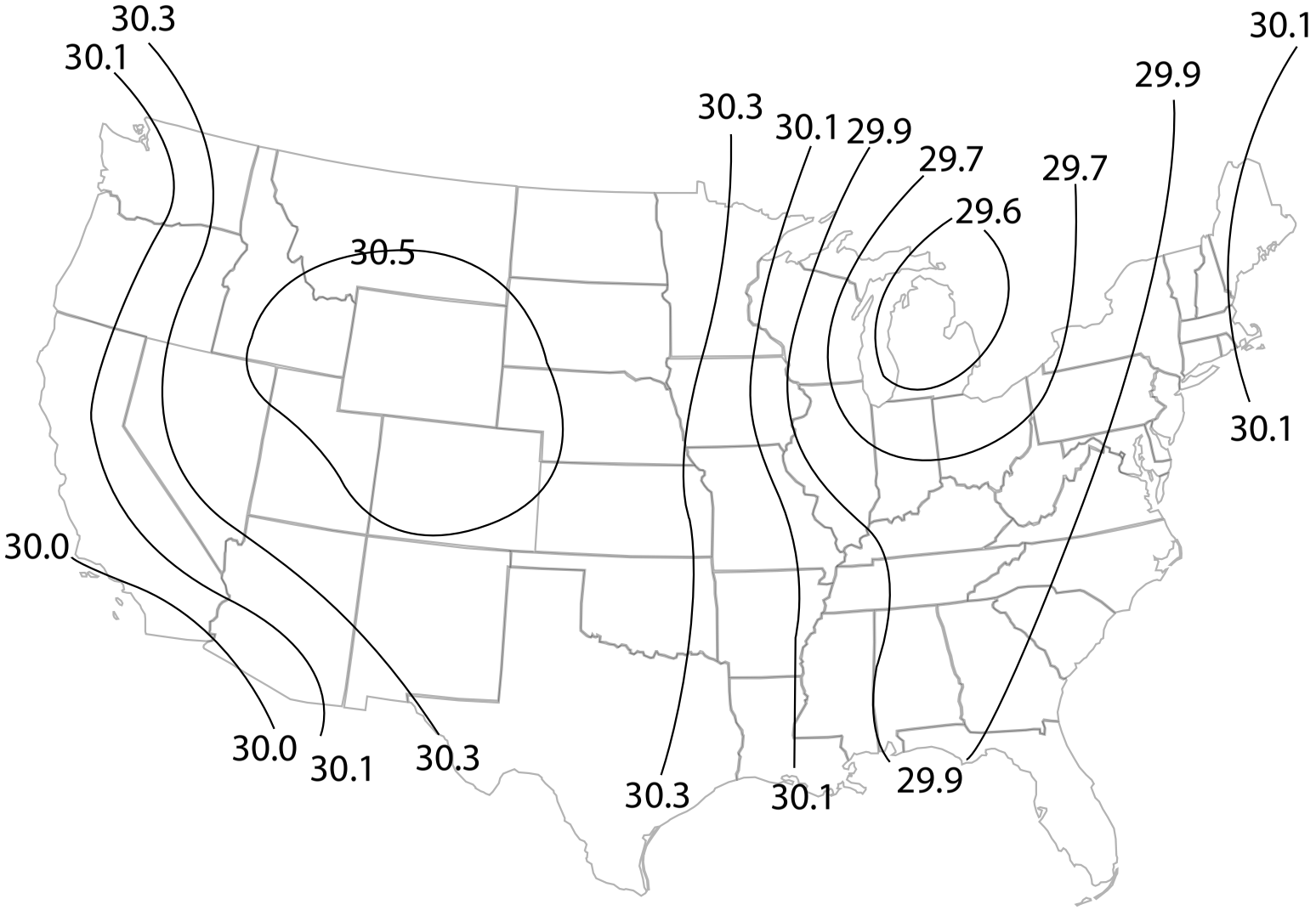


Diagram 2. 11pm on a clear moonlit night

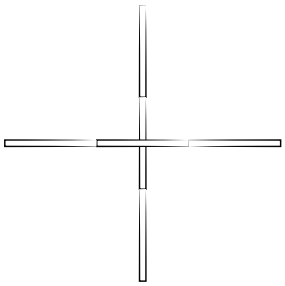
Label the map with High and Low Pressure. Where is air rising? Falling?

