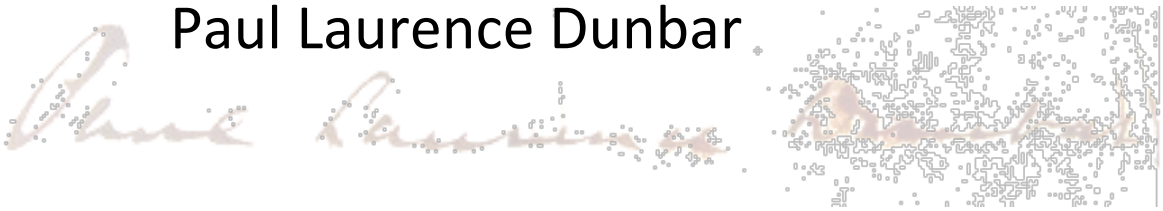
The Wright Brothers

and

Paul Laurence Dunbar



A Study of:

Flying Machines, Propellers, Catapults, Printing Process

PK-12 Teachers' Guide

to Dayton Aviation Heritage National Historical Park

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Pre-K through Second Grade

Flying Machines

Grade Levels: PK-2

Summary & Purpose:

This flying machine lesson is one of four lessons for pre-school through second grade students to study the Wright brothers and Paul Laurence Dunbar. Students will learn the history of flying machines, from the first hot air balloons to modern airplanes. Students will learn about the contributions of various historical figures, especially those of Orville and Wilbur Wright, and engage in a "First in Flight" debate. Students will explore different types of flying machines, analyze the positive and negative aspects of each, and use the engineering design process to land flying machine models safely.

The field of aeronautics and the questions about flight are vital to the age in which we live. Therefore, this unit will address multiple science, social studies, math, and language arts standards as students explore the topic of flight. Students will learn about how weather changes and why those changes were so important to the first flight. They will also explore forces and energy. Resources will be used to research the past and represent events on timelines. Most of all, students will be exposed to a rich, positive learning experience which will encourage further exploration and foster a love of learning.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. The Wright-Dunbar Interpretive Center houses some artifacts and replicas from the earliest Wright Flyers, including a model of the first Wright Flyer engine. The Huffman Prairie Flying Field Interpretive Center highlights the history of flight from the first flight to the modern era of air travel. At the Huffman Prairie Flying Field Interpretive Center, visitors will find various models of planes, videos, and hands-on exhibits of flight. They will also experience a flight simulator modeled after an early military Wright Flyer. The Huffman Prairie Flying Field includes a replica of a hangar and a catapult similar to those utilized by the

Wright brothers. Signs and placards throughout the park sites also give a rich and detailed history of flight.

Essential Questions & Enduring Understandings:

1. **How does weather change?** Weather changes constantly. Weather can change multiple times in a day, from day to day, week to week, and season to season. These changes are caused by changes in energy and can be predicted by everyone from scientists to school children.

2. **How can we describe things around us?** Objects and materials can be described by their properties; such as size, shape, color, texture, and buoyancy.

3. **How can we show the way in which things have changed?** One way that we can show how things have changed is by using a timeline. Timelines can include words, pictures, and/or artifacts. Timelines can show changes on a large scale, such as the history of flight, or a small scale, such as events in a child's life or events during a single week.

4. **What kind of flying machine works best?** A flying machine, like many other things, can only be evaluated according to how well it achieves its purpose. If the purpose is to stay up in the air as long as possible, one type may work best. If the purpose is to land as close to a specific location as possible, another type may work best. If the purpose is to travel farthest, a third type may be best.

Lesson Overview:

Day 1	Introduce the history of flight, including "First in Flight" Discuss the interaction of weather and flight
Day 2	Explore different types of flying machines
Day 3	Imagine and design a safe landing for a flying machine
Day 4	Build and test a safe landing for a flying machine
Day 5	Redesign and retest a safe landing Write a letter to announce a successful flight

Vocabulary:

catapult – a machine that helps launch planes into the air

dirigible – a type of flying machine that used lighter-than-air gasses inside a giant balloon

flying machine – anything created by people to help them fly

glider – a type of flying machine that does not have an engine

passenger – a person who rides in a flying machine while someone else pilots it

pilot – a person who flies a flying machine

telegram – a letter sent quickly, like a fax, to another place

weather – the amounts of wind, precipitation, and temperature outside

Materials:

For the class:

- The Story of Flight: Early flying machines, balloons, blimps, gliders, warplanes, and jets published by Scholastic, 1994.
- Chart paper
- Chart markers
- US map (recommended, but not required)
- North Carolina and Ohio license plates (or pictures)
- 2 – Balsa wood gliders
- 2 – Propeller-driven balsa planes
- 2 – Slingshot/catapult launched gliders
- Copy paper
- String (15 feet) or rope (50 feet)
- Sidewalk chalk (optional)
- Duct tape
- Copy of 1903 telegram from Orville and Wilbur Wright
- My Brothers' Flying Machine: Wilbur, Orville, and Me by Jane Yolen, illustrated by Jim Burke, 2003

The actual number of planes needed may vary based on the age and number of students in the class.

