Mission Aerospace: An Ah-Maze-ing Adventure

A Guide for Teachers and Students

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Dear Teacher,

Thank you for welcoming the topic of aviation and aerospace engineering into your classroom! These lessons and activities are meant to pique your students' curiosity, summon their enthusiasm, and bring them to aerospace engineer status.

You will find some lessons best suited for use before your visit to Mission Aerospace, some for after your visit, and many could be used either pre or post visit. The intention of this guide is to give you a way to expand and extend the learning from the Mission Aerospace exhibit with your students in a variety of exciting ways, from art and writing, to hands-on science labs and engineering challenges.

Needs vary from student to student and class to class and we encourage you to make adjustments to these lessons and activities to fit your needs and show your creative flair. We would love to hear what worked for you and your kids! Send your questions or feedback to: education@minotaurmazes.com.

Again, we appreciate your joining us in promoting the exploration of the skies. You and your students are in for an out-of-this-world experience!

Enjoy!
Leah Ritz

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Content Guide

Below is a list of recommended content areas and grade levels for each lesson and activity. Lessons can be adapted as needed.

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Lesson 1: It’s Rocket Science	X	X								*	*	*	*	*	*	*	*	*	
Lesson 2: Balloon Rockets		X								*	*	*	*	*	*	*	*	*	
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	Engineering Design	Physical Science	Life Science	Earth Science	Nature of Science	Mathematics	Language Arts	Social Studies	Visual Arts	K	1st	2nd	3rd	4th	5th	6th	7th	8th	H.S.
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Lesson 1: It's Rocket Science

Grade: K-8th grade

Duration: 45-60 minutes

Standards:

- *NGSS Physical Science* – Relationships between forces and energy; Types of interactions between objects with different forces and energy
- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare a design with others to determine the best solution.

Objective:

- Students will become familiar with the parts of a rocket, the forces acting upon rockets during flight, and use the engineering design process to create a functioning paper rocket.

Key Vocabulary:

- nose cone, payload, body tube, fins, propulsion system, engineering design

Materials:

- paper, pencils, notecards, tape, scissors, glue sticks, straws, cardstock, stomp rocket launcher or 2-liter bottle and hose launching system

Additional Resources:

- NASA Advanced High-Power Paper Rocket activity guide

Procedure:

1. Engage students to find out what they already know about rockets. Ask them to describe how a rocket is different from an airplane.
2. Ask students to identify some of the uses for rockets. Explain that rockets are used for scientific inquiry in outer space, but also on Earth. Rockets are frequently used to launch satellites that collect information about Earth and the rest of our solar system. The earliest satellites played key roles in the Cold War, allowing the Soviet Union and the United States to spy on each other. Most satellites today focus on the world around us and reveal information on things like upcoming weather, natural disasters, roadways, and changes in our environment.
3. Ask younger students to draw along on paper while the teacher draws a rocket on the whiteboard or uses an overhead image of a rocket to identify parts. Older students may do this independently and then check their work upon completion. Discuss how each feature of a rocket helps it fly:

   a. **Nose Cone** – The term nose cone refers to the forward-most section of a rocket, guided missile, or aircraft. The cone is shaped to offer minimum aerodynamic resistance.
   b. **Payload Section** – Payload is the term for what the rocket is meant to carry, and there is a section of the rocket designed specifically to carry the payload.
   c. **Body tube** – Refers to the frame of the rocket.
   d. **Fins –** Appendages on rockets that are useful for stabilizing during flight.
   e. **Propulsion system** – This provides power and direction to the rocket.
4. Divide students into partners and/or allow them to work individually. Introduce the rocket design challenge and their objective to design an aerodynamic rocket that will travel as far as possible. Review the engineering design process and explain that there will be four parts to the rocket construction – planning, building, testing and analysis.
5. Planning Phase: Overview the available materials with students and give them 5-10 minutes to plan and draw out their rockets on paper. Older students should list the materials they would like to use and why. Optional: include a budget and assign values to building materials. Older students must stick within their budget and try to also build an economical and efficient rocket.
6. Building Phase: Give 15 minutes for rocket construction. Use paper to make the body tube. Make sure the body tube can fit over the launcher and is not obstructed by the fins.
7. Testing Phase: Allow 10-15 minutes for students to test and redesign their rockets. Use a stomp rocket launcher or a two-liter bottle and hose to test.
8. Analysis Phase: Ask students what materials they used, what designs worked well or didn't work at all, and how they might change their design to improve results? As a class, identify some of the qualities that make up the best rockets and why.
9. Real world connection: Discuss why it is important for rocket engineers to make very precise measurements when designing, building and flying rockets.

Lesson 2: Balloon Rockets

Grade: K-8th

Duration: 30-45 minutes

Standards:

- *NGSS Physical Science* – Relationships between forces and energy; Types of interactions between objects with different forces and energy

Objective:

- Students will explore forces of propulsion by creating a balloon powered rocket and testing the effects of air pressure on distance traveled.

Key Vocabulary:

- thrust, propulsion, drag, resistance, air pressure

Materials:

- string or yarn, tape, plastic baggies (quart, gallon, and sandwich sized), scissors, straws, tape, 9”-12” round balloons, variety of balloons in all shapes and sizes, tape measure or yard stick, graph paper (optional)

Additional Resources:

- NASA Beginner’s Guide to Rockets: Rocket Propulsion activity

Advance Preparation:

- Thread half of a straw onto several pieces of string. String should be approximately 20 feet in length but can vary depending on the size of the classroom space. Make sure the straw can move freely along the string.

Procedure:

1. Show students a video of a rocket launch and ask them to observe how the rocket gets off the ground. Explain that the rocket gets off the ground because of an incredible force called thrust that helps the rocket overcome the force of gravity and propels it off the ground. In the case of the rocket, the thrust is caused by the combustion of jet fuel. Rockets must carry enough fuel to help them blast off of Earth’s surface and sometimes out of our atmosphere.
2. Introduce the activity as one that will look at thrust and propulsion. Explain to students that because jet fuel isn’t safe to use in a classroom, this activity will use air pressure as the force that provides thrust to propel the rockets we’ll be making today.
3. Divide students into groups of three and give each group a string with the straw on it, a quart-

sized plastic baggie, tape, and a balloon for each child. In each group of three, assign two students to start out as string holders with one on either end. These two students should stand far enough apart from each other that the string is taut between them and approximately parallel to the ground. The third student will be the rocket launcher. Have students rotate positions so everyone gets a chance to launch the rocket.

4. Demonstrate to students how to make a rocket launching device by taping the side of the plastic bag to the straw on the string so the open end is facing in line with the string. Put the balloon in the bag and inflate it so it fits tightly in the bag with the tail sticking out in the opposite direction of travel. Let go of the end of the balloon so the air pushes out and forces the balloon to travel along the string, parallel to the ground. If students will be measuring, demonstrate how to measure the distance travelled by the balloon using a tape measure or yardstick. Advise students not to over inflate the balloon or it will not allow the rocket to fly adequately.
5. When it is time for the students to test, have students identify the direction of travel of the rocket and align the straw/bag apparatus so that it will fly down the string when it is inflated and released. This is the direction of thrust that is propelling the balloon rocket.
6. Give students several opportunities to test their rocket and use a tape measure or yard stick to determine the distance travelled. If desired, provide students with record keeping paper or keep track of distances as a class on a big chart paper. (Can omit measurement and record keeping with younger students).
7. Have students pause the rocket launching and predict how the amount of inflation will affect the distance traveled. Point out that the size of our balloon is restricted by the bag that it is in, which is similar to how a rocket's fuel is restricted by the size and shape of the rocket.
8. Hand out gallon and sandwich-sized plastic baggies. Let students test their rockets in baggies of different sizes to see how the amount of air held by the balloon will affect the distance it travels. Alternatively, you can provide students with different sizes and shapes of balloons (small round, big round, short and skinny, long and skinny balloons.) If desired and if time and student ability allow, these results can be graphed.
    a. Optional Extension (for older students): try adding weights to the baggies to see how weight affects distance traveled. Is there a relationship between the amount of added weight and the size the balloon needs to be inflated to get the balloon to travel as far as it did without the weights?
9. After students have conducted tests with different sizes of plastic baggies and/or weights, discuss observations and results. Ask students how the size of the blown balloon affects the thrust of the balloon and therefore the distance traveled by the balloon rocket.
10. Wrap up by tying this activity to the real world. Ask students how this activity helps us understand airplane and rocket design. Airplanes and rockets need a lot of fuel to travel very far, just like our balloon rocket that needed to be really inflated to travel a great distance. That means that airplane and rocket designers have to think about how their machine will be able to hold all the necessary fuel to transport cargo, passengers, etc. over long distances.

Lesson 3: Roto-Copter Lab

Grade: 3rd-8th

Duration: 30- 45 minutes

Standards:
- *NGSS Nature of Science* – Planning and carrying out an investigation in which variables are controlled and data is analyzed to identify design aspects for improvement.

Objective:
- Students will practice using a scientific procedure to determine how variables affect the fall speed of a paper helicopter.

