

CONVECTION CONNECTION

Overview:

During this project, students observe convection current by performing two lab experiments. As a result of these activities, students develop an understanding of the process of convection, and apply the knowledge to processes in the atmosphere.

Objectives:

The student will:

- draw or define convection;
- learn that convection current can occur in any fluid substance (air, gas, water, etc.);
- learn that hot fluids rise and cool fluids sink; and
- learn that convection current occurs in Earth's atmosphere, contributing to wind.

Targeted Alaska Grade Level Expectations:

Science

- [7-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [7] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct simple repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.
- [8] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct repeatable investigations, in order to record, analyze (i.e., range, mean, media, mode), interpret data and present findings.
- [8]SD3.2 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by recognizing types of energy transfer (convection, conduction, and radiation) and how they affect weather.

Vocabulary:

atmosphere – the mixture of gases that surrounds Earth or some other celestial body; held by the force of gravity and forms various layers at different heights, including the troposphere, stratosphere, mesosphere, thermosphere, and exosphere; Earth's atmosphere, called air, is rich in nitrogen and oxygen

convection – the transfer of heat energy through liquids and gases by the movement of molecules; when molecules of liquid or gas come in contact with a source of heat, they move apart and away from the source of heat, and cooler molecules take their place; eventually, as the cooler molecules are heated, they move as well, and a convection current forms, transferring the heat

current – a flowing movement in a liquid or gas, especially one that follows a recognizable course

cycle – an interval of time during which a regularly repeated sequence of events occurs

fluid – a substance, such as air or water, in which the atoms or molecules can freely move past one another; fluids flow easily and take on the shape of their container

hypothesis – a statement that explains a set of facts and can be tested to determine if it is false or inaccurate

wind – a current of air, especially a natural one, that moves along or parallel to the ground

Whole Picture:

Convection is the transfer of heat energy through liquids and gases (fluid) by the movement of molecules. Temperature difference is the catalyst that begins the convection process. There may be a difference in temperature within the fluid, between the fluid and its boundary, or from the application of an external heat

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source. It is one of the three primary mechanisms of heat transfer (the others being conduction and radiation). The basic premise behind convection is that when material cools, it becomes more dense so it sinks and heated matter becomes more buoyant and rises.

Convection plays a role in the movement of air in Earth's atmosphere. When air close to Earth's surface is heated by solar energy it becomes less dense and rises. Cooler, more dense air sinks, rushing in to fill the space. The cooler air then heats, rises and the process continues. The American Meteorological Society defines convection as this: "Vertical air circulation in which cool air sinks and forces warm air to rise."

The process is visible in a pot of water on a hot stovetop. The heated water expands (becoming lighter or more buoyant) and rises to the top. The cooler water sinks. The process repeats and a circulation cycle is visible. Fluid trapped in such a cycle is called a convection cell, a common weather phenomenon.

Materials:

- Clear glass beaker that can be placed on a hot plate
- Hot plate
- Water
- Paper dots or confetti
- Safety goggles
- Ruler
- Sticky notes (7 per student)
- Manufactured pinwheel (1 per group) *Note: If manufactured pinwheels are unavailable, a pinwheel template is included with the lesson.
- STUDENT WORKSHEET: "Convection Hypothesis"
- STUDENT WORKSHEET: "Convection Connection Vocabulary"
- STUDENT WORKSHEET: "Convection Makes the Wheel Go 'Round"
- SUPPLEMENTAL: "Pinwheel Template"

Activity Preparation:

1. Assemble materials for each convection experiment.
2. Write the vocabulary words on the board, leaving space around and between for notes and the definition.
3. Write the quote by Effie Kokrine on the board: "When the heat generates to the bottom of the ground and circulates to the top and all around, it gets warmer."