Optional: go online to find air pressure maps. What is the barometric pressure at your school?



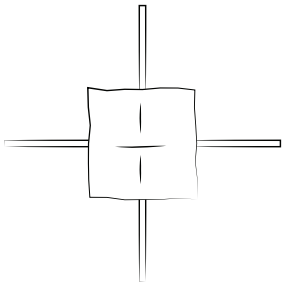
EXTENSION: HOW DOES A HOT AIR BALLOON WORK?

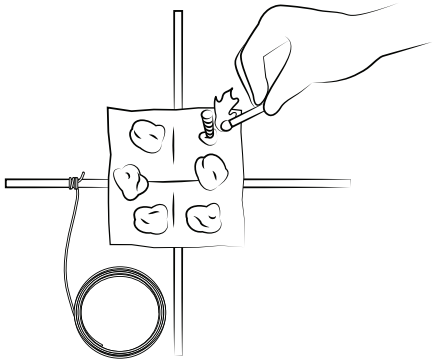
A hot air balloon has gas heaters to heat the air inside the balloon. As the air is heated, the air molecules begin to move faster which causes them to move farther apart. As they move farther apart, the overall density of the air in the balloon becomes less than the density of the air outside the balloon. The balloon begins to rise because the less dense hot air lifts the balloon and "floats" on top of the denser, cooler air around it. To bring the balloon down, some of the hot air is let out in openings at the top and cooler air is brought in through the bottom (the heat is turned off). This increases the density of the balloon and causes it to descend.



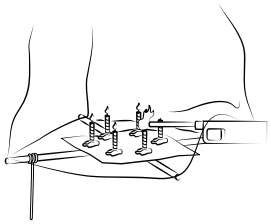
Procedure

1. Measure the diameter of the opening to the garbage bag. Multiply that number by .75 to find how long to make the straws for the base. Example: if the opening is 24 inches, then the straws need to be 18 inches long.
2. Make a straw base by making a ½ inch slit in one end of a straw and inserting that end in the end of another straw. Continue until you reach the length calculated above. Repeat for the second straw.





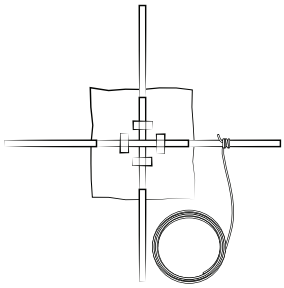
3. Form a cross with two straws so that the two straws form right angles. Tape the two straws together using a small amount of tape.
4. Attach the 5-inch square piece of aluminum foil in the center of the base by taping it to the four straws.
5. Cut the birthday candles in half and attach the six pieces to the foil.
6. Insert the base into the opening of the bag. Have a partner hold the top of the bag while you tape the bottom of the bag to each end of the four straws.



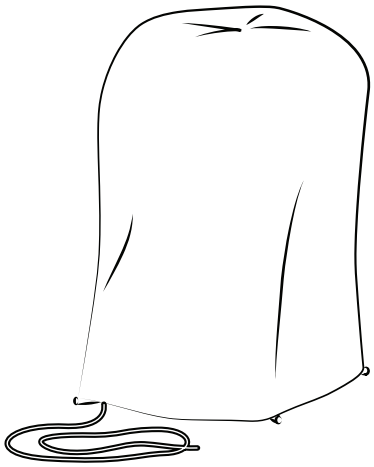
⚠ CAUTION!

You will be using plastic bags and small candles. You must be very careful *not* to let the candle burn the plastic bags you are using as the hot air balloon.