Key Vocabulary:
- helicopter, experiment, variable, constant

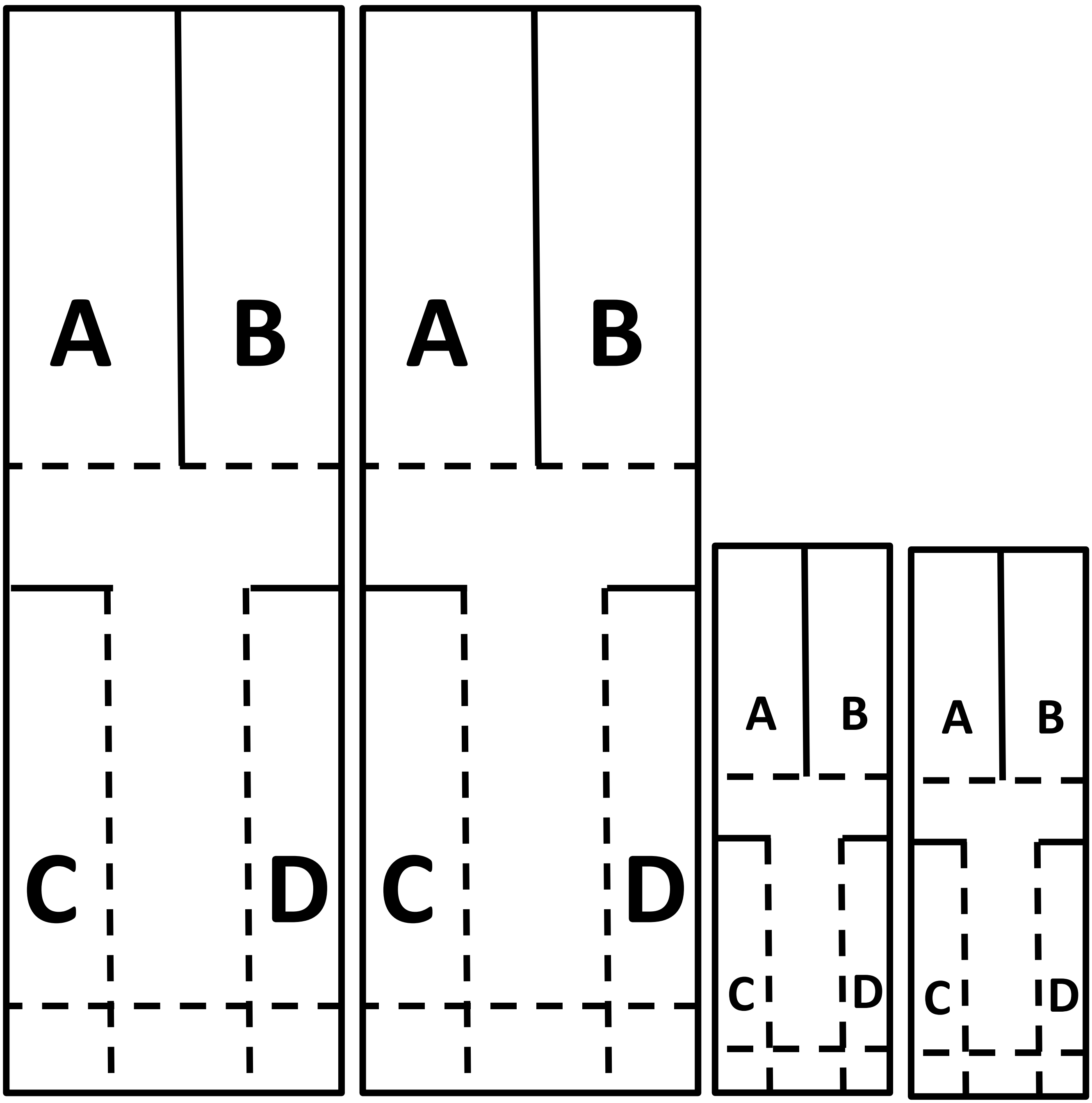
Materials:
- print-out of the attached Roto-Copter pattern (enough for three or more copters per student), pencil, scissors, paper clips, stopwatch, paper for recording results

Additional Resources:
- Exploratorium Roto-Copter activity

Procedure:
1. Introduce the activity by engaging what students already know about helicopters. This activity will explore helicopter flight from the point of view of a helicopter engineer whose goal is to increase the amount of time a helicopter stays in the air. If a helicopter malfunctions and is going to crash, more time spent in the air means a less forceful and potentially dangerous crash. We will use roto-copters to simulate helicopters and experiment to find out how to make them stay in the air longer as they fall.
2. Using a pre-built roto-copter, demonstrate how to launch the copter by holding it overhead and dropping it. Ask students to make observations about its motion as it falls.
3. Discuss why the roto-copter spins. When the roto-copter falls, air pushes up against the blades, bending them up just a little. When air pushes upward on the slanted blade, some of that thrust becomes a sideways, or horizontal, push. Because there are two blades getting the same push in opposite directions, the two opposing thrusts work together to cause it to spin. If you bend the blades in the opposite directions, the roto-copter will spin in the opposite direction as it falls.
4. Explain that in this experiment, we are going to make roto-copters out of paper to simulate helicopters and alter one variable of the copter to change how long it takes to reach the ground.

5. If ability allows, discuss experimental design with the students, including how to identify variables, set up a control, and make three additional treatment roto-copters with variations. Example: After conducting research you decide that longer wings will make the rotocopter fall slower. Plan and conduct an experiment with roto-copters that have wings of different lengths. Remember: Do not change anything except the wing length in each design. All other factors remain constant.
6. Students can work individually or with partners to observe and record the time it takes for each roto-copter to fall to the ground from a fixed distance.
7. Depending on age and ability, calculate the speed of each trial using a stopwatch and record the data for 3-5 trials of each copter. With older students, use this as an opportunity to discuss the importance of multiple trials.
8. Following experimentation, discuss results with students to determine which designs were most effective at slowing down the fall of the roto-copter.
9. Optional: At the end of the lab, have students create a poster or give a brief presentation to share their findings. The presentation should include the elements of the experiment: problem, hypothesis, procedure, data, analysis, conclusion, and the winning design.

Roto-Copter Pattern



Roto-Copter patterns can be found in the Exploratorium Roto-Copter activity guide
https://www.exploratorium.edu/science_explorer/roto_patterns.html

Lesson 4: Packing a Payload

Grade: 3rd-High School

Duration: 45 minutes

Standards:
- *Common Core Mathematics* – Measuring length; Representing and interpreting data graphically.
- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare a design with others to determine the optimal solution.
- *NGSS Nature of Science* – Scientific understanding is based on empirical knowledge gained from conducting experiments, gathering data and analyzing results.

Objective:
- Students will use a graph to represent and interpret paper airplane design as a function of its ability to travel a certain distance with a given payload.

Key Vocabulary:
- payload, cargo plane, balance, independent variable, dependent variable, scatter plot

Recommended Prior Knowledge:
- basic graphing knowledge including X- and Y- axis, origin, scale, plotting points, interpreting graphs

Materials:
- paper for airplanes (printer paper, cardstock or construction paper), paper airplane designs as a handout or as printed templates, pennies or penny sized zinc washers, paper clips, yardsticks or tape measure, graph drawn on chart paper or whiteboard, tape, markers

Additional Resources:
- Paper Airplane Depot website for paper airplane instructions and troubleshooting tips

Procedure:
1. Introduce students to the idea of cargo planes and the challenge of the day: to build a cargo paper airplane that can fly the farthest with a certain load.
2. Work with students to develop a class record-keeping system using chart paper or a whiteboard. Create an X, Y graph with number of weights as the dependent variable on the x-axis and distance as the independent variable on the y-axis. Review the process of creating a scatter plot by placing points at the correct (X, Y) location.
3. Review parts of a plane and where the cargo or payload is carried, typically within the body of

the plane.

4. Build paper airplanes. Provide students with a template printed on paper or have them build their own from provided instructions. *Glider* or *Dart* style paper airplanes may work best. Alternatively, allow students to create and test their own design.
5. Hypothesize with students how adding a payload to the plane will change how it flies. Explain that students will be using pennies or washers as weights in their airplanes.
6. Add payloads to the inside of the fold of the plane and on the tops of the wings, starting with 2-4 weights at first. Evenly disperse the pennies or washers along the inside of the fold and tops of the wings and tape them in place. This may be a good opportunity to talk about balancing weight, which is important in the real world, especially on small aircraft.
7. Line up students at the end of the tape measure and have them test their planes by throwing them along the tape measure. Have students make note of their airplanes distance and record the distance on the class chart paper next to the number of weights their airplane carried.
8. Add 2-4 more pennies to the inside of the airplane.
9. Have students predict how adding weight will affect the distance traveled.
10. Test again and have students record the new distance.
11. Repeat steps 6-10 a few more times.
12. Return to the graph paper and look at the figure created. To more clearly show trends, draw a line of best fit to turn the scatter plot into a line graph.
13. Discuss the results and any trends that appear as a result of increasing payload.
14. Real world connection: After discussing design solutions to help the plane carry more weight for a longer distance, explain that aerospace engineers must take payload into account when designing airplane bodies. Wing and body designs must be maximized for efficiency to promote lift and glide and prevent drag.
15. Optional Extension for older students: Students can research real-world airplane designs and make modifications to the wings and bodies of their paper airplanes based on research. Allow them to test the plane again and compare the distance traveled with the original distance for that weight.

Lesson 5: Going the Distance

Grade: 3rd-8th

Duration: 45 minutes

Standards:

- *Common Core Mathematics* – Measuring length and representing and interpreting data graphically.
- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare a solution with others to determine the best solution.
- *NGSS Nature of Science* – Scientific understanding is based on empirical knowledge gained from conducting experiments, gathering data and analyzing results.

Objective:

- Students will build and test different types of paper airplanes. They will use graphical data to interpret how airplane design affects the distance it travels.

Key Vocabulary:

- independent variable, dependent variable, line graph, scatter plot, mean, quantitative data, qualitative data

Recommended Prior Knowledge:

- basic graphing skills such as X- and Y- axis, origin, scale, plotting points, interpreting graphs, calculating mean

Materials:

- pictures of different types of airplanes (as printout or for projection), 8.5 x 11 inch paper, paper airplane instruction printouts or folding templates of different airplane designs, scissors, tape, chart paper or whiteboard with X, Y graph drawn, markers, tape measure or yard sticks

Additional Resources:

- Paper Airplane Depot website for paper airplane instructions and troubleshooting tips

Procedure:

1. Show students pictures of different types of airplanes such as fighter planes, passenger planes, bombers, cargo planes, small propeller engine planes, etc.
2. Ask students to make observations of each type of plane and make an argument based on observation for the airplane's purpose. (Example: A cargo plane is good for carrying lots of stuff because it has a very big body and the wings look stout and sturdy.)

