A Unit of Study for Grades K–2 and 6–8

LEGO TRAVEL ADVENTURE

WHAT will you build?

CHILDREN'S MUSEUM INDIANAPOLIS

ACKNOWLEDGEMENTS

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CHILDREN'S MUSEUM INDIANAPOLIS®

The Children's Museum of Indianapolis is a nonprofit institution dedicated to providing extraordinary learning experiences that have the power to transform the lives of children and families. It is the largest children's museum in the world and serves more than 1 million people across Indiana as well as visitors from other states and nations. The museum provides special programs and experiences for students as well as teaching materials and professional development opportunities for teachers. To plan a visit or learn more about educational programs and resources, visit the Teacher section of the museum's website, **childrensmuseum.org**.

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LEGO TRAVEL ADVENTURE

Produced by the Children's Museum of Indianapolis

Introduction

Travel Adventures!

Throughout history, inventors and explorers have been inspired by distant places and the idea of creating vehicles that can transport people on new adventures. Using the idea of travel as a theme, this unit of study enables students to plan an adventure that encourages them to think geographically and apply physical science concepts as they work cooperatively to build and test transportation models. Building with LEGO® bricks helps children exercise creativity and develop thinking and problem-solving skills. This unit provides opportunities for students to use their imaginations as well as LEGO bricks and accessories to understand how objects move over land and water and in the air.

Enduring Idea

There are different ways to get from here to there. Using LEGO bricks, you can think creatively, imagine, and build vehicles for all sorts of environments and plan the travel adventure of your dreams.

The Exhibit

LEGO® Travel Adventure provides an immersive environment where children can experience professionally built LEGO brick models of air, land, and sea vehicles and use LEGO bricks in creative vehicle building. As they discover how to build vehicles for different environments and obstacles, they learn the function of different parts, including sails, wheels, and rudders, and begin to examine questions such as "How do you steer a vehicle?" A visit to the exhibit just before students begin to explore the idea of travel and transportation might inspire discussions, questions, and interest in discovering more about the topic. A visit after students have begun projects can help them expand their exploration and develop their projects in new directions.

The Unit of Study

This unit of study is designed to complement the *LEGO® Travel Adventure* exhibit and extend learning into the classroom by inspiring students to imagine a travel adventure and presenting the challenge to design, build, and test a vehicle that can take them over land and water and through the air. This project-based unit is made up of layered experiences for Grades K–2 and 3–5. Students use inquiry and problem-solving skills to determine what type of vehicle or vehicles will get them to their destination. This project provides the opportunity for students to learn and apply concepts in basic physical science, engineering, and social studies as they exercise thinking and language arts skills. As students work to solve the problem of how to get from here to there, they follow the design process by brainstorming, working with the materials they have, building, testing, revising, and sharing results.

Play Well!

The term LEGO® was inspired by the Danish phrase *leg godt*, which means "play well." Each lesson in this unit has an element of **play** to inspire students' creative thinking and discussion in the classroom and beyond!

Approach to Teaching and Learning

The learning experiences in this unit of study are designed around the **Reggio Emilia Approach**. Named for the Italian town where it was first developed, this educational philosophy views the student as an active constructor of knowledge and focuses on exploration and discovery in a rich learning environment. Teachers will notice the use of language and classroom strategies that support this approach, including:

- **Provocation for Discussion**. In a *provocation*, the teacher provides time for exploration of materials, an environment, or an idea to help students extend their thinking. This is time for students to explore, ask questions, and generate conversations about what they are investigating. In this unit, the inspiration for a discussion might come from museum visits, books, a variety of maps, a tub of water, and some LEGO® bricks, or a variety of LEGO® accessories. The conversations and questions the students build from their investigations help the teacher plan and facilitate learning.
- **Discussion and Application.** In this part of an experience, students have conversations centered on a specific idea and, like professional scientists or explorers, get to test their idea. In this unit, the teacher might provide a mini-lesson about differences in terrain, and then the students test the lesson's concepts by discovering how vehicles respond to varied surfaces.
- **Vocabulary Integration.** Teachers will notice the vocabulary and concepts included in this unit represent a range of levels and complexities—anything from "sail" to "friction." This intentional variety in vocabulary is included to help teachers differentiate learning opportunities to best meet the needs of their students. The vocabulary should be integrated into the context of conversations and explorations to provide rich and meaningful experiences for all learners.
- **Documentation.** The use of the term *documentation* is also inspired by the Reggio Emilia Approach and simply means making learning visible through the projects and products students create. In this unit, an example might include putting the student-constructed vehicles on display to inspire more conversations and to allow other students to try them out. Another example might be to take pictures of an investigation and then encourage students to describe and write down what they were doing in that picture so that others can understand.
- **Concluding Conversations.** Concluding conversations help wrap up an idea or concept for the activity, but hopefully the conversations with the students are never over! Concluding conversations help students restate their learning, ask questions, explain ideas to others, and extend their learning to other contexts. This is a good time for teachers to learn what related ideas the students would like to explore. For example, if a LEGO® vehicle travels well in a sand tub in the classroom, how will it travel in the sandbox on the playground?

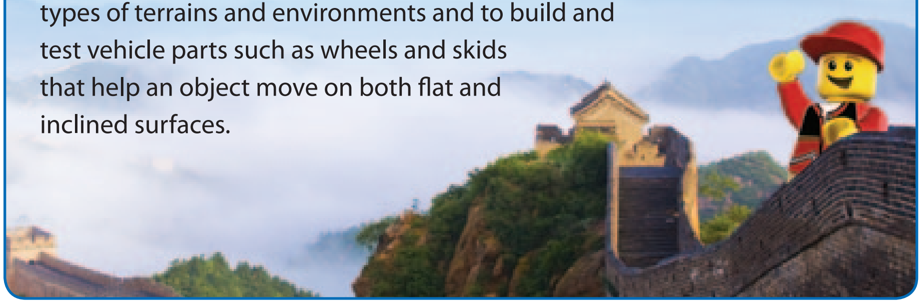
Introduction

WHAT'S AHEAD?

Lesson 1

Adventures on Land

Students encounter the idea of travel to distant places through children's fiction and nonfiction and by examining physical maps to identify the physical features a traveler would experience on land. They consider the types of vehicles they would need to travel over different types of terrains and environments and to build and test vehicle parts such as wheels and skids that help an object move on both flat and inclined surfaces.



Lesson 2

Adventures on Water

Students use maps to identify different types of water features, such as rivers, lakes, and oceans. They experiment with different types of materials to determine what causes objects to sink or float. They consider the types of water vehicles and test different ways to move and steer a vehicle on or through the water.

Lesson 3

Adventures in the Air

Students identify the different types of vehicles they might use to travel by air. They investigate to discover that air is matter and use that concept to experiment with push/pull forces such as lift, drag, thrust, and weight to design and test vehicles for flight.

Culminating Experience

The Travel Adventure of Your Dreams!

Students use maps and globes to identify a travel adventure destination. Working in teams, they create a map, brainstorm solutions to obstacles, and create designs for vehicles that will take them to their dream destination. They build and test vehicles made from LEGO® bricks and report on the results of their projects.

Teacher Community of Inquiry
Student and Teacher Work Online

Share your experiences using this unit of study with your colleagues through the museum's online community dedicated exclusively to educators at **tcmteachers.org.** View student work and learn how to share your students' work online. Stay up-to-date on special learning opportunities for students and teachers at the museum. Discuss ideas and learn what other teachers are doing to enhance students' experiences at the museum and in the classroom. Visit **tcmteachers.org** to become a part of the museum's teacher community today.

WHAT WILL STUDENTS LEARN?

This unit helps students achieve specific academic standards in

- Science
- Social Studies
- English Language Arts

WHAT WILL STUDENTS BE ABLE TO DO?

Unit Goals

Students will

- examine the role of inventors and inventions in helping people travel in different environments such as land, water, and air.
- use physical maps to identify land and water features.
- identify the types of vehicles needed to travel on different terrains and in different environments.
- experiment with forces that cause an object to move.
- test different inventions, such as wheels and skids, to explain how they help an object move over different surfaces.
- explore the factors that cause objects made of different materials to sink or float.
- try out different ways of moving and steering an object on or through the water.
- give examples demonstrating that air is matter.
- explain how push and pull forces affect different materials as they move through the air.
- plan a travel adventure and create maps to destinations.
- build and test a LEGO® vehicle or vehicles for a travel adventure and report on the results.

GETTING STARTED

Classroom Environment

Create an environment that is rich in images and resources related to travel and transportation. Images might include travel posters, photos, magazines, and artworks featuring different environments and modes of transportation. Collect children's fiction and nonfiction on transportation inventions, vehicles, and travel. Be sure to include maps, globes, and an atlas. Set up three "travel centers" where students can work in small groups to research travel on land, on water and in the air. It is also important to have small tables or other spaces where cooperative groups can work on LEGO vehicle building projects.

Family Connections

Most parents and other family members have fond memories of building with LEGO® bricks. Include families in the conversation about transportation and travel adventures and let them know that students will be using LEGO bricks and accessories to design vehicles and plan imaginary trips. Families may want to share memories, donate LEGO® sets, or start a building project at home. Families may want to discuss their real travel experiences, photos, and mementos with children at home or in the classroom. They may also want to turn everyday trips into learning opportunities by inspiring children's curiosity about how to find the way to locations in the community and beyond or about how vehicles and their parts work to carry passengers and cargo from place to place. They may want to help children explore further by finding library books and websites that match their travel adventure interests.

Lesson 1 — Adventures on Land

In this lesson, students encounter the idea of travel to distant places through children's literature. They explore maps to learn how they help travelers find their way and to identify physical features and a variety of terrains on Earth's surface. They use this information to test ways of building an effective vehicle for travel on land. Students brainstorm different destinations they would like to visit and begin to think about and define problems in the context of travel and motion.

Objectives

Students will

- listen to and read children's fiction and nonfiction related to travel and transportation
- examine maps, identify the different parts of a map, and explain how maps can help travelers find their way
- use maps to identify different types of physical features a traveler would experience on land and the different types of obstacles to be overcome
- create simple maps and use map symbols and legends to analyze and share information
- give examples of the types of vehicles they would need to travel on different types of terrains and in various environments
- explain the concept of friction and how it affects the way things move
- build LEGO® vehicles and test different vehicle parts, such as wheels and skids, that make an object move more easily
- test vehicles to see how they move on both flat and inclined surfaces
- create data sheets, record their findings, and compare results

Focus question

What kind of vehicle can you build that will move on land over different types of terrain?

You will need . . .

Materials

Experience 1

- A variety of physical maps — local, state, national, world (See Google Earth for different types of maps in your area. For example, go to **indiana-map.org/relief-map.htm** for a relief map of Indiana.)
- Travel books and magazines showing different types of terrains and environments
- Several assembled LEGO® vehicles (at least 2 per map)
- Buckets of LEGO® bricks and accessories for creating vehicles at each building table or space (LEGO® tires are helpful but not necessary at this point).

Experience 2

- Student-designed LEGO vehicles
- A variety of terrain tubs — a group of long containers that can fit on a table or desk that teachers can fill with a variety of materials representing terrain (for example: marbles, sand, sandpaper, dirt, rocks, smooth cardboard, twigs, and water frozen to resemble an icy terrain)

- Think outside the box — outside the classroom! Do you have a place outdoors on the school playground that would be good for vehicle testing?

Experience 3

- LEGO® wheels of all sizes and treads
- The terrain tubs used in Experience 2 or samples of different surfaces, such as smooth, rough, and carpeted (sandpaper works well to simulate roughness)
- An example of a skid (such as sled rails or round furniture sliders)
- Student-constructed data sheets that reflect what the students want to investigate (completed after the discussion on page 17)

Experience 4

- LEGO vehicles with a variety of wheels and treads
- Materials to create flat and inclined surfaces or terrain tubs for testing vehicles
- Paper for making classroom charts
- Books on wheeled inventions (see the **Resources** section)

Time

Investigations may take time for students to develop and carry out. Allow three to five class periods for the inquiry experiences in Lesson 1.

Teacher Tip

See Rubistar rubric maker (**rubistar.4teachers.org**) for an easy way to create data sheets. Encourage students to focus on a limited number of differences. A student-constructed data sheet might look like the one below, which tests two different tire types: a tire with deep tread and a tire with smooth tread, over three different surfaces.

