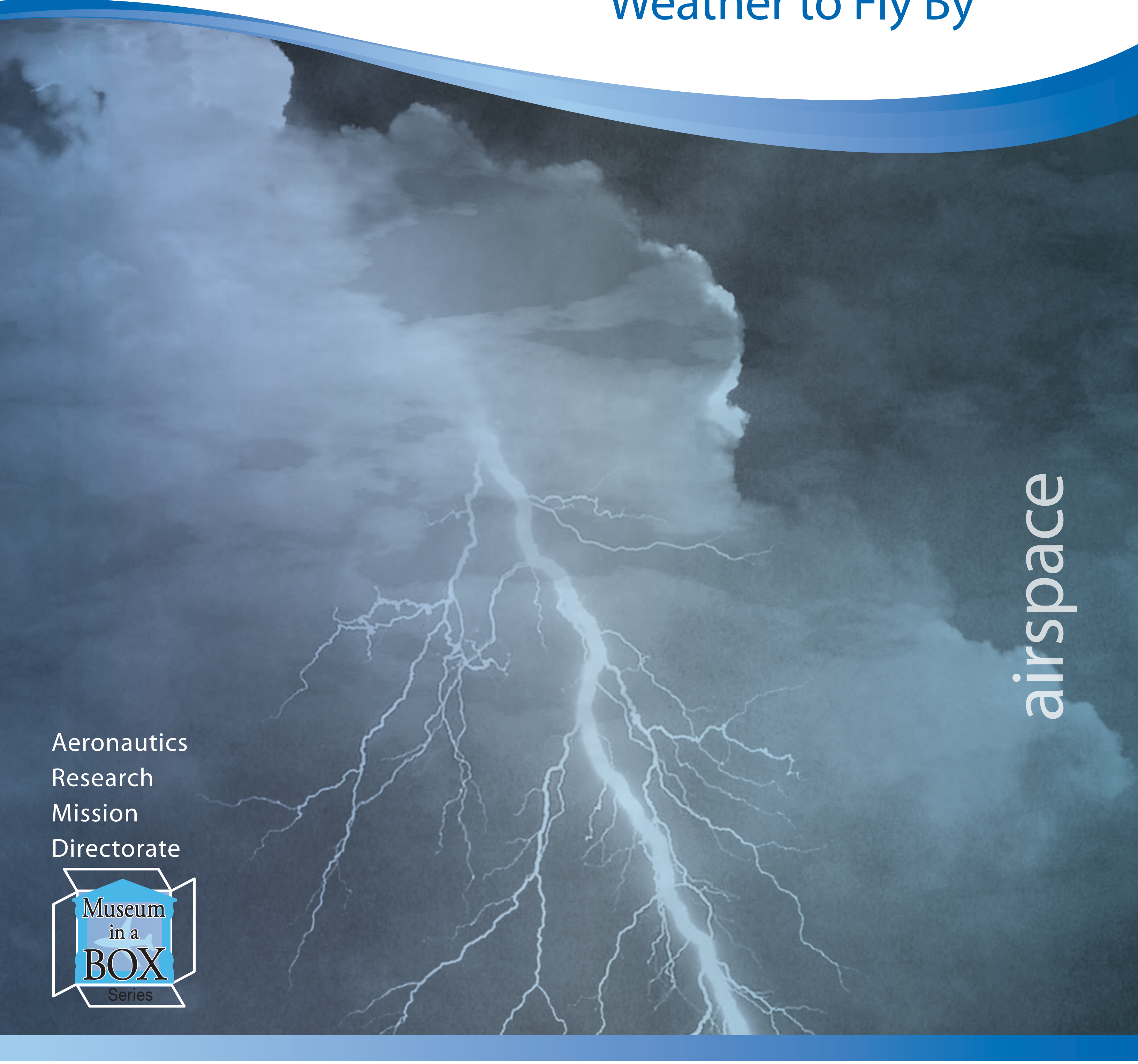
National Aeronautics and Space Administration

GRADES **K-8**

Weather to Fly By



airspace

Aeronautics Research Mission Directorate

Museum in a BOX Series

www.nasa.gov

Weather to Fly By

Lesson Overview

This lesson includes various demonstrations to help students learn how density and other properties change weather conditions that can have an effect on flight, and why it's important for a pilot to be familiar with these conditions. Students will engage in activities to gain a better understanding of the terms air mass and density, how weather conditions are created, and the instrument meteorologists use to measure wind speed.

Objectives

Students will:

1. Discover that while invisible, air has mass and occupies space.
2. Determine that though two items look identical, they may not have the same density.
3. Simulate lightning through the creation of static electricity.
4. Observe the formation of a tornado by creating a fluid vortex.
5. Learn how to measure wind speed by building an anemometer.
6. Simulate how a satellite senses infrared energy to detect clouds.

Materials:

In the Box

Plastic fish tank

Stopwatch

Small piece of animal fur

Anemometer Kit

Provided by User

2 Unopened soda cans of the same size, one containing a diet soda, one containing a regular soda

2 Empty soda bottles, washed and with the labels removed, with a small hole (~7mm) drilled into one cap

4 Small paper cups (per group)

2 Straight plastic drinking straws (per group)

8 Styrofoam cups

Thumb tack (1 per group)

Stopwatch/Timer/Clock (1 per group; 1 included in MIB)

Permanent marker

Scissors (1 per group, or per class)

Stapler (1 per group, or per class)

Electric fan, air vent or other source of wind

Clear drinking glass

Paper towel

Strong tape, such as duct tape or electrical tape

Water

Styrofoam plate or tray

Pencil with eraser (1 per group)

Aluminum pie plate

Large metal cookie sheet

Small squares of paper in 4-5 different colors

GRADES K-8

Time Requirements: 2 hours 5 minutes

Background

The Weather and its Effects on Flying

Weather is the state of the atmosphere with respect to wind speed and direction, temperature, moisture and pressure. A pilot needs to take all of these things into consideration while flying since it has a significant impact on the ability of both the airplane and the pilot to perform properly. The atmosphere is made of up three different layers: The mesosphere, stratosphere and troposphere (Fig. 1). Weather occurs in the troposphere, which is the lowest layer. The tropopause, which is the upper edge of the troposphere, where weather typically ends, is anywhere from 5 miles above the Earth's surface at the poles, to as much as 11 miles above the surface at the equator. Weather is primarily driven by temperature and moisture differences between two places. The different temperatures affect the pressure of the air, which causes the warm air from the high pressure areas to move to areas of low pressure. This movement of the air is what we refer to as wind.