Each group may choose one of the following flying machines:

- Balsa wood glider
- Propeller-driven balsa plane
- Slingshot/catapult launched glider

For each group:

- Tape measure
- Stopwatch
- Lego figure
- Materials to improve landing (student choice)
- Paper

As students work on their design challenge on days three, four, and five, they will determine what materials they want to use. These choices can be limited based on what is available in the classroom or students may bring materials from home.

Background Information:

Over the past 600 years, various people have made attempts at flight with various levels of success. Leonardo da Vinci designed flying machines from 1485-1500, but never attempted to build or fly any such machines. The first flying machine was a hot air balloon, flown by the Montgolfier brothers in 1783. In 1849, in a glider designed by George Cayley, a 10-year-old boy made short hops in the air. In 1890, Clement Ader made a short, powered hop in the air in a flying machine, but the flight was neither sustained nor controlled. From 1891-1896, a German man named Otto Lilienthal made numerous flights in his gliders until he died in an 1896 crash. Orville and Wilbur Wright learned from many of these people as they designed the first successful powered, heavier-than-air, practical flying machine. The debate over "First in Flight" involves many of these people.

Procedures:

Day 1:

1. Ask students "Who were the first people to fly?" Students with prior knowledge will likely answer that the Wright brothers were the first people to fly. Tell students that the answer will depend on what "fly" means.
2. Read or paraphrase sections of the book <u>The Story of Flight: Early flying machines, balloons, blimps, gliders, warplanes, and jets</u>, published by Scholastic. Specifically focus on hot air balloons, dirigibles, gliders, and the Wright brothers' 1903 flights.

3. Draw a timeline on a sheet of chart paper. Explain that a timeline helps people see the order in which events happened. Mark the following events on the timeline:

   1783 – First person flies in hot air balloon
   1852 – First person flies in a dirigible (blimp)
   1853 – First person flies in a glider
   1903 – Wright brothers' first flight in Kitty Hawk, NC
   1904 – Wright brothers fly in Dayton, OH

4. Display the locations of Dayton, Ohio and Kitty Hawk, North Carolina, on a map of the United States. Explain that even though all the planning was done in Dayton, the Wright brothers travelled to Kitty Hawk, because it was windier there than in Dayton. The brothers needed the wind to help them lift the plane off the ground. This led them to study the weather patterns around the United States.
5. Discuss how weather changes every day as well as seasonally. Explain that changes in weather limited when and where the Wrights could test their new flying machines.
6. Show students pictures of Ohio and North Carolina license plates. Ask students to share their thoughts on the slogans "Birthplace of Aviation" and "First in Flight." Accept all responses, but encourage students to think critically and refer back to the timeline.

Day 2:

1. Show students different types of model flying machines: a paper airplane, a balsa wood glider, a rubber band powered propeller plane, and a rubber band catapulted glider. Pass them around so all students can examine them.
2. Take the class outside and demonstrate how to work each type of flying machine. Divide the class into groups and let them take turns flying the planes. Rotate so each group has a chance to fly each type of plane. Have students try to see how far the planes will go, how straight they will fly, and how long they will stay in the air.
3. Back in the classroom, discuss the characteristics of each flying machine. Have students share both physical characteristics (color, shape, weight, etc.) and characteristics of their ability to fly (how

The timeline can be horizontal or vertical; whichever is easier for students to understand.

First and second grade students should be learning to read and create timelines. Pre-k and kindergarten students do not need to learn how to read a timeline yet.

If it is possible to get actual license plates from each state, tape around the edges of the license plates for safety.

Students should be aware of the debate and share their thoughts, but do not need to engage in a mock debate about who was first in flight.

If it is not possible to take students outside, this activity can be done in a hallway or gymnasium.

they are powered, distance, direction, time in air, how they landed, etc.).

4. Make a table on chart paper showing characteristics of flights for each type of plane and display for later use. Older students may copy this chart in their science journals.
5. Discuss the benefits of each type of plane – for example, the rubber band catapulted plane may be best if traveling in a straight line is what is most important, while the paper airplane may be best if doing flips in the air is most important. Discuss the challenges of each type of plane – for example, the propeller plane and catapult gliders will be less effective if the rubber band breaks.
6. Inform the students that over the next few days, they will be using the things they learned to solve a problem.