Experience 3: Sample Data Sheet

	Smooth Surface Observations	Rough Surface Observations	Bumpy Surface Observations
1 Tire with deep tread		Made it across surface	
2 Tire with smooth tread	Traveled quickly	Flipped over	

Academic Standards
National Academic Standards

National Common Core State Standards
English Language Arts
Grades K–2: K.W.8, K.L.6, K.SL.1, K.SL.4, K.SL.5, 1.SL.5, 2.W.6, 2.L.6, 2.SL.1, 2.SL.3, 2. SL.4,
Grades 3–5: 3.L.4, 3.W.2, 3.W.7, 3.SL.1, 3.SL.3, 3.SL.4, 4.W.7, 4.SL.1, 5.W.7, 5.W.8, 5.SL.1, 5.SL.4

Science — National Research Council
Grades K–12
Content Standards: Unifying Concepts and Process
- Evidence, Models, and Explanations

Grades K–5
Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science
- Positions and Motion of Objects
- Motions and Forces

Content Standards E: Science and Technology
- Abilities of technological design
- Understanding about science and technology

Content Standard G: History and Nature of Science
- Science as a human endeavor

National Council for the Social Studies
People, Places, and Environments — Early Grades
Learners will understand:
- location, direction, distance, and scale (b)
- physical characteristics, human interactions with the environment (c)
- use of maps, globes, and geospatial technologies (i)

Vocabulary

Maps and Map Concepts

globe: a scale model of Earth in the form of a sphere

compass rose: a symbol on a map that indicates the map's orientation in relationship to the cardinal and intermediate directions

cardinal directions: the four main points of the compass: north, south, east, and west

cultural features: characteristics of a place that have been created by humans, such as roads, cities, and state and national boundaries

map: a graphic representation of all or part of Earth's surface, usually drawn to scale on a flat surface

map legend: a description or key to symbols used on a map

physical features: geographic characteristics that occur in nature, such as land and water forms, natural vegetation, and wildlife

physical map: a map that shows geographic features, such as landforms and bodies of water

political map: a map that shows human features, such as political boundaries, roads, and cities

Travel and Motion

friction: the rubbing of a surface of one object on another; surface resistance relative to motion; conflict between people or nations because of differing ideas

motion: the act or process of changing position or place

skid: a plank, bar, or log on which a load is supported (such as the runners of an old-fashioned sled)

terrain: ground characterized by its physical characteristics (such as a rocky terrain)

tread: the part of a wheel or tire that makes contact with the road; the grooved outside part of a rubber tire

wheel: a circular frame of a hard material that is capable of turning on an axle

Experience 1: Land Ho!

Students examine physical maps, including local, state, national, and world maps, to identify the different types of physical features that a traveler would experience on land. They identify different obstacles that would have to be overcome and consider the types of vehicles they would need to travel on different types of terrains in various environments.

Procedures

- **Introduction of Topic**
  The teacher and students explore a book selection that introduces the idea of travel to distant places, such as *Oh, the Places You'll Go!* by Dr. Seuss.
  - Students in **Grades K–2** might take a picture walk through the book while students in **Grades 3–5** explore the book through readers' theater.
  - Students and teacher can observe the many varieties of transportation and terrains that Dr. Seuss includes in the book.
  - Allow students to examine books and magazines to find photos of some of the real places and environments.
  - During the exploration, students can brainstorm different destinations they would like to visit and begin to think about their journeys in the context of travel, how to get there, **terrain**, and **motion**.

- **Provocation for Discussion**
  - Lay out several physical maps on the floor with two or more LEGO® vehicles on each map. In pairs or small groups, students use the vehicles to "roam around" the map.
  - Group members take turns with one student "driving" the car, while others make a list of the things they notice about the maps, such as differences in color, patterns, symbols, and labels.

Continued on next page.

Discussion

In a whole group, discuss students' observations and conversations about what they noticed when their team "traveled" the maps.

- Ask students: How is a **map** different from a photo of a place? Help them understand that a map is a special kind of drawing that represents Earth or a part of Earth.
- Other questions might include: What are the different colors used for? What type of labels do you notice on the maps? Why does the **physical map** look like it has texture?
- Help students understand that map symbols stand for real things like forests, mountains, and deserts. The **map legend** explains the symbols on the map.
- Ask students to find the **compass rose** and help them identify the **cardinal directions** on the map.
- Ask: What different obstacles or challenges might there be if you were walking on, driving through, or taking a train across the environment in your map? What would the **terrain** be like?

Application and Documentation

Students use what they have learned to create a drawing or a map of a place that interests them.

- **Grades K–2**: Students choose a familiar place, create a drawing, and then draw a map of that place. They could then discuss the different features of a map and explain how a photo, drawing, and map are similar and different.
- **Grades 3–5**: Students create a map of a place based on a photo from a travel magazine or a way-finding map from one favorite place they know to another, using symbols along with a legend that explains what the symbols mean.

Concluding Conversation

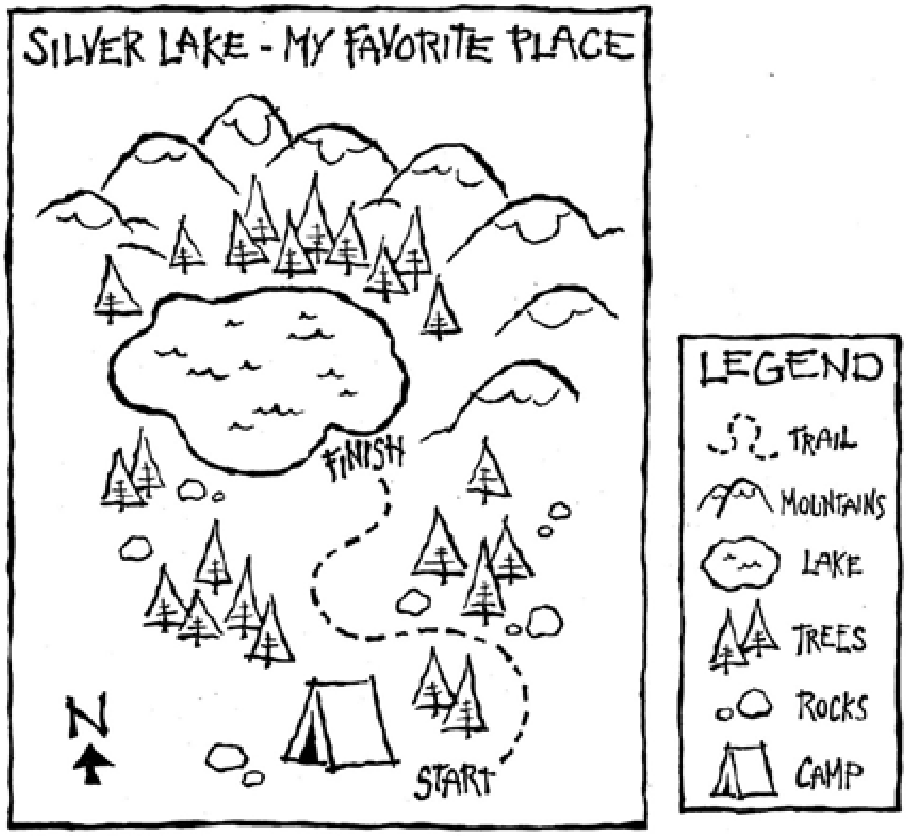
Students use map vocabulary and describe their maps and the different physical features and terrains they represent. They discuss the best kind of vehicle to travel around the map.

What is a map?

A **map** is a graphic representation of a portion of Earth. It is a special kind of drawing that shows the relationships among different places and things. There are two major types of maps. **Reference maps** include physical maps that show natural features, such as landforms and bodies of water, and political maps that show nations, states, and the locations of towns, cities, and other features that have been created by people. **Thematic maps** provide data on a particular topic or theme, such as climate or population. Maps are usually drawn to scale on a flat surface using an aerial (overhead) perspective. Mapmakers select information that is important for the purpose of the map and use symbols and other visual elements, such as color, texture, and pattern, to convey information. A map is different from a **globe**, which is a spherical model of Earth.

Children and Maps

Children are often very creative in making maps, and it is important to let their understanding of map concepts develop gradually. Discuss similarities and differences between photos, drawings, and maps. One important similarity is that photos, pictures, and maps represent or depict something in the world. One difference is that a photo shows everything in the camera's viewfinder. In a drawing or a map, the artist or mapmaker can't show everything and must select only certain things to convey an idea or information. Point of view or perspective is an important difference in drawings and most maps. Children often draw pictures as if they were looking directly at a person, place, or thing. It is very common for children to combine this "eye-level" perspective with other perspectives in drawing maps. Most but not all maps are drawn from aerial perspective, as if the viewer were looking at a place from directly above. Give children opportunities to draw familiar objects, like the top of their desks or a LEGO® vehicle from directly above. Learning to use different points of view is a skill they can use in other projects.



Experience 2: Make It Move!

Students use what they have learned about physical features and terrains to build a LEGO® vehicle and test it over different surface textures and conditions to see how it moves.

Take It Outside!

To the extent possible, enable children to conduct tests outdoors over natural and manufactured surfaces, such as grass, dirt, gravel, concrete, and asphalt. When this isn't possible, surfaces can be simulated in the classroom using the terrain tubs.

Procedures

- **Provocation for Discussion**
  Remind students of their discussion of maps and vehicles for different terrains. Help students explore further as they create a simple LEGO vehicle and test it outdoors or use the terrain tubs to see how it rolls on different textures, such as smooth and rough; different materials, such as sand and dirt; and different conditions, such as dry, wet, and icy.

- **Application and Discussion**
  Students discuss their observations of how the vehicle moved on different surfaces and conditions.
  - After the students have had time to discuss observations, they can decide which ones interest them the most and which kinds of surfaces they would like to investigate further.
  - **Grades K–2**: Students might work in pairs to carry out a guided experience testing the movement of an object over two or three different surfaces.
  - **Grades 3–5**: Students can work in small groups to choose the surfaces they want to investigate, test the vehicle, measure the distances traveled, and record and share information.

- Students at all grade levels can create data sheets to record the type of data they want to examine. The data sheet might include different qualities they find interesting to investigate, such as speed, control (does the vehicle go in a straight line?), or off-road ability. Try Rubistar rubric maker (**rubistar.4teachers**.org) for an easy way to create the data sheet. (See page 9 for a sample).

- **Extended Discussion**
  Students debate why they had different results over different surfaces. Explain the concept of **friction** (the force resisting motion) and how it makes it more difficult for objects to move. Ask students: Are there times when you want more friction? Why? When have you experienced friction?

Try It Out!

Have the students rub their hands together really quickly to demonstrate friction. Ask students how their hands feel — hot, by chance? They have just discovered *dry friction*, when two solid objects rub together. Next, have a student put one hand in a tub of water and move the hand around. *Skin friction* is produced by the surface of an object as it resists the force of drag through a liquid. Ask students if they have felt this friction at some time when they were swimming!

Experience 3: Roll It!

Students use what they learned in **Experience 2** to modify the LEGO® vehicles and test different parts that make an object move more easily, such as wheels and skids.

Procedures

- **Provocation and Discussion**
  Students use the LEGO vehicles they developed to experiment with different types of LEGO® **wheels**, such as narrow or wide, or that have smooth surfaces or **tread** (grooves). Have a conversation about the characteristics of different treads.
  - Encourage students to think about what types of treads might be used on different terrains.
  - What types of treads are found on the vehicles they travel in on the way to school or with their families?
- **Application**
  Students test different types of wheels to see how they perform over specific terrains or different surfaces such as smooth, rough, and bumpy.
  - In a guided experience, **K–2 students** work in pairs to test two different types of wheels over two or three surfaces.
  - **Students in Grade 3–5** work in groups to test and compare several wheel types and surfaces.
  - Students record their information on the data sheet and compare results with each other.
- **Extension**
  Ask students if they have ever gone sledding. What kind of sled did they use? Some students may have experience with sleds that use runners or **skids**. Ask students why they think a sled moves so easily over snow or ice. Would the use of skids help a vehicle travel well on different surfaces? Investigate with your students and test skids and rollers on different terrains.

Watch It! This short YouTube video shows one person moving an RV with skids: **youtube.com/watch?v=98_I7uEZTxY**

Try It Out! Using what they have learned about friction, students discuss why wheels work better than skids on most surfaces. Using a regular chair and a chair on rollers, have students determine which one works best to move the teacher (yes, you!) across the room. Then have students brainstorm what they could use to move you more easily in the regular chair (such as putting the chair on a sled or skids). Encourage students to use their new vocabulary as they try out these ideas. Have a student document the event, and don't forget to share it with families!

Experience 4: Ups and Downs

In this experience, students test their LEGO® vehicles to see how they move on both flat and inclined surfaces.

Procedures

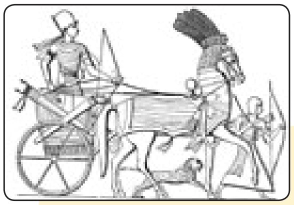
- **Provocation for Discussion**
  Remind students of their experiences with maps and ask if they included hills or mountains on their maps. Ask students to discuss the challenges of travelling up and down such terrain.

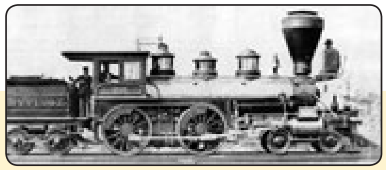
- **Discussion and Application**
  Students test the vehicles they built and modified in Experiences 2 and 3 by using inclined surfaces outside or using the terrain tubs to simulate hills and mountains.
  - During this experience, the students can vary the slope of the container by putting books or wedges underneath the tubs.
  - Before they begin the test, ask students how they think their LEGO vehicles will perform. What will cause a vehicle to travel the greatest distance?
  - To compare performance between flat or slightly inclined surfaces and sharply inclined surfaces, students start their vehicles at the top of the incline, measure the distance traveled from the top of the ramp to where the car stops, and record the results on their data sheets.