3. Introduce the design challenge for the day and that the objective is to investigate different types of airplane designs and their functions.
4. Work with students to develop a record keeping system that utilizes an X, Y coordinate system to mark the flight distance (independent variable) of each type of plane (dependent variable). Record each type of plane as a different color marker in order to see trends in flight patterns. In addition to the X, Y graph, you may also keep a box beside the chart for students to fill in with observations of flight quality. Use this as an opportunity to discuss the difference between quantitative and qualitative data.
5. Divide students into groups and assign each group a different type of airplane to create. Students will follow instructions to each create a type of paper airplane. Examples of paper airplane patterns include Dart, Bullet, Delta Wing, Harrier, Glider, etc.
6. Students should take turns launching their airplanes from the end of the tape measure and recording the distance (quantitative data) and flight characteristics (qualitative data) such as whether or not the plane flew straight, spun, flipped over, took a nosedive, etc.
7. Students should conduct at least three trials and record the data. This is an opportunity to discuss the importance of conducting multiple scientific trials.
8. If time and ability allow, have students work with their group to calculate an average flight distance for their type of airplane. Use this as an opportunity to discuss variation within tests. For example, did the same person launch the plane the same way every time?
9. Wrap up by reviewing the class data chart. Discuss the trends in flight patterns and identify which type of design would be best suited for a certain purpose such as fighter planes, passenger planes, bombers, carrier planes, etc. and why.

Lesson 6: Unidentified Flying Objects

Age: 2nd-5th grade

Duration: 30-45 minutes

Standards:

- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare a solution with others to determine the optimal solution.
- *NGSS Physical Science* – Relationships between forces and energy; Types of interactions between objects with different forces and energy

Objective:

- Students will explore unconventional designs of flying objects and discuss how they are able to stay in the air.

Key Vocabulary:

- air pressure, high pressure, low pressure, lift

Materials:

- 3x5 notecards, 8.5x11 inch printer paper, scissors, pencils, tape, straight straws

Additional Resources:

- PBS Kids Hoop Glider activity
- Children's Museum of Houston Gyro Flyer activity

Procedure:

1. Engage students by asking what they already know about flight. Be sure to have them identify things that fly (birds, airplanes, rockets, etc.) and ask them to try and explain why they fly. Some students may already understand lift and drag.
2. Review the concept of lift by blowing over a thin strip of paper held up to the bottom of the lip. As the fast air moves over the top of the paper, it creates a low pressure zone. Higher pressure air from below the paper rushes up to fill the zone and lifts the paper with it, thus creating the floating paper effect. This is a demonstration of Bernoulli's principle.
3. Explain that we know birds and airplanes and many things with wings fly, so the challenge in this activity is to build a couple things that we wouldn't normally think of as flying contraptions.
4. Unidentified Flying Object #1: Hoop Glider (Reference PBS Kids Hoop Glider activity for instructions and diagrams.) – Hand out instructions or have the class follow along to build a hoop glider using a straight straw, 3x5" note card and tape. Cut the notecard into thirds so there are three strips that are 1 inch by 5 inches long. On one end of the straw, create a circle with

one strip and tape it into place. On the other end of the straw, tape two strips of paper together so the circle is twice the size and tape it into place. The circles should line up with each other so you could look down the straw through the hoops like a telescope.

5. Have students line up and do a mass launch of the gliders, tossing the small end of the glider first. Discuss observations about their flight. If time allows, adjust the hoops to see how spacing and angle affect the flight of the glider.
6. Unidentified Flying Object #2: Paper Gyro (Reference Children's Museum of Houston Gyro Flyer activity for instructions, pictures, and a video.) – Hand out instructions or have students follow along with the construction of a paper gyroscope. Give each student a piece of 8.5x11" printer paper. Fold the paper in half the long way, open it, then fold the top half down to the crease. Fold the top half over the crease so the paper is now about a third as wide as it was. Fold the top half in half down to the crease. Roll the paper around and tuck the folds into each other using a piece of tape to secure them.
7. Line the students up for a mass launch. Hold the paper gyro flyer like a football with the folded end pointing away from the body. Toss the flyers like a football with the outside edge rolling off the fingers upon release to create a spiral motion. Watch the gyro flyers and discuss observations about the flight.
8. Wrap up by comparing the two flying objects with each other. As a big group, decide which one flies the best and make guesses about why? Discuss: Why don't our airplanes look like either of those flying objects? Ask students to use what they know about flight and high and low pressure zones to explain how air travels around each object causing it to fly.

Lesson 7: Flight Designed by Nature

Grade: K-5th

Duration: 30-45 minutes

Standards:

- *NGSS Life Science* – Different plant and animal traits, or adaptations, that are passed down over time help organisms survive within their environment.
- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare a solution with others to determine the optimal solution.

Objective:

- Students will understand how animal adaptations have been used as inspiration for the engineering and design of airplanes and other human inventions.

Key Vocabulary:

- biomimicry, engineering, flight, adaptations

Materials:

- computer with Internet and projector, pictures and/or video of birds in flight, pictures of different types of airplanes (see attached), paper, pencils, scissors, books

Additional Resources:

- Cornell Lab of Ornithology Amazing Birds curriculum
- Cornell Lab of Ornithology Flight and Feathers video resource

Background information for teachers:

- **Biomimicry:** People have used nature for inspiration throughout history. By observing animals, plants and natural processes, we gain insight into what works and what does not. For engineers, these observations are helpful in the design process and for inspiring new inventions using natural technologies. The most well-known example of biomimicry is Velcro® that was designed to behave like the cockleburs that stick to animals (and people) when they brush by the plant.

Procedure:

1. Introduce the big idea for the day: Biomimicry – using characteristics of living things to create solutions to real life problems.
2. Ask students to identify what kinds of things fly and what they have in common. Animals that fly are birds and bats and they both have wings. Airplanes fly and they also have wings. Even some types of kites that fly have wings. Humans have used the bird body and wings for inspiration for

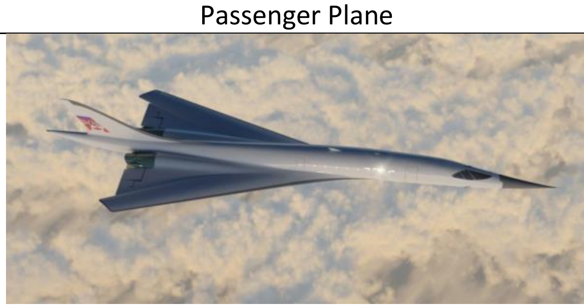
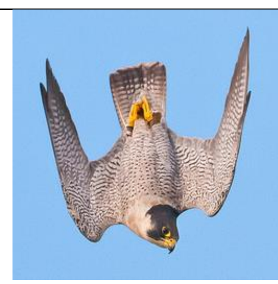
flight. Airplane wings and body shape are modeled after birds. Airplanes can even change the shapes of their wings using panels that move up and down like birds do with their wing and tail feathers when they fly.

3. Explain that over time, birds have developed wing shapes that behave in ways that help them survive in their unique environments. Show the students pictures of different bird wing types and speculate on what they are useful for (gliding, soaring, fast takeoff, etc.) and how that trait might be advantageous to the bird. Follow up on this discussion by watching a video of different birds flying provided by Cornell Lab of Ornithology on their Flight and Feathers webpage: http://www.birds.cornell.edu/physics/lessons/elementary/flight
4. To demonstrate why the longer wings are for gliding, have students stand with their arms straight out from their sides, shoulder height. Have them flap their arms as wings for 30 seconds and count the number of flaps. Next have them pick up a heavy book in each hand and flap again. This will show that the big, heavy wings of birds such as albatross and vultures make it difficult to keep flapping, therefore they instead use them to glide or soar using the air currents.
5. Use pictures to help compare bird wing types to airplane wing types (see attached resource). Discuss with students: How are fighter jet wings shaped differently from commercial jet plane wings? What are the advantages of each shape? Fighter jets need to take off quickly and be highly maneuverable, whereas commercial jets just need to glide through the air and carry lots of weight. Compare pictures of swallows versus albatross to compare bird and plane features.
6. Like birds use different types of feathers in their wings and tail to control their flight, airplanes have rudders in their wings and tails to help the plane move up and down and slow down when landing. To experiment with this idea, have students make a paper airplane and use scissors to cut and bend the wings into different shapes to adjust and test how the airplanes fly.
7. Wrap up by returning to the idea of biomimicry and discussing how humans have used birds and other flying animals as inspiration for our flying machines. What else could nature inspire?

Comparison of airplane wing type (left) to analogous bird wing type (right)

Glider Plane

Albatross

 Fighter Jet	 Swallow
 Cargo Plane	 Pelican
 Passenger Plane	 Eagle
 Supersonic Jet	 Falcon
 Small Engine Plane	 Sparrow

Lesson 8: Wright Brothers

Grade: 2nd-5th

Duration: 45-90 minutes

Standards:

- *Common Core Language Arts* – Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. Recount stories, determine the central message and explain how it is conveyed through key details in the text.
- *NCSS Social Studies* – Individuals, Groups, and Institutions. Learning influential figures in history.
- *NGSS Engineering Design* – Define a problem, develop and test a model or solution using appropriate materials. Compare solution with others to determine the optimal solution.

Objective:

- Students will learn about the pioneers of aviation, the Wright brothers, and apply the engineering design process to invent something new out of everyday items.