Day 3:

1. Review the section of the chart made during the previous lesson that deals with how the planes landed.
2. Have students imagine that they are only as tall as their fingernail, and that they need to get from one place in the classroom to another. Discuss which kind of plane they would want to ride on. Have students give reasons for their choices. Accept all responses.
3. Have students imagine sitting on different planes as they are landing. Discuss which plane would make them feel safest. Have students give reasons for their choices. Accept all responses.
4. On chart paper, draw a large bulls-eye. Explain to students that they will have to fly a plane with a passenger (show students the Lego figure) to the airport (represented by the bulls-eye) which will be 15 feet away.
5. Have students individually decide which type of plane they want to use, how they will attach the "passenger" to the plane, and how they will land the plane safely. Older students will write down their ideas and/or draw a sketch of their ideas.
6. Divide the class into groups of 2-3. Have the groups compare their ideas and come to a group decision about what they will try. Groups should draw and label a plan, including any materials they think they can use. Some students will choose to make adaptations to the plane while others may want to make a softer

First and second grade students can use measuring tapes and stopwatches to record mathematical data about each flight.

Encourage students to give reasons for their evaluations rather than saying something was "good" or "bad."

These discussions could also be done in partners or small groups depending on the age of your students. For pre-k students, this may work best in small groups while other students are at classroom centers.

It may be helpful to print pictures of the different flying machines and have students sketch around or on top of the pictures as they plan.

In pre-k, this can be done as a whole group or small groups while other students are at classroom centers.

landing area.

7. Collect the plans to review. You may choose to gather materials for students, have them bring materials from home, or a combination of the two.

Day 4

1. Pass out group plans. Remind students that they are trying to safely land a passenger at the "airport" 15 feet away. Allow students to gather their materials and begin building.
2. When students are finished building their flying machines, take everything outside where students can run their test flights.
    a. On a basketball court or sidewalk, make a circle on the ground with a 15-foot radius. You can use a string 15 feet long and a piece of chalk to draw the circle. If that is not possible, obtain a 50-foot long rope and stretch it into a circle on the ground.
    b. Place the bulls-eye in the center of the circle, taping or weighting it down so it does not blow away.
3. Have students take turns choosing a spot outside the circle from which to throw their flying machine. If students have chosen to try to pad the landing zone as a solution, they should place their designed padding on the bulls-eye before throwing.
4. Older students can use a tape measure to see how close to the bulls-eye each flight landed. These numbers can be added to a chart along with results regarding "passenger safety."
5. Depending upon time, you may allow students a second or third attempt.
6. Return to the classroom and analyze the results. Discuss these with the students. Have each group share their design with the class and talk about their data.

It is best to prepare the "airport" ahead of time. If this is not possible, have the students help.

To make a circle from a string 15 feet long, tie the chalk to one end, have one person stand in the center holding the other end of the string. Use the string as a compass to draw the circle.

To make a circle from a 50 foot rope, have your students hold the rope along its length, spread into a circle, connect the ends, and lay it on the ground.

Be sure not to allow students to throw their planes while others are taking measurements. Younger students can simply describe where their planes landed using relative location words (next to, on top of, in front, etc.).

Day 5

1. Read or paraphrase the pages beginning "Back to Kitty Hawk they went…" and the next page beginning "On December 17…" from My Brothers' Flying Machine: Wilbur, Orville, and Me by Jane Yolen, illustrated by Jim Burke. Ensure students understand that the Wright brothers had to overcome challenges in their first attempts at flight before they built a successful flying machine.
2. Review class data collected during the first flights. Have students share what things went wrong and why.

3. As a class or in small groups, brainstorm ideas on how to improve results. Have students draw a new diagram of their flying machine, landing mechanism and/or passenger safety plan.
4. Allow students time to plan and build an improved design. They will need to use materials available in the classroom; otherwise another day will need to be added in order for students to gather materials from home.
5. When students are prepared, take them outside to repeat the testing procedure from Day 4. Have students measure and record results.
6. In the classroom, display and read a copy of the telegram sent by the Wright brothers on December 17, 1903 announcing their success.
7. Instruct students to write a letter to their parents announcing their success in creating a flying machine.

In pre-k and kindergarten, this can be done whole group. In first and second grade, students should work in small groups.

If possible, display the telegram on a screen or board so all students can see it.

In pre-k and kindergarten, this can be done as a shared writing.

