



# FLIGHT

EDUCATOR GUIDE

## UEN CORE STANDARDS ADDRESSED IN FLIGHT:

### Kindergarten Science:

#### Standard 3, Objective 1

Identify how non-living things move.

- Observe and record how objects move in different ways, e.g., fast, slow, zigzag, round and round, up and down, straight line, back and forth, slide, roll, bounce, spin, swing, float, and glide.
- Compare and contrast how physical properties of objects affect their movement, e.g., hard, soft, feathered, round, square, cone, geometric shapes.

#### Standard 3, Objective 2

Describe parts of non-living things.

- Describe how parts are used to build things and how things can be taken apart.
- Explain why things may not work the same if some of the parts are missing.

#### Standard 4, Objective 1

Investigate living things.

- Construct questions, give reasons, and share findings about all living things.
- Compare and contrast young plants and animals with their parents.
- Describe some changes in plants and animals that are so slow or so fast that they are hard to see (e.g., seasonal change, "fast" blooming flower, slow growth, hatching egg).

#### Standard 4, Objective 2

Describe the parts of living things.

- Differentiate between the five senses and related body parts.
- Identify major parts of plants, e.g., roots, stem, leaf, flower, trunk, branches.
- Compare the parts of different animals, e.g., skin, fur, feathers, scales; hand, wing, flipper, fin.

### First Grade Science:

#### Standard 3, Objective 1

Analyze changes in the movement of nonliving things.

- Describe, classify, and communicate observations about the motion of objects, e.g., straight, zigzag, circular, curved, back-and-forth, and fast or slow.
- Compare and contrast the movement of objects using drawings, graphs, and numbers.
- Explain how a push or pull can affect how an object moves.

#### Standard 3, Objective 2

- Analyze objects and record their properties.
- Sort, classify, and chart objects by observable properties, e.g., size, shape, color, and texture.
- Predict measurable properties such as weight, temperature, and whether objects sink or float; test and record data.
- Predict, identify, and describe changes in matter

when heated, cooled, or mixed with water.

#### Standard 4, Objective 1

Communicate observations about the similarities and differences between offspring and between populations.

- Communicate observations about plants and animals, including humans, and how they resemble their parents.
- Analyze the individual similarities and differences within and across larger groups.

#### Standard 4, Objective 2

Living things change and depend upon their environment to satisfy their basic needs.

- Make observations about living things and their environment using the five senses.
- Identify how natural earth materials (e.g., food, water, air, light, and space), help to sustain plant and animal life.
- Describe and model life cycles of living things.

### Second Grade Science:

#### Standard 3, Objective 1

Communicate observations about falling objects.

- Observe falling objects and identify things that prevent them from reaching the ground.
- Communicate observations that similar objects of varying masses fall at the same rate.

#### Standard 3, Objective 2

Compare and contrast the differences in how different materials respond to change.

- Model physical changes of various materials.
- Investigate and provide evidence that matter is not destroyed or created through changes.

#### Standard 4, Objective 1

Tell how external features affect an animals' ability to survive in its environment.

- Compare and contrast the characteristics of living things in different habitats.
- Develop, communicate, and justify an explanation as to why a habitat is or is not suitable for a specific organism.
- Create possible explanations as to why some organisms no longer exist, but similar organisms are still alive today.

#### Standard 4, Objective 2

Identify basic needs of living things (plants and animals) and their abilities to meet their needs.

- Communicate and justify how the physical characteristics of living things help them meet their basic needs.
- Observe, record, and compare how the behaviors and reactions of living things help them meet their basic needs.
- Identify behaviors and reactions of living things in response to changes in the environment including seasonal changes in temperature and precipitation.

### Third Grade Science:

#### Standard 3, Objective 1

Demonstrate how forces cause changes in speed or direction of objects.

- a. Show that objects at rest will not move unless a force is applied to them.
- b. Compare the forces of pushing and pulling.
- c. Investigate how forces applied through simple machines affect the direction and/or amount of resulting force.

#### Standard 3, Objective 2

Demonstrate that the greater the force applied to an object, the greater the change in speed or direction of the object.

- a. Predict and observe what happens when a force is applied to an object (e.g., wind, flowing water).
- b. Compare and chart the relative effects of a force of the same strength on objects of different weight (e.g., the breeze from a fan will move a piece of paper but may not move a piece of cardboard).
- c. Compare the relative effects of forces of different strengths on an object (e.g., strong wind affects an object differently than a breeze).
- d. Conduct a simple investigation to show what happens when objects of various weights collide with one another (e.g., marbles, balls).
- e. Show how these concepts apply to various activities (e.g., batting a ball, kicking a ball, hitting a golf ball with a golf club) in terms of force, motion, speed, direction, and distance (e.g. slow, fast, hit hard, hit soft).

#### Standard 4, Objective 1

Demonstrate that gravity is a force.

- a. Button to show lessons.
- b. Demonstrate that a force is required to overcome gravity.
- c. Use measurement to demonstrate that heavier objects require more force than lighter ones to overcome gravity.

#### Standard 4, Objective 2

Describe the effects of gravity on the motion of an object.

- a. Compare how the motion of an object rolling up or down a hill changes with the incline of the hill.
- b. Observe, record, and compare the effect of gravity on several objects in motion (e.g., a thrown ball and a dropped ball falling to Earth).
- c. Pose questions about gravity and forces.

### Sixth Grade Science:

#### Standard 4, Objective 2

Describe the appearance and apparent motion of groups of stars in the night sky relative to Earth and how various cultures have understood and used them.

- a. Locate and identify stars that are grouped in

patterns in the night sky.

- b. Identify ways people have historically grouped stars in the night sky.
- c. Recognize that stars in a constellation are not all the same distance from Earth.
- d. Relate the seasonal change in the appearance of the night sky to Earth's position.
- e. Describe ways that familiar groups of stars may be used for navigation and calendars.

### Sixth Grade Social Studies:

#### Standard 1, Objective 4

Analyze how the earliest civilizations created technologies and systems to meet community and personal needs.

- a. Identify innovations in manmade structures over time (e.g. irrigation, roads, building materials) and their influence on meeting needs.
- b. Examine the evolution and importance of writing.
- c. Identify cultural expressions that reflect these systems (e.g. architecture, artistic expression, medicine, philosophy, drama, literature).
- d. Compare social classes, vocations, and gender roles within ancient civilizations.

### Eighth Grade Science:

#### Standard 4, Objective 1

Investigate the transfer of energy through various materials.