7. Attach a lightweight string to one of the straws

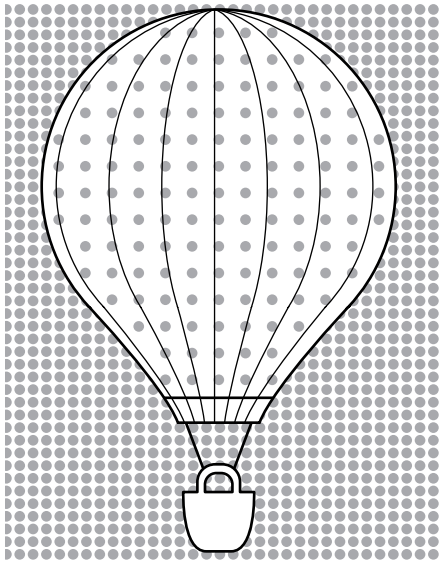


8. While your partner holds the completed balloon vertically, carefully light the six candles. (Fireplace lighters work, but keep the flame away from the bag.)
9. Continue to hold the bag vertically as it fills with hot air.
10. Once the bag is fully filled, gently set it down on the floor. It should remain fully extended while on the floor.
11. In a few minutes, the bag will begin to rise. Use the string to keep it at a desired height. If it fails to rise after a few minutes, check to see if all the candles are lit.

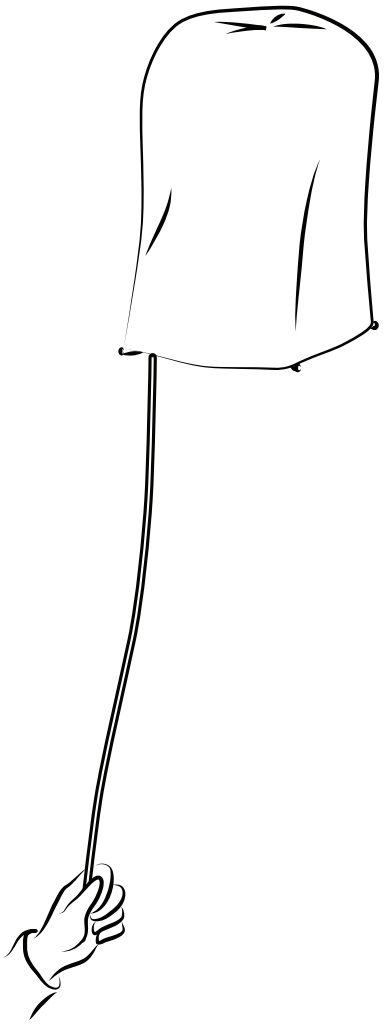


It will stay up until the candles burn out (4 to 5 minutes) and then sink slowly.

The balloon rises because the air in the bag is displaced. As the hot air rises, cooler air comes in to replace the displaced air and we have wind.



Heating air causes it to expand and become less dense.

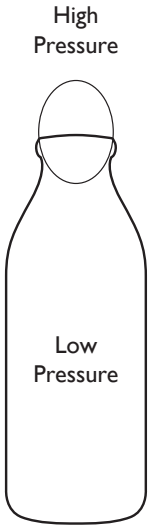


Hard question

If you know the volume and mass of the balloon, you can determine how much air you need to displace to lift a given mass. Using this number, students can calculate the size of the bag that could lift a member of the class.

WHAT CAUSES WIND

Relationship between Temperature and Pressure



1. What happened to the egg on top of the bottle you were observing?
   Student observation

2&3. Why did this happen? Label pressure areas on the drawing.
   Heat inside the bottle warmed the air, causing it to expand (molecules farther apart) and escape, which created lower pressure inside the bottle. The egg then blocked the entrance, causing a barrier to form between the higher pressure outside the bottle and the lower pressure inside. As the air inside the bottle cooled, the air contracted (molecules now closer together) and the higher pressure air from outside pushed the egg into the bottle.