Key Vocabulary:

- inventor, invention, problem solving, engineering design process

Materials:

- children's story about the Wright brothers, construction paper, markers, tape, glue, scissors, recyclable materials and other consumables, paper, pencil

Additional Resources:

- *The Wright Brothers* by Elizabeth MacLeod (a Kids Can Read book) – for Grades 1-3
- *Who Were the Wright Brothers?* by James Buckley Jr. (a Who Was? book) – for Grades 3-6

Procedure:

1. Read an age appropriate story about the Wright Brothers first flight such as *The Wright Brothers* by Elizabeth MacLeod (a Kids Can Read book for Grades 1-3) or *Who Were the Wright Brothers?* by James Buckley Jr. (a Who Was? Book for Grades 3-6)
2. While reading the story, prompt students to notice things about Orville and Wilbur Wright including: What did they do as children? When and where did they live? What was it like where they lived? What were influential things in their lives? What types of careers did they take on as adults? What personality traits did they have? What kinds of problems did they solve? Did the Wright brothers ever give up when something failed? What was their inspiration for creating the first airplane? What ideas and everyday items did they combine to create the first airplane?
3. After discussing the story, explain to students that Orville and Wilbur Wright were inventors

who were able to think creatively to solve problems by using common items in unique ways. They pursued their ideas and tested them many times until they got something that worked. Even then, they kept working to improve.

4. Introduce the engineering design process to students where you identify and research a problem, then design, build and test solutions until coming up with the best solution to the problem. Discuss how Orville and Wilbur Wright used this process when they invented the airplane. Explain that the students are now going to invent something new out of something old using the same engineering design process. During the following activity, students may keep notes about the steps of the engineering design process as they follow it.
5. Challenge the students to become inventors. Allow students to work in groups or individually depending on ability. Give each student or group a blank piece of paper and pencil and challenge them to complete one of the following depending on interest and ability.
    a. Challenge 1 (for younger students): Show the students a variety of everyday objects. As a class discuss what each of the objects is and how it is typically used. Challenge students (individually or in small groups) to pick just one of the objects and think of what else it could be used for. For example, if one of the items is a trash can, it could also be used as a drum. The goal of this activity is to encourage students to think creatively.
    b. Challenge 2 (for older students): Have each student or group think of two different everyday objects in their lives, such as a car and a microwave or a toothbrush and a shovel. These objects can be anything from food to toys. Alternatively, the teacher can assign objects. Make sure students write the objects on their paper. The challenge is to combine aspects of these items into a new invention. For example, a group that has a blender and a radio may combine the parts to create a smart blender that can mix up a smoothie to match the type of music that is playing. The goal of the challenge is less to come up with a brand new item and more about practicing creativity.
    c. Challenge 3 (for older students): Ask students or groups to reverse engineer an everyday object and make new things out of it. If necessary, allow students to do research to investigate the components of an object to see its individual parts. For example, a group who is reverse engineering a vacuum may turn part of it into a hair brush using the brush wheel, a jump rope using the electrical cord, and a windshield ice scraper using the handle. The goal of this challenge is thinking about combining smaller parts to make something new.
6. Regardless of which challenge is picked, students should draw out ideas on paper and older students may write a brief description of the object or create a magazine advertisement for it.
7. If time is available, give students the opportunity to build their new invention out of recycled materials. At the end of class when the object is built, have students give brief presentations of their new inventions.

Lesson 9: Staying Afloat

Grade: 3rd-8th

Duration: 30 minutes

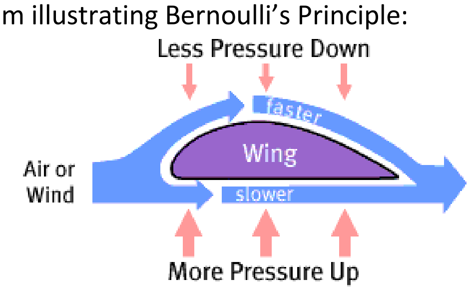
Standards:
- *NGSS Physical Science* – Relationships between forces and energy; Types of interactions between objects with different forces and energy

Objectives:
- Students will be able to identify forces that allow airplanes to fly by participating in demonstrations of Bernoulli's principle.

Key Vocabulary:
- air pressure, high pressure, low pressure, lift, airfoil

Materials:
- bendy straws, small funnels to fit inside the straw, ping pong balls, hair dryer, strips of paper (approximately 2in. x 8 in.), paper clips, tape

Procedure:
1. Engage students by asking them to ponder: How do things fly? After a few ideas are shared, explain to students that it wasn't until a Swiss mathematician and scientist, Daniel Bernoulli, made an important discovery about the movement of air that humans were able to make great advances in flight. Bernoulli discovered that if fluid (like air or water) in an area is moving faster than the surrounding area it lowers the pressure.
2. Demonstrate this principle by giving students each a thin strip of paper. Hold the paper on the chin under the bottom lip and blow quickly over the top of the paper. The once droopy paper should rise up.
3. As students explore this phenomenon, explain that the fast moving air over the top of the paper creates a low pressure zone. Under the paper is relatively higher pressure and the air forces up to fill in the low pressure zone. Use a diagram to help explain this effect.
    a. Diagram illustrating Bernoulli's Principle:



4. Demonstrate the same effect with ping pong ball levitation. Show students how you can hold up a ping pong ball using a blow dryer. Explain that this is not magic and that the students can achieve the same effect if they create enough pressure with their breath.
5. Have students lie on their backs with a straw in their mouth. Have them hold a ping pong ball over the straw and see if they can get it to float in the air by blowing air through the straw. This won't work! But have students attach a small funnel to the bendy end of the straw and try again. Secure the straw using tape, but be sure not to pinch the straw shut. Put the ball in the funnel and blow through the straw. This time the ball will float! As an added challenge, see if they can get the ball to float in the funnel when it's upside down.
6. Reiterate how this floatation occurs using a diagram. The fast air coming out of the straw makes the pressure underneath the ball lower than the pressure around it. Air tries to move from where there is a lot of pressure to where there is a little pressure and that movement causes force called lift. This is known as Bernoulli's Principle.
7. Explain that Bernoulli's Principle is important for many things, one of those being airplane wings. Airplane wings are airfoils, meaning their shape is curved at the top and flat at the bottom. This makes the air at the top of the wing travel further than the air at the bottom. For the air traveling at the top of the wing to reach the other side at the same time as the air at the bottom, it has to move faster. The airfoil design forces air to move faster over the top of the wing, creating a low pressure zone. Since the air at the bottom of the wing has higher pressure than the top, it creates lift, pushing the wings upwards. Differently shaped airfoils can create different amounts of lift and drag.
8. Let's try to find out just how much force lift can provide. Make sure each student still has their small strip of paper and give them several paper clips. With the strip of paper against their chins, just below their mouth, have student blow outward and watch as the paper rises. Now attach a paperclip to the end of the paper away from their chin and have them repeat the process. How many paper clips can they lift?
9. As a wrap up, reiterate the basics of Bernoulli's Principle and have students identify how lift plays a role in the flight of airplanes.

Lesson 10: Magnetic Compasses

Grade: 3rd-8th

Duration: 30-45 minutes

Standards:

- *NGSS Physical Science* – Magnetism is a force that can act on things from far a distance and can be used as a problem-solving tool when applied scientifically.
- *NGSS Engineering Design* – Define a simple problem and design a tool within given constraints.
- *NGSS Earth Science* – Earth has a magnetic field that can be mapped through space.

Objective:

- Students will explore the properties of magnets and use them to create a simple navigation tool, the compass.

Key Vocabulary:

- compass, navigate, navigation, magnet, magnetic field

Recommended Prior Knowledge:

- cardinal directions

Materials:

- small handheld compasses, cork, water, clear cups or jars, small ceramic disc magnets, paperclips, iron filings, strong bar magnet, white paper, brass fasteners

Additional Resources:

- See attached diagram for magnetic compass construction

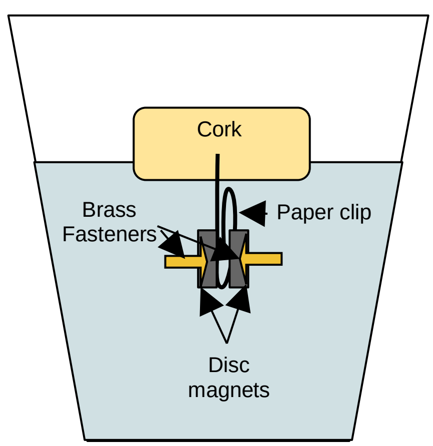
Procedure:

1. At the beginning of class, work with students to label the walls of the classroom north, south, east, and west. After deciding on the final orientation, ask students to think about how we know which way is north? Is north always the same anywhere you are on Earth?
2. Pass out compasses to partners or small groups of students so that each student is able to see and interact with a compass. If possible, allow each student to hold a compass.
3. Demonstrate how to properly hold a compass so that it is parallel to the ground, in front of the body. Have students hold the compass in their hands and spin slowly around in the circle while watching the needle. Ask students what observations they made of the needle in the middle of the compass. *Caution*: Holding compasses near each other will cause them to misread.
4. Explain that the needle in the middle of the compass has a north and south point and the side

that indicates north is always pointing north, no matter which way you are facing when you hold it. However, the needle needs to be able to spin freely in the container for it to work correctly.