- a. Relate the energy of a wave to wavelength.
- b. Compare the transfer of energy (i.e., sound, light, earthquake waves, heat) through various mediums.
- c. Describe the spread of energy away from an energy-producing source.
- d. Compare the transfer of heat by conduction, convection, and radiation and provide examples of each.
- e. Demonstrate how white light can be separated into the visible color spectrum.

#### Standard 4, Objective 2

Examine the force exerted on objects by gravity.

- a. Distinguish between mass and weight.
- b. Cite examples of how Earth's gravitational force on an object depends upon the mass of the object.
- c. Describe how Earth's gravitational force on an object depends upon the distance of the object from Earth.
- d. Design and build structures to support a load.
- e. Engineer (design and build) a machine that uses gravity to accomplish a task.



# FLIGHT

## **EXHIBIT OBJECTIVE:**

FLIGHT is a permissive, interactive exhibit that allows visitors and students to explore the history, culture, science and technology of the phenomenon of flight.

## **EXHIBIT COMPONENTS/TABLE OF CONTENTS**

- 1 Leonardo Da Vinci Wall
- 1 Dream Tunnel
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## LEONARDO DA VINCI WALL

### Student Walkthrough:

As with any exhibit at The Leonardo, our first objectives are to support The Leonardo's mission and make connections to our namesake, Leonardo da Vinci. The Da Vinci Wall makes many direct connections to one of Leonardo's principle fascinations: the project of human flight.

Students will first be introduced to this historical fact and then peruse the contents of the wall, which will present engaging evidence of it. Students will see the actual sketches da Vinci did of wing designs, an ornithopter, an aerial screw, a hang glider, and a parachute — with quotes about these designs from da Vinci himself, stories about his life and the relevant notes about his varied sources of inspiration.

### Learning Objectives:

- Learn why there is an exhibit on the subject of flight here at The Leonardo.

## DREAM TUNNEL

### Student Walkthrough:

The only entrance to FLIGHT is through the Dream Tunnel and 1969 Room components, which are designed to be experiential, with implicit learning objectives.

In studying the intricate ceiling of the Dream Tunnel, students will learn that for as long as we have been here on Earth, human beings have marveled at birds and other creatures that soar through the skies — the drive to fly is universal across time and place. The constellational images were carefully curated, designed and arranged to demonstrate that every culture, in its own way, has dreamt of flight.

### Learning Objective:

- Observe that the project of flight is connected deeply to human history, science, and technology.

## 1969 ROOM

### Description:

The Dream Tunnel component will lead students into the 1969 Room component, where two child mannequins sit looking at the original footage of the famous 1969 moon landing. This historic moment was specifically chosen as a moment when something that was previously a dream was made a reality. Students can imagine themselves as the child mannequins and wonder what future events they might experience (the first person on Mars, for example.) The exhibits staff at The Leonardo call this component the "beating heart of the exhibit."

### Learning Objective:

- Highlight a historic moment that captures the emotion of inspiration animating the entire exhibit.

## INTERACTIVES

### Conceptual Organization:

There are seven core interactives (labeled "Flight Tests") within the exhibit structure. Four of the seven are devoted to covering one of the four forces of flight each: lift, drag, thrust and weight. The remaining three are each devoted to the three principle modes of flight: buoyant flight (e.g. balloons), projectile flight (e.g. rockets), and aerodynamic flight (e.g. airplanes.)

## FLIGHT TEST: THRUST

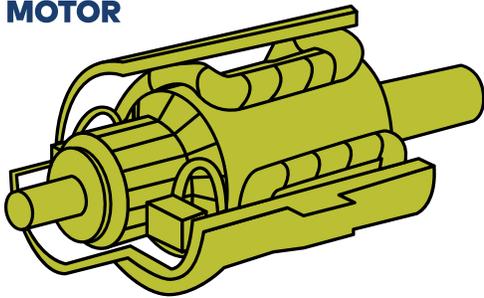
### Student Walkthrough:

Students will engage a race between three airplanes with different motor powers on a skytrack and watch who wins.

### Central Concept:

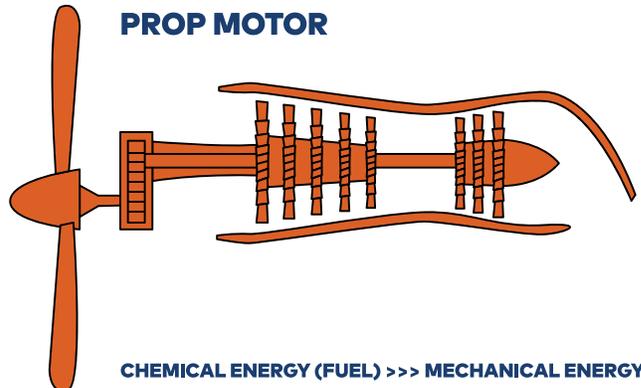
Thrust is the force that moves an aircraft through the air. Newton's 3rd law says that if you push on something it pushes back with equal force. So if an airplane pushes on the air, the air pushes back, thrusting us through the sky.

#### ELECTRIC MOTOR



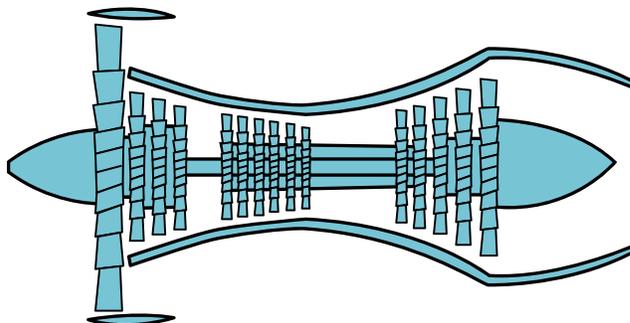
ELECTRICAL ENERGY >>> MECHANICAL ENERGY

#### PROP MOTOR



CHEMICAL ENERGY (FUEL) >>> MECHANICAL ENERGY

#### JET ENGINE



CHEMICAL ENERGY (FUEL) >>> MECHANICAL ENERGY

## FLIGHT TEST: LIFT

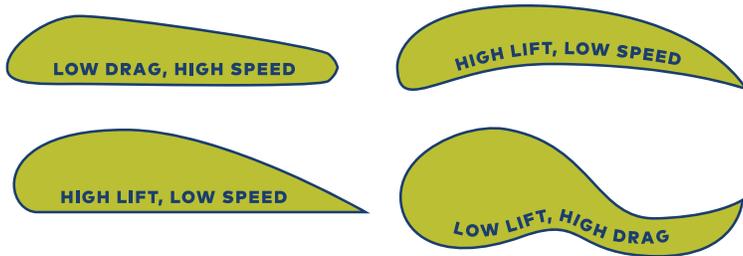
### Student Walkthrough:

Students will make controlled adjustments to an airfoil, testing which factors contribute to an effective or ineffective airfoil.