Resources:

News clippings of Wright brothers: http://www.paperlessarchives.com/wbscrapbooks.html

My Brothers' Flying Machine: Wilbur, Orville, and Me by Jane Yolen, illustrated by Jim Burke; ISBN 0-316-97159-6; 2003.

Airborne: A Photobiography of Wilbur and Orville Wright by Mary Collins, National Geographic Society, 2003. Includes a copy of the telegram on page 39.

The Story of Flight: Early flying machines, balloons, blimps, gliders, warplanes, and jets Scholastic, 1994.

Extensions:

Have students make a photo timeline of their life by bringing pictures of themselves at birth and at each birthday. Older students may bring photos of memorable events in a 1-2 year span. Arrange the photos along a timeline and have students label the dates and summarize the events.

Try different types of rubber bands inside the propeller-driven plane. See which flies farthest or fastest.

Find pictures of airplanes from different years. Create a photo timeline of how airplanes have changed.

Fly two different planes. Measure how far each flew in inches. Subtract to find the difference. Fly three planes and measure the distances travelled in inches. Use >, < and = to compare the three flights.

Make a bar graph showing how far different planes flew. Color the bars different colors to show the accuracy of each flight (e.g., green bars show planes that landed on target, yellow were close to the target, red were far from the target).

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm, and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Propellers

Grade Levels: PK-2

Summary & Purpose:

This propeller lesson is one of four lessons for pre-school through second grade students to study the Wright brothers and Paul Laurence Dunbar. Students will learn that wind is moving air, and that it can occur naturally or through human effort. Students will explore the differences between windmills and turbines, which transform naturally-occurring wind energy to mechanical or electrical energy, and propellers, which transform mechanical or electrical energy into wind energy. Students will use the engineering design process to develop a propeller design.

While propeller design is a limited field of study, this unit will address multiple science, social studies, math, and language arts standards. Students will learn that air is not just the empty space between objects, but that air has properties of its own. This will aid students' understanding of weather and how it changes. Students will also learn about force and energy. Most of all, students will be exposed to a rich, positive learning experience which will encourage further exploration and foster a love of learning.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. At the Huffman Prairie Flying Field Interpretive Center, located at the top of Wright Brothers Hill overlooking Huffman Prairie, as well as at the Wright-Dunbar Interpretive Center, visitors will find helpful information on propellers. The centers provide examples of the innovations in propeller design made by Orville and Wilbur Wright as well as the developments made after their involvement in the field of aviation ended. Models and descriptions of some of the propellers can also be found at the Huffman Prairie Flying Field Interpretive Center.

Essential Questions & Enduring Understandings:

1. **What is wind?** Wind is moving air. The sun heats the air, which makes it move around the earth.

2. **How can we describe things around us?** Objects and materials can be described by their properties, such as size, shape, color, texture, and buoyancy.

3. **How can people create wind?** One way that people can create wind is by using propellers that push, or propel, the air in one direction.

Lesson Overview:

Day 1	Explore propellers Discover differences between propellers and windmills
Day 2	Design and build propellers
Day 3	Analyze data from first tests Redesign propellers
Day 4	History/Writing lesson

Vocabulary:

blade – an arm of a propeller or windmill

failure point – the instance at which something no longer works as it was designed to work

hub – the center of a propeller or windmill where the blades attach

propeller – a device that spins in order to push air

properties – characteristics that define an object

wind – moving air; this occurs in nature as a result of the sun heating the surface of the Earth

Materials:

For the class:

- Chart paper
- Sticky notes
- Markers
- Hand-powered toy helicopter, 1 per student
- 1 – Bag play sand
- Tape measure, fabric

For each student team (2-3 students):

- 10 – Tinkertoy spools
- 1 – Tinkertoy rod, 10”
- 4 –Tinkertoy rods, 5”
- 4 – 3x5” index cards
- 1 – Roll of masking tape, 1.5”
- 1 – Half-gallon paper jug, empty
- 1 – Small funnel
- 1 – String, 48 inches

Hand-powered toy helicopters can be purchased from Dayton Aviation Heritage National Historical Park, your local hobby shop, or online.

If Tinkertoys are not available, propellers can be created using a Styrofoam ball as the hub and craft sticks with index cards as blades. If using these materials, each student group will need their own propeller assembly, as multiple groups cannot use the same piece of Styrofoam.

Background Information:

Orville and Wilbur Wright came to understand that a propeller works like a rotary wing. As the propeller spins, it generates thrust by creating a low-pressure area in front of the propeller and a high-pressure area behind. This makes the air move backward, pushing the plane forward at the same time. The airfoil shape of the propeller, the speed at which it spins, and other factors, affect the efficacy of the propeller.