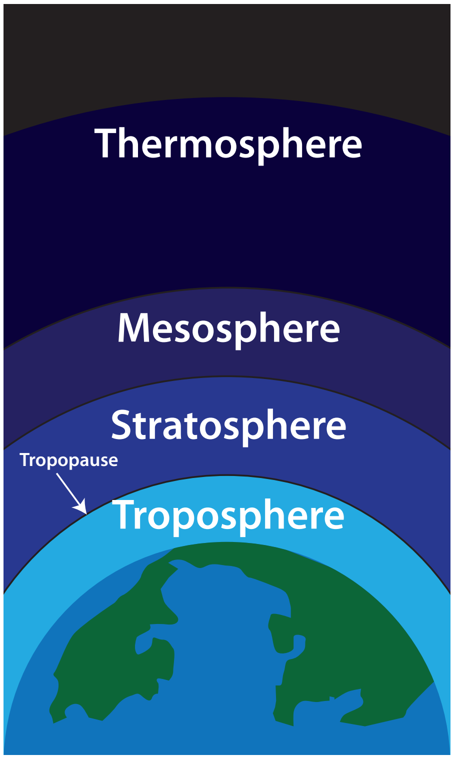


Fig. 1 The Earth's atmosphere

When flying long distances, it is quite common to take off and land in completely different weather conditions. However, since weather systems are often localized, landing conditions may be different even if you have only flown a few miles away. Before pilots take off it is important that they fully understand how the weather will affect their flight. Some of the items most commonly checked before a flight are wind, temperature and pressure, clouds (ceiling height and type) and dew point.

Wind: Wind direction and speed play an important role for an aircraft in flight as well as and during take-off and landing. Aviation weather reports include information for both surface winds and winds aloft, or the winds at altitude. When taking off or landing, a pilot ideally wants what is known as a headwind, where the air flows opposite to the direction of travel. This enables the aircraft to use less runway, or to carry more weight into the air. Having a headwind while in flight though will make the plane slower and burn more fuel; therefore during flight a tailwind is preferred. The opposite of a headwind, a tailwind is when air flows with the direction of travel.

One final term that pilots refer to is a crosswind. While having little effect in cruise flight, a strong crosswind, or wind blowing from the side of the aircraft, makes landing more difficult as it is harder to keep the aircraft aligned with the runway.

Temperature & Pressure: Since the sun heats the Earth unevenly, it creates air masses of varying density and pressure. Air reacts to these changes like a liquid, always trying to maintain a state of equilibrium. As such, these air masses move from the high pressure areas to the low pressure areas, creating what is more commonly known as wind. Strong winds occur when air masses of very different pressures are very close together.

Clouds: A cloud is nothing more than molecules of moisture in the atmosphere. Clouds vary in appearance due to differing atmospheric conditions, such as temperature, that cause them to form. When pilots understand the conditions in which a cloud is formed, they will have a better understanding of the weather they will encounter during a flight.

Stratus - A stratus cloud is a flat featureless cloud which usually covers a large portion of the sky. These clouds can either be high and transparent or low and gray. The air mass in which stratus clouds form is usually stable, as indicated by their smooth, flat appearance (Img. 1).

Cumulus - Cumulus clouds are the white puffy clouds which form when warm air rises (Img. 2). These clouds have a greater vertical development than the stratus cloud and because of the lifting action, may have unstable air associated with them.

Cumulonimbus - Cumulonimbus clouds are similar to cumulus clouds although they are usually associated with thunderstorms (Img. 3). Where possible, pilots avoid flying through these types of clouds as they generally equate to turbulent air and can contain hailstones, which can damage the aircraft. During the hot summer months, these clouds can reach as high as 60,000 feet (18,288 m).

Cirrus - Cirrus clouds are high altitude wispy clouds composed of ice crystals (Img. 4). These clouds are generally higher than most aircraft fly.

Dew Point: The dew point is the temperature to which the air must be cooled in order to reach saturation. Pilots will find that as the dew point gets closer to the current temperature, they will be more likely to encounter fog or clouds during their flight.

Img. 1 A stratus-covered sky over Key West, Florida

Img. 2 A collection of cumulus clouds over Southwest Florida, August 2009

Img. 3 An example of a cumulonimbus cloud seen over Pensacola, Florida

Img. 4 Cirrus clouds over Florida, August 2006

Activity 1

Air and the Space it Occupies

GRADES K-8

Time Requirements: 15 minutes

Materials:

In the Box

Plastic fish tank

Provided by User

Clear drinking glass
Paper towel
Tape (optional); preferably double-sided

Worksheets

None

Reference Materials

None

Key Terms:

Mass
Density

Objective:

Students will observe that while invisible, air has mass and occupies space.

Activity Overview:

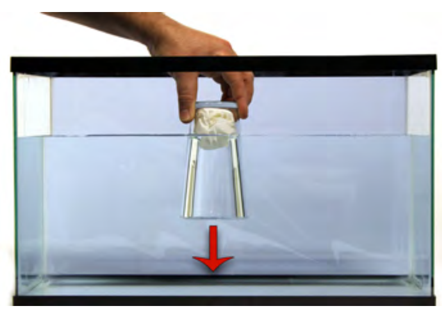
In this activity, students will take an air filled glass and attempt to displace that air with water. In doing so, they will discover that no two masses may occupy the same space simultaneously.

Activity:

1. **Fill the plastic fish tank with water.**
   It is important that the vessel be filled sufficiently with water to submerge the entire glass.

2. **Crush a dry paper towel into a ball and place it securely at the bottom of the cup.** Depending on the size of the towel and the glass, you may want to use a small piece of double-sided tape to prevent the paper towel from falling when the glass is inverted.

3. **Ask the students to predict what they think will happen to the paper towel once the glass is submerged upside down in water.**
   At this point do not correct the students' answers.



4. **Invert the glass and slowly lower it vertically into the water until it is completely submerged.**

5. **Hold the glass in the water for a few seconds and then remove it, taking care to ensure the glass remains vertical.**

6. **Remove the paper towel from the glass, straighten it and hold it up for the students to see.**
It is important to demonstrate that the towel is still dry.

7. **Ask the students to predict why the towel is still dry.**
As the students answer, it may be necessary to guide them towards the correct solution, which is that the air in the glass is preventing the water from reaching the towel.

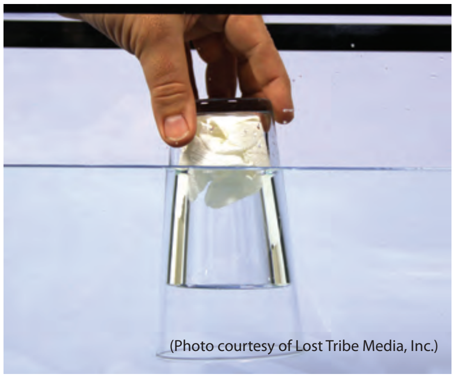
8. **Repeat the experiment, only this time tilt the glass slowly, allowing the air to gradually escape the glass.**
This will demonstrate that the air can now escape and is being replaced by the water (as indicated by the bubbles), which causes the paper towel to become wet.