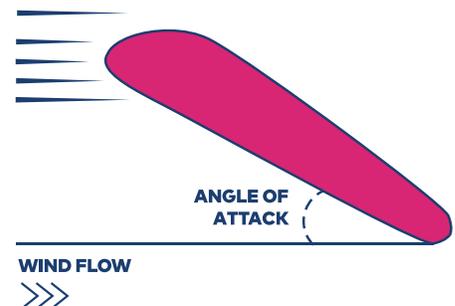
### Central Concept:

The amount of lift a wing creates depends on three crucial factors: airfoil shape, wing area and angle of attack.

Airfoil shape examples:



Angle of Attack diagram:



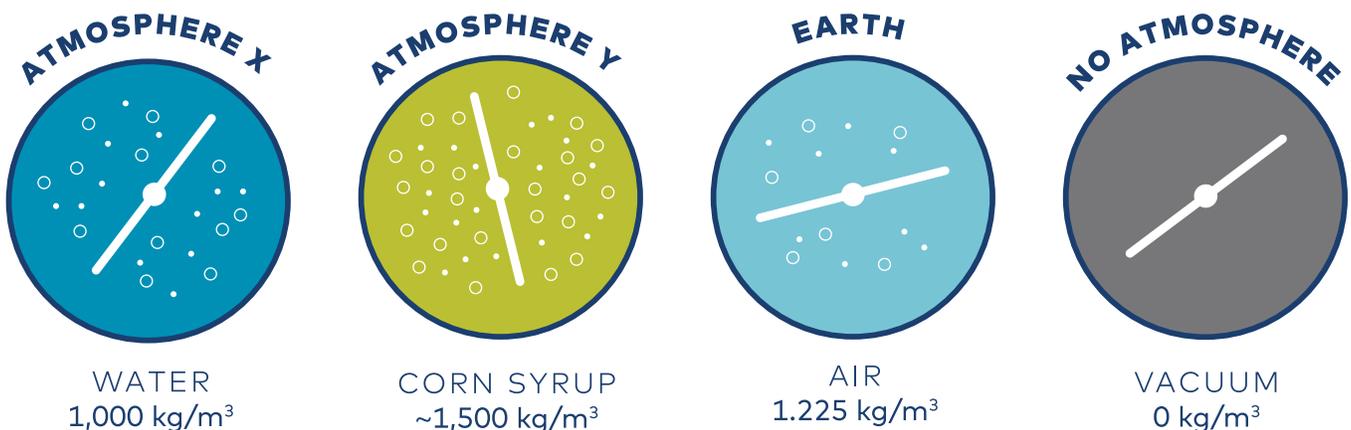
## FLIGHT TEST: DRAG

### Student Walkthrough:

Students will spin paddles and physically feel the resistance generated by different "atmospheres" (in this case, corn oil, water, air and a vacuum.)

### Central Concept:

Drag is the force felt moving through a substance, like the resistance we feel swimming through water. Airplanes flying through the Earth's atmosphere also experience drag, because air acts just like a liquid.



## FLIGHT TEST: WEIGHT (TERMINAL VELOCITY)

### Student Walkthrough:

Students determine the terminal velocity of an object in a wind tube by increasing wind speed until that object floats.

### Central Concept:

The speed of the wind in the tube is the fastest speed the object could reach falling from the sky! Terminal velocity is the maximum speed an object reaches when falling. It depends on the medium the objects falls through, the shape of the object and its weight!

Just like in the atmosphere, the forces in the tube cancel each other. The weight of the object is in balance with the force of the wind from the fan. In the atmosphere, the object travels at the terminal velocity, but in our simulation, the wind travels at that velocity.



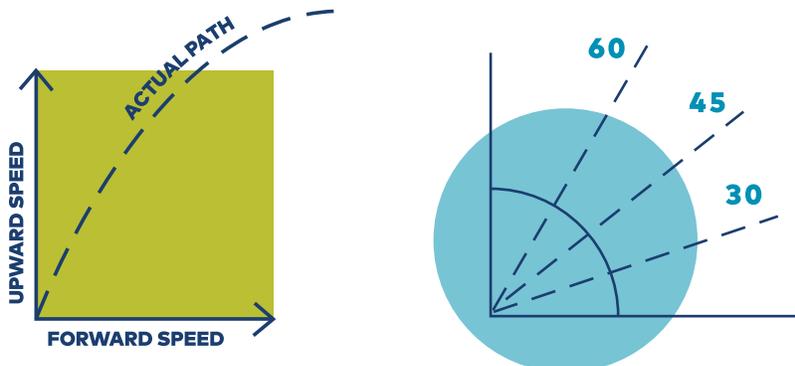
## FLIGHT TEST: PROJECTILE TRAJECTORIES (ROCKET)

### Student Walkthrough:

Students will launch soft projectiles through an air cannon which they will be able to aim. The process of aiming will allow them to explore the central concept: the effect of trajectory angle on distance travelled.

### Central Concept:

There's a connection between angles and how far something will go! Imagine an object's path being split into two parts: an upward part and a forward part. The upward part determines how much time the object stays in the air. The forward part determines how far the object will go, as long as it stays in the air. If our object only goes upwards it won't go anywhere. If it only goes forward, it won't get off the ground. Is there a middle ground between these two?