Activity Procedure:

1. Review vocabulary. Hand out seven sticky notes to each student (one for each vocabulary word). Refer students to the words written on the board. Ask students to write what each one means and/or what it brings to mind on a separate sticky note, then place it near the corresponding word. Allow a few minutes then review the notes. If needed, fill in missing information (refer to Vocabulary section).
2. Discuss what Athabascan Elder Effie Kokrine said: "When the heat generates to the bottom of the ground and circulates to the top and all around, it gets warmer." Effie's quote describes convection. As the sun heats Earth, the air around Earth gets hotter. This hot air is less dense than the cold air above it, so the hot air rises. The cold air sinks toward Earth's surface, where it warms. Meanwhile, the air that initially rose becomes cold again and sinks back to replace the newly warmed air. This cycle of moving warm and cold air is an example of convection. Convection creates wind, which is simply moving air.
3. Distribute the Student Worksheet: "Convection Hypothesis." Ask students if they think convection can occur in water. Ask students to record their predictions in the hypothesis section of the worksheet. Explain students will perform an experiment to determine if convection occurs in water.
4. Divide students into groups and distribute supplies for "Convection Hypothesis" lab. If confetti is unavailable, ask students to use hole punches to create a mound of paper dots. Ask students to follow the instructions on the Convection Hypothesis Worksheet to perform the experiment.

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5. Discuss student observations and results. Students should understand that as the water in the bottom of the beaker warmed and rose to the surface, the paper dots also began to rise. At the surface, the water cooled. Warm water rising from the bottom pushed cool water toward the edges of the beaker. At these cooler edges, the water began to sink again, carrying the paper dots with it. Any fluid substance (air, gas, water, etc.) can be heated and experience convection.
6. Distribute the STUDENT WORKSHEETS: "Convection Data" and "Convection Conclusion." Ask students to complete the worksheets. As they do so, do a safety check to be sure all hot plates are "off."
(Teacher's Note: Because this experiment requires that the hot plate cools completely between labs, it would be a good idea to break the lesson into two parts, either with a break in the middle or completed on two separate days.)
7. Ask students to consider the previous experiment where they could easily observe convection in the fluid (water) using the paper dots. Explain that they are now going to experiment with a different fluid: air. Remind the students that hot air rises because it is less dense.
8. Distribute STUDENT WORKSHEET "Convection Makes the Wheel Go 'Round" and supplies needed for the lab. Do a safety check and make sure no hot plates are "on" until the appropriate time in the lab. Ask students to complete the lab according to the directions.
9. Distribute STUDENT WORKSHEET: "Convection Connection Vocabulary" and ask students to complete.
10. Discuss the similarities and differences between convection current in Earth's atmosphere and the convection current illustrated by each of the labs.

Critical Thinking Questions:

1. What surprised you about the experiment(s) you conducted?
2. What would happen in the convection cycle if there were more than one heat source?
3. What would happen if different heat sources were heating fluid at a different rate?
4. Where does wind come from in the cold, winter months?
5. When you open a door in the winter, is the cold coming in or is the heat going out? Which is first? Explain.
6. Remind student of Effie Kokrine's words: "When the heat generates to the bottom of the ground and circulates to the top and all around, it gets warmer." Ask: How can you apply what you have learned today to Effie's words? What is the heat source? What is being heated?

Extension Ideas:

Ask students to research and report on how convection plays a part in home heating. Students should consider how different methods of home heating contribute to a convective cycle. For example, radiant heat (heated floors) may act differently than a wood stove. Students should choose two different heating options, describe their function and diagram how each might be affected by convection.

Answers:

STUDENT WORKSHEET: "Convection Hypothesis"

Diagram answers are shown at right.

1. D
2. C
3. Answers will vary.
4. Answers will vary.
5. C
6. A

Diagram 1: No Heat Source

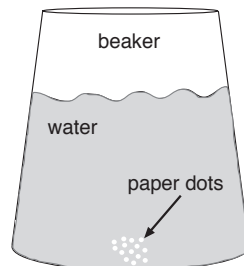
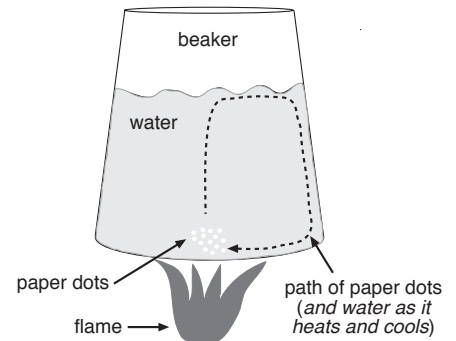