   Label the diagram with "Lower Pressure" on the inside of the bottle and "Higher Pressure" on the outside above the egg.

Bag Experiment

4. Could you blow the bag up when it was under a book?
   Student observation

5. Why or why not?
   Explanation: As the bag is blown up, it inflates due to higher pressure introduced inside. This higher pressure exerts a force that can lift objects, such as books.

Air Can Exert a Force

13. a. On sunny days, the Sun heats the land in the morning more quickly than it heats the nearby ocean. Because of this, the air over the land will **rise / fall** and the pressure over the land will **increase / decrease**. Because of this, the wind will blow **toward / away** from the ocean and **toward / away** from the land.

On Diagram 1 below, draw in arrows to show where air is rising and falling and in which direction the wind will flow.

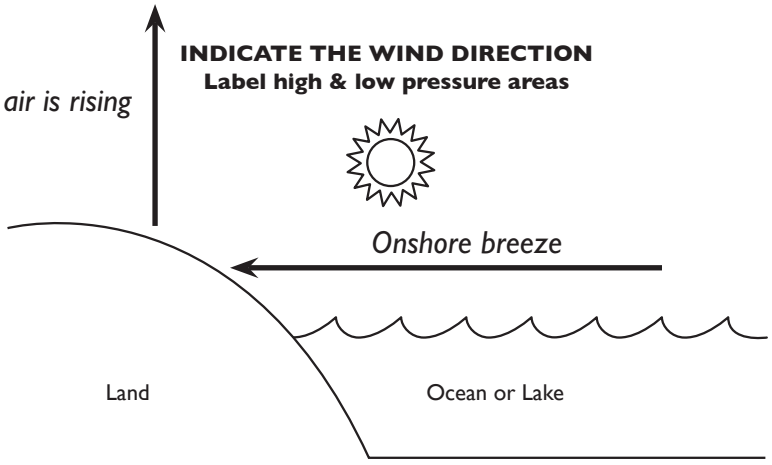


Diagram 1: 11am on a sunny day

b. In the evening, when the sun goes down, the land cools down which cools the air above it. Because of this, the air over the land will **rise / fall** and the pressure over the land will **increase / decrease**. Because of this, the wind will blow **toward / away** from the ocean and **toward / away** from the land.

On Diagram 2 below, draw in arrows to show where air is rising and falling and in which direction the wind will flow.

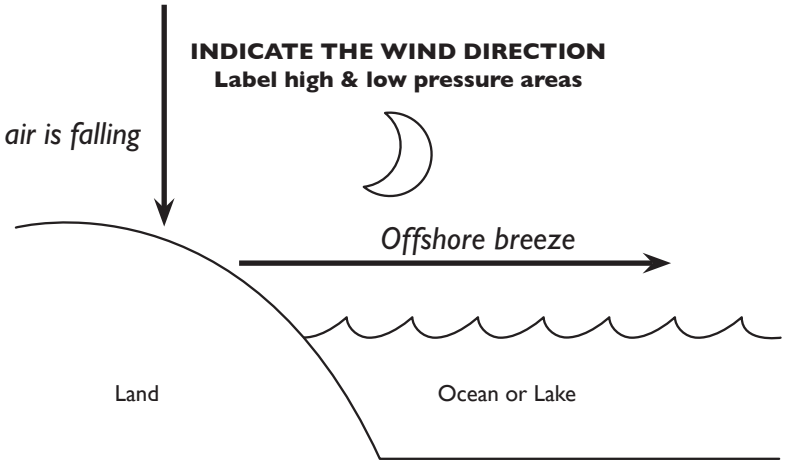


Diagram 2. 11pm on a clear moonlit night

US Map with Isobars

High pressure is over the western states centered over Wyoming with a pressure of 30.5 inches of mercury. Air is falling in this area.

Low pressure is over the Midwest centered over Michigan with a pressure of 29.6 inches of mercury. Air is rising in this area.