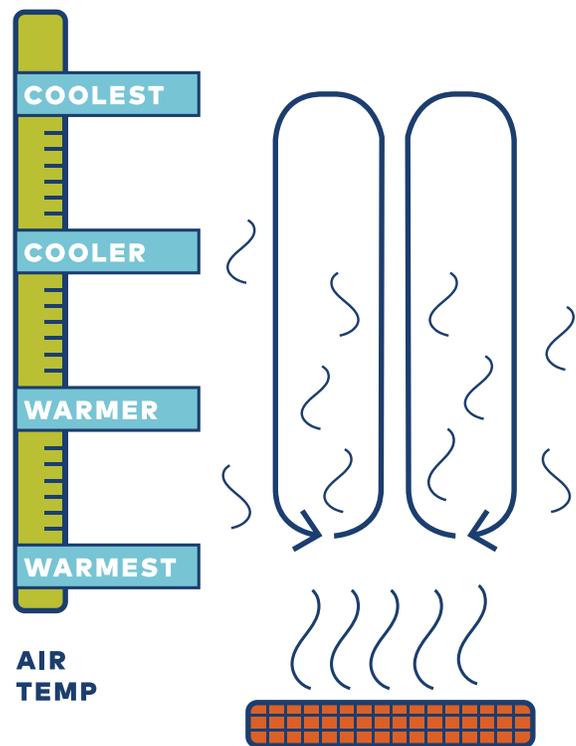
## FLIGHT TEST: BUOYANT FORCE (BALLOONS)

### Student Walkthrough:

Students will control the delivery of heat to a balloon, causing it to rise.

### Central Concept:

Air is made of molecules. Heat is a form of energy. When air molecules are heated they become more energetic. They zip around and move away from each other – the air expands. In a hot-air balloon, the air molecules collide with the inside of the balloon, creating pressure, while the outside air presses against the balloon surface in the opposite direction. When the inside pressure is greater than the outside pressure, the balloon will begin to rise.



## FLIGHT TEST: AIRFOILS (AIRPLANES)

### Student Walkthrough:

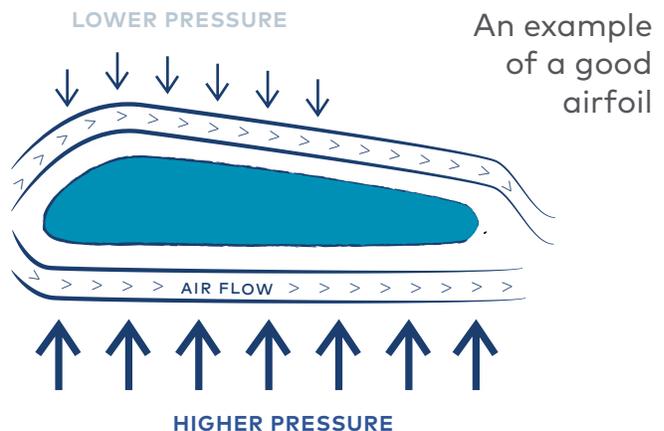
Students will choose different airfoils to test and compare in a wind tunnel.

### Central Concept:

An airfoil is any shape that generates lift when moving through the air. A wing is an airfoil. Bernoulli's Principle says that when pressure goes up, velocity (or speed) goes down. When the air above a wing moves quicker, the pressure decreases. As air below the wing slows down, the pressure increases. The net difference between these pressures produces lift.

The math behind Bernoulli's Principle:

$$P \propto \frac{1}{V}$$



# INNOVATORS, AVIATORS, EXPLORERS

## Description:

It took all kinds of people to get humanity airborne, and it will take those same kinds of people to transform the way we fly today. Innovators solve stubborn problems in aviation by thinking about them in different ways, even if their solutions seem a little crazy. Aviators daringly master the technology of aircraft and learn things about them no one else knows. Explorers are intrepid souls who look to new frontiers and feel the ambition to be the first to get there.

## Learning Objectives:

- Students will read about the varied personality types highlighted by the history of flight so that they can more easily identify with them.



## Did You Know?

There are two people on this wall from Utah; Aviator Gail Halvorson and Explorer Jake Garn. Can your students find them?

## C131

### Description:

The C131 Convair Samaritan proved to be a highly reliable aircraft throughout its 40 years of use by the U.S. Air Force and Navy (from 1950 to 1990.) The C131 in this exhibit was used for transporting important military personnel and was found in a huge airplane graveyard in the desert of Arizona.

### Did You Know?

The Davis-Monthen Air Force Boneyard where our C131 is from is the largest in the world! Check the Teacher Resources section at the end of this guide for the URL.

## MIG 21 MONOLITH

### Description:

The MiG family is made up of versatile and speedy fighter jets that the Soviet Union used to defend its vast airspace. When they were first being produced in 1940, MiGs spurred Soviet innovation in supersonic technology, cabin pressurization and radar. The MiG that hangs from this exhibit's ceiling is decades old, but MiG jets are still being built — the newest batch arrived in 2007.

### Did You Know?

The MiG above you is a MiG-21UM, released in 1968 as a two-seat training version of the MiG-21MF. "UM" means "Uchebny Modernizovanny," or "Modernized Training."

## BIPLANE & THE CULTURE OF FLIGHT WALL

### Description:

The Oldfield Baby Great Lakes is a build-it-yourself biplane. A biplane is simply a plane with two wings stacked one above the other. Even though most planes now have one set of wings, the biplane is still a source of inspiration for the many people who love to look at, fly, learn about, and build airplanes. As a tribute to this wonderful culture of flight, The Leonardo — with the help of our community — will build our very own biplane, right here in this exhibit.

### Learning Objective:

- Students will observe the ways in which flight has affected broader cultures and has inspired whole subcultures.

### Did You Know?

The biplane was brought here with the help of the Experimental Aircraft Association, which promotes and supports interest and exploration in aviation for all ages.

## KIOSKS

### Conceptual Organization:

- Each kiosk focuses on a particular mode: buoyant, aerodynamic and projectile modes.
- All kiosks are divided into history, science and technology.