For young students, discuss that air is all around us, that we breathe it, and that it can be moved. Demonstrate by blowing up a balloon and releasing the balloon to fly around the room.

Procedures:

Day 1:

1. Show the video “The Wright Brothers in Flight” at http://www.youtube.com/watch?v=q3beVhDiyio. Have students tell what they think is

pushing the airplane through the air. If necessary, watch the video again. Point out the propellers as they are started.

2. Have students share other objects they have seen that look like the propellers in the video. Write or draw each object on a sticky note and place on a sheet of chart paper. Some connections will likely be made to other propellers, while some students may have seen windmills or wind turbines. Include all student connections on the chart.
3. Take students outside. Give each student a hand-powered helicopter toy. Demonstrate how the toy works and discuss safety rules. Allow students to explore with the helicopters for a few minutes before collecting them and returning to class.
4. Show students the video "Crazy Windmills" at http://www.youtube.com/watch?v=Gu3EyzOYpGY. Have students share the connections they see between the propellers on the Wright Flyer, the hand-powered helicopters, and the wind turbines (referred to as windmills) in the video. Elicit that the propellers and helicopter toys make the air move, while the windmills/turbines are moved by the wind.
5. Look back at the sticky notes. Have students help categorize the notes into objects that work like propellers and objects that work like windmills. Students may not yet understand the difference, but will develop a greater understanding throughout this unit.
6. Show students a map of Dayton, Ohio with the locations of the Wright Cycle shop and Huffman Prairie marked. Discuss that Orville and Wilbur Wright worked on their propeller designs in Dayton, but travelled to Huffman Prairie to practice flying their planes. Using the map scale, show students approximately how far apart familiar places are (e.g., how far school is from home, how far school is from a familiar store or other landmark, and how far the school is from the Wright Cycle shop and Huffman Prairie).
7. Explain that in the next lesson, students will have an opportunity to design a propeller, just like the Wright brothers.

First and second grade students should be able to answer other questions about the map as well as using the title, map key, compass rose, and additional map features.

Although the Cycle Shop located in Dayton, Ohio, is one of the brothers' five original shops, it is not the location where they designed and built their Flyers. The Flyers were designed and built at their 1127 West Third Street location in Dayton. In 1936, Henry Ford acquired this shop and moved it to his museum in Dearborn, Michigan with Orville's support.

Day 2:

1. Before class, set up a space for students to test the propellers that will be created during today's lesson. Use clear tape to attach the 0" end of the measuring tape about 5 inches from the edge of a table. Stretch the measuring tape to the opposite end of the table and tape it taut to the table. Fold a single sheet of copy paper in half (hamburger bun style), and then unfold it so it can stand upright.

2. Review observations from Day 1. Introduce the vocabulary terms: propeller, blade, and hub. Have students identify the hub and blades on a hand-powered helicopter. Help students infer that the toy helicopter is a type of propeller.
3. Pass the toy helicopters out while instructing students not to fly them in the classroom. Have students examine them and share what they notice about how they are made. Record student comments on chart paper. Elicit that the blades of the helicopter are attached to the hub at an angle if students do not bring it up.
    a. Have students describe the physical characteristics of the helicopters: texture, color, size, and weight.
    b. Have students describe different ways to make the helicopter move: throwing, dropping, waving back and forth, or spinning (clockwise or counterclockwise).
4. Guide students to create a Tinkertoy propeller hub (Appendix B).
    a. Measure and add about 6 cups of sand to the jug using the funnel.
    b. Measure and mark two spots near the top in the center of opposite sides of the half-gallon jug. Using a sharpened pencil, carefully make a hole at each mark.
    c. Push a 10" Tinkertoy rod through the jug.
    d. Attach a Tinkertoy spool on one end of the 10" rod.
    e. Tie a knot in one end of the string. Slide the string into the opposite end of the 10" rod so the knot catches in the slit at the end of the rod. Tie another spool at the other end of the string.
5. Guide students to create propeller blades.
    a. Lay an index card flat on the table. Lay one 5" Tinkertoy rod lengthwise on top of the card, leaving room for the blade to be attached to the hub.
    b. Tape the rod to the card by putting masking tape along the length of the rod/card.
    c. Repeat with all remaining rods and cards to make 4 total blades.
6. Have students observe how the blades can be added to the hub to create a propeller.
7. Explain to students that they will be pushing, or propelling air with their propellers, just like the Wright brothers did, to help their

Students will likely be surprised by the fact that if a helicopter is held upside down and spun counterclockwise, it will fly upside down; and If a helicopter is spun clockwise (upside down or right-side-up), it will propel itself down.

For younger students, the teacher should create the base and hub of the propellers, as this is