Discussion Points:

1. **Why did the paper towel stay dry during the first part of the experiment?**
Before the glass was placed into the water, it was full of air. As the air could not escape the glass, it prevented the water from entering. The air prevented the water from entering the glass because no two masses can be in the same place at the same time.

2. **Why did the paper towel get wet when the glass was tilted to the side?**
As the air escaped from the glass, it allowed the water to take its place inside the glass.

3. **Why didn't the water pass through the air in the glass to wet the towel?**
Water has a greater density than air, which means that the air will always try to be above the water. In this demonstration however, the air was restricted by the glass so that it couldn't move upward. Instead, the water was forced to rise above the air (Img. 5).



Img. 5 Air in the glass prevents the water from entering

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE

- Property of objects and materials

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

NATIONAL SCIENCE STANDARDS 5-8

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

PHYSICAL SCIENCE

- Properties and changes of properties in matter

SCIENCE AND TECHNOLOGY

- Abilities of technological design
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Activity 2 — Which Object is More Dense?

GRADES K-8

Time Requirements: 15 minutes

Materials:

In the Box

Plastic fish tank

Provided by User

2 Unopened soda cans of the same size, one containing a diet soda, one containing a regular soda

Water

Worksheets

None

Reference Materials

None

Key Terms:

Density

Aspartame

Objective:

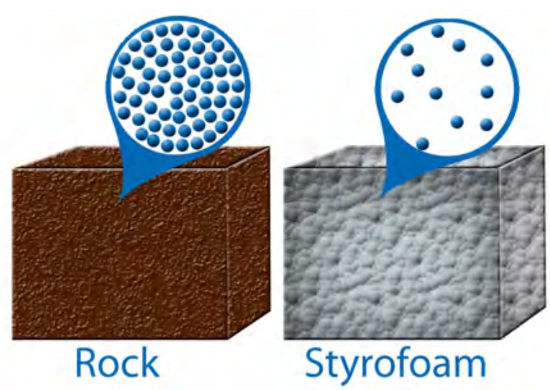
Students will learn that even though two objects may look, feel, and appear to be exactly the same, their densities may be different.

Activity Overview:

Students will compare the densities of two soda cans that look the same and contain the same amount of liquid by submerging them in a liquid of known density, water.

Before beginning this activity, fill the fish tank with water.

Activity:



1. **Explain to the class that density is a measurement of the compactness of a material, as measured in terms of mass per unit of volume.** Density is used to describe the compactness of the molecules within an object. For example, a solid rock that measures one cubic meter (1m x 1m x 1m) weighs more (and therefore has more mass) than one cubic meter of Styrofoam. This is because the rock is denser, or has more molecules per cubic meter, than the Styrofoam. We can calculate an object's density by using the formula Density = Mass / Volume.

2. **Pass the two soda cans around the class.** Ask the students to compare them for similarities and differences.
   It should be discovered that the cans are the same size, appear to be the same weight and contain the same quantity (volume) of soda.

3. **Place the can of regular soda in the water.**
   Students should observe that it sinks to the bottom of the container.

4. **Ask the students to explain why the can of soda sank.**
   If necessary, guide the discussion in order to ascertain that the can of soda sank because the density of the can and its contents was greater than that of the water.

5. **Now, hold up the can of diet soda and ask the students to hypothesize as to what might happen when the can is placed in the water.**
   It is likely that the students will assume that this can will also sink. For now, do not correct this assumption.

6. **Place the diet soda can into the water. Instead of sinking, it should float.** Ask the students why this can floated when an identical can sunk.
   If necessary, guide the discussion so that the students discover that while the two cans are virtually identical, it is the density of the soda inside that is making the can float. The diet soda, while being in the same quantity as the regular soda, is significantly less dense than water, causing it to float.

Discussion Points:

1. **What is the difference between regular and diet soda that causes such a change in density?**
   The can of regular soda contains sugar instead of a much stronger chemical sweetener. Since the large quantity of sugar adds to the mass (and therefore the density) of the soda, it will make the can denser than water, causing it to sink. (You can note the grams of sugar in a regular can of soda from the Nutritional Information on the label of the can.) The diet soda, by comparison, uses aspartame, a chemical that requires just a very small amount to accomplish the same level of sweetness.

2. **If two cans of diet soda were glued together, would it still float? What if it was one REALLY big can?**
   Probably, yes. While there would be additional mass from the glue, the overall density of the cans of diet soda would not change due to an additional quantity. As such, regardless of how much diet soda there was present, it would always float. Changing the quantity of an item doesn't change its density.

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE

- Property of objects and materials

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

NATIONAL SCIENCE STANDARDS 5-8

SCIENCE AS INQUIRY

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Activity 3

How to Make Lightning

GRADES **K-8**

Time Requirements: 15 minutes

Materials:

In the Box

Small piece of animal fur

Provided by User

Styrofoam plate
Thumb tack
Pencil with eraser
Aluminum pie plate

Worksheets

None

Reference Materials

None

Key Terms:

Electron
Charge
Conductor
Static electricity

Objective:

By creating static electricity, students will learn how lightning occurs naturally in the atmosphere.

Activity Overview:

Lightning is the discharge of electrical energy between positively and negatively charged areas in the atmosphere. It can occur within a cloud, between clouds or between a cloud and the ground. Lightning is simply static electricity on a very large scale. Using the apparatus below, students will make their own lightning on a smaller scale.

Before starting this activity, you may find it helpful to dim the lights in the room, or close the blinds if possible. A darker room will provide for a more dramatic presentation.

Activity:

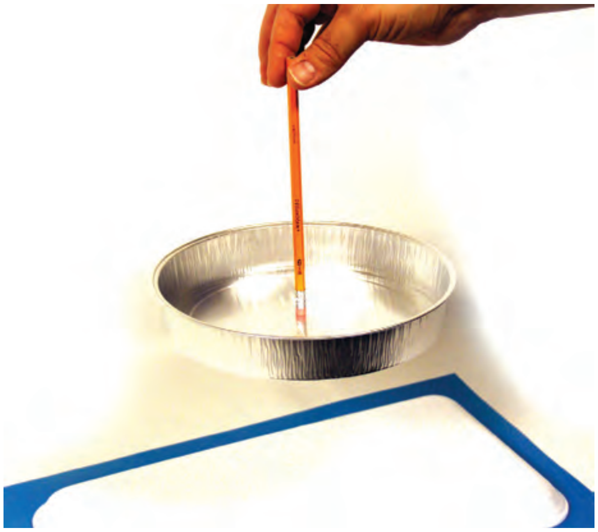
1. **To begin, secure the eraser-end of the pencil to the center of the aluminum pie plate using the thumb tack.** The goal is to provide a way of picking up the plate without touching it. The pencil eraser insulates the plate from your hand.

   Note: You may need to make a hole in the Styrofoam plate to provide a recess for the thumbtack, as the Styrofoam and metal plates must come into contact with one another later in this activity.

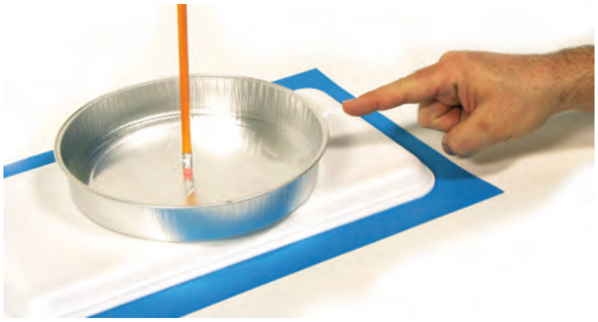
2. **Next, rub the Styrofoam plate vigorously against the fur.** The goal is to build up a layer of static electricity on the Styrofoam plate. It will take about 15-20 seconds of rubbing to accomplish this.

3. **Now, place the Styrofoam plate on a non-metallic table.**

4. **Using the pencil handle, pick up the aluminum pie pan and hold it approximately 6 inches above the Styrofoam plate, and drop the pie plate onto the Styrofoam.**
   Caution: Be careful not to touch either plate at this time!
   Before completing the next step, have the students stand close to the plates as the spark is quite small and hard to see.



5. **Slowly bring your pointed finger towards the metal pie plate.**
   A spark will jump from the pie plate to your finger.



6. **Now, using the pencil, raise the pie plate approximately 3 inches above the Styrofoam plate.**
   Using your other hand, slowly bring your pointed finger closer to the pie plate. Another spark will jump from your finger to the pie plate.

7. **If desired, have the students repeat this demonstration.**
   Start with Step 2 and repeat as desired.

Discussion Points:

1. **What happened just before you touched the aluminum pie pan?**
   A spark was created.

2. **Why do you think this happened?**
   The spark was created because of a build-up in static electricity. Normally, the Styrofoam plate contains an equal number of electrons and protons, meaning that it is neutrally charged. When the Styrofoam plate was rubbed against the fur, it took electrons from the fur and added them to the plate. As the plate now has extra electrons, and because the electrons are negatively charged, this made the Styrofoam plate negatively charged. When you placed the pie plate on top of the Styrofoam, the electrons in the pie plate wanted to move as far away as possible from the large quantity of electrons in the Styrofoam plate. Just like with magnets, opposites attract, similar repels!

When you put your finger close to the pie plate, the electrons in the pie plate saw a way of getting even farther away from the extra electrons in the Styrofoam – by leaving the pie plate entirely and going to your finger. It is this transfer of electrons that caused the spark.

The electrons do this in an attempt to make the combined unit of pie plate and Styrofoam plate as close to neutral as possible. However when the plates are separated, this leaves the pie plate positively charged (due to its lack of electrons) while the Styrofoam plate retains its negative charge.

3. **So, why did we get another spark when we lifted the pie plate and touched it again?**
   When you first touched the plate, the electrons belonging to the pie plate jumped to your finger, which made your finger (and you) negatively charged. This meant the pie plate had fewer electrons than it was supposed to have, which made it positively charged. After you lifted it away from the Styrofoam, the pie plate (being positively charged) wanted the electrons back, so as soon as you brought your finger near the plate, all the electrons that had previously jumped into your finger went back to the plate.

4. **How does it work in the real world? How do clouds produce lightning?**
   In simple terms, when two clouds rub together it acts the same way as when you rubbed the fur onto the Styrofoam plate. Electrons from one cloud build up on the other cloud. Eventually there are simply too many electrons for one cloud to hold and they all decide to leave and head toward the first positively-charged (or neutrally-charged) body they can find, either another cloud or the Earth.

5. **How does this experiment relate to the flight of an aircraft?**
   The majority of airplanes are made from aluminum, which is a great conductor of electricity. As they fly, the friction of the air rubbing past the plane causes static electricity to build up, which can affect the aircraft's communication and navigation systems. To prevent this, aircraft are designed to dissipate this static electricity by using small devices called 'Static Wicks'. As their name implies, these devices channel the static electricity away from the fuselage of the aircraft and out to the wings and tail, where it can be safely discharged back into the atmosphere.

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

• Abilities necessary to do scientific inquiry

• Understanding about scientific inquiry

PHYSICAL SCIENCE

• Property of objects and materials

SCIENCE AND TECHNOLOGY

• Abilities of technological design

• Understanding about science and technology

NATIONAL SCIENCE STANDARDS 5-8

SCIENCE AS INQUIRY

• Abilities necessary to do scientific inquiry

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PHYSICAL SCIENCE

• Properties and changes of properties in matter

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Activity 4 Tornado In A Bottle

GRADES K-8

Time Requirements: 20 minutes

Materials:

In the Box

Food coloring

Provided by User

2 Empty soda bottles, washed and with the labels removed, with a small hole (~7mm) drilled into one cap

Strong tape, such as duct tape or electrical tape

Water

Worksheets

None

Reference Materials

None

Key Terms:

Density

Mass

Vortex

Vacuum

Objective:

Students will observe how a vortex is created and discover basic fluid dynamics.

Activity Overview:

In this activity students will observe the creation of a water vortex by swirling water in a bottle. The swirling motion of the bottle creates a vacuum, as well as a pathway for the air as the water displaces the air mass below.

Before beginning this activity, drill a hole in the cap of one of the soda bottles, discarding the other cap. Using the duct or electrical tape, secure the cap upside-down onto the bottle so that the threads are exposed. This will allow for the bottles to be re-used/refilled as needed. Fill the other bottle 2/3 full of water, add a few drops of food coloring, and then screw the other bottle assembly to it. Until you are ready to start the demonstration, ensure that the bottle containing the water is on the bottom!

Note: For photographic purposes we added food coloring to the water. This is highly recommended to allow the students to better observe the demonstration.

Activity:

1. **Start this demonstration by showing the students a photo of a tornado from the Images section (Img. 6).**
Explain that, in very basic terms, a tornado is created when warm air tries to rise upwards through a mass of heavy, dense air. As it rises, it is replaced by the dense air and heavy rain from above. The wind causes this descending air mass to start rotating, which when the conditions are just right, causes a tornado.

Img. 6 A tornado in Kansas, May 23rd, 2008

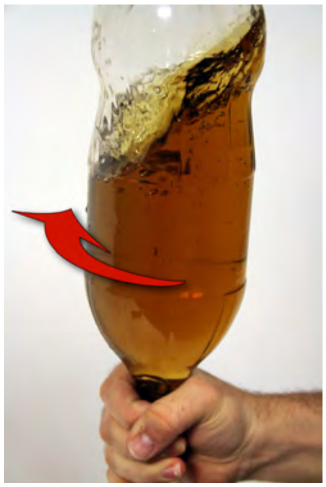
2. **Show the students your prepared bottle assembly.**
Explain that the water will represent the dense air and rain and the empty bottle represents the warm air.

3. **Invert the bottles so that the bottle containing the water is on top.**
*You will notice that just a thin, intermittent stream of water enters the lower bottle. If you have completed **Activity 1**, ask the students why the water is pouring so erratically. If not, explain as follows:*

The water is a more dense mass than the air in the bottle below and a more dense mass always tries to sink below a less dense mass. However, it cannot do so in this case as the air in the lower bottle has no means of escape. The gulping noise is the sound of the air forcing itself past the water through a combination of vacuum and gravity.

4. **Start swirling the bottle assembly.**
Caution: Do NOT shake!
As the rotational speed increases, a water vortex will form in the upper bottle and water will start flowing smoothly into the lower bottle. Ask the students why the water is now flowing smoothly.

The swirling water is creating a water vortex. The vortex is a funnel shape with a hollow center, just like a tornado. As such, the air from the bottle below can now pass unrestricted through the center of the vortex and into the bottle above.



5. **If desired, have the students perform the demonstration themselves by inverting the bottle again so that the water is back on top.**

Discussion Points:

1. **Can you name any other places where you have seen this effect before?**
   Answers may include bathtubs and sinks when they drain.

2. **Why did the water sink quicker when we swirled the bottle faster?**
   As the water rotated, the hole in the center grew larger which allowed more air to pass through. Since the air can escape quicker, it allows the denser water to descend faster too.

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Activity 5

Making an Anemometer

GRADES **K-8**

Time Requirements: 30 minutes

Materials:

In the Box

Anemometer Kit

Provided by User

4 small paper cups (per group)

2 straight plastic drinking straws (per group)

1 Thumb tack (per group)

1 Pencil with eraser (per group)

1 Timer / Clock / Watch (per group)

1 Permanent marker

1 Pair of scissors (per group, or per class)

1 Stapler (per group, or per class)

Tape

Electric fan, air vent, or other source of wind

Worksheets

Wind Speed Comparison (Worksheet 1)

Reference Materials

None

Key Terms:

Anemometer

Objective:

Students will discover how wind speed is measured.

Activity Overview:

As discussed in the **Background** information, it is vitally important for pilots to know the speed of the wind they will be flying in. In this activity, students will build an anemometer using straws and cups. By measuring the number of revolutions the device makes in a given time, students will be able to measure the speed of the wind.

Activity:

1. **Review the Background information with the students.**

2. **Divide the students into groups of 3-4 students.**

3. **Demonstrate how to create the anemometer and have the students follow along as you complete each step.**
   If these items are not available, a single Anemometer kit is included in the MIB.

   a. Using tape to secure them, arrange the two plastic drinking straws to create a cross with four legs of equal length.

   b. Push the thumb tack through the center of the cross and into the eraser of the pencil. This will create the axle and provide something to hold the anemometer with.

c. Staple a paper cup to each leg, ensuring they all point in the same direction.

d. Using the marker, clearly mark one of the cups so it can be differentiated from the others while spinning.

4. **By blowing on the anemometer, demonstrate how the paper cups collect the wind energy and convert it into motion.**

5. **Have the students place their anemometers into a steady source of wind, such as a fan or air vent, or the wind outside.** Ask the students to count the number of revolutions their anemometer makes in one minute by counting how many times the marked cup passes.

6. **Have the groups compare their findings.** Did everyone's anemometer spin at the same speed?
Based on the assumption that everyone used the same length straws and same sized cups, the results should be very similar for the same wind source.

7. **Optional: If desired, have the students repeat this experiment outside each day for a week and record their findings on the Wind Speed Comparison Worksheet.**
Compare the number of rotations of their devices to the actual wind speed as reported in the local media, or by visiting www.weather.gov. Is there a correlation?
The goal is to determine that there is a direct correlation between the rotational speed of the anemometer and the reported wind speeds.

Discussion Points:

1. **Our devices don't tell us the actual wind speed, only the number of rotations the anemometer makes. How could we make these devices more useful and give us the actual wind speed?**
To record actual wind velocity, we would need to know the precise speed at which our anemometer rotates for a known wind speed. We could do this by using the device for a week and plotting the results on a graph, and then comparing the wind speed against the rotational speed. From there, we could calibrate our device and use it to measure unknown wind speeds.

2. **How could this machine be better designed? Are there any inherent problems with the design that might cause spurious readings?**

Paper Cups – despite being wax coated, will eventually fail from being exposed to the elements. Plastic cups would help with this.

Thumb Tack/Pencil axle – Could cause unwanted friction which could slow down the rotational speed. Mounting on a post with lubricated bearings would help reduce the friction.

Straws – These are fairly flexible and may absorb some of the wind energy, slowing the rotation. Using a stiffer material would help.

NATIONAL SCIENCE STANDARDS K-4

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Activity 6 Detecting Clouds Using Infrared Energy

GRADES K-8

Time Requirements: 30 minutes

Materials:

In the Box

None

Provided by User

8 Styrofoam cups

Water

1 Pen or marker that can write on the cups

1 Large metal cookie sheet

Small squares of paper in 4-5 different colors (enough to cover the cookie sheet)

Worksheets

None

Reference Materials

None

Key Terms:

Infrared energy

Objective:

By using only their hands, students will demonstrate how a satellite's infrared detector can see weather by creating a thermal image map.

Activity Overview:

Cloud cover plays an important role in aviation. As well as reducing visibility for landing, clouds can also help pilots predict how turbulent the flight will be. In this activity, students will discover how satellites use infrared energy to locate clouds and track storms.

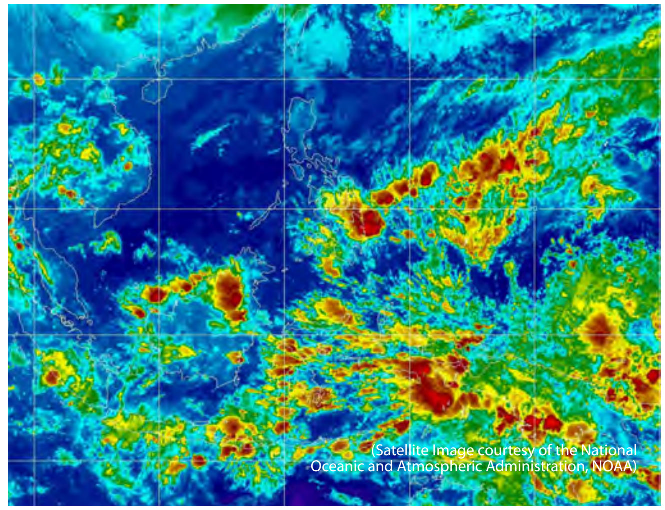
Some preparation is required prior to starting this activity:

Without the students seeing, fill the 8 Styrofoam cups with water of various temperatures. Use the pen to mark the temperature of the water (V. Hot, Hot, Warm, etc.) on the cups for later reference. For the most effect, and if safe to do so, use a wide range of temperatures ranging from extremely hot tap water, to ice water. Then place the 8 cups in various locations on a table but so they can all be covered by the cookie sheet.

Activity:

1. **Before beginning this activity, ensure the above set-up instructions have been completed.**
   The time spent explaining this activity to the students will give the cookie sheet a chance to heat/cool as necessary. For classes with many students, it may be beneficial to set up multiple sets of cups and trays.

2. **Show the students the false-color infrared satellite image (Img. 7).** Explain that by using satellites and adding color to enhance the image, meteorologists can use them to identify where the weather systems are located.
   For advanced students who desire more detail, you can also explain that the temperature of a cloud is a good indicator of its altitude; the higher clouds are colder than the lower ones. Typically, warm clouds are a good indicator of poorer weather and usually associated with rain. The (relatively) very hot clouds are normally storm producing clouds associated with heavy rain and turbulence.



Img. 7 A false-color infrared satellite image of Southeast Asia

3. **Using just their hands, have the students gauge the temperature of the cookie sheet in various locations, using the colored paper to indicate areas of differing temperature.**
   It may be easier to first establish the areas of extreme hot/cold using just two colors, then fill in the rest incrementally.

4. **Once the cookie sheet has been completely covered with paper, gently remove the sheet and compare the color coding to the markings on the cups underneath.**
   The students will discover that without ever seeing the cups, or knowing the temperature of the water, they have correctly located the areas of hot and cold.

Discussion Points:

1. **How is this possible? How could we determine the areas of hot/cold water without ever touching the water?**
   All objects, whether hot or cold, emit infrared energy. The cookie sheet absorbed that energy and converted it back into a temperature which could be detected by your hand.

2. **Where else have you seen infrared energy in use?**
Some answers may include: toy ovens; thermal imaging cameras (used by firefighters to detect trapped people); heat lamps or space heaters; TV remote controls.

Reference Materials

Glossary

Anemometer:
A device used to measure the speed of wind through a measurement of its rotational speed

Aspertame:
A chemically based artificial sweetener; often contained in products branded as "diet" where it is replacing the sugar of the "regular" variety

Charge:
The measure of the number of electrons in an object, or a measure of electricity

Conductor:
A material that provides little resistance to an electrical current or thermal energy

Crosswind:
Air moving perpendicular to the path of travel of an aircraft

Cumulus:
A type of cloud; associated with unstable air, these clouds are white and puffy in appearance

Cumulonimbus:
A type of cloud; similar in appearance to cumulus, cumulonimbus clouds are taller, more unstable and are associated with thunderstorms

Density:
The compactness of the molecules within a body of matter; a body that is more dense has more tightly packed molecules

Electron:
A negatively charged particle

Headwind:
Air moving opposite to the direction of travel of an aircraft

Infrared energy:
Light with a wavelength shorter than that which is visible to humans; infrared energy is outside of the range of visible light

Mass:
The measure of the amount of material contained in a body of matter

Stratus:
A type of cloud, usually a flat layer, grey in appearance; commonly referred to as an "overcast sky"

Static electricity:

A collection of excess surface electrons, usually generated through friction

Tailwind:

Air moving in the same direction as the path of travel of an aircraft

Vortex:

Commonly referred to as a whirlpool or a tornado, a vortex is a body of swirling or rotating mass that generates a vacuum at its center

Vacuum:

An area absolutely devoid of matter; often used with the term “suction” as a vacuum attempts to “suck” matter into it

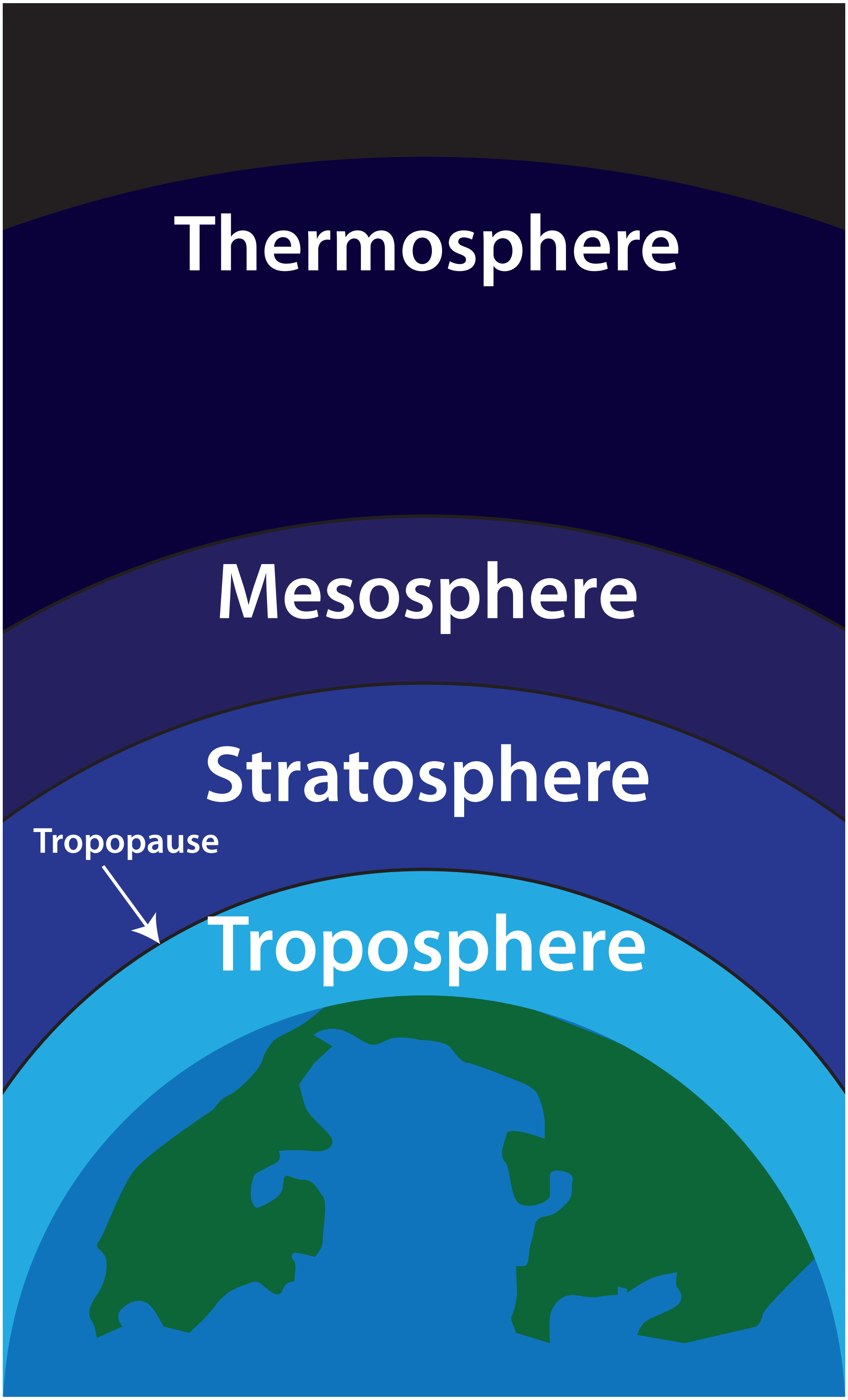
Wind:

The name given to the movement of an air mass

Winds aloft:

The name given to describe winds at the altitude of flight

Fig. 1 The Earth's atmosphere

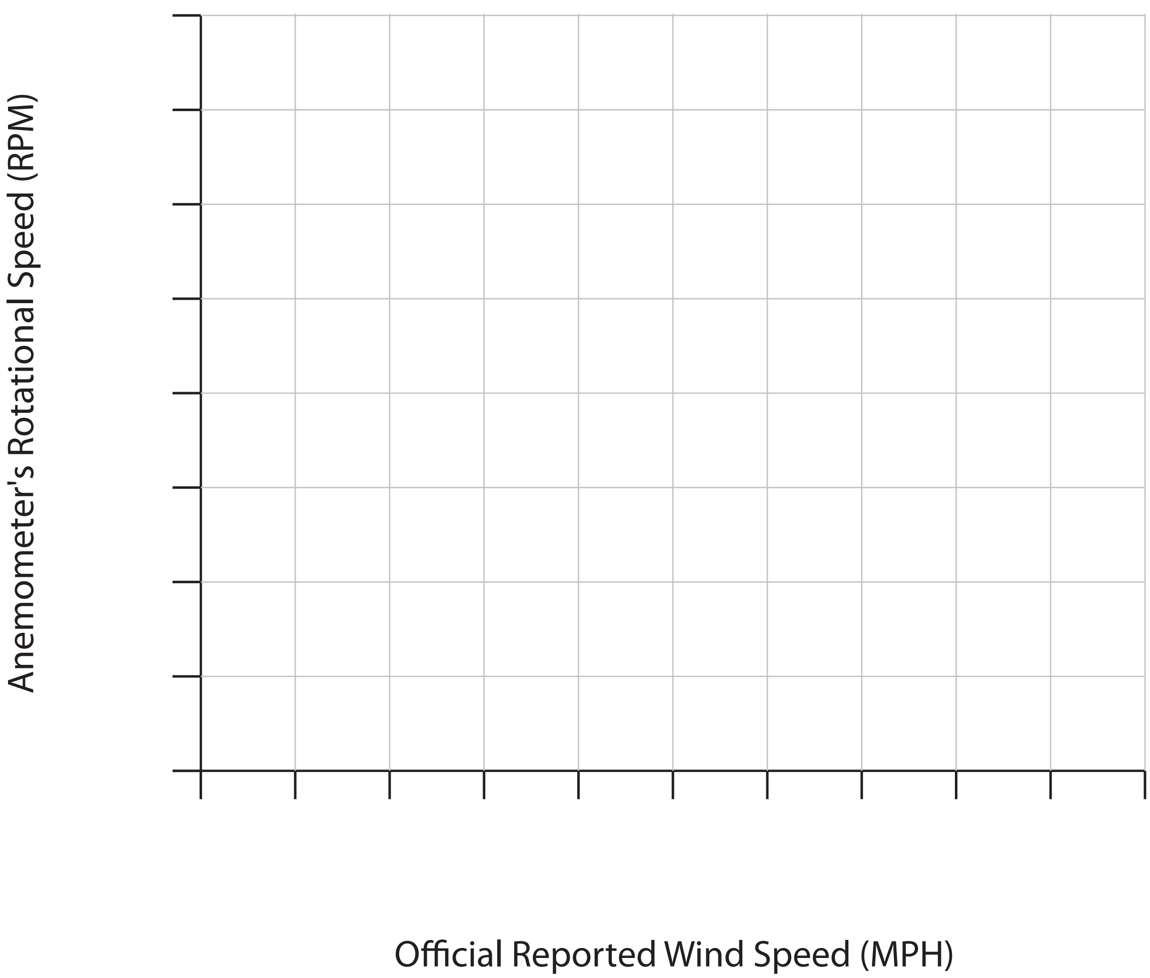


Worksheets

Worksheet 1 Wind Speed Comparison

Day	Anemometer's Rotational Speed (RPM)	Official Reported Wind Speed (MPH)

At the end of the week, plot your results on the graph below to visually determine the correlation between the number of rotations your anemometer made in one minute and the wind speed as reported by the National Weather Service. Label the tick marks on the X and Y axes to define a scale that best displays your results.



Images

Img. 1 A stratus-covered sky over Key West, Florida

(Photo courtesy of NOAA and The National Weather Service Weather Forecast Office, Key West, FL)

Img. 2 A collection of cumulus clouds over Southwest Florida, August 2009

(Photo courtesy of NOAA and The National Weather Service Weather Forecast Office, Key West, FL)

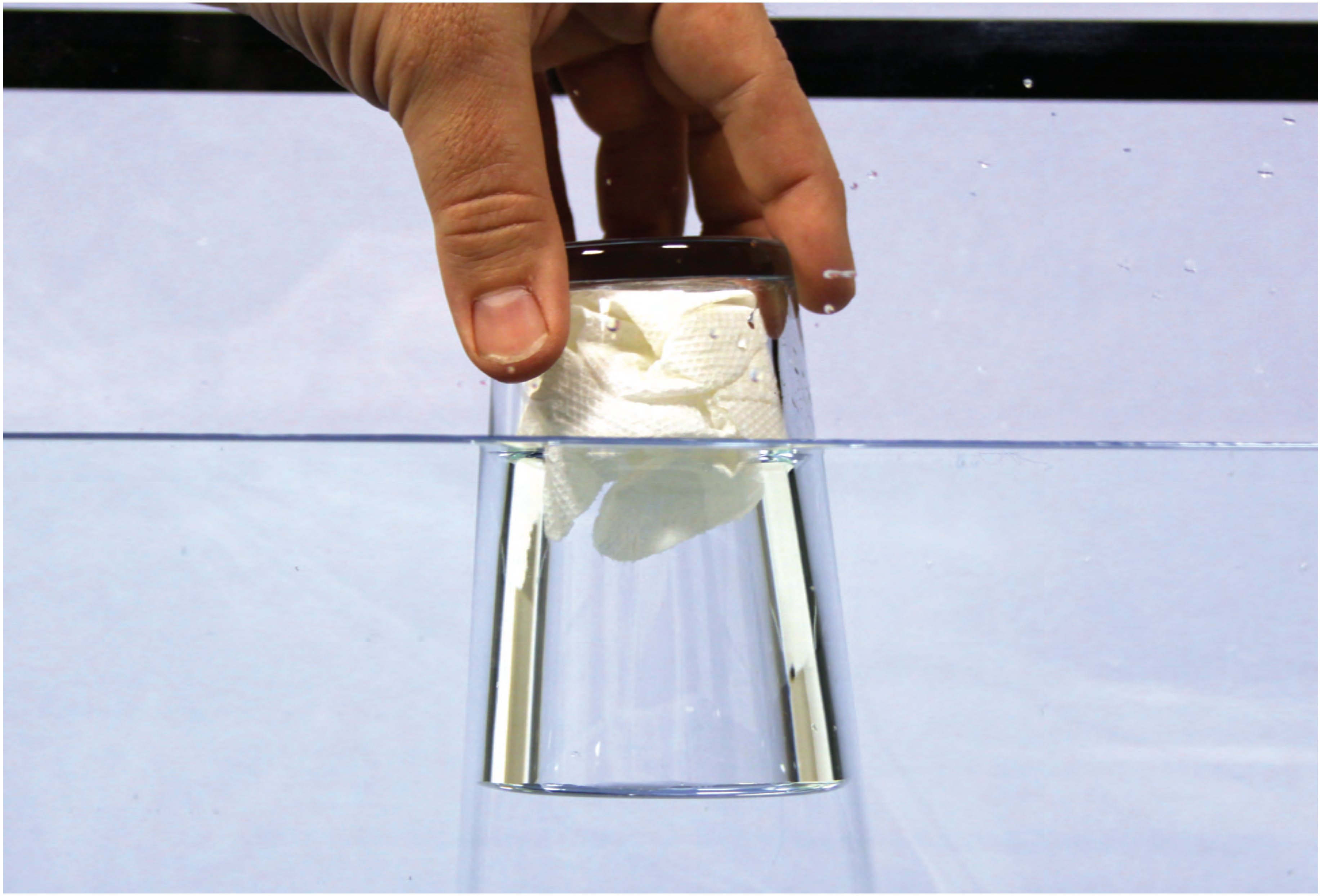
Img. 3 An example of a cumulonimbus cloud seen over Pensacola, Florida

(Photo courtesy of NOAA and The National Weather Service Weather Forecast Office, Key West, FL)

Img. 4 Cirrus clouds over Florida, August 2006

(Photo courtesy of NOAA and The National Weather Service Weather Forecast Office, Key West, FL)

Img. 5 Air in the glass prevents the water from entering

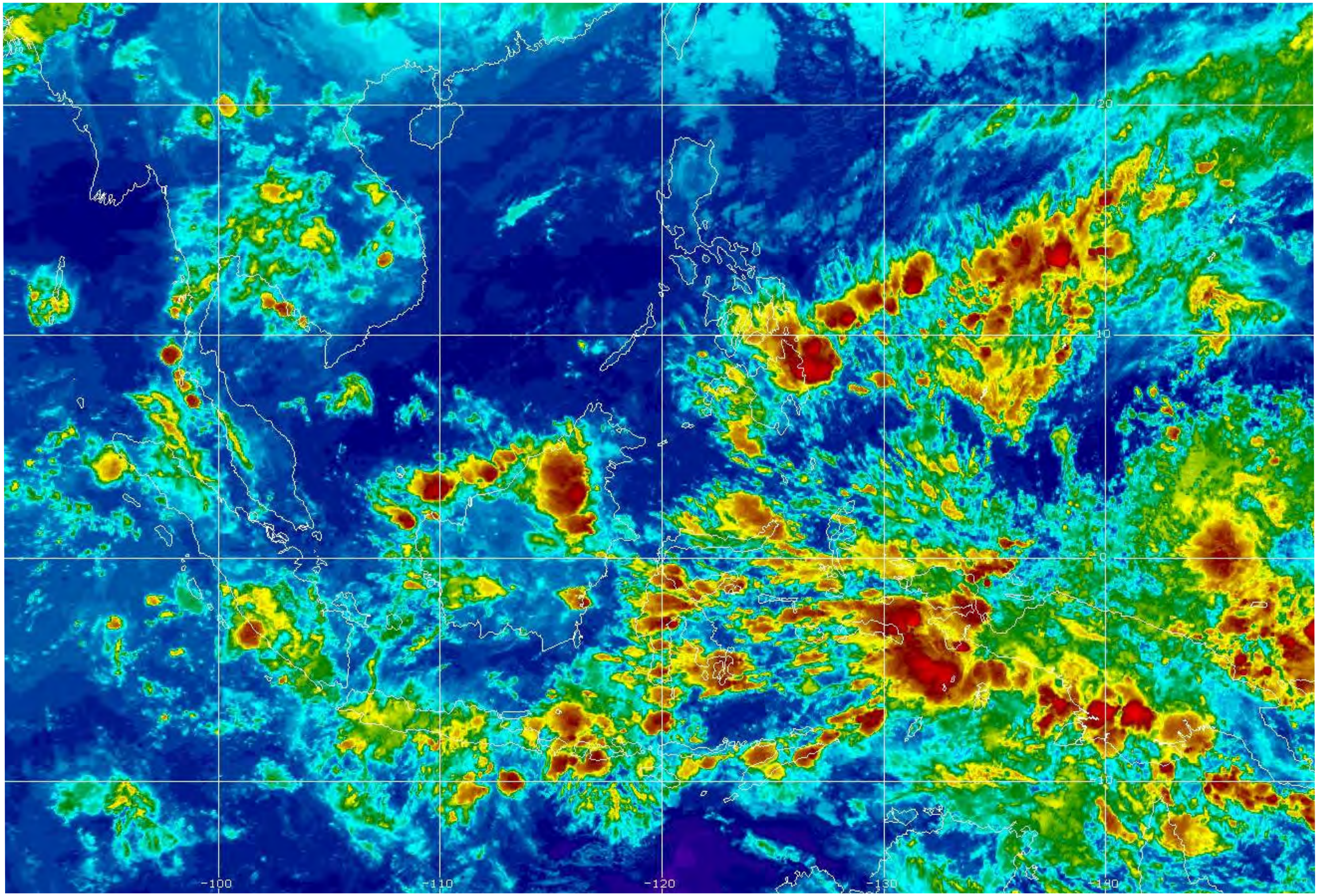


(Photo courtesy of Lost Tribe Media, Inc.)

Img. 6 A tornado in Kansas, May 23rd, 2008

(Photo courtesy of Sean Waugh –NOAA / NSSL)

Img. 7 A false-color infrared satellite image of Southeast Asia



(Satellite Image courtesy of the National Oceanic and Atmospheric Administration, NOAA)

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