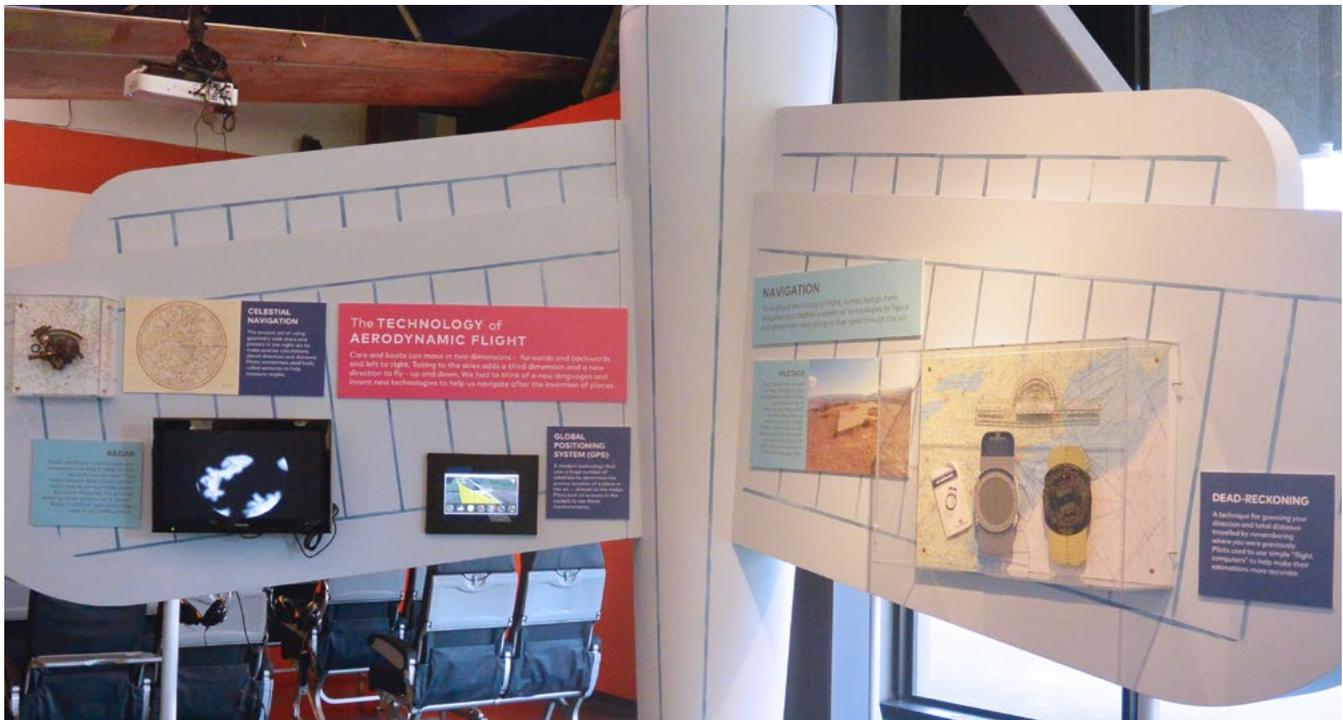
### AERODYNAMIC KIOSK:

#### Student Walkthrough:

Here students focus on the mode of winged, or aerodynamic flight, mostly within the time period of American aviation during the early 20th century. Students will explore the science, technology and history of this era through the language and mood of feverish competition and intrepidity – conveyed by keywords like Bigger, Larger, Faster, Higher. Scientific subjects like Newtonian forces, the geometry of navigation, air pressure and the Doppler effect are presented to the student in this context. They will also learn about the technologies developed for moving through the air – such as airfoil function and plane flap types – and historical methods of navigation, from dead-reckoning to radar. Finally, students will explore the history of this mode through ten or so key “moments” in this period, high points in the long list of accomplishments and feats in the development of the modern airplane.

#### Learning Objectives:

- In covering aerodynamic (winged) flight, the student will explore the history, science and technology of this flight mode.



## ROCKET KIOSK:

### Student Walkthrough:

This kiosk introduces the mode of rocket flight to the student, with a thematic emphasis on ingenuity and problem solving. It presents the science, technology and history of rocketry while figuratively suggesting that space is the new frontier that the skies once were. Scientific concepts are distilled for the student into four major obstacles that are unique to rocket/space flight, such as the speed required to escape Earth's gravity and the uniquely dangerous properties of the environment of space. Technology, again focused on tactile experiences, will convey to the student a simple dichotomy between the amount of energy needed to leave Earth and the amount of energy required to move through space, while covering the relevant technologies on either side. The rocket history the student surveys will introduce a dozen historic moments in which human beings brought their "Earthly" knowledge to bear on the myth-like ambition of space flight.

### Learning Objectives:

- In covering rocket flight, the student will explore the history, science and technology of this flight mode.



## BUOYANT KIOSK:

### Student Walkthrough:

At this kiosk students will explore the mode of lighter-than-air, or buoyant flight, with themes of simplicity and inspiration. The kiosk presents the science, technology and history of this mode with an emphasis on taking cues from the natural world. In the science section, students will see the story of three natural gases – air, hydrogen and helium – and how they enable different kinds of buoyant flight, such as a recreational hot-air balloon or a dirigible (airship) like the Hindenburg. Technologies are conveyed to the student in a highly tactile way, presenting (literally) the basic materials needed to form different kinds of balloons (featuring canvas and silk) and different materials that modern baskets are made from, like rattan (wicker) or aluminum. Students will peruse the history of buoyant flight, which selects roughly 10 separate moments from its long development (stretching back at least to the 16th century), while focusing on the necessity to study nature in order to fly.

### Learning Objective:

In covering buoyant flight, the student will explore the history, science and technology of this flight mode.



## THE IMAGINATION OF FLIGHT

### Description:

Viewing a short, entertaining film, students will learn that to get off the ground we had to experience many failures--sometimes very funny ones. But it was our willingness to experiment and fail that made human flight a reality. All the machines and gizmos we created over the centuries offer a unique window into the human imagination.

### Learning Objectives:

- Students will observe that failure and funny ideas are necessary to make grander achievements in flight.

## ANIMAL FLIGHT

### Description:

Nature figured out how to fly before humans. Leonardo da Vinci believed that the only way we could ever fly was by copying what we saw in the natural world. Birds, bees, bats squids and even squirrels each offer their own secrets for reaching the skies.

### Learning Objectives:

- Even the youngest students can learn a wide variety of solutions nature has imagined for the problem of flight.

## FUTURE OF FLIGHT

### Student Walkthrough:

Students will explore a large-scale infographic that outlines some of the problems that exist in the realm of terrestrial flight and frontier of spaceflight.

### Description:

The larger project of human flight is never over. There are problems we need to solve soon: What new materials can help us build better aircraft? Could solar-powered aircraft help protect our environment? What kinds of things can we do with drones?

Then there are the captivating questions about the future of flight: When will human feet touch down on Mars? How soon before commercial space travel is here? How can we travel at the incredible speeds necessary to reach other planets, other stars?

These and other questions will keep the heart of human flight beating for centuries to come.

### Learning Objectives:

- Students will learn what problems exist on the horizon of flight, and point to how they could solve them.

# THIRD GRADE PRE- AND POST-VISIT GUIDE

## Description

Students will "defy gravity" by participating in a lively experiment using their own sense of movement to understand the basics of flight. Students will do an experiment in which they "fly" for short periods and then evaluate factors that might either decrease or increase their "flight duration."