5. Ask students if they can think of anything else that has a north and south pole? Explain that a magnet does!
6. Pass out small ceramic disc magnets and ask students to put the magnet near their compass. Ask students to observe as the compass needle spins to meet the magnet.
7. Demonstrate magnetic fields by pouring iron filings on a piece of white paper and putting a strong bar magnet underneath. Have students observe what happens to the iron filings when this is done. Can students see little hairy lines of iron filings form? Explain that this is the magnetic field that surrounds each magnet. Since Earth is a big magnet, it has invisible magnetic field lines surrounding it out into space. The compass picks up on the magnetic field lines and the needle always spins to point north and south along those field lines.
8. Explain to students that compasses are a very old technology and early navigators including sailors and aviators relied on low-tech compasses to help them get where they wanted to go.
9. Introduce the activity to make a simple compass using just a magnet, some metal, and a cup of water to float our compass.
10. Help students construct homemade compasses. (See the attached diagram for one way to make a simple magnetic compass.) Unfold the first bend of a paperclip and poke the end into a cork. Stick two small ceramic disc magnets together with the folded part of the paperclip between them, just below the cork. Use brass fasteners to make the compass needle, attaching them to the sides of the disc magnets so that they are pointing in opposite directions. Fill a tall clear cup or jar with water and set the apparatus inside. The compass should be able to float without touching the sides or bottom of the container so it can orient correctly with one brass fastener facing north the other south.
11. After the compass is built, have students identify which side points north and which points south. Students can bend the brass fastener that points south to help identify it.
12. If time allows, challenge the students to follow instructions using their compasses. For example: Walk 5 paces North, 3 paces West, 2 paces South, and 1 pace East, etc.
13. End with discussion about why compasses are important for travelers.

Magnetic compass construction diagram:



Lesson 11: Navigating by Map

Grade: 4th-8th

Duration: 30-45 minutes

Standards:

- *NCSS Social Studies* – Physical geography literacy and map reading skills; Science, Technology & Society. Modern life as we know it would be impossible without technology and the science that supports it.

Objective:

- Students will practice using latitude and longitude to locate points of interest on a map. Students will discuss the importance of using accurate locations in navigation.

Key Vocabulary:

- latitude, longitude, equator, prime meridian

Recommended Prior Knowledge:

- basic geography including knowledge of major landforms and features, map reading skills such as identifying lines of latitude and longitude, cardinal directions, legend, scale, etc.

Materials:

- Computer with projector and access to Google Earth or Google Maps, large map, variety of map projections printed out, a globe, world maps (see attached for example) printed that show lines of latitude and longitude as well as major geographical features like oceans, major rivers, continents, and major mountain ranges labeled (enough for two copies per student), pencils or markers

Procedure:

1. As a class, use Google Earth to navigate to significant geographic features around your city, state, and world. Challenge students to identify each object and where it is located.
2. After identifying several points of interest, ask students to think about how they would very accurately tell another person where something is located. Is there a way to be precise that is universally recognized?
3. Explain to students that one way we can tell precise locations is with the latitude and longitude coordinate system. This standardized system was the precursor to many modern navigational systems like GPS.
4. Show students a map and identify the lines of latitude and longitude, including the equator and prime meridian. Demonstrate how finding points on maps is like plotting points X, Y coordinates.

5. Divide students into partners and hand out a world map to each student (see attached for example map). Have students each mark 4 continents or geographic features like oceans, rivers, or mountain ranges making note of the longitude and latitude of each location. These are like the "ships" in the game Battleship.
    a. Teacher's Note: To facilitate the game and highlight areas of interest, teachers may choose 10-12 features for students to choose from when they identify their 4 items.
    b. Alternatively, this game may be played with maps of specific continents or parts of the world if students are focusing on a particular area of the world.
6. Partners will take turns guessing to identify each other's locations. One partner will state a latitude and longitude coordinate as a guess for a location. The second partner will respond with "Hit" or "Miss" depending on if the location of the geographic feature was guessed. Play until one partner finds all of the other's geographic features. Players can use different color markers or shaped marks to track guesses versus their own objects.
7. After playing world map battleship, discuss with students why knowing latitude and longitude is important for navigation. Explain that travelers must know precise locations or they might end up landing a boat or an airplane somewhere where they can't safely touch down.
8. To extend on the idea of latitude and longitude lines, explain how maps are all different and can distort what things look like in real life. Demonstrate by holding up a map and trying to fold it into a globe, or holding up an accurate globe map projection and laying it flat. What happens to the lines of latitude and longitude and sizes and shapes of countries? Discuss what challenges affect navigators trying to travel around a round planet using a flat piece of paper.
9. As an optional activity, ask students to determine the line of best travel from one point to another on a globe. They are trying to find the shortest possible distance. Give students a string to help measure. Notice that the shortest distance is not a straight line, but actually an arc that bends North in the northern hemisphere and south in the southern hemisphere. This path is called the Great Circle and has been used by people navigating across the globe for centuries.

World Battleship Map

https://www.lonelyplanet.com/blog/2015/11/20/mapping-the-world-with-lonely-planet-kids/

Lesson 12: SONAR and RADAR

Grade: 2nd-5th

Duration: 30-45 minutes

Standards:

- *NGSS Life Science* – Different plant and animal traits, or adaptations, help organisms survive within their environment.
- *NGSS Physical Science* – Create a model of waves to understand how they make objects move and can be used to transfer information.

Objective:

- Students will be able to explain how the animal adaptation, echolocation, has inspired advances in SONAR and RADAR technology used by aviators.

Materials:

- blindfolds, shallow trays like cookie sheets, water, small rocks or toys, computer with Internet and projector

Key Vocabulary:

- echo, echolocation, vibration, sound wave, RADAR, SONAR, navigate

Additional Resources:

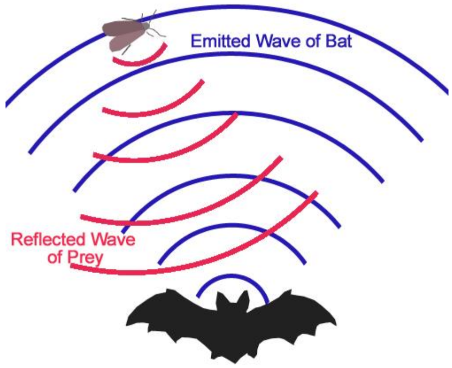
- Science News for Kids article - Explainer: What are lidar, radar, and sonar?

Procedure:

1. Play Bat-Moth echolocation game
   a. Pick 2 student volunteers and have the others form a large circle, big enough for two students to move around in.
   b. Blindfold the 2 student volunteers. One will be the Bat and the other the Moth; the students making the circle will be Trees.
   c. The Bat and Moth will be in the circle (make sure they don't go out) and whenever the Bat says "Bat" the Moth will respond "Moth" (like the game Marco Polo). The bat can say "Bat" however many times they want to and the moth must respond; if they bump into the trees the students can say "Tree"
   d. Play until the Bat catches the Moth and repeat with new students as the Bat and Moth
2. After playing the game, discuss how this game represented the animal adaptation, echolocation.
   a. Ask students what "Echo" means and what it means "to locate" something.
   b. Echolocation is a system used by bats, dolphins, whales and a few other animals that

uses sound echoes to help the animals locate things like family, prey, and obstacles.

c. Sound is made by vibrating molecules and when you start a vibration it moves out in all directions, like the ripples in a pond.
d. These sound waves will move away from the animal, and if something is ahead of it, the sound strikes it and bounces back like in the game when the bat said "bat" the moth had to respond "moth."
e. Draw a bat using sonar on the board showing sound waves going out and returning.



3. Military scientists and engineers invented a system like echolocation that aviators, sailors, and other travelers use to help locate objects. These systems are called SONAR, which uses high pitched sound waves like bats, and RADAR, which uses electromagnetic radiation waves that can't be seen or heard.
4. Watch an animation on YouTube of a RADAR or SONAR screen. Point out the waves as they travel and objects as they appear when the wave passes over them.
    a. Example YouTube Animation: https://www.youtube.com/watch?v=w_q2dqUdi8U
5. We can observe how these technologies work in a tray of water. Divide students in small groups and give each group a plastic tray. Fill the tray part way full with water. Set a few rocks or small, heavy toys in the water so the tops are showing above the surface of the water. Let students take turns making small waves, or vibrations with their fingers. If students make one small ripple at a time, they should see the ripple travel toward the rock and stop. Smaller waves (in this case maybe too small to be seen) are returned back by the object and could be detected by sensors, much like how a ship uses SONAR underwater.
6. Wrap up by discussing the value of SONAR and RADAR for navigators and the importance of being able to "see" obstacles before coming upon them. Could this technology be used in places where you can't see very well like at night, in the clouds, or underwater? Where else could this technology be used, like in medicine to see unborn babies or detect cancerous tumors?

Lesson 13: Fidget Spinner Gyroscope

Grade: 6th-8th

Duration: 20-30 minutes

Standards:
- *NGSS Physical Science* – Relationships between forces and energy; Types of interactions between objects with different forces and energy

Objective:
- Students will explore forces that stabilize gyroscopes and how gyroscopes are used in navigation.

Key Vocabulary:
- force, gyroscope, stabilize, momentum

Materials:
- sharpened pencils, fidget spinners, flathead screwdriver, masking tape (optional)

Additional Resources:
- Navigating Gyrations activity from The Space Place, spaceplace.nasa.gov

Advance Preparation:
- Use a flathead screwdriver to pop the covers off the central ball bearing in each fidget spinner that will be used. Make sure sharpened pencils can fit through the center of each spinner.