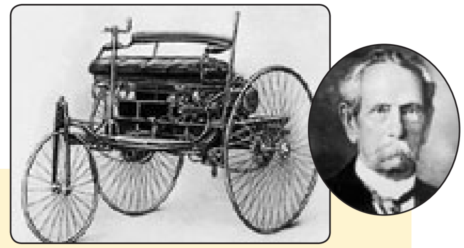
- **Extension**
  Students add weight to their vehicle to explore the effects on both flat and inclined surfaces.
  - The students can then use a new data sheet and try their vehicle tests again to compare how their vehicles performed.
  - Students consider why more weight would make something go faster and travel farther downhill. What type of vehicle would be harder to stop when driving down a hill, a fast sports car or a slow truck? Why?
  - Students in **Grades 3–5** can use what they are learning about the force of gravity and its relationship in this discussion.

- **Concluding Conversation**
  Students at all grade levels discuss the question of why objects move more easily down an inclined surface. Are real cars tested like this before they are sold? What else would be fun to test at another time?

- **Documentation**
  Record observations as a group when Experiences 1, 2, 3, and 4 are complete, and then create a classroom chart.
  - What have students learned about the way vehicles travel on land over different types of terrain?
  - Ask students: If you worked for a car company, what type of vehicle would you like to design?
  - Students should be encouraged to keep their vehicles out for others to "test drive." Invite other members of the school community to highlight students' learning and contribute their own designs!







A World on Wheels

The first wheeled vehicles used for transportation appear in archeological records dating back to 3500 BC, in ancient Mesopotamia. These were two-wheeled military chariots. The earliest four-wheeled vehicles have been found in ancient Rome. These early carts paved the way for the creation of wagons and carriages pulled by animals.

Roads called wagonways were used in Germany in the 1500s and consisted of wooden rails for horse-drawn wagons. By the 1700s iron replaced wood in rails and the invention of the steam engine paved the way for the railroad era. In 1804 the first steam engine took two hours to travel nine miles from a Welsh ironworks to a nearby town. Twenty years later rails carried both goods and passengers. Electricity eventually modernized rail travel and grew to include subways, trolley cars, and elevated trains.
The late 19th century found two-wheeled transportation in vogue again. The first bicycle, made in 1817 mostly of wood, had no pedals and was powered by a rider's feet. By the late 1800s the bicycle included brakes, pedals, padded seats, and wheel chains. The bicycle liberated women and changed the way they dressed forever but popularity of the bicycle declined with the invention of the first motorized vehicle. It was a tricycle, powered by a steam engine, built by Nicolas-Joseph Cugnot in the late 1700s.

In 1886 German engineer Karl Benz invented the first gasoline-powered automobile. Over the next 25 years design and technology advanced the automobile's design but its use was expensive and limited. Henry Ford and his creation of the production line and the Model T in 1908 made the automobile available to nearly everybody. Today we can't imagine life without the automobile. Over the years the auto has changed nearly every aspect of society. Just think of all the industries and products created just because nearly everyone in the world travels on wheels!

For more about transportation, visit these websites:

- **Smithsonian National Museum of American History**
  America on the Move
  americanhistory.si.edu/onthemove/
- **Smithsonian National Air and Space Museum**
  nasm.si.edu
- **Museum of Transportation**
  transportmuseumassociation.org
- **The Henry Ford Museum: Transportation in America**
  thehenryford.org/education/transportationInAmerica.aspx

Children's Literature Connections

Student investigation of maps and travel inventions, such as wheeled vehicles, may inspire more exploration through books. Try these titles:

Grades K–2
Around Town by Victoria Taylor
Cars and Trucks and Things that Go! by Richard Scarry

Grades 3–5
A Rubber Tire (How It's Made) by Sarah Ridley
Tire Mountain by Andrea Cheng
Travel Through Time: Cycle Power by Jane Shuter
Wheels of Change: How Women Rode the Bicycle to Freedom (With a Few Flat Tires Along the Way) by Sue Macy

Lesson 2 — Adventures on Water

Students explore maps to identify different types of water features and consider the travel challenges each one would present. They experiment with different types of materials to determine what factors cause objects to sink or float and test different ways of moving a vehicle through water.

Objectives

Students will

- distinguish between land and water on maps and globes and identify different types of water features, such as rivers, lakes, and oceans
- record and share information about the characteristics of different types of water features
- consider factors such as size, water movement, and distance in choosing a water vehicle
- use map scale to calculate distances across large bodies of water on a map (Grades 3–5)
- experiment with different materials to learn why they sink or float
- use their understanding of density to modify objects so they will float

Focus questions

- What types of water vehicle designs are best suited to different bodies of water?
- How can you build and steer a vehicle that will float and move on water?
- Why do objects sink or float in water?

You will need . . .

Materials

Experience 1

- a variety of physical maps and globes for group work
- markers or crayons
- white chart paper
- string and rulers for measuring the distance (Grades 3–5)
- paper for recording distance (Grades 3–5)

Experience 2

- a variety of objects for sinking and floating tests
- a clear tub full of clean water
- small tubs of clean water for small group work
- several cans of regular and diet soft drinks (Grades 3–5)
- a scale for measuring the weight of objects (Grades 3–5)
- a hydrometer for measuring density (Grades 3–5)

Experience 3

- several toy boats with sails
- Lego® bricks and plates for boat building
- photos or videos of fish of various types (for rudder provocation)
- plastic spoons and popsicle sticks (1 per student)
- paper to make fans or small battery-operated fans for small groups
- towels for cleanup!

Teacher Tip

Water A to Z

Do you know what a "burn" is? There are over 60 names for different bodies of water. If you have students interested in learning more, point them toward the wonderful resources on this website: worldatlas.com/aatlas/lista.htm

Adventures on Water

Vocabulary

buoyancy: the tendency of an object to float or rise when in a fluid

bow: the front of a boat

density: for beginning scientists, the amount of "stuff" an object contains; for more advanced scientists, the mass of a substance per unit of volume

hull: the body of a boat

hydrometer: an instrument for measuring the density of liquids

knots: the unit of speed for watercraft

lake: a large inland body of fresh water or salt water

mainsail: the primary sail on a boat (attached to the mainmast)

ocean: the large body of salt water that covers nearly three-fourths of Earth's surface; one of the large bodies of water that makes up the ocean

propeller: a type of fan that pushes water or air to propel a boat or aircraft

river: a large natural stream of usually fresh water flowing toward an ocean, a sea, a lake, or another river

rudder: an underwater blade attached to a boat to help steer it

scale: the ratio of a distance on a physical map to the actual distance

sea: a large body of salt water connected to but not as large as an ocean and which may be partially enclosed by land

stern: the rear of the ship or boat

Academic Standards
National Academic Standards

National Common Core State Standards English Language Arts

Grades K–2: K.W.8, K.L.6, K.SL.1, K.SL.4, K.SL.5, 1.SL.5, 2.W.6, 2.W.8, 2.SL.1, 2.SL.3, 2. SL.4,
Grades 3–5: 3.L.4, 3.W.2, 3.W.7, 3.SL.1, 3.SL.3, 3.SL.4, 4.W.7, 4.SL.1, 5.W.7, 5.W.8, 5.SL.1, 5.SL.4

Science — National Research Council Grades K–12

Content Standards: Unifying Concepts and Process
- Evidence, Models, and Explanations

Grades K–5

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science
- Positions and Motion of Objects
- Motions and Forces

Content Standards E: Science and Technology
- Abilities of technological design
- Understanding about science and technology

Content Standard G: History and Nature of Science
- Science as a human endeavor

National Council for the Social Studies

People, Places, and Environments — Early Grades

Learners will understand:
- location, direction, distance, and scale (b)
- physical characteristics, human interactions with the environment (c)
- use of maps, globes, and geospatial technologies (i)

From Sails to Steam and Steel

The earliest form of transportation may have been the boat. Archaeological findings dating back over 10,000 years ago, in what was Mesopotamia, show the earliest boats were simple hollowed-out logs. In ancient Egypt, boats played an important part in the commerce of the region. Egyptians may have used boats on the Nile River to transport stones to build the Great Pyramids, and also created early sailing ships. These ships consisted of wood planks bound together and sealed with reeds. Sails were made of either linen or papyrus. Early water transportation was limited to travel on rivers and oceans but over time people began building their own waterways. The Chinese, Greek, Roman, and Egyptian civilizations built canals. People used oars or animals to power boats along the canals.

This tomb painting from 1450 BC provides clues to the construction and operation of ancient Egyptian ships.

An early 20th-century steamship, the Normannia, *lies at anchor in the Mediterranean Sea near the port of Algiers, Algeria.*

Over the centuries the use of sails in water transportation became more prevalent. As more and more sails were added to ships in the 16th and 17th centuries, worldwide exploration and commerce grew. The invention of steam-powered engines changed travel on water. Steamships and steamboats traveled both oceans and rivers. The first steamboat traveled on the Delaware River in 1787. In the 1880s steam-driven riverboats had paddle wheels on either side. Wooden ships eventually gave way to the development of iron and steel boats and to greater use of ships for military operations. In the 20th century, steel also made it possible to build huge ocean liners like the *Titanic*.

Today ships and boats perform much needed work throughout the world. Cruise ships sailing the oceans carry not just people but also swimming pools, restaurants, and theaters. Hovercrafts are popular boats that float above the water on cushions of air. Nuclear-powered ships can sail for as long as three years without having to be refueled. Seaplanes can travel both on land and in the air. Who knows what the future might hold for those who love to travel on water!

To learn more, visit the following websites:

- **Smithsonian National Museum of American History**
  On the Water
  americanhistory.si.edu/onthewater
- **Museum of Transportation**
  transportmuseumassociation.org
- **Owls Head Transportation Museum**
  ohtm.org/new_edu.html

Experience 1: Water, Water Everywhere

Students in **Grades K–2** distinguish between land and water on maps and globes and identify features, such as rivers, lakes, and oceans. They discuss the different ways people can travel on water.

Students in **Grades 3–5** explore maps, scale, and boat design. Students choose a large body of water, use scale to calculate distances, and determine how long it would take to cross at a certain point by rowboat, sailboat, or powerboat. After their exploration of water vessels, all students use LEGO® bricks and plates to design and build the perfect boat.

Procedures

Grades K–2

- **Provocation for Discussion**
  To begin the conversation, engage students in a brief Blue Scavenger Hunt: Students work in pairs to investigate blue areas they find on the map.
  - Students should discuss these questions: What do the blue areas look like? Is the blue made up of squiggly lines, different shapes, or whole objects? What does the color blue stand for on the map? What names do you notice for the different areas or bodies of water?
  - As a class, have the students share their observations while the teacher or students help record the information to categorize characteristics of **rivers**, **lakes**, **seas**, and **oceans**.
  - Ask the students: In what ways could you travel on these different bodies of water? What kinds of things would help people travel or move through the water? Record their ideas on a chart for reference for a later activity.

- **Application and Discussion**
  - Ask students: What kind of vehicle would work best for a river, lake, or ocean? Would the size of the body of water make a difference in the vehicle you choose? What features would the vehicle need to have? How would you steer it? Where would you keep it? If it doesn't have a motor for power, how would it move?
  - After considering the questions, students pick a body of water and on chart paper, design a

vehicle that could travel well on that particular waterway. Encourage students to integrate new vocabulary in their designs and in their discussions with other students.

- **Extension: Build It!**
  Encourage students to build their designs with LEGO® bricks and plates and put them on display.

Grades 3–5

- **Provocation for discussion**
  - In small groups, students explore their maps and talk about how long it might take to travel across the large body of water.
  - Encourage the students to think about challenges along the way, such as storms, high winds, rough waters, and natural features like reefs that need to be avoided.
  - Students use a ruler and string to measure and record the distance across a body of water on their map.
  - To confirm results, each small group can travel to other small group maps to record the distance and compare measurements. Help students notice that not all maps use the same scale.

Teacher Tip

Begin the exploration in Experience 1 with *The History of Water Travel* by Renzo Rossi. The book includes many interesting pictures that are good for spurring questions and conversations.

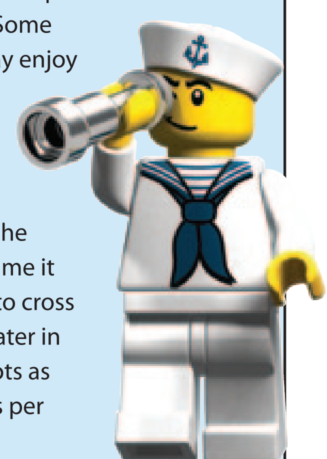
- **Discussion and Application**
  - In a whole group, share the small group observations. The teacher might ask: How do you measure distance on a map? Did you notice anything on the map that might help you find the distance from place to place?
  - Help students identify the map **scale** for a map and model the process of calculating the distance from one point to another using the scale, string, and a ruler. Have a few student volunteers come up and try it out themselves.
  - Have small groups go back to their map and use the map scale to calculate distances in miles.

- **Extended Discussion**
  - Ask students what else they need to know, in addition to the distance to be traveled, in order to find out how long it would take to cross a body of water. Students will realize that they will need to know how fast a water vehicle can go in order to find out how long it might take to cross a specific body of water.
  - Students in small groups can decide on a specific kind of watercraft and use websites and reference books to determine a potential speed. They can then calculate how long it might take to cross a body of water.
  - Remind students that wind and water conditions can make a big difference in how fast a vessel can travel. For example: How long would it take to cross Lake Michigan from Chicago, Illinois, to Holland, Michigan, in a sailboat if the wind were blowing from the west at 10 miles per hour?