Students will gain a greater understanding of the four forces of flight, which include:

- Drag
- Thrust
- Lift
- Weight

## Objectives:

Science Standards 3.3.1, 3.3.2, 3.4.1, 3.4.2. Refer to inside cover of this guide for detailed descriptions of these standards.

## Explore: Let Students Work On Problems with Minimal Direct Instruction

Materials:

- Large sheet of paper
- Tape
- Dirt or stamp pad
- Ruler or meter stick.
- Colored markers to differentiate each student
- Timer/stopwatch with a second hand

Preparation:

Activity is to be done in groups of 3-4 students each. Tape a large piece of paper to the wall for each group of students (brown wrapping paper or sheets of newspaper will do). Each student will need an ink pad, pencil, ruler or meter stick and tape

### Pre-Visit Experiment #1

- Tell students: "Today we are going to DEFY GRAVITY and see how high we can fly!"
- Divide students into cooperative groups and instruct students to gather by the paper on the walls, then number the students in the order they will take turns.
- Instruct students to observe you as you model the following:
  - Dip one finger in ink and while standing with feet flat on the floor, stretch arms out as far as they can and mark the highest point you can reach on the paper. Instruct students to put initials on paper. Tell students "I will count to three and then say JUMP! At that moment you will need to jump and mark the paper by touching it at the top of your jump. You will then need to initial you mark.
  - Prep the students and then begin the activity with enthusiasm, giving students three turns each and reminding them to initial each time.
  - Instruct students to then work cooperatively and use a ruler or meter stick to measure the vertical difference in height between their standing and jumping marks, explaining that this is how high they can jump. Record answers and observations.
  - You probably noticed that taller kids did not necessarily have higher jumps. Remember, you measured the jump height from your reach. (The standing mark) and not the ground. The best jumpers in the world can clear heights up to 2.4 meters, but they lift their center of mass considerably higher than that distance!

Ask the students/Turn and Talk: Is jumping really flying? Have students share out responses. Some things like rockets, cannonballs, and baseballs fly like jumping kids. They are pushed into the air by engines or muscles. Airplanes are more complex! Engines push them forward, and air pushes and holds them up. Thrust, drag, weight, and lift are the four forces.

Remind students that these are forces they will learn about in their visit to the FLIGHT exhibit.

### Pre-Visit Experiment #2

Now that we have compared how high we can jump to objects like rockets, cannonballs and baseballs, let's ask two new questions:

1. How long do you think you can fly?
2. How long do you think you can stay in the air when you jump?

At this time call 1-3 students and then one at a time instruct them again with a countdown and when you say "JUMP!" Be sure to time their jump and record it, using a stopwatch.

## Explain: Get Students to Explain Concept in Their Terms, Then Provide Formal Definitions

When activity is completed, ask students the following two questions:

1. What do you think might help you jump higher?
2. What else could you do to make your jumps last longer?

Create whiteboard or anchor chart of responses. Refer to key vocabulary terms below as you share out responses as a class.

### Vocabulary:

**Thrust:** The force developed by a propeller or jet engine that drives an airplane through the air. In the jumping activity, student's leg muscles provided thrust.

**Weight:** A measure of the heaviness of an object.

**Drag:** The resistance caused by the shape of an object and its movement throughout the air.

**Lift:** The upward force created by a difference in air pressure. Moving air creates this difference as it moves around an airfoil (e.g., a wing).

### Further Questions:

"If you were thinking of jumping off a trampoline or diving board; launching yourself with a pole vault, catapult, or a rocket, or exercise to get stronger muscles, springy shoes or a rocket booster might help your jump, then you were thinking about thrust. (The force that pushes you during flight).

"If you were thinking that you needed to wear lighter clothing, lose weight, or travel to a planet with smaller gravity than earth's (the moon), you were thinking about weight (the force that holds you to the ground)

If you thought that wearing skin-tight clothing or that a slick suit or helmet would make you jump higher or that a parachute would keep you in the air longer, then you were thinking about drag (the resistance of air against things that fly).

"Most people have experienced how thrust, drag and weight can help them jump higher, or "fly", but few people are familiar with lift. Lift is a push that comes from the air. You were thinking about this force if you decided that wearing wings or holding helium balloons would help you jump higher. While planes and birds have to be moving to get enough of this push to fly, hot-air balloons are light enough for their size that the air will lift them up whether or not the balloon is moving."

Ask students: "Do you think that everything that flies uses all four forces?" The answer is no. Only two forces - weight and thrust - act on spacecraft. Lift and drag are not factors in spacecraft flight, because there is no air in space.

## Evaluate: Assess Students' New Knowledge or Skills

**Post-Visit Activities: Refer to our Teacher Resources page at the end of this guide for helpful links and instructions.**

- Build a timeline of the history of flight or aviation.
- Have students create a "Living Museum" of aviators and explorers in the gym or cafeteria of your school (see resources). Invite students, parents and teachers to the live museum one day during their recess or PE time.
- Have students partner with another student and write a short paragraph of what life would be like if we traveled to Mars one day as a bell ringer activity in writing .
- Have them keep the following questions in mind:
  1. Could it be possible to land on Mars one day? Why or why not?
  2. Could it be possible to travel at incredible speeds one day? Why or why not?
- Have students research in cooperative groups the history of what a MIG and C131 is. Have them list different times they were used throughout history. Research maps in the US that contain aviation boneyards/graveyards. Take a virtual field trip if possible.
- Discuss the Flight Simulator, the MiG and C131. Ask the kids to imagine themselves flying from one point to another. Complete the map and distance activity with your student using technology where they measure possible distances from one city to another, a great activity to do around Math Lessons!

# SIXTH GRADE PRE- AND POST-VISIT GUIDE

## Description:

Students will enjoy learning about Leonardo da Vinci and his fond interest in flight while simultaneously exploring throughout the exhibit and gaining a greater understanding of contributions that have been made by humankind throughout history.

## What objectives are met?

Science Standard 6.4.2 and Social Studies Standard 6.1.4. Refer to inside cover of this guide for detailed descriptions of these standards.

## Engage: Get Students To Ask Questions and Show Prior Knowledge

### Pre-Visit Activities

Ask Students to brainstorm if they know what cultures or civilizations had an early interest in flight.

- Chinese kite flying in 400 BC

Ask the students if they know of any examples of early flying machines, real or imagined.