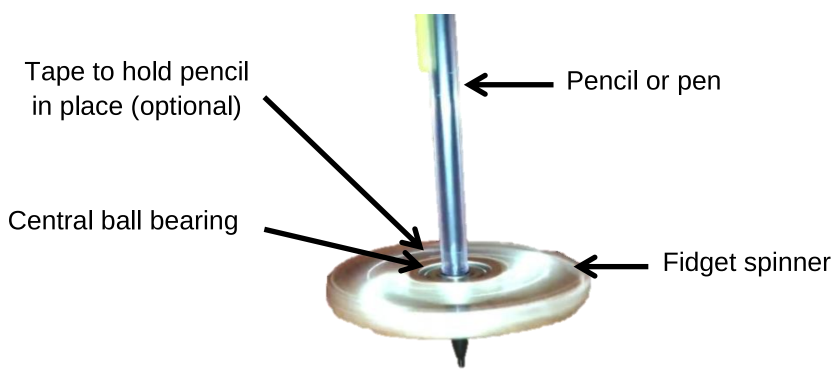
Procedure:
1. Pass out sharpened pencils to each student. Ask students to stand up by their chairs or stay seated and carefully try to balance the pencil by its point on the tips of their fingers. Let students try several times and make observations.
2. Review the results with the students. It is highly unlikely that the students were able to balance the pencil for very long on their fingertips. As a class, watch Minute Physics on YouTube for a 3 minute overview on the forces acting on the pencil and an explanation of why it is impossible to balance a pencil on its tip for more than a couple of seconds:
    a. Minute Physics: https://www.youtube.com/watch?v=U3vAoJhIWms&feature=youtu.be
3. Recap the video by explaining to students that without a stabilizing force, the pencil or any other top heavy object will quickly become unbalanced. Gravity will pull on the unbalanced weight of the pencil and quickly cause it to fall over. Balancing the pencil or other objects requires active stabilization. Even the slightest bump at the atomic level can cause some objects to become unbalanced.
4. If there are enough fidget spinners, pass them out to students. Otherwise, use one fidget

spinner for a class demonstration. Place the pencil in the central ball bearing of the fidget spinner so that the spinner is stuck on the pencil just above the sharpened point of the pencil. If the pencil does not stay in the ball bearing, you may wrap masking tape around the pencil to make it fit snugly in the bearing hole.

   a. See attached diagram or video instructions for how to make a pencil-fidget spinner gyroscope: https://www.youtube.com/watch?v=9NBTY81MTIU

5. Challenge the students to use the fidget spinner to help stabilize the pencil for more than a few seconds. Demonstrate how to use one hand to hold the pencil upright with the tip on the table while using the other hand to spin the fidget spinner as fast as possible. Let go of the pencil and it should stand up for a few seconds like a spinning top. Have students make observations of the apparatus. Notice how the fidget spinner and pencil spin at different rates. This is different than a spinning top where the whole top, including the axle, spin in a circle. Additionally, the pencil will start out straight and then being to wobble in a circle, especially as the spinner starts to slow down and the stabilizing force of the spinner weakens.
6. Instruct students to keep hold of the pencil with one hand, spin the fidget spinner, and carefully move the pencil in a figure eight pattern with the wrist. Ask students to pay careful attention to any changes in force that occur as the spinner changes orientation. Do they notice any resistance to their motion as they make the figure eight? Explain that changing the orientation of the spinner will change the direction of force that results from the angular momentum. Changes in this force may be felt as resistance to motion while the spinner is moving.
7. Explain to students that the moving fidget spinner acts like a gyroscope. The spinning mass of the fidget spinner provides a stabilizing force that keeps the pencil balanced and from falling over as a result of gravity. We can feel that force as the resistance when moving the pencil-fidget spinner gyroscope around as it is spinning.
8. Real world connection: Gyroscopes can be used to provide stability, as in the standing pencil demonstration, or they can be used to maintain a reference direction. The latter is useful in navigation systems like those found on airplanes and rockets. Modern gyroscopes can detect small changes in direction when slight movements cause the mass of the gyroscope to wobble out of its normal orientation. Navigation systems redirect course based on these changes.

Diagram for assembling fidget spinner-pencil gyroscope:



Lesson 14: Nose Art Airplane Graffiti

Grade: 6th-High School

Duration: two or three 45 minute sessions

Standards:
- *NCSS Social Studies* – Individual Development and Identity. Personal identity is shaped by one's culture, by groups, and by institutional influences.
- *NCAS Visual Arts* – Shape an artistic investigation of an aspect of present day life using a contemporary practice of art or design.

Objective:
- Students will explore personal and group identity within the military by studying and mimicking the graffiti used to decorate and identify aircraft.

Key Vocabulary:
- fuselage, folk art, graffiti, personal identity

Materials:
- printed photos or a prepared presentation of select nose art designs*, art paper, assorted art media such as colored pencils, pastels, oil pastels, paint, markers, etc.

Note: Because some airplane nose art may not be appropriate for younger audiences, we recommend selecting the pictures ahead of time rather than having students research independently.

Additional Resources:
- [Wikipedia: Nose Art] for bibliography resources, background information and examples

Procedure:
1. Provide students with background information and context for nose art with a slideshow presentation. Wikimedia Commons has many public domain images of airplane nose art*.
   a. **Teacher's Note:** Because some airplane nose art may not be appropriate for younger audiences, we recommend selecting the pictures ahead of time rather than having students research independently.
2. While presenting on nose art, key points to make about the history and significance include:
   a. Nose art is a decorative painting or design on the fuselage, usually the front, of an aircraft, and is largely a military tradition. Because of its individual and unofficial nature, as well as its ties to labor and a specific group, it is considered folk art.
   b. World War I nose art was usually an embellished or extravagant squadron insignia, while

true nose art appeared during World War II, which is considered the heyday of the genre. At the height of the war, nose-artists, typically members of the ground crew, were in very high demand in the U.S. Air Force and were paid quite well for their services. While nose art was not officially approved, regulations against it were not enforced and air force commanders tolerated it in an effort to boost aircrew morale.

c. Nose art began for practical reasons of identifying friendly units during World War I, but the practice evolved to express individuality often constrained by the uniformity of the military, to evoke memories of home and peacetime life, and as a kind of psychological protection against the stresses of war and the probability of death.
d. The first recorded piece of nose art was a sea monster on an Italian flying boat in 1913. This was followed by the practice of painting a mouth beneath propellers, begun by German pilots in World War I. The prancing horse of Italian pilot Francesco Baracca was another well-known image that became the emblem of the car company Ferrari.
e. American nose art themes varied, ranging from actresses such as Rita Hayworth and Betty Grable and cartoon characters such as Donald Duck, Bugs Bunny, and Popeye to patriotic characters (Yankee Doodle) and fictional heroes (Sam Spade). Lucky symbols such as dice and playing cards also inspired nose art while other works included animals, nicknames, hometowns, and popular song and movie titles.

3. After reviewing and discussing the designs of several nose art pieces, ask students to speculate on the artistic and social significance of nose art. How is nose art a representation of individuality? Why would the air force commanders allow planes to be painted?
4. How would you paint an airplane? Assign students or allow them to pick a type of airplane and maybe even a historical military campaign. Students should create their own airplane nose art using graffiti-style design characteristics. Finished products should include an artist's statement, or paragraph, describing their inspiration and the significance of their work.

"Sharkmouth" Bf 110C of ZG 76, May 1940
(Licensed Creative Commons)

B-24 nose art at the National Museum of the Mighty Eighth Air Force (Licensed Creative Commons)

Lesson 15: High Altitude Poetry

Grade: 6th-High School

Duration: 30-45 minutes

Standards:

- *Common Core Language Arts* – Determine the meaning of words and phrases as they are used in text; analyze the impact of specific word choices on meaning and tone. Write narratives to develop real or imagined experiences or events using effective technique and well-chosen details.

Objective:

- Students will explore the effects of aviation on military pilots through creative expression.

Key Vocabulary:

- altitude, hypoxia, sonnet, allusion

Recommended Prior Knowledge:

- stanza, syllable, rhyming

Materials:

- "High Flight" by John Magee, background information on John Magee and airplane dogfights during WWI and WWII, sonnet writing template (see attached)

Additional Resources:

- Wikipedia for general background information and bibliography on the life of John Magee

Procedure:

1. Provide students with a short reading and photographs to give context to the life of John Gillespie Magee Jr.
2. As a class, read the poem *High Flight* written Magee in 1941. This has become one of the most famous poems about aviation.

Oh! I have slipped the surly bonds of earth
And danced the skies on laughter-silvered wings;
Sunward I've climbed, and joined the tumbling mirth
Of sun-split clouds – and done a hundred things
You have not dreamed of – wheeled and soared and swung
High in the sunlit silence. Hov'ring there,

I've chased the shouting wind along, and flung
My eager craft through footless halls of air.
Up, up the long, delirious, burning blue
I've topped the wind-swept heights with easy grace
Where never lark, or even eagle flew -
And, while with silent lifting mind I've trod
The high untrespassed sanctity of space,
Put out my hand and touched the face of God.

3. After reading the poem, instruct students to think-pair-share in response to this question: What do you think this poem is referring to?
4. Explain that in 2007, the BBC speculated that "High Flight's" inspiration was due in part to hypoxia (oxygen deprivation) experienced by the author in his Spitfire airplane. Apparently, Magee had written in his logbook about experiencing the symptoms of hypoxia while flying at an altitude over 10,000 feet. Share with students a list of symptoms commonly associated with hypoxia including confusion, shortness of breath, rapid breathing, changes in skin color, fast heart rate, coughing/wheezing, and sweating.
5. Divide students into partners or have them work individually to revisit the poem and highlight language within the poem that alludes to flying at high altitudes or oxygen deprivation.
6. Explain to students that before going to war, Magee was studying English and poetry in college. This poem is written as an English sonnet, which is composed of three quatrains and a final couplet. It follows the rhyme pattern a-b-a-b-c-d-c-d-e-f-e-f-g-g with each line containing 10 syllables. As a class, break down the poem structurally to identify the pattern of rhyming.
7. Students should practice writing a sonnet about a hobby, experience or other important thing in their lives. Give students a sonnet writing template if necessary to help them follow the correct rhyme scheme.

Writing Sonnets

Name: ________________________

English sonnets are a form of poetry that was created during the Renaissance. English sonnets consist of 14 lines: three, four line stanzas, accompanied by a two line closing stanza. The rhyming scheme for the English sonnet is:

abab
cdcd
efef
gg

This means that the first and third lines of each four line stanza rhyme and the second and fourth lines of each four line stanza rhyme. The two lines of the closing stanza should rhyme as well.