- **Documentation**
  - After talking about map scale, vessel speed, and weather conditions, students can design a more efficient watercraft for future travel across the body of water.
  - In what creative ways could the new watercraft be energy-efficient? What special features and parts might the watercraft include? Students can use chart paper or LEGO® bricks to design their crafts individually or in small groups.
  - Students can label their watercraft and then write a description of how it works and why it is an invention for the future. Be sure to give the students a chance to show off their work. Models, drawings, and student writing might be displayed in the media center or another area of the school.

Knots or Not?

"Old salts" (experienced sailors) usually calculate the speed of water vessels in **knots** per hour rather than miles. Some students may enjoy researching the origin of the term and calculating the amount of time it would take to cross a body of water in terms of knots as well as miles per hour.



Experience 2: Float Your Boat!

In this experience, students explore the concept of **buoyancy** using a variety of materials.

Grades K–2: Students experiment with different materials and objects and discover that some objects sink and others float. They discuss why this happens and learn that the **density** of materials affects the way they behave in the water.

Grades 3–5: Students learn about the concept of **density** as they experiment with similar objects that sink and float and determine how materials and objects can be modified to make them float.

Teacher Tip

The PBS station in Indianapolis has produced a video that describes the concept of density in a student-friendly way. At **wfyi.org/IndianaExpeditions** see the *Sink or Float* video in Season 1, 103 — Physical Science.

Procedures

Grades K–2

- **Provocation for Discussion**
  Assemble a plastic tub with clear water and a group of objects of different sizes, shapes, and materials, such as LEGO® bricks, wooden blocks, sticks, plastic and plastic foam containers, aluminum plates, paper clips, and other objects made of metal.
  - Explain to students that they are going to play the role of scientific observers. Their eyes and brains have to be alert and remember what is going on without talking.
  - The scientific observers' job is to watch as you test a variety of objects in the water, observe what happens, and think carefully about why some objects are behaving the way they do.
- **Discussion and Application**
  - After the test, ask the students why certain objects in the experiment floated and others sank. Do students notice any similar characteristics among the floating objects or the sinking objects? Does the shape of an object seem to make a difference?
  - Using small tubs of water, have students test objects and materials in pairs or small groups. Students can create record sheets to record what they decide to test and the result of the test. Does the size of an object make a difference? Does the shape make a difference?
- **Concluding Discussion**
  - Discuss students' findings from their record sheets. Ask students to describe similarities and differences in the materials that make up the objects they tested.
  - Help students understand that all materials are made up of particles that are too small to see. When these particles are packed very closely together, the material is dense. Objects made of dense material are likely to sink. Objects made of materials with less **density** are more likely to float.
  - The shape of an object is important and helps determine if it will sink or float. Metal is a material that is very dense. Ask students about objects they tested that are made of metal, such as the aluminum pie plate and the paper clips.

- They will remember that the paper clips sank but the metal pie plate was able to float. Point out that this is due to the hollowed-out shape of the pie plate. Ask students why they think boats that are made of metal can float.

Teacher Tip

Sink or Float?

Encourage students to create a "Sink or Float Museum" with objects they bring from home. Don't be afraid to try unusual objects. Fruit has really interesting sinking/floating properties. A specific fruit might sink while others float . . . a great conversation starter!

Grades 3–5

- **Provocation for Discussion**
  Use a large clear tub of clean water and ask two students to put a can of Coke and a can of Diet Coke in tub of water.
  - All students should observe carefully to see what happens. The can of Coke will sink and the Diet Coke will float.
  - Ask students: Why does the can of Diet Coke have more **buoyancy** than the can of regular Coke? Have one student record possible explanations.

- **Discussion and Application**
  - Students may suggest several possibilities, such as: one can is heavier than the other, one can is larger, or the two cans are made of different materials. Other students may wonder if there is something different about the ingredients inside.
  - Place students in small research groups based on the possible explanations that they want to explore. It is good scientific procedure for more than one group to test each of the possibilities. That way groups can compare results.
  - Have groups state each possibility they want to test in the form of a prediction about the outcome such as: "One can will sink and the other will float because one can weighs more than the other" or "One can will sink and the other will float because the ingredients inside are different in some way."
  - Students should discuss and decide how to test their predictions. Small groups might:
    - Weigh and measure cans and then examine the materials they are made of.
    - Empty the contents of the cans into two identical containers and weigh them, weigh the empty Coke and Diet Coke cans, and try floating the empty cans
    - Check and compare the list of ingredients in the cans. How are they similar and different?

- **Concluding Discussion**
  - Bring students together in a large group and ask which predictions were supported.
  - When small groups report their findings, they will discover that groups that examined the ingredients in the Coke and Diet Coke cans had the right idea.
  - The can of Coke sank because it has more "stuff" (sugar) dissolved in the liquid. The Diet Coke contains artificial sweetener. It may float because the artificial sweetener is less dense or because less is added to the Diet Coke, making the drink less dense.
  - This experiment can help illustrate the idea that even if objects are the same size and shape, one may sink while the other floats, depending on the **density** of each object.

- **Extension**
  - Challenge the students to create a way to make the Coke can float in the water. What materials can they use?
  - Have the students bring in materials from home or collect materials around the school to help them with their creation.
  - In pairs or small groups, give the students time to prepare their design and then test their objects with the whole class.

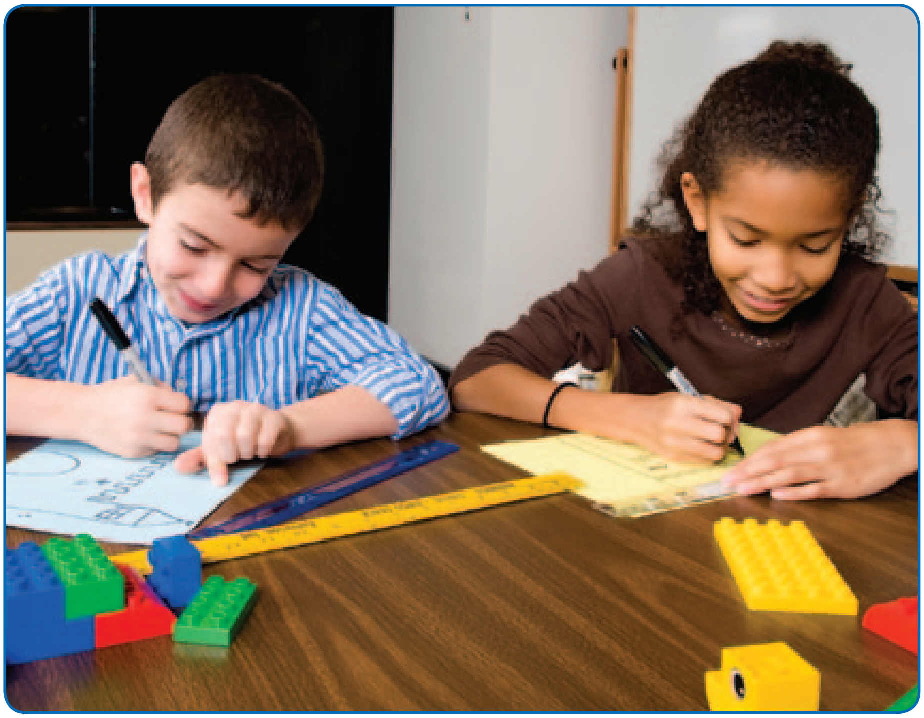
- **Documentation**
  Have the students photograph or take videos of the "Coke Float" tests to share with others. They can either narrate the video or write talking points to go with it to share their learning.

Teacher Tip

To further explore and provoke dynamic conversations, try testing the density of liquids. Gather a variety, such as corn syrup, dish soap, and vegetable oil. Have the students observe and then record what happens when 2 or 3 tablespoons of each liquid are added to water. Which liquids are more or less dense than water? Students can confirm findings by testing each liquid with an **hydrometer**. What other liquids would be interesting to try?

Experience 3: Set Sail!

Students test different ways of moving a vehicle on or through the water. Students examine the way that paddles, oars, sails, and rudders push against the water and can be used to move and steer a boat. They experiment with moving air to determine how a sail works. The use all that they have learned to design a LEGO® boat and modify it to make it float.



Procedures

Grades K–2 and 3–5

- **Provocation for Discussion**
  - In small groups with a small tub of clean water at each station, have students experiment with their hands to gently push the water away and bring the water forward. Can they push more water with their hands in a fist or open? With their fingers stretched out or together?
  - Have students move their hands from side to side in the water with their fingers together. Can they feel the push of the water against their hands, first in one direction and then the next? Students can also try out several kinds of "tools," such as plastic spoons, popsicle sticks, and rubber spatulas.
  - Introduce videos and photos of sharks and other fish. Ask students to observe how the fish move and steer their bodies through the water. Does this remind them of what they were doing with their hands and their water-pushing tools?
- **Discussion**
  - When the students report back on their experience moving water with their hands, initiate a conversation about their flat hands, spoons, and popsicle sticks being similar to an **oar** or **paddle** on a boat that pushes against the water to help the boat to move.
  - Ask how the shark and other fish "steer" their bodies. Encourage students to discuss the role of the tailfin on a fish and how it compares to the way a **rudder** is used to steer a boat.
- **Application**
  - Ask students to use what they already know about how boats move and brainstorm about the best ways to move toy sailboats across tubs of water. Challenge the students to think of ways of moving the boats without touching them.
  - The teacher can guide the discussion about the use of sails and how they "catch" moving air, which pushes the boat forward.
  - Student can then work in small groups to devise a way to generate wind and make their boats move. They might make paper fans or use electric fans and experiment with the angle and "speed" of the air movement to see how it affects their boats.

Concluding Discussion

- In a large group discussion, students can share ideas that worked best with their classmates.
- What were the biggest problems they encountered? How did they try to solve these problems?

Extensions

- Introduce students to books and websites that show rudders and different types of oars (some flat and some slightly cupped). Some students may want to find out why different oars are used for different purposes.
- Students will enjoy the challenge of this experiment! How can they move the air to get the boat to tip over? Which direction does the wind have to come from? How fast does the wind need to be to tip the boat? If a real boat were caught in a storm with a lot of wind, what would they recommend the captain of the boat do to avoid tipping over?

Children's Literature Connections

Students will find inspiration and information for their projects in books like these:

A History of Water Travel by Rossi Renzo
Making Waves: Water Travel Past and Present by Jane Shuter
The Longitude Prize by Joan Dash

Assessment: Build a LEGO® Boat

Students design and build a water vehicle made of LEGO® bricks, plates, and accessories and explain the intended function of each of its parts. They use what they have learned about the concept of density to choose materials and add modifications intended to help the vehicle float. They test the vehicle and explain how push/pull forces can be used to make it move on the water.

Lesson 3 — Adventures in the Air

In this lesson, students examine the idea that air is matter and that it exerts a force on objects. They experiment to learn how push/pull forces and the properties of flight, such as lift, drag, weight, and thrust, affect different materials when they move through the air. They build a kite to see how moving air causes a kite to fly and test a simple glider to explore how it can be steered in different directions. They brainstorm ways to design vehicles for sustained flight and use what they have learned to build aircraft from LEGO® bricks and accessories.

Focus questions

- What is air? Is it something or nothing?
- How can air make an object lift off the ground?
- How does the shape of an object affect the way it moves in the air?
- What are the forces that affect flight?
- How can a pilot steer a glider or airplane in different directions?
- What is needed for an aircraft to sustain flight?
- How do you design and build a vehicle that will move through the air?

Flight adventures

The Children's Museum of Indianapolis has developed *Curious Scientific Investigators: Flight Adventures*, a unit of study and online video components for **Grades 3–5** (**childrensmuseum.org/flightadventures**). The unit of study provides lessons on the forces of flight and patterns and instructions for building and testing parachutes, kites, rockets, and a simple glider.

Objectives

Students will

- identify early inventions related to flight
- give examples that demonstrate that air is matter
- construct parachutes, kites, and gliders to experiment with the forces of flight
- describe push forces, such as lift and thrust, and opposing pull forces, such as weight and drag
- give examples of how push and pull forces influence flight
- explain how different types of aircraft move through the air
- identify the parts of an aircraft they have designed and explain how they work to balance push and pull forces and achieve flight

You will need . . .

Materials

Experience 1

- books, photos, and illustrations showing different types of aircraft
- sticky notes
- paper for constructing a chart
- paper napkin parachute instructions on pages 30-31

- materials for making parachute — construction paper, scissors, tape, string, hole punch, and paper clips

Experience 2

- books with photos and illustrations of Chinese, Japanese, and modern kites
- chart paper or white board to record students' ideas
- standard-size grocery bags or large sheets of heavy construction paper
- kite diagram on page 32
- pencils and rulers or meter sticks
- scissors
- crayons or colored markers
- string and yarn or ribbon
- small table fan

Experience 3

- books on flight and inventors of early aircraft (see the **Resources** section)
- plastic foam plates or paper for making gliders
- LEGO® bricks, plates, and accessories

Forces of Flight

Flight through the air is possible because air is matter. Like all matter, air takes up space and has mass. The forces of flight result from the interaction of the aircraft (matter in solid form) and air (matter in the form of gas). In flight, **push** forces (lift and thrust) oppose **pull** forces (gravity and drag). A push force creates thrust that moves an aircraft forward, and drag opposes it, slowing down the forward motion. A push force creates lift that opposes the pull weight of an aircraft so that it can rise through the air.