- Greek mathematician and engineer, Hero of Alexandria (sometimes known as "Heron of Alexandria") created an "aeolipile" (seen left), an invention which used jets of steam and air pressure to create rotary motion.
- Evidence of man's desire to fly appears in Myths and Legends, like the Greek Legend of Pegasus, a winged horse. Another ancient Greek legend, Icarus and Daedalus made wings of wax and feathers and attempted to fly.

Ask students if they know how Leonardo da Vinci, made a contribution to flight.

- During the 15th century Da Vinci developed plans for an Ornithopter, and although it was never created, today's helicopter is based on the concept.
- Optional: Show timeline that outlines the history of flight. Refer to Teacher Resources at the end of this guide.

Ask students to brainstorm any examples of modern developments in flight.

- Airplanes, biplanes, jets, drones
- Rockets, stealth fighters, etc.
- Hot air balloons, hang gliders

Throughout history, civilizations and societies have continued to create technologies to meet their needs. Ask students to keep this in mind as they learn about navigation. Ask students: How did people navigate during ancient times?

- Maps, Compasses, Stars

Before we had maps and GPS, before there were complex math instruments to guide pilots, there were "reference points" used to assist in navigation. Constellations were used as "reference points".

Ask students if they can brainstorm any cultural examples of constellations used as "reference points."

1. Sailors guiding ships through the night that transported African Americans who were fleeing slavery. Refer to the song The Drinking Gourd which represented the Big Dipper (see right), found near the North Star and explain that African Americans used the Gourd as their ticket to freedom.
2. Oregon Trail Pioneers used constellations during their migration west.

Remind students that during their visit they will be introduced to the history, technology and science of flight and to look for early examples of flight and navigational tools. Then, compare and contrast these with modern day flight.

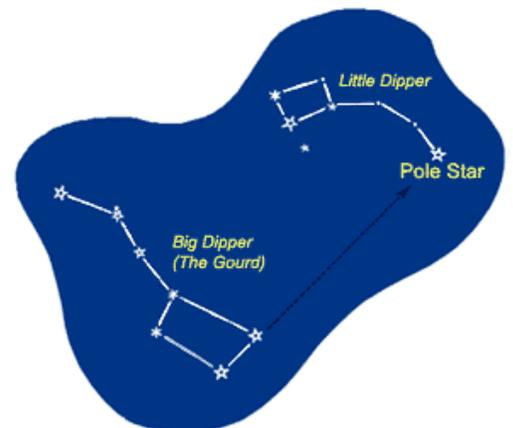


Image from [www.parents-choice.org](http://www.parents-choice.org)

## Explore: Let Students Work On Problems with Minimal Direct Instruction

During your visit be sure to begin at our Da Vinci Wall (refer to the education guide). From this starting point you will be able to:

- Enter the exhibit through the Dream Tunnel while observing constellations and early examples of imaginary flight machines. Refer to the "resources" section to get detailed explanations of what you are actually viewing!
- Observe various instruments used historically in aviation. Hear a sonic boom and the first sounds to ever come from space.
- Study the history of aviation, rocket technology and buoyancy.
- Practice using Flight Simulators that were donated by Rockwell Collins and used for real pilot trainings.
- Experience one of our "Flight Test" interactive displays that focuses on the four forces of flight as well as various modes of flight.
- Get up close to a C131, view a MiG, and learn about their origin.
- Pause at the Future of Flight wall and learn about NASA's plans for space exploration within the next decade and see some drones.

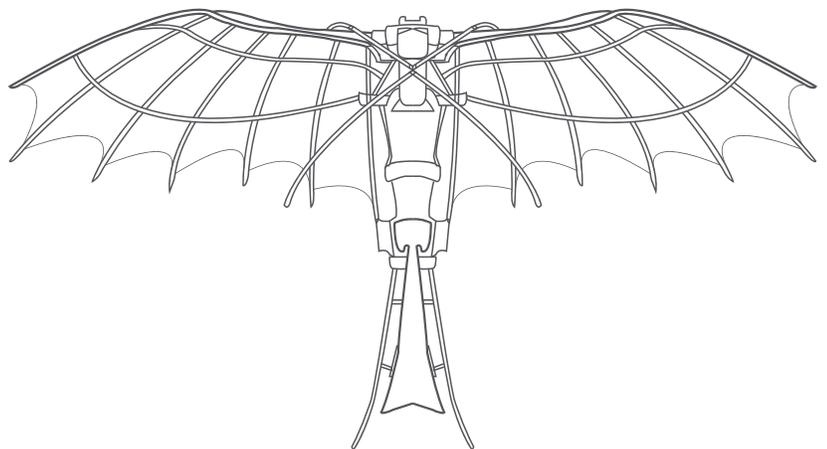
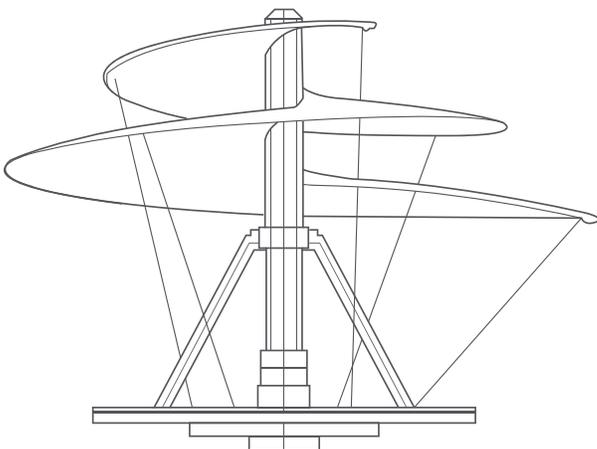
## Explain: get students to explain concept in their terms, then provide formal definitions

**Post-Visit Activities: Refer to our Teacher Resources page at the end of this guide for helpful links and instructions.**

After the visit to the Leo, ask students the following questions:

1. What is a constellation? *A pattern in the stars that has been identified and named.*
2. What is the name of the song that was used by the Underground Railroad in which the star Polaris and the Big Dipper is used as a "reference point?" *"Follow The Drinking Gourd."*
3. Define navigation and provide an example of a flight instrument that is used in modern times. *Navigation: the process or activity of accurately ascertaining one's position and planning and following a route. Radio navigation, Automatic Direction Finder, GPS or Global Positioning System.*
4. Give one example of a complex math instrument that was used to guide pilots in earlier times. *Example: sextant - a device which helped pilots measure angles.*
5. What is pilotage? *The process of directing the movement of a ship (image of pilotage) or aircraft by visual or electronic observations of recognizable landmarks.*
6. List the Four Forces of Flight. *Lift, drag, thrust, and weight.*
7. What are the Three Modes of flight? Give one example of each. *Buoyancy - hot air balloons; projectile flight - rockets; aerodynamic - airplanes.*
8. What is the name of the flight machine that inspired the building of our modern helicopter? Who developed the sketches for this? *Ornithopter; Leonardo da Vinci.*
9. What culture first developed early attempts at flight and in what century? *China - 400 B.C.*

Below: Leonardo's Aerial Screw and Ornithopter



## Elaborate: Let Students Apply New Knowledge or Skills to a New Project

### TCHART on Cultural and Scientific uses of GPS and Constellations

1. Have students generate a list of examples for each and share out.
2. Review the responses given as a class and refer to resources for more information if needed.