Diagram 2: Active Heat Source



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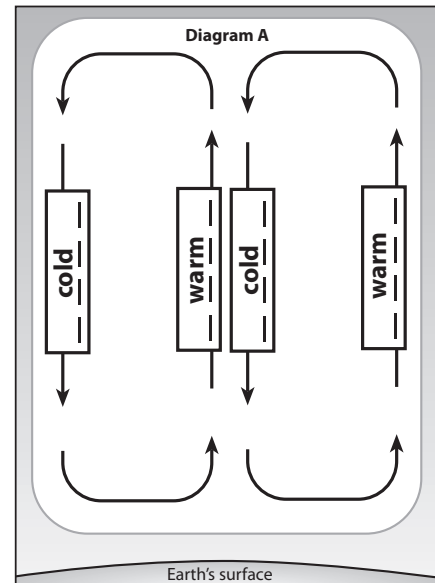
STUDENT WORKSHEET: "Convection Connection Vocabulary"

1. convection
2. wind
3. cycle
4. current
5. hypothesis
6. atmosphere
7. fluid

Diagram answer is shown at right.

STUDENT WORKSHEET: "Convection Makes the Wheel Go 'Round'"

1. No
2. Yes
3. Answer should indicate that a heat source was added.
4. Answers will vary.



NAME: _____
CONVECTION HYPOTHESIS

Testable Question/Problem:

What will happen to paper dots submerged in a beaker of water if the water is heated?

Background Information/Observations:

As the sun heats Earth, the air around Earth gets hotter. This hot air is less dense than the cold air above it, so the hot air rises. The cold air sinks toward Earth's surface, where it warms. Meanwhile the air that initially rose becomes cold again and sinks back to replace the newly warmed air. This cycle of moving warm and cold air is called convection, and is what creates wind. Wind is simply moving air.

Hypothesis:

In the box below, draw a diagram of what you think will happen to the paper dots when the beaker of water is placed on a hot plate and heated.



Perform the Experiment:

Materials:

- Clear glass beaker
- Hot plate
- Water
- Paper dots
- Safety goggles

Procedure:

1. Put on safety goggles.
2. Pour 250-300 ml of water into the beaker.
3. Sprinkle paper dots over the top of the water. If the dots do not sink, push them under the water with a pencil until they rest at the bottom of the beaker.
4. Observe the beaker of water. Complete Diagram 1: No Heat Source, in the Data section of this Lab Packet.
5. Turn on the hot plate and place the beaker of water on the burner. Heat the water slowly.
6. Observe the beaker of water as it heats for 10 minutes. Complete Diagram 2: Active Heat Source, in the Data section of this Lab Packet.

Data:

In the boxes below, draw the beaker of water with the paper dots in it. Label the beaker, water, paper dots, heat source (if applicable), and the path of movement of the paper dots (if any).

Diagram 1: No Heat Source



Diagram 2: Active Heat Source



NAME: _____
CONVECTION HYPOTHESIS

Analysis of Data:

1. Circle the correct answer. What are the differences between your observations for Diagram 1 and Diagram 2?
 - A. In Diagram 1 the paper dots remained still, while in Diagram 2 the paper dots moved.
 - B. In Diagram 1 the paper dots moved, while in Diagram 2 the paper dots remained still.
 - C. In Diagram 1 there was no heat source, while in Diagram 2 there was a heat source beneath the beaker.
 - D. Both a and c.

2. Circle the correct answer. What are the differences between your observations for Diagram 1 and Diagram 2?
 - A. As the water warmed, the paper dots floated to the surface and remained on top of the water.
 - B. As the water warmed, the paper dots remained motionless on the bottom of the beaker.
 - C. As the water warmed, the paper dots were carried by rising water to the surface, where the water cooled and began to sink again, carrying the paper dots with it back to the bottom of the beaker.
 - D. As the water warmed, the paper dots were shifted by hot water to the bottom edges of the beaker, where they remained, fluttering gently in the current.