Vocabulary

air: a mixture of gases including oxygen, carbon dioxide, nitrogen, and water vapor

elevon: a moveable part of an aircraft used to control movement and direction

engine: a machine that changes energy into movement

flight: a process that enables an object that is heavier than air to take off and move through the air

force: an effect that pushes or pulls an object in motion or causes an object's motion to change speed or direction

four forces of flight

- **drag**: a force that opposes the motion of an object
- **lift**: a force that opposes the weight of a moving object and holds it up
- **thrust:** a force that propels an object in a specific direction
- **weight**: the force an object exerts due to gravity

glider: an aircraft without an engine

gravity: the attraction between two masses; a force that pulls objects toward Earth

inventor: a person who creates something new through the use of imagination, thought, or experimentation

kite: a light object, usually with a balancing tail, designed with surface areas that resist moving air, intended to be flown in the air on an attached string

mass: the property of matter that gives it weight and inertia; the amount of material in a given substance or object

matter: the substance of which a physical object is composed; anything that takes up space and has mass

parachute: a device used to slow down an object moving through the atmosphere

pilot: a person who steers a ship or manages the controls of an aircraft or spaceship

Academic Standards

National Common Core State Standards

English Language Arts

Grades K–2: K.W.8, K.L.6, K.SL.1, K.SL.4, K.SL.5, 1.W.2, 1.W.8, 1.L.6, 1.SL.1, 1.SL.3, 1.SL.5, 2.W.6, 2.W.8, 2.SL.1, 2.SL.3, 2. SL.4,

Grades 3–5: 3.W.2, 3.W.7, 3.W.8, 3.L.4, 3.SL.1, 3.SL.3, 3.SL.4, 4.W.7, 4.SL.1, 5.W.8, 5.SL.1, 5.SL.4, 5.SL. 5

Science — National Research Council

Grades K–12

Content Standards: Unifying Concepts and Process

- Evidence, Models, and Explanations

Grades K–5

Content Standard A: Science as Inquiry

Abilities necessary to do scientific inquiry

- Understanding about scientific inquiry

Content Standard B: Physical Science

- Positions and Motion of Objects

Motions and Forces

Content Standards E: Science and Technology

- Abilities of technological design
- Understanding about science and technology

Content Standard G: History and Nature of Science

- Science as a human endeavor

Experience 1: Up in the Air

Students examine books and photos and brainstorm the many different kinds of aircraft. They recall their experiences in Lesson 2, where they learned that air can be used to push against a sail and move a boat. They use a parachute to explore how air pushes up against an object and slows it down as it falls.

NASA PHOTO / TONY LANDIS

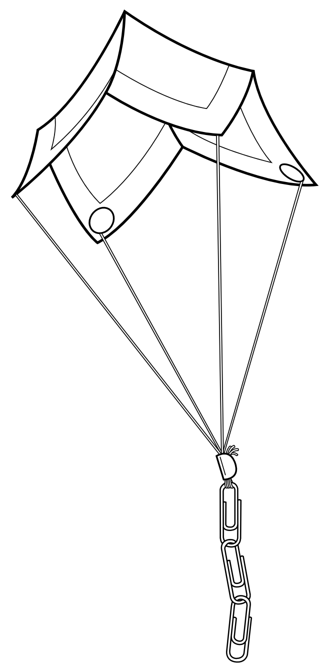
The X-38 prototype of the Crew Return Vehicle for the International Space Station undergoes a test with its 7,500-square-foot parafoil.

Procedures

- **Provocation for Discussion**
  - Revisit the book *Oh, the Places You'll Go!* by Dr. Seuss or other books suggested in this unit and discuss illustrations and photos showing different types of aircraft.
  - In small groups, guide students through an air travel brainstorming session about all the different ways humans can travel through the air.
  - Students might think of different types of planes, parachutes, jetpacks, hot-air balloons, gliders, blimps, hang gliders, helicopters, and others.
  - Younger students might draw images while older students write down aircraft types on sticky notes, one for each type.
  - When the small groups complete the task, all the groups come together to categorize the items on their list in a class chart.
  - Guide the class in creating simple categories that make sense according to students' developmental level and interests. For example, aircraft could be categorized as those with or without wings or with or without motors.

Teacher Tip

For the purposes of this lesson, focus student attention on travel through the air. Students will probably think of spaceships, which are not aircraft because they are designed to travel through interplanetary space, not through the air. The Space Shuttle is not considered an aircraft because its primary purpose is space travel, but it does function as a glider when it returns to Earth's atmosphere.



- **Discussion and Application**
  - One of the aircraft students have identified on their chart may be a **parachute**. Engage students in an experiment to see how a parachute works.

- Make a small paper parachute from a 10" (25 cm.) square beverage napkin. Cut four pieces of string 10" (25 cm.) long. Using a sticky dot, or small pieces of tape, attach a string to each corner. Bring the loose ends of the four strings together and run them through a paper clip. Tie the end of the strings together to form a loop. The paper clip should hang from the loop.
- Working in pairs, one student releases the parachute with the paper clip and drops another paper clip at the same time. The other student watches to see which paper clip hits the floor first.
- Repeat the experiment several times and ask students to report on the results. Students may also want to try attaching three or more paper clips to the parachute and dropping a chain of the same number of paper clips to compare the outcome.

Grades K–2

- **Concluding Discussion**
  - Ask students why they think the parachute caused the paper clip(s) to fall more slowly.
  - Remind them of their experience with the sailboat in Lesson 2. Encourage students to describe how moving air can **push** against a sail on a boat. How is the parachute like the sail? How is it different?
  - Discuss how the air pushes against the parachute as it falls and causes it to fall more slowly.
  - Does this experiment give students clues about how moving air causes objects to fly? Have they seen things like dry leaves flying in the wind?

Grades 3–5

- **Concluding Discussion**
  - Remind students of their experience with the sailboat in Lesson 2, when they used moving air to push against a sail on a boat. How is the parachute similar to and different from the sail?
  - Ask students: How can air **push** against an object like a sail or the canopy of a parachute? What is air?
  - If students have not been introduced to the idea that air is **matter**, help them develop the concept with the balloon demonstration. See sidebar. If students have had earlier experiences with this concept, remind them that air is matter. All matter takes up space and has mass. Matter comes in three forms: solid, liquid, and gas.

Watch It!

The Smithsonian National Air and Space Museum has a wonderful learner-centered website about "How Things Fly" (howthingsfly.si.edu) that also teaches about the forces of flight.

Teacher Tip

The Matter of Matter

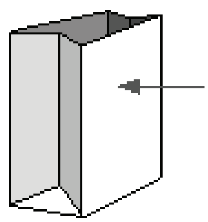
Students in Kindergarten and Grade 1 are using their senses to learn about a variety of materials and their physical properties. They are beginning to classify materials as solid and liquid but they may have difficulty understanding that air is made up of matter in the form of gas. Even though they can't see it, younger students still can feel moving air from the wind or a fan and can begin to understand that air is "something" rather than "nothing." Students in Grade 2 and above are experimenting with materials in different states and are learning that some materials, such as water, can be heated or cooled and transformed into gas or solid forms. All students may benefit from the balloon demonstration on page 12 of the *Flight Adventures* unit of study. In this experience students compare an inflated balloon to one that is not inflated to demonstrate that air is matter.

Student Handout

Sled Kite

A sled kite is simple to build and a powerful lifting machine in light-to-moderate breezes.
You can vary the dimensions of the pattern provided here to create a kite with a different surface area.

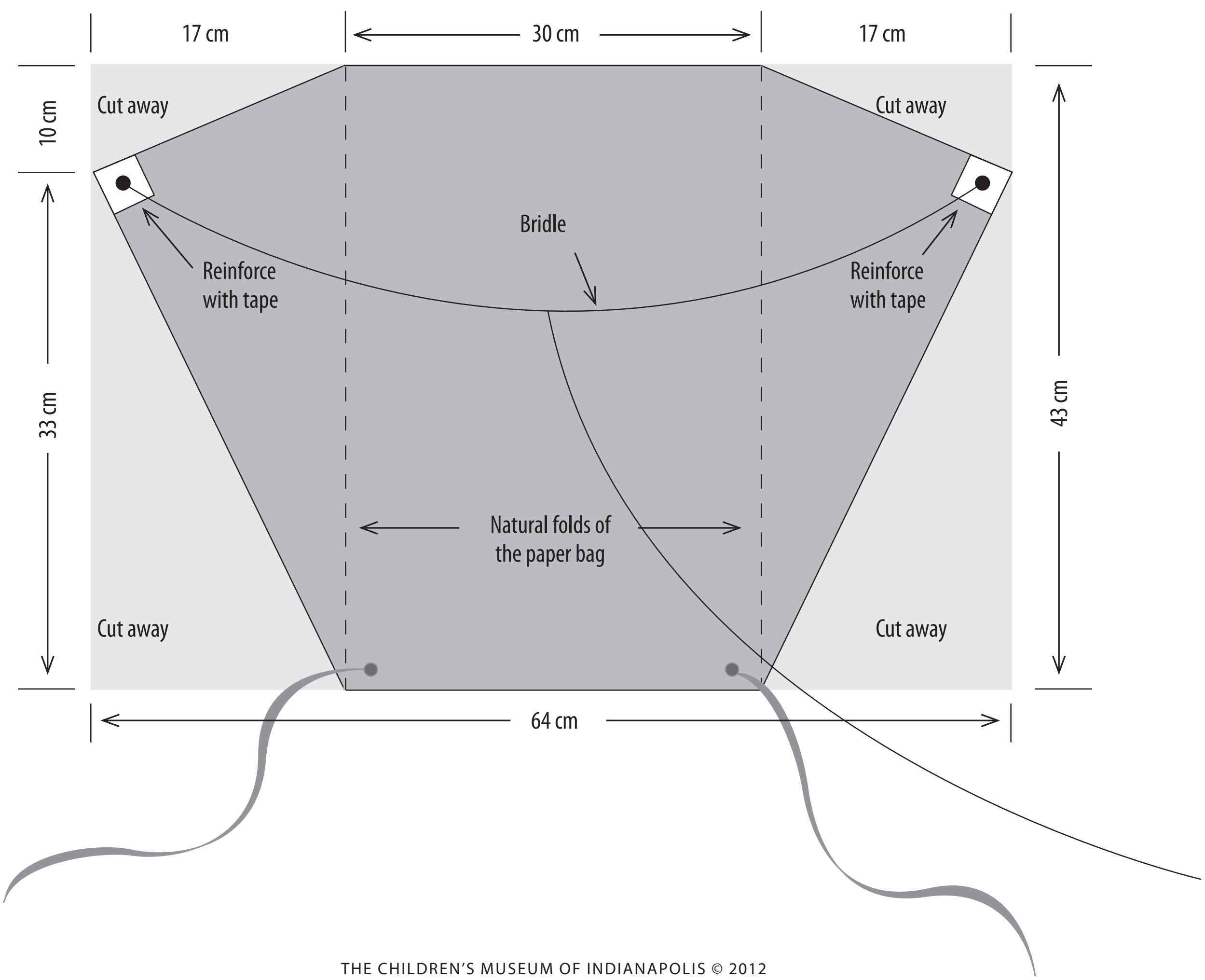
Materials	Tools
Standard-size brown paper grocery bags	Pencils
Masking tape	Meter sticks or rulers
Bridle string	Scissors
Tail (streamers, yarn, or machine tape)	Colored markers



Kite construction: Complete the following construction steps.

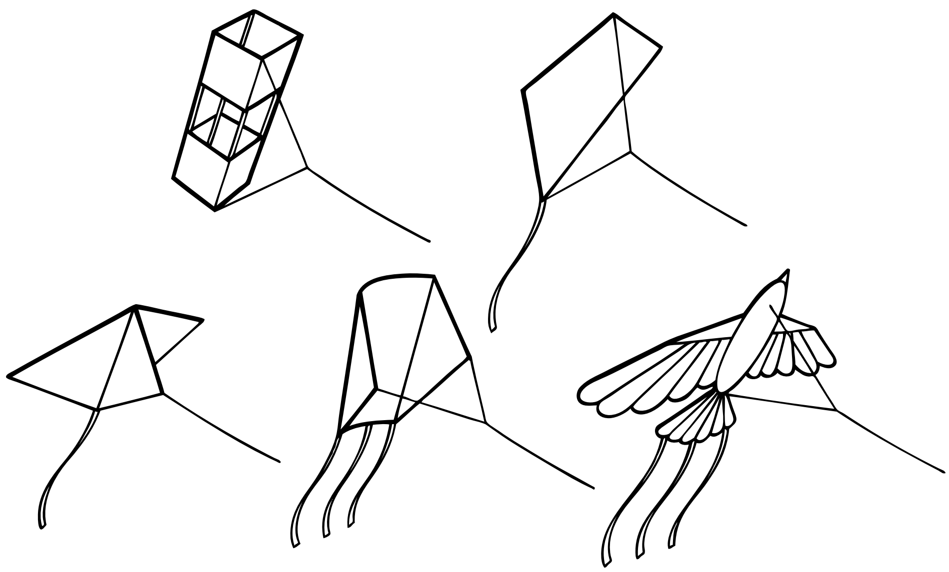
1. Use the dimensions below to create your kite.
2. Cut out one side and the bottom of a standard-size brown paper grocery bag.
3. Unfold the bag and copy onto it the dimensions given in the illustration.
4. Reinforce the bridle-attachment points with tape and attach bridle string (approximately 2 meters in length, depending on the kite). Tie a simple loop knot at the midpoint of the bridle.
5. Decorate as desired using colored markers.