GPS: Cultural Uses	GPS: Scientific Uses
<ul style="list-style-type: none"><li>• Geocaching (using clues and GPS tracking to find hidden caches)</li><li>• Recreational: hiking, biking, skiing, etc.,</li><li>• Cars, boats, planes, navigation (ex. Garmin is a company that sells navigation devices)</li><li>• Smart phone: navigation</li></ul>	<ul style="list-style-type: none"><li>• Dept. of Defense uses it to track land, sea and airborne vessels to determine their three dimensional position, velocity and time in any type of weather. This is far better method than radio navigation systems.</li><li>• Meteorologists can track weather balloons</li><li>• Surveying: Measuring how buildings might shift in an earthquake or after a disaster like Oklahoma bombings</li><li>• Marine archeology: Used to help guide boats that are tracking shipwrecks</li><li>• Geologists: Used data to determine Mt. Everest is getting taller</li><li>• Used in Minnesota by scientists to track migration patterns and feeding habits of deer</li></ul>

Constellations: Cultural Uses	Constellations: Scientific Uses
<ul style="list-style-type: none"><li>• Religion</li><li>• Storytelling: Myths, legends, tales told by Greeks, Mayans, Native Americans, Celts, Asians</li><li>• Agriculture: Calendars</li><li>• Astrology</li><li>• As navigation: Served as sky map for Underground Railroad, westward expansion</li></ul>	<ul style="list-style-type: none"><li>• Astronomy: Tracking bright stars, locating galaxies and nebulae (clusters of gas and dust)</li></ul>

### Writing Activity:



Have students write a short narrative in which they identify themselves as a "Dystopian Protagonist" struggling to survive in a dystopian society. Tell students they are attempting to escape this society by planning a secret flight mission and the story should include sensory language and dialogue between characters. View the following resource for a definition of dystopian society.

[http://www.readwritethink.org/files/resources/lesson\\_images/lesson926/DefinitionCharacteristics.pdf](http://www.readwritethink.org/files/resources/lesson_images/lesson926/DefinitionCharacteristics.pdf)

Ask students to generate a short list of some dystopian novels written for middle-schoolers (e.g. *Hunger Games* series by Suzanne Collins, *Among the Hidden* by Margaret Peterson Haddix, *City of Ember* by Jeanne DuPrau, *Divergent* series by Veronica Roth, *Maze Runner* by James Dashner)

Before students write about their experiences, ask them to think about the following questions, keeping their visit to the Flight exhibit in mind.

- What is their final destination? Mars? A space station? Another part of the planet? Were there any aviators or explorers that inspired them or that could be potential characters in their narratives?
- What kinds of examples of modern day or ancient flying machines that they saw in the museum might be useful, if any? (Ask students to recall what they saw in the Dream Tunnel, or on our Future of Flight wall as a warm-up.) A hot air balloon? A rocket suit? Animal-like wings made from the forest? An ornithopter re-engineered?
- Would it be possible to use modern navigation systems or would they need to rely on constellations? Would they need to adapt and build an extraordinary device to navigate with?

## Evaluate: Assess Students' New Knowledge or Skills

**Post-Visit Activities:** Refer to our Teacher Resources page at the end of this guide for helpful links and instructions.

## TEACHER RESOURCES

Timeline of flight:

<https://www.loc.gov/exhibits/treasures/wb-timeline.html>

The History of Aviation

[https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/historyof flight.html](https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/historyof%20flight.html)

Famous firsts in Aviation

[https://www.teachervision.com/tv/printables/uk/Famous\\_Firsts\\_Aviation.pdf](https://www.teachervision.com/tv/printables/uk/Famous_Firsts_Aviation.pdf)

Flight Navigation systems

<http://virtualskies.arc.nasa.gov/navigation/3.html>

What is a GPS?

<https://www.loc.gov/rr/scitech/mysteries/global.html>

Students can examine the language scientists have created since the invention of flight. Ask students what "GPS" stands for and explain that it did not exist 100 years ago (now used for things like air traffic control). Discuss with students when the first GPS was introduced.

[http://www.nasa.gov/directorates/heo/scan/communications/policy/policy\\_pnt.html](http://www.nasa.gov/directorates/heo/scan/communications/policy/policy_pnt.html)

A middle schooler's guide to the history of GPS and its impact on society:

[http://www.mainemaritimemuseum.org/media/docs/resources/2013/03/08/Global\\_Positioning\\_Systems.pdf](http://www.mainemaritimemuseum.org/media/docs/resources/2013/03/08/Global_Positioning_Systems.pdf)

Constellations as a Guide: NASA Quest has provided an informative link if you want to share the song "Follow The Drinking Gourd"

<http://quest.arc.nasa.gov/ltc/special/mlk/gourd2.html>

The History behind "Follow The Drinking Gourd"

<http://www.followthedrinkinggourd.org/>

Virtual Field trip to Mars

<http://www.youvisit.com/tour/ryan.lee/87131>

Review an example of navigational equipment.

[http://www.brighthubengineering.com/seafaring/31615-marine-navigational-equipment-the-sextant/#imgn\\_3](http://www.brighthubengineering.com/seafaring/31615-marine-navigational-equipment-the-sextant/#imgn_3)

View how a Navigational Flight Plotter is used in Aviation training

<https://www.youtube.com/watch?v=5igMoXj8Nqiew>

Take a virtual tour of the Monthen-Davis boneyard where our c-131 is from.

<http://www.airplaneboneyards.com/davis-monthan-afb-amarg-airplane-boneyard.htm>

View this cool interactive map of airplanes and post WW2 aircraft boneyards and storage facilities in the United States!

<http://www.airplaneboneyards.com/map-of-plane-boneyards-united-states.htm>





**EXPLORE. ENGAGE CREATE.**

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