Conclusion:

3. Was your hypothesis proved or disproved? Use a complete sentence.

4. Briefly explain how you came to your conclusion.

Further Questions:

5. What did the path of paper dots in Diagram 2 represent?
 - A. the movement of the water
 - B. convection current
 - C. both a and b
 - D. none of the above

6. What powers convection current in the air surrounding Earth?
 - A. the sun
 - B. the moon
 - C. other planets
 - D. the atmosphere

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CONVECTION CONNECTION VOCABULARY

Directions: Fill in the blanks below by unscrambling the words.

1. tonceniovc _____

The transfer of heat energy through liquids and gases by the movement of molecules. When molecules of the liquid or gas come in contact with a source of heat, they move apart and away from the source of heat, and cooler molecules take their place.

2. dwin _____

A current of air, especially a natural one, that moves along or parallel to the ground.

3. lycce _____

An interval of time during which a regularly repeated sequence of events occurs.

4. rertunc _____

A flowing movement in a liquid or gas, especially on that follows a recognizable course.

5. shyoshepti _____

A statement that explains a set of facts and can be tested to determine if it is false or inaccurate.

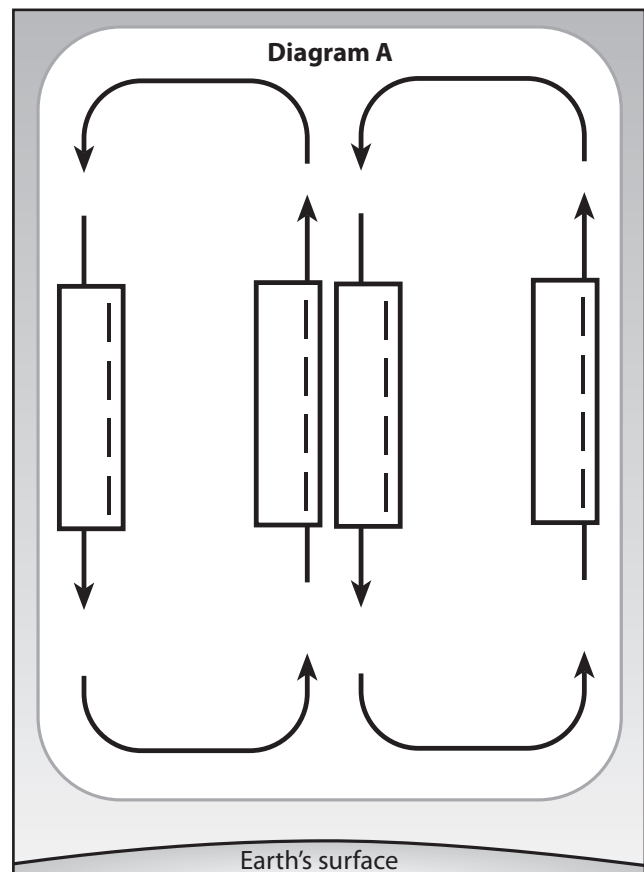
6. hotreemaps _____

The mixture of gases that surrounds Earth or some other celestial body. It is held by the force of gravity and forms various layers at different heights, including the troposphere, stratosphere, mesosphere, thermosphere, and exosphere.

7. dluif _____

A substance, such as air or water, in which the atoms or molecules can freely move past one another.

Directions: Diagram A shows convection cells in motion. Label the boxes on each arrow either warm or cold to show the direction of temperature flow.



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CONVECTION MAKES THE WHEEL GO 'ROUND

Now that you've had a really good view of the way convection works in water, let's take the process to the air.

Directions for Lab

Testable Question/Problem:

Is it possible to make the pinwheel spin by placing it near a heat source?

Hypothesis:

Circle one: It *is / is not* possible to make the pinwheel spin simply by placing it near a heat source.