Kite Diagram



Experience 2: Go Fly a Kite!

Students use their understanding that air is matter to investigate how moving air causes a kite to fly. They construct and fly a simple kite to examine the effect of weight and lift.



- **Provocation and Discussion**
  - Remind students of their brainstorming chart and the many different aircraft they identified. Explain to students that one of the earliest flight inventions may have been the kite.
  - Introduce books like *Kites: Magic Wishes that Fly Up to the Sky* by Demi and images of many different kinds of kites. The Chinese and Japanese designs have been developed and used for hundreds of years.
  - Discuss the many different shapes kites can have and consider what they may have in common.
  - Remind students of their earlier discussion about air being matter. Help them remember how air can **push** against a sail or a falling object such as a parachute.
  - Discuss things in nature that they have seen flying through the air, such as leaves and butterflies. Ask students: What do these objects have in common? What are their shapes like? Why do you think these things can fly in moving air? Does the shape of an object have anything to do with its ability to fly? Make notes on their ideas on the white board or chart paper.

- **Application**
  - To test their ideas have students construct "sled" kites from brown paper grocery bags or large sheets of sturdy construction paper, using the dimensions in the diagram on page 32. Dimensions of the pattern can be reduced to make a smaller kite.
  - For **Grades K–2**, the pattern may be pre-measured for students to cut out and decorate with crayons or colored markers. They may need assistance attaching the bridle strings and tailpieces.
  - Students in **Grades 3 and 4** can use rulers and their math skills to measure off the pattern based on the dimensions provided. They should decorate the kite before adding the bridle strings and ribbons or yarn tailpieces.
  - When kites are ready to fly, have students hold onto the strings and place the kites in front of a stationary table fan to observe how the kites behave in the moving air.

- **Concluding Conversation**
  - Ask students to explain how air can make an object like a kite **lift** up into the air. What happens when the fan is turned off?
  - Remind students that in **Experience 1** they discovered that air is matter and that it can slow down a falling object by pushing up against it as it falls. Moving air can also lift an object up off the ground.
  - Experiment with other kite shapes and kites outside. What if there's no wind? Running and pulling the kite causes it to move through the air and creates enough lift to cause the kite to rise in the air. Ask: What happens when you stop running? Why?

Experience 3: Take Off!

Students consider early flight inventions and the people who first learned to design and build aircraft. They construct and test a simple glider and explore the functions of wings and controls. They learn that the weight of an object is the force the object exerts due to gravity. They consider the question: What does it take for an object to take off and keep flying?

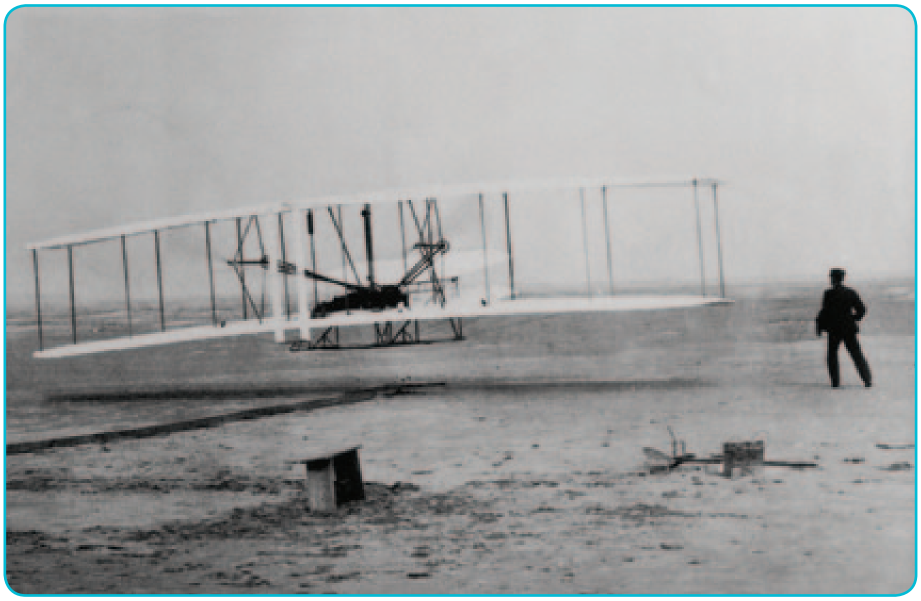


PHOTO COURTESY OF NASA

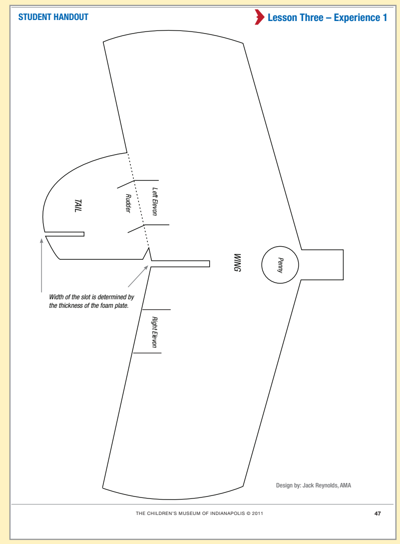
On December 17, 1903, Wilbur and Orville Wright flew the first successful powered airplane over the sand dunes of Kitty Hawk, North Carolina.

Procedures

- **Provocation and Discussion**
  - Remind students of the Chinese and Japanese kites they learned about in Experience 2. Explain that human beings have dreamed of flying since very early time. Ask where they think the inspiration for kites and early flight inventions came from.
  - Help students think of examples of flight from nature. For example, Leonardo da Vinci studied birds in flight and created more than 100 drawings of "flying machines."
  - Highlight photos and illustrations of early flight inventions from books, such as *Early Flying Machines* by Henry Dale and *Flying Machine* or *Flight* by Andrew Nahum.
  - Ask students to record questions, common characteristics, and observations about these inventions using a graphic organizer such as a web or T chart. As an alternative, students in Grades 3–5 might create a timeline of inventions showing how, in some cases, ideas build on each other to inspire the next invention.

Teacher Tip

For this experience, use paper glider templates from **funpaperairplanes .com** or the foam plastic plate FPG-9 Glider model on page 47 of the *Flight Adventures* unit of study available on The Children's Museum website: **childrensmuseum.org/ flightadventures**.



If using the paper templates, try the "Arrow," perhaps the easiest for younger students, the "Interceptor," or the "Raptor." Like the FPG-9, these gliders have **elevons,** sometimes called flaps, that can be adjusted to control flight. To fly and test the gliders, it will be important to have a large open space outdoors or in a gym or cafeteria.

Students should practice launching the gliders and making minor adjustments to cause them to fly straight. Have students launch the gliders by raising one arm straight above their heads, and thrusting the gliders gently forward as they release. Students must be careful never to launch a glider toward another person.

Application

- Ask students: What were some of the biggest problems flying machine inventers had to overcome? Help students record responses on the whiteboard or chart paper.
- Explain that inventors first learned how to deal with these problems by experimenting with kites and gliders. The first glider inventors and pilots had to figure out how to build gliders that were light enough to get off the ground and strong enough to carry a person. They also had to learn how to control and steer the gliders.
- To explore launch control problems, students can construct and fly gliders made of paper or plastic foam plates.
- **Grades K–2**
  Carry out guided tests of a simple gilder, such as the "Arrow." Help students as they fold the paper for their gliders. It will be important to make sharp folds along the lines indicated in the template. Test the glider with the elevons in neutral (aligned with the body), elevons up, elevons down, and one elevon up with one down. Ask students to observe and record results using a chart like the one on page 38.
- **Grades 3–5**
  After students practice flying their gliders, have them work in small groups to test one of the paper glider models or the FPG-9 with the elevons in the positions described above and record on their charts. Students can take turns being launchers, observers, and recorders. In the follow up discussion, remind students how their kites flew in moving air. Ask: What made your gliders fly?

  Explain that **thrust** is the force that is used to propel aircraft through the air. Thrust creates lift by causing air to move over the surface of an aircraft. In this case, students created thrust when they used their arms to propel gliders into the air.

PHOTO COURTESY OF NASA

In 1901, the Wright brothers experimented with the forces of flight by constructing a glider and flying it like a kite.

Discussion

- Discuss students' observations and questions in a large group. Students should be able to describe how adjusting the elevons caused the glider to move in different directions. With the flaps in neutral position the glider should fly straight. The glider should rise up with elevons up and dive with elevons down. With the right elevon up and the left down, it should roll to the right. With the left elevon up and the right down, it should roll to the left.
- Ask students: Why does changing the position of the elevons change the direction of the glider?
- Remind students that they have learned that air is matter and that it can push against objects and change their movements. Adjusting the position of the elevons causes them to interact with the air to change the direction of a glider or airplane.
- Explain that the invention of elevon flaps and other controls allowed pilots to control the movement of gliders. But there was still a problem. It was hard to get a glider off the ground and then it couldn't fly for long or very far. How could they get gliders to take off and keep flying?

Extension

- Ask students to reflect on their experiments with the parachutes, kites, and gliders.
- Ask: What happened to the parachutes when several paper clips were added? What happened when the fan was turned off? What happened when they stopped running with the kites?
- Ask: What happened to your gliders after they flew a short distance? Students will probably suggest that the weight of the gliders finally caused them to fall to the ground.
- Explain to students that air pushes on an object and lifts it into the air, but the air pushes against an object and creates **drag**. The force of drag slowed down the gliders and allowed their weight to bring them down.
- For students in **Grades 3–5**, connect this observation to other experiences related to gravity. Explain that objects have weight because of **gravity**, a force that pulls objects toward Earth. For flight to be possible, a stronger force must overcome gravity.

Assessment: Earn Your Wings!

- Ask students: What is the difference between a glider and an airplane? To overcome the force of gravity and keep the glider in the air, what would you need?
- Introduce students to the Wright brothers, who invented a gasoline engine for a glider and created the first airplane that could take off and fly for some distance on its own. Ask students: What new ways can you think of to make an airplane fly?
- Based on the concepts they have learned in previous experiences in this unit, students make predictions and explore ways to get objects off the ground and fly. They brainstorm ways to design vehicles for sustained flight.
- To demonstrate their ideas, students design and build an aircraft made of LEGO® bricks and explain the functions of parts that would allow it to take flight, move, and change direction in the air. Designs can be accompanied by talking points or written descriptions of what the pilot of the aircraft needs to know.
- If possible, invite a parent or other volunteer with experience in aviation and ask them to give feedback on students' creations. Students can generate questions and ask what the expert thinks about the future of air travel.

Teacher Tip

Remind students that all the methods that help people travel through air depend on the forces of flight: lift, drag, gravity, and thrust. If inventors hadn't learned how to use these forces, we would be stuck on the ground. Teachers and learners can explore the forces that help keep airplanes flying with model airplanes. For more information, visit the website of the Academy of Model Aeronautics: **modelaircraft.org/education**

Children's Literature Connections

Leonardo and the Flying Boy by Laurence Anholt

The Berenstain Bears Fly-It! by Stan and Jan Berenstain

Captain Arsenio: Inventions and (Mis)Adventures in Flight by Pablo Bernasconi

Early Flying Machines by Henry Dale

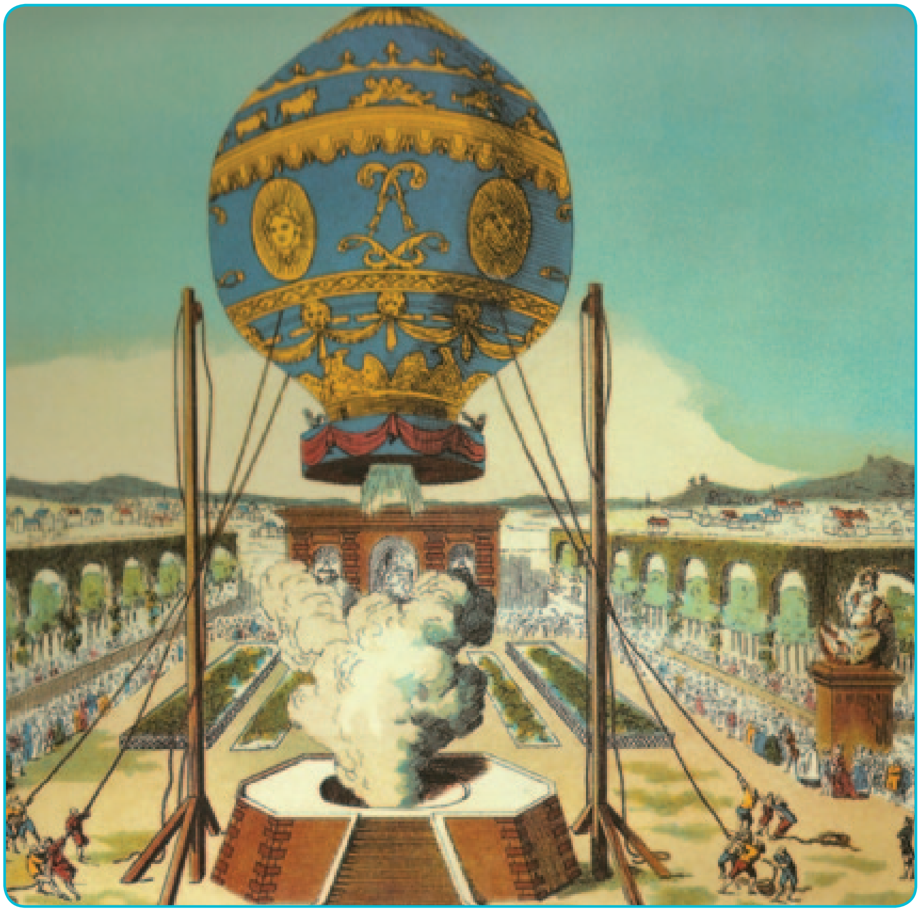
Kites: Magic Wishes that Fly Up to the Sky by Demi

Flight and *Flying Machines* by Andrew Nahum

Air and Flight by Sally Hewitt

How People Learned to Fly by Fran Hodgkins

Dreams and Flying Machines



The first manned hot-air balloon, designed by the Montgolfier brothers, takes off near Paris in 1783.