Each line of the stanza should have no more and no less than ten syllables.

Try writing your own sonnet:

Rhyme a: ____
Rhyme b: ____
Rhyme a: ____
Rhyme b: ____

Rhyme c: ____
Rhyme d: ____
Rhyme c: ____
Rhyme d: ____

Rhyme e: ____
Rhyme f: ____
Rhyme e: ____
Rhyme f: ____

Rhyme g: ____
Rhyme g: ____

Lesson 16: The Great Space Race

Grade: 6th-High School

Duration: 45 minutes

Standards:
- *NCSS Social Studies* – Power and Governance. Understanding the historical development of structures of power, authority, and governance and their evolving functions in contemporary U.S. society.
- *Common Core Language Arts* – Write narratives to develop real or imagined experiences or events using effective technique and well-chosen details.

Objective:
- Students will become familiar with the events leading up to the first moon landing through research on key players and events during the Space Race.

Key Vocabulary:
- Cold War, Space Race, satellite, Sputnik

Recommended Prior Knowledge:
- Some knowledge on international relations following World War II during the Cold War is recommended but not required

Materials:
- written or video timeline of key events during the space race, note paper, pencils

Additional Resources:
- Space.com Timeline: 50 years of spaceflight
- PBS NOVA Space Race Timeline

Procedure:
1. Engage students by asking them to raise their hands if they've ever used a cell phone? Had to find a route on Google maps? Checked the weather? Had instant milk or dairy creamer? Used a cordless appliance? Not gotten sick after drinking milk or fruit juice? If you answered yes to any of these, you have directly benefited from the United States' participation in the space race and the rush to send satellites and people into space.
2. Introduce the era of the Space Race and Cold War between the Soviet Union and the United States from post-WWII until the 1980s.
3. Read or watch a video timeline of the key points of the Space Race between 1945-1970

   a. Space.com Timeline: 50 years of spaceflight https://www.space.com/4422-timeline-50-years-spaceflight.html
   b. PBS NOVA Space Race Timeline: http://www.pbs.org/wgbh/nova/astrospies/time-nf.html
4. While reading or watching the timeline, students should keep track of key events, players, and their impacts during the space race, paying particular attention between 1957-1969.
5. After watching or reading the Space Race timeline, have students select a key event for further research. Assign students to create a front page newspaper article and illustration about the event. Key points in the article should include 1) event details including who, what, when, where, why and how, and 2) the significance and impact of the event on the people and countries involved.

Activity 1: Fun with Flight Word Search

Name:___________________________________ Date: ______________

Find and circle the words in the word search below:

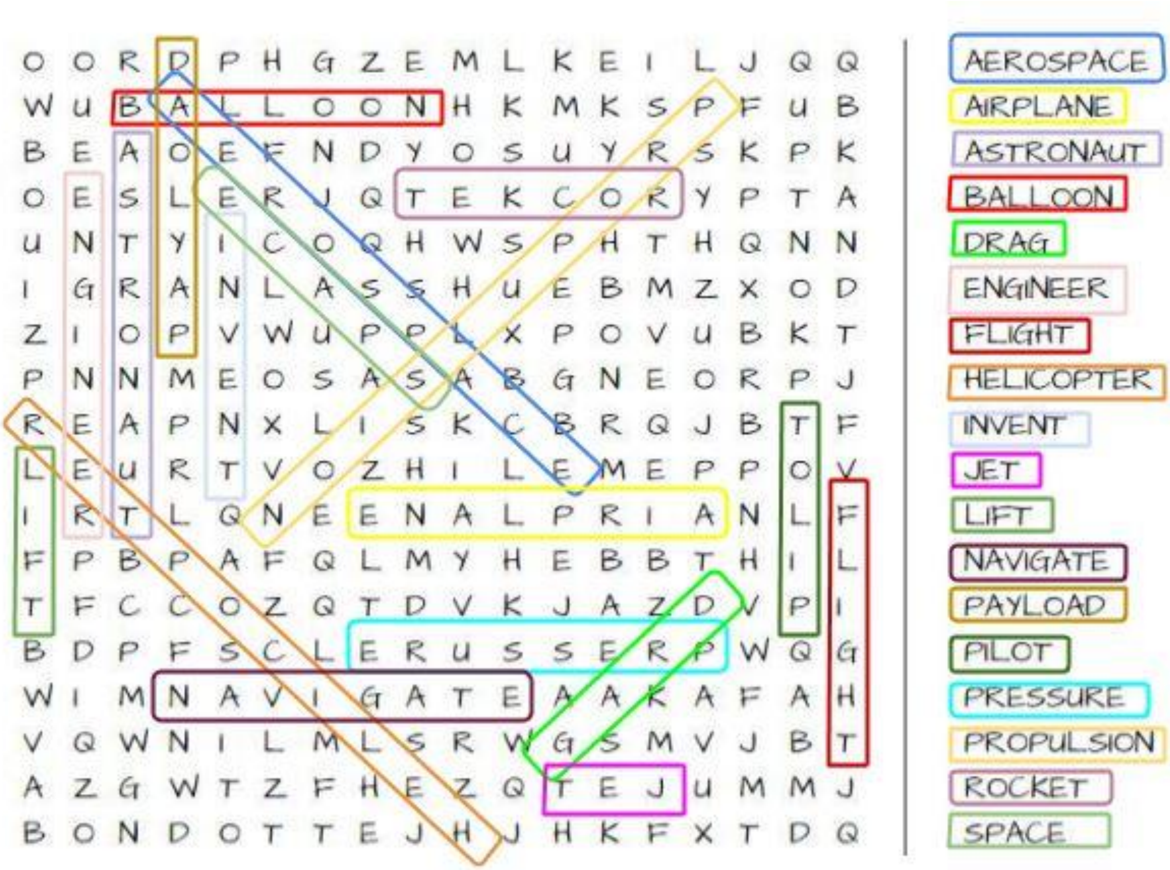
O	O	R	D	P	H	G	Z	E	M	L	K	E	I	L	J	Q	Q
W	U	B	A	L	L	O	O	N	H	K	M	K	S	P	F	U	B
B	E	A	O	E	F	N	D	Y	O	S	U	Y	R	S	K	P	K
O	E	S	L	E	R	J	Q	T	E	K	C	O	R	Y	P	T	A
U	N	T	Y	I	C	O	Q	H	W	S	P	H	T	H	Q	N	N
I	G	R	A	N	L	A	S	S	H	U	E	B	M	Z	X	O	D
Z	I	O	P	V	W	U	P	P	L	X	P	O	V	U	B	K	T
P	N	N	M	E	O	S	A	S	A	B	G	N	E	O	R	P	J
R	E	A	P	N	X	L	I	S	K	C	B	R	Q	J	B	T	F
L	E	U	R	T	V	O	Z	H	I	L	E	M	E	P	P	O	V
I	R	T	L	Q	N	E	E	N	A	L	P	R	I	A	N	L	F
F	P	B	P	A	F	Q	L	M	Y	H	E	B	B	T	H	I	L
T	F	C	C	O	Z	Q	T	D	V	K	J	A	Z	D	V	P	I
B	D	P	F	S	C	L	E	R	U	S	S	E	R	P	W	Q	G
W	I	M	N	A	V	I	G	A	T	E	A	A	K	A	F	A	H
V	Q	W	N	I	L	M	L	S	R	W	G	S	M	V	J	B	T
A	Z	G	W	T	Z	F	H	E	Z	Q	T	E	J	U	M	M	J
B	O	N	D	O	T	T	E	J	H	J	H	K	F	X	T	D	Q

AEROSPACE
AIRPLANE
ASTRONAUT
BALLOON
DRAG
ENGINEER
FLIGHT
HELICOPTER
INVENT
JET
LIFT
NAVIGATE
PAYLOAD
PILOT
PRESSURE
PROPULSION
ROCKET
SPACE

Created by:

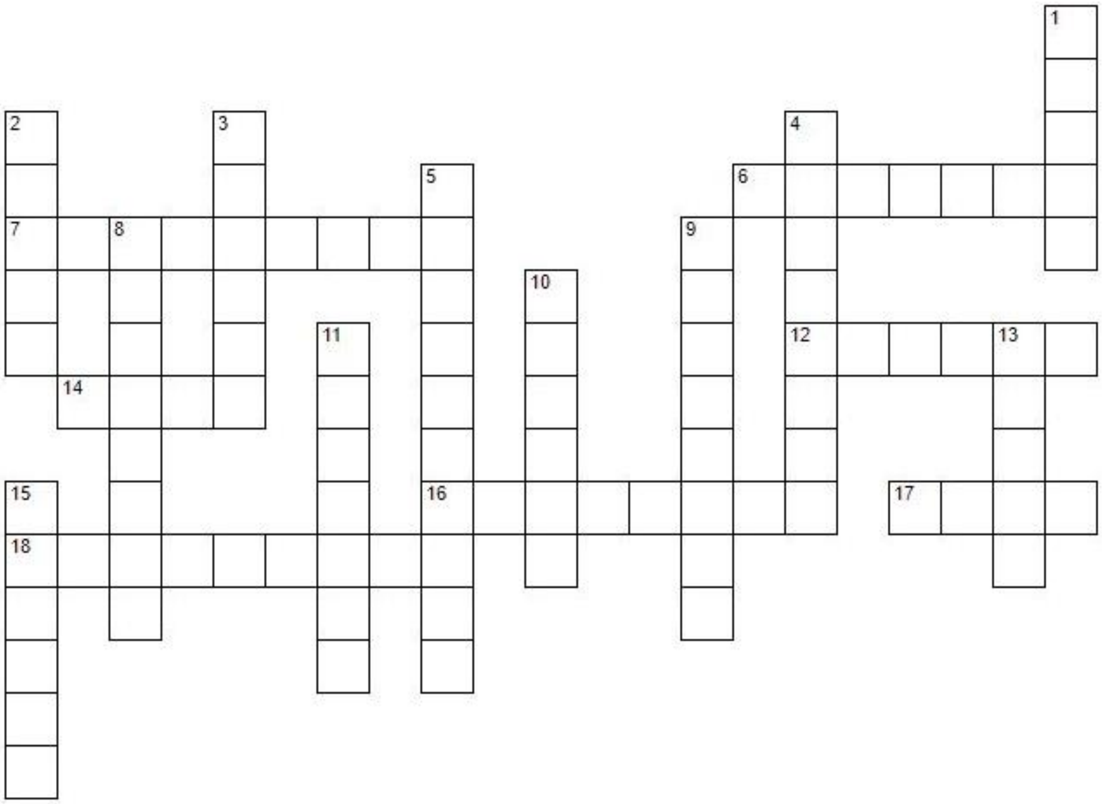
Fun with Flight Word Search

Answer Key



Activity 2: Learning to Fly Crossword

Name:_________________________________ Date: ______________



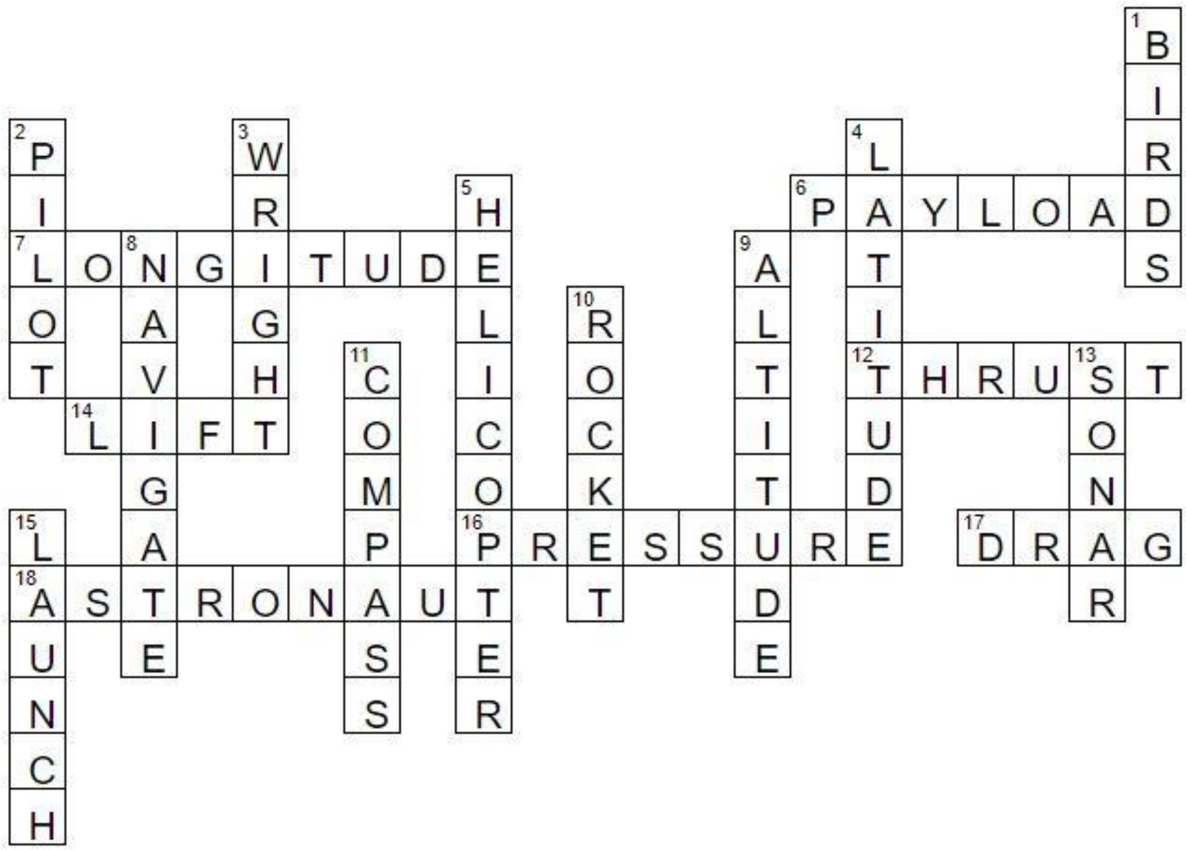
ACROSS	DOWN	ANSWERS	
6. Cargo carried by a rocket or plane	1. Animals that inspired airplane shape	Navigate	Latitude
7. Map lines running north-south	2. Person who flies planes	Longitude	Altitude
12. Force that propels an object	3. Brothers who took the first flight	Astronaut	Launch
14. Force that allows plane wings to fly	4. The Equator is one of these lines	Compass	SONAR
16. Caused by air inside balloons	5. Flying machine without wings	Pilot	Wright
17. Force that slows down flying objects	8. Find directions	Payload	Thrust
18. Space explorer	9. Height above sea level	Helicopter	Lift
	10 .Used to launch things into space	Birds	Drag
	11. Navigation tool	Pressure	Rocket
	13. Navigation technology from bats		
	15. Lift off from the ground		

Created by:

minotaur mazes

Learning to Fly Crossword

Answer Key



Activity 3: Space Flight Sequencing

Number the pictures of a space flight 1-7 in the order that they happen, with 1 first and 7 last.

____ 

Water landing

____ 

Rocket launch

____ 

Final preparations

____ 

View of Earth

____ 

Capsule recovery

____ 

Capsule recovery

____ 

Space walk

These photos come from the Records of the National Aeronautics and Space Administration.
National Archives Identifiers: 6734377; 6734374; 6734379; 6734371; 6734376; 6734375; 4728365

Space Flight Sequencing

Answer Key

5

Water landing

2

Rocket launch

1

Final preparations

3

View of Earth

7

Capsule recovery

6

Capsule recovery

4

Space walk

These photos come from the Records of the National Aeronautics and Space Administration.
National Archives Identifiers: 6734377; 6734374; 6734379; 6734371; 6734376; 6734375; 4728365

Additional Resources

Resources for aviation and aerospace education:

Smithsonian Institute: How Things Fly
- http://howthingsfly.si.edu/

Minnesota Department of Transportation: Aviation Education
- http://www.dot.state.mn.us/aero/aviationeducation/documents/publications/windwaterwings.pdf

Science Kids: Flight Lesson Plans
- http://www.sciencekids.co.nz/lessonplans/flight.html

Activity Resources and Web Bibliography:

Children's Museum of Houston Gyro Flyer activity
- https://www.cmhouston.org/gyro-flyer
- Activity instructions and extensions for making a paper gyro flyer.

Cornell Lab of Ornithology Amazing Birds curriculum
- http://www.birds.cornell.edu/physics/lessons/elementary/pdfs/tm
- Extensive curriculum on bird wings, bodies, flight, beaks, bones, and other adaptations.

Cornell Lab of Ornithology Flight and Feathers video resource
- http://www.birds.cornell.edu/physics/lessons/elementary/flight
- Brief videos highlighting certain types of birds in flight to compare wing types of birds that soar, dive, take short flights, etc.

Exploratorium Roto-Copter activity
- https://www.exploratorium.edu/science_explorer/roto-copter.html
- Instructions for making and testing roto-copters and some background information.

NASA Advanced High-Power Paper Rocket
- https://www.nasa.gov/pdf/295786main_Rockets_Adv_High_Power_Paper.pdf
- Background information on rockets and detailed instructions for paper rocket construction, worksheet for rocket design, and ideas for extensions including parachute canopy system.

NASA Beginner's Guide to Rockets: Rocket Propulsion
- https://spaceflightsystems.grc.nasa.gov/education/rocket/Lessons/propulsionS_act.html
- Detailed information on the physics of the balloon rocket. Ideas for experimental design and worksheet for data recording.

Navigating by Good Gyrations

- https://www.nasa.gov/pdf/404920main_Navitigating_Gyrations.pdf
- A NASA produced activity guide to understanding gyroscopes. This guide explains how to use a bicycle wheel to demonstrate angular momentum and gyroscope precession.

Paper Airplane Depot

- http://paperplanedepot.com/all-designs/
- Large variety of paper airplane designs and troubleshooting tips for improved flight

PBS Kids Hoop Glider activity

- https://pbskids.org/zoom/printables/activities/pdfs/hoopglider.pdf
- Activity instructions and extensions for making a straw and notecard hoop glider.

PBS NOVA Space Race Timeline

- http://www.pbs.org/wgbh/nova/astrospies/time-nf.html
- Dates and descriptions of key events during the space race from 1955-1975.

The Process of Early Space Flight

- https://www.docsteach.org/activities/student/the-process-of-early-space-flight-the-gemini-program
- Pictures for sequencing the space flight process.

Science News for Kids article - Explainer: What are lidar, radar, and sonar?

- https://www.sciencenewsforstudents.org/article/explainer-what-are-lidar-radar-and-sonar
- Article describing three technologies that rely on echoes to acquire information and navigate landscapes. Article is written at about a 9th grade level of reading.

Space.com Timeline: 50 years of spaceflight

- https://www.space.com/4422-timeline-50-years-spaceflight.html
- Dates and descriptions of key events in the development of flight, starting with the invention of gunpowder to make rockets in 11th Century China and advancing through 2007. Specific attention is paid to dates 1957 to 2007 to celebrate 50 years since the launch of Sputnik.

Wikipedia: John Gillespie Magee Jr.

- https://en.wikipedia.org/wiki/John_Gillespie_Magee_Jr.
- Background information, photos, and bibliography of additional resources on the life of John Gillespie Magee and his poem, *High Flight*

Wikipedia: Nose Art

- https://en.wikipedia.org/wiki/Nose_art
- Background information, public domain and creative licensed photographs of examples, and bibliography for additional resources.