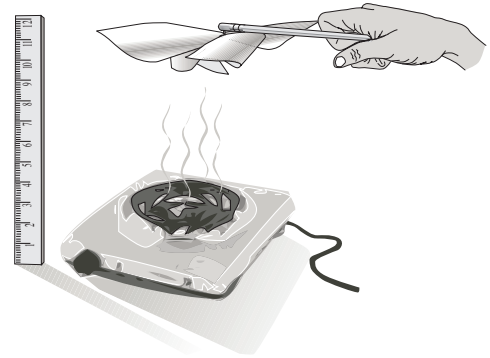
Experiment:

Materials

- Pinwheel
- Hot plate
- Safety goggles
- Ruler

Procedure:

1. Put on safety goggles.
2. Place pinwheel over hot plate and observe for two to three minutes.
3. Answer Question 1: No Heat Source in Data section.
4. Turn on the hot plate to lowest setting. Keep pinwheel at the same spot as in Step 2. Observe the pinwheel for two to three minutes.
5. Answer Question 2: Heat Source in Data section.
6. Complete the rest of the worksheet.

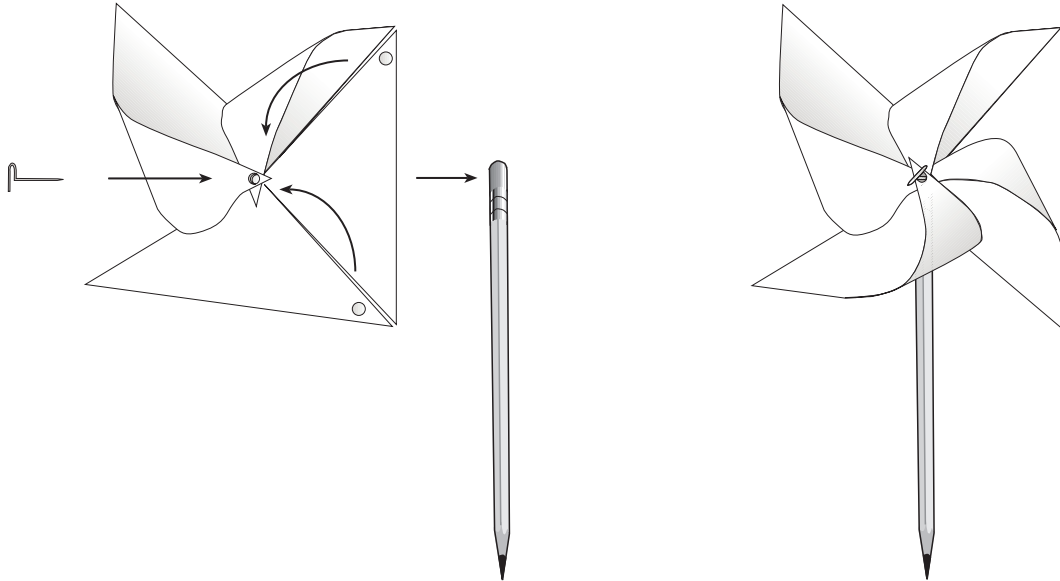


Data:

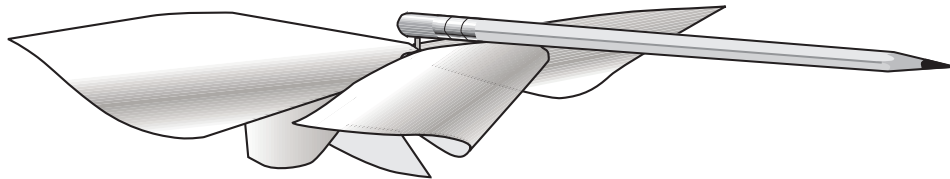
1. No heat source: Is your pinwheel moving? (yes or no) _____
2. Heat source: Is your pinwheel moving? (yes or no) _____
3. The only thing that changed between question 1 and question 2 was _____
4. Was your hypothesis proved or disproved? What did you observe that helped you decide? Please answer in complete sentences.

PINWHEEL TEMPLATE

1. Cut around the square then along the dotted lines.
2. Use a hole punch to put holes in the four marked corners.
3. Bend each corner with a hole to the center star, but don't crease your folds.
4. Push a thumbtack through the holes and through the center star into the eraser of a pencil. Don't push it too tight.



After you have constructed your pinwheel, test it to make sure it spins freely by blowing gently on the curved edges. Adjust thumbtack as necessary. You may need to wiggle it a little to make sure it moves freely in the eraser.



PINWHEEL TEMPLATE