PHOTO COURTESY OF NASA

E17 Drag Research Model – On September 8, 1950, a technician prepares to measure the forces of thrust and drag on the flight of a research model.

Human beings have always dreamed of flying. The dream came true in 1783 when the Montgolfier brothers, of France, invented the first practical hot-air balloon. In September that year a Montgolfier balloon carrying a sheep, a duck, and a rooster flew for eight minutes in a demonstration for King Louis XIV. In November, humans flew in an untethered hot-air balloon for the first time.

Called the "father of aviation," Sir George Cayley, of England, experimented with kites and created the first full-size glider. In 1849, Cayley's 10-year-old son and a servant became the first humans to go on a non-balloon flight. From that point, the race was on to create the first gas engine-powered flying machine. Orville and Wilbur Wright won the race, flying the first airplane in 1903 at Kitty Hawk, North Carolina. The flight lasted only 12 seconds but it launched rapid developments in aviation.

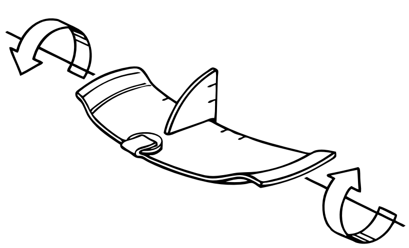
As airplanes evolved, new flying machines began to appear. In the 14th century, Leonardo da Vinci had the first idea for a helicopter based on a spiral and screw. Helicopters are rotorcrafts and can hover, fly forward, and land vertically. The first helicopter flight was made in 1907. Today the helicopter has advanced from an experimental craft to one used for search and rescue, aerial photography, firefighting, construction, and military operations.

Airplanes led to bigger dreams, and space travel began in the 1960s. Supersonic transports (SSTs) were used from 1978 until 1999 and could travel faster than the speed of sound. The creation of the space shuttle in 1981 combined the utility of airplanes and the power of rocket-fueled engines. Though the shuttle program has been retired, humans still dream of flight. In the future we may use flying taxis and flying cars and people may climb aboard space vehicles as often as they do airplanes.

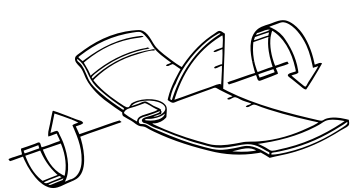
Student Handout

Glider Flight Test Chart

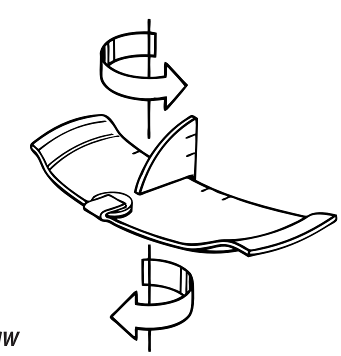
Group: Glider:	Describe how the glider flies
Elevons neutral	
Elevons bent up slightly	
Elevons bent down slightly	
Right elevon up, left elevon down	
Left elevon up, right elevon down	



Pitch



Roll



Yaw

Culminating Experience: The Travel Adventure of Your Dreams!

- Create a travel blog, website, or e-poster documenting the stages of the design process the adventurers encountered during the imaginary trip.
- Create a PowerPoint presentation using images and text to document their project.
- Create a "suitcase" with items that represent their trip and use it in an oral presentation.
- Create a travel guide with digital images and information to assist future travelers.
- Write a story about the journey from the point of view of the vehicle they have created.

Challenge students to think of vehicles and ideas to inspire future travel. What kind of sustainable or environmentally friendly methods could be used? Students use maps, globes, and their imaginations to identify the destination for the travel adventure of their dreams. The only rule is that their adventure must involve travel over land, on water, and in the air. Working in teams, students engage in the design process by creating a map to their dream destination and identifying the various obstacles to overcome. They brainstorm solutions to travel problems and create designs on paper for a vehicle or vehicles that will take them plus any personal items or equipment they might need. They build and test vehicles made from LEGO® bricks and revise their designs for a successful journey.

To report on the various stages of their projects and share what they have learned, students use technology and select from a choice board with the following options:

Resources

Books for Students

Anholt, Laurence. *Leonardo and the Flying Boy: A Story about Leonardo da Vinci.* Hauppage, NY: Barron's, 2000.
A fictional account of the life of Leonardo, told from the perspective of a young student, and illustrated with real reproductions of the master's works. (Grades K–3)

Berenstain, Stan and Jan. *The Berenstain Bears Fly-It! Up, Up, and Away.* New York: Random House, 1996.
The Berenstain Bears learn about flight inventions and build paper gliders and rockets powered by balloons. Glider and rocket instructions are included. (Grades 3–5)

Bernasconi, Pablo. *Captain Arsenio: Inventions and (Mis)Adventures in Flight.* Boston: Houghton Mifflin, 2005.
Students will laugh out loud at this fictional work purporting to be pages from the recently discovered 1780s diary of Captain Manuel J. Arsenio, in which are recorded his inventions the Motocanary, the Aerial Submarine, the Hamstertronic, and other failed attempts to create a flying machine. (Grades 3–5)

Biggs, Brian. *Everything Goes: On Land.* New York: HarperCollins, 2011.
Explore the big city with Henry and his dad as they check out everything from cars to RVs to construction vehicles. (Grades K–2)

Cheng, Andrea. *Tire Mountain*. Honesdale, PA: Boyds Mills Press, 2007.
Aaron loves to collect old tires from his dad's repair shop. When his parents consider moving the family out of the city, Aaron convinces them to stay. (Grades K–2)

Civardi, Anne. *Going on a Plane.* Tulsa, OK: EDC Publishing, 2005.
This picture book introduces young children to the experience of flying on a plane. (Grade K)

Compestine, Ying Chang. *The Story of Kites.* New York: Holiday House, 2003.
Beautifully illustrated by YongSheng Xuan, this book tells the story of the Kang brothers, who create kites to keep birds out of their rice fields. (Grades 3–5)

Dale, Henry. *Early Flying Machines.* New York: Oxford University Press, 1992.
This illustrated book surveys the early history of flight, from the first recorded history of man's attempt to fly to the successful flight of the Wright brothers. (Grades 3–5)

Dash, Joan. *The Longitude Prize.* New York: Farrar, Straus and Giroux, 2000.
After losing thousands of sailors at sea, the British Parliament offers a reward to whoever can invent a navigational device. Clockmaker John Harrison's invention is successful but he must persist in a lifelong fight for recognition of his work. (Grade 5+)

Demi. Kites: *Magic Wishes that Fly Up to the Sky.* New York: Crown Publishers, 1999.
Beautiful illustrations make this book suitable for younger children. Older children will also enjoy the legend of how kites were invented and the symbolism of the animals and other figures found in Chinese kites. (Grades K–5+)

Gaffney, Timothy. *Wee and the Wright Brothers.* New York: Henry Holt, 2004.
Children of all ages will delight in this picture-book account of the adventurous Wee, a rodent reporter from the "Mouse News" who travels to Kitty Hawk, North Carolina, to cover Wilbur and Orville Wright's historic 1903 flight. (Grades K–5+)

Graham, Ian. *The Best Book of Speed Machines.* New York: Kingfisher. 2002.
Racecars, speedboats, hypersonic aircraft and more are explained for a child's reading level, enriched with illustrations. (Grades K–2)

Hewitt, Sally. *Air and Flight.* New York: Children's Press/It's Science, 2000.
In answering the question "What is air?" this book explains the importance of air for all living things and how it makes flight possible. Instructions for a paper-plate parachute are included. (Grades K–5)

Hodgkins, Fran. *How People Learned to Fly.* New York: HarperCollins, 2007.
The basics of flight, including gravity, lift, drag, and thrust, along with instructions for paper gliders, are explained in this well-illustrated nonfiction book. (Grades K–5)

Kalman, Bobbie. *Travel in the Early Days.* New York: Crabtree, 2000. This introduction to different modes of travel helps students understand how inventions for moving on land, over water, and through the air have changed the world. (Grades 3–5)

Macy, Sue. *Wheels of Change: How Women Rode the Bicycle to Freedom (With a Few Flat Tires Along the Way).* Washington, D.C.: National Geographic, 2011.
This nonfiction book includes historic photos and ads that show how bicycles affected women's history, bringing innovations in fashion as well as social liberation and change. (Grade 5+)

Murphy, Stuart. *Let's Fly a Kite.* New York: HarperCollins, 2000.
Bob and Hannah learn the math concept of symmetry and the importance of sharing when they try to fly a kite. (Grades 3–5)

Books for Students

Nahum, Andrew. *Flight* (DK Eyewitness). New York: Knopf, 2011.
This well-illustrated history of flight focuses on the various inventions, such as curved wings, gas engines, propellers, and controls that enable aircraft to fly. (Grades 3–5+)

Nahum, Andrew. *Flying Machine* (DK Eyewitness). New York: Knopf, 2004.
This guide to the history of flight looks at different kinds of aircraft and includes information on pilot gear, how wings provide lift, and why some planes have pressurized cabins. (Grades 3–5+)

O'Brien, Patrick. *Steam, Smoke, and Steel: Back in Time with Trains.* Watertown, MA: Charlesbridge, 2000.
Children learn about the development of railroad engines from coal to steam through the story of a boy and his family of train engineers. (Grades K–2)

Ridley, Sarah. *A Rubber Tire (How It's Made).* Milwaukee, WI: Gareth Stevens, 2006.
Follow a rubber tire from the early stages of raw materials through production to learn the extraordinary story of how it is made. (Grades 3–5)

Rossi, Renzo. *The History of Water Travel.* Farmington Hills, MI: Gale/Blackbirch Press, 2005.
Explore rafts, barges, gondolas, and other forms of watercraft powered by wind, engines, and human strength. (Grades 3–5)

Rustad, Martha. *Transportation in Many Cultures.* North Mankato: Capstone, 2009.
Learn about different cultures' transportation to and from home and school and around their towns. (Grades 3–5)

Scarry, Richard. *Cars and Trucks and Things that Go!* New York: Golden Books, 2009.
The pig family starts out for a picnic at the beach and encounters every type of vehicle known to man or beast. This family classic engages learners of all ages with humorous story lines and illustrations. (Grade K+)

Shuter, Jane. *Cycle Power (Travel Through Time).* North Mankato, MN: Raintree, 2005.
Learn about travel on two wheels, from a boneshaker of the past to a motorcycle today. (Grades 3–5)

Shuter, Jane. *Making Waves: Water Travel Past and Present (Travel Through Time).* North Mankato, MN: Raintree, 2004.
From early canoes to modern ocean liners and everything in between, this book shows the importance of water travel through history. (Grades 3–5)

Smith, Alastair. *Travel and Transport: Then and Now.* Tulsa, OK: EDC Publishing, 2000.
This interactive book helps younger children have fun as they learn how the methods of transportation have changed over the course of history. (Grades K–2)

Seuss, Dr. *Oh, the Places You'll Go!* New York: Random House, 1990.
Seuss's story reminds readers that on all journeys there are perils to face, fun to be had, and many ways of traveling from here to there. (Grades K–2+)

Taylor, Victoria. *Around Town.* New York: DK Publishing, 2009.
This introduction to LEGO® travel provides age-appropriate stories to develop general knowledge and reading skills. Stories progress from simple sentences to challenging sentence structures. (Grade K)

Turnbull, Andy. *By Truck to the North: My Arctic Adventure.* Toronto: Annick Press, 1998.
Students experience the challenge of Arctic travel as they climb aboard an 18-wheeler. Adventures include the Northern Lights, a whiteout, and icy roads. A colorful map guides the way. (Grades 3–5)

Williams, Brian. *Karl Benz* (Pioneers of Science). New York: Scholastic, 1991.
Readers follow the life of Karl Benz from his time as a student in Germany to his role as an engineer and the inventor of the first motorized car. (Grades 3–5)

Wood, Jenny. *The Children's Atlas of People and Places: Travel the World and Visit People in Far-Off Lands.* Minneapolis: Lerner, 1993.
Maps, facts, and more than 200 photographs present the diverse people and places of the world. (Grades K–5)

Yates, Vicki. *Travel (Then and Now).* North Mankato, MN: Raintree, 2008.
Learn how people moved from place to place in the past and compare that to how we make journeys today. (Grades K–2)

Yolen, Jane. *My Brothers' Flying Machine: Wilbur, Orville, and Me.* New York: Little, Brown, 2003.
This well-documented account of the Wright brothers is told from the perspective of their sister Katharine, who provided support and encouragement. (Grades 3–5)

Resources

Books for Teachers

McDermott, Lillian C. *Physics by Inquiry*. Hoboken, NJ: John Wiley & Sons, 1996.
An essential resource for teachers, this two-volume set provides strategies for teaching fundamental concepts in the physical sciences using the inquiry approach.

Macaulay, David. *The Way Things Work*. Boston: Houghton Mifflin, 1988.
This classic resource uses humorous illustrations to provide a comprehensive overview of hundreds of machines, including boats, wheeled vehicles, and aircraft, and explains the scientific principles that enable them to work.

Websites

Academy of Model Aeronautics
modelaircraft.org/education
The Academy encourages young people to learn about flight through local clubs dedicated to building, flying, and demonstrating model aircraft. Use the search feature to find a club near your school.

The Children's Museum of Indianapolis
childrensmuseum.org/flightadventures
The website for the Curious Scientific Investigators: Flight Adventures unit of study includes patterns for paper kites and gliders. Access online videos that include instructions and demonstrations:

Indianapolis Public Television (WFYI)
wfyi.org/IndianaExpeditions/
The local program Indiana Expeditions provides a number of science-related experiences. For a student-friendly demonstration of **density**, see the Sink or Float video.

LEGO® Education
legoeducation.us
This site provides information on books, curriculum, professional development, and LEGO sets and spare parts. Topics include hands-on approaches to topics such as aerospace, math, robotics, simple machines, and STEM projects.

Museum of Transportation
transportmuseumassociation.org

NASA Beginner's Guide to Aeronautics
grc.nasa.gov/WWW/K-12/airplane/index.html

NASA for Educators
nasa.gov/audience/foreducators/index.html

NASA for Students
nasa.gov/audience/forstudents/index.html

Owls Head Transportation Museum
ohtm.org/new_edu.html

Smithsonian National Air and Space Museum
nasm.si.edu
The Smithsonian provides information on aviation and historic aircraft on its site. To learn about the forces of flight and How Things Fly, students can access an age-appropriate page: **howthingsfly.si.edu**

Smithsonian National Museum of American History
America on the Move
americanhistory.si.edu/onthemove/
On the Water
americanhistory.si.edu/onthewater

The Henry Ford Museum
Transportation in America
thehenryford.org/education/transportationInAmerica.aspx

Glossary

Lesson 1

Maps and Map Concepts

globe: a scale model of Earth in the form of a sphere

compass rose: a symbol on a map that indicates the map's orientation in relationship to the cardinal and intermediate directions

cardinal directions: the four main points of the compass: north, south, east, and west

cultural features: characteristics of a place that have been created by humans, such as roads, cities, and state and national boundaries

map: a graphic representation of all or part of Earth's surface, usually drawn to scale on a flat surface

map legend: a description or key to symbols used on a map

physical features: geographic characteristics that occur in nature, such as land and water forms, natural vegetation, and wildlife

physical map: a map that shows geographic features, such as landforms and bodies of water

political map: a map that shows human features, such as political boundaries, roads, and cities

Travel and Motion

friction: the rubbing of a surface of one object on another; surface resistance relative to motion; conflict between people or nations because of differing ideas

motion: the act or process of changing position or place

skid: a plank, bar, or log on which a load is supported (such as the runners of an old-fashioned sled)

terrain: ground characterized by its physical characteristics (such as a rocky terrain)

tread: the part of a wheel or tire that makes contact with the road; the grooved outside part of a rubber tire

wheel: a circular frame of a hard material that is capable of turning on an axle

Lesson 2

buoyancy: the tendency of an object to float or rise when in a fluid

bow: the front of a boat

density: for beginning scientists, the amount of "stuff" an object contains; for more advanced scientists, the mass of a substance per unit of volume.

hull: the body of a boat

hydrometer: an instrument for measuring the density of liquids

knots: the unit of speed for watercraft

lake: a large inland body of fresh water or salt water

mainsail: the primary sail on a boat (attached to the mainmast)

ocean: the large body of salt water that covers nearly three-fourths of Earth's surface; one of the large bodies of water that make up the ocean

propeller: a type of fan that pushes water or air to propel a boat or aircraft

river: a large natural stream of usually fresh water flowing toward an ocean, a sea, a lake, or another river.

rudder: an underwater blade attached to a boat to help steer it

scale: the ratio of a distance on a physical map to the actual distance

sea: a large body of salt water connected to but not as large as an ocean and which may be partially enclosed by land

stern: the rear of the ship or boat

Lesson 3

air: a mixture of gases including oxygen, carbon dioxide, nitrogen, and water vapor

elevon: a moveable part of an aircraft used to control movement and direction

engine: a machine that changes energy into movement

flight: a process that enables an object that is heavier than air to take off and move through the air

force: an effect that pushes or pulls an object in motion or causes an object's motion to change speed or direction

four forces of flight

drag: a force that opposes the motion of an object

lift: a force that opposes the weight of a moving object and holds it up

thrust: a force that propels an object in a specific direction

weight: the force an object exerts due to gravity

glider: an aircraft without an engine

gravity: the attraction between two masses; a force that pulls objects toward Earth

inventor: a person who creates something new through the use of imagination, thought, or experimentation

kite: a light object, usually with a balancing tail, designed with surface areas that resist moving air, intended to be flown in the air on an attached string

mass: the property of matter that gives it weight and inertia; the amount of material in a given substance or object

matter: the substance of which a physical object is composed; anything that takes up space and has mass

parachute: a device used to slow down an object moving through the atmosphere

pilot: a person who steers a ship or manages the controls of an aircraft or spaceship

Resources

Academic Standards

This unit of study addresses specific national and state academic standards in science, language arts, and social studies.

National Standards
National Science Standards
National Research Council (NRC), 1996

Grades K–12
Content Standards: Unifying Concepts and Process
- Evidence, Models, and Explanations

Grades K–5
Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science
- Positions and Motion of Objects
- Motions and Forces

Content Standards E: Science and Technology
- Abilities of technological design
- Understanding about science and technology

Content Standard G: History and Nature of Science
- Science as a human endeavor

National Common Core State Standards — English Language Arts
A number of states have adopted the Common Core State Standards for English Language Arts in Reading, Writing, Speaking and Listening, and Language Acquisition and Use.

K.W.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

K.L.6 Use words and phrases acquired through conversations, reading and being read to, and responding to texts.

K.SL.1 Participate in collaborative conversations about kindergarten topics and texts with peers and adults in small and larger groups.
- Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion).
- Continue a conversation through multiple exchanges

K.SL.4 Describe familiar people, places, things, and events and, with prompting and support, provide additional detail.

K.SL.5 Add drawings or other visual displays to descriptions as desired to provide additional detail

1.W.2 Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.

1.W.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

1.L.6 Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using frequently occurring conjunctions to signal simple relationships (e.g., because).

1.SL.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.
- Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion).
- Build on others' talk in conversations by responding to the comments of others through multiple exchanges
- Ask questions to clear up any confusion about the topics and texts under discussion.

1.SL.3 Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood.

1.SL.5 Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings.

2.W.2 Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section.

2.W.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.

2.W.8 Recall information from experiences or gather information from provided sources to answer a question.

2.L.6 Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using adjectives and adverbs to describe.

2.SL.1 Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.
- Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
- Build on others' talk in conversations by linking their comments to the remarks of others
- Ask for clarification and further explanation as needed about the topics and texts under discussion.

2.SL.3 Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

2. SL.4 Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.

3.W.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- Introduce a topic and group related information together; include illustrations when useful to aiding comprehension.

- Develop the topic with facts, definitions, and details.Use linking words and phrases (e.g., also, another, and, more, but) to connect ideas within categories of information.
- Provide a concluding statement or section.

3.W.8 Recall information from experiences or gather information from provided sources to answer a question.

3.W.7 Conduct short research projects that build knowledge about a topic

3.L.4 Determine or clarify the meaning of unknown and multiple-meaning word and phrases based on grade 3 reading and content, choosing flexibly from a range of strategies.
- Use sentence-level context as a clue to the meaning of a word or phrase.
- Determine the meaning of the new word formed when a known affix is added to a known word (e.g., agreeable/disagreeable, comfortable/uncomfortable, care/careless, heat/preheat).
- Use a known root word as a clue to the meaning of an unknown word with the same root (e.g., company, companion).
- Use glossaries or beginning dictionaries, both print and digital, to determine or clarify the precise meaning of key words and phrases.

3.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.
- Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
- Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others.
- Explain their own ideas and understanding in light of the discussion.

3.SL.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

3.SL.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

4.W.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

4.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.
- Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- Follow agreed-upon rules for discussions and carry out assigned roles.
- Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.
- Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.

5.W.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

5.W.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

5.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.
- Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- Follow agreed-upon rules for discussions and carry out assigned roles.
- Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

5.SL.4 Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

5.SL.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

National Council for the Social Studies

People, Places, and Environments — Early Grades

Learners will understand:
- location, direction, distance, and scale (b)
- physical characteristics, human interactions with the environment (c)
- use of maps, globes, and geospatial technologies (i)

Indiana's Academic Standards

Indiana's Academic Standards in Science, 2010

This unit addresses Indiana Process Standards for The Nature of Science and The Design Process and integrates them with Content Standard 1: Physical Science and Content Standard 4: Science, Engineering and Technology.

- **Process Standards for the Nature of Science include**:
  - Making observations, questions, and predictions;
  - Designing a test and planning and carrying out investigations using appropriate tools and technologies;
  - Testing predictions with multiple tests;
  - Keeping accurate records and communicating findings to others;
  - Comparing the results of an investigation with the prediction.

- **Process Standards for the Design Process include:**
  - Identifying a need or problem to be solved;
  - Brainstorming potential solutions;
  - Selecting a solution and the materials needed;
  - Creating, evaluating, and testing the solution;
  - Communicating the solution and evidence of results;
  - Communicating how to improve the solution.

- **Content Standards:**

Physical Sciences

K.1.1 Use all senses as appropriate to observe, sort and describe objects according to their composition and physical properties, such as size, color and shape. Explain these choices to others and generate questions about the objects.

K.1.2 Identify and explain possible uses for an object based on its properties and compare these uses with other students' ideas.

1.1.1 Use all senses as appropriate to identify the component parts of objects and the materials from which they are made.

2.1.4 Observe, sketch, demonstrate and compare how objects can move in different ways (e.g., straight, zig-zag, back-and-forth, rolling, fast and slow).

2.1.5 Describe the position or motion of an object relative to a point of reference (e.g., background, another object).

2.1.6 Observe, demonstrate, sketch and compare how applied force (i.e., push or pull) changes the motion of objects.

2.1.7 Investigate the motion of objects when they are acted upon at a distance by forces like gravity and magnetism.

2.4.2 Identify technologies developed by humans to meet human needs. Investigate the limitations of technologies and how they have improved quality of life.

3.4.2 Define the uses and types of simple machines and utilize simple machines in the solution to a "real world" problem.

4.4.1 Investigate transportation systems and devices that operate on or in land, water, air and space and recognize the forces (lift, drag, friction, thrust and gravity) that affect their motion.

4.4.3 Investigate how changes in speed or direction are caused by forces: the greater the force exerted on an object, the greater the change.

4.4.4 Define a problem in the context of motion and transportation. Propose a solution to this problem by evaluating, reevaluating and testing the design. Gather evidence about how well the design meets the needs of the problem. Document the design so that it can be easily replicated.

5.4.2 Investigate the purpose of prototypes and models when designing a solution to a problem and how limitations in cost and design features might affect their construction.

Indiana's Academic Standards for Social Studies, 2007
Geography

K.3.1 Use words related to location, direction, and distance, including here/there, over/under, left/right, above/below, forward/backward, and between.

K.3.2 Identify maps and globes as ways of representing Earth and understand the basic difference between a map and a globe.

1.3.2 The World in Spatial Terms: Identify and describe continents, oceans, cities and roads on maps and globes.

1.3.4 Places and Regions: Identify and describe physical features and human features of the local community including home, school and neighborhood.

2.3.3 Places and Regions: Compare neighborhoods in your community and explain how physical features of the community affect people living there.

2.3.4 Physical Systems: On a map, identify physical features of the local community

3.3.1 The World in Spatial Terms: Use labels and symbols to locate and identify physical and political features on maps and globes. Label a map of the Midwest, identifying states, major rivers, lakes and the Great Lakes.

4.3.1 The World in Spatial Terms: Use latitude and longitude to identify physical and human features of Indiana.

4.3.2 The World in Spatial Terms: Estimate distances between two places on a map, using a scale of miles, and use cardinal and intermediate directions when referring to relative location.

4.3.6 Physical Systems: Describe Indiana's landforms (lithosphere), water features (hydrosphere), and plants and animals (biosphere).

4.3.9 Human Systems: Explain the importance of major transportation routes, including rivers, in the exploration, settlement and growth of Indiana and in the state's location as a crossroad of America.

5.3.3 Places and Regions: Name and locate states, regions, major cities and capitals, major rivers and mountain ranges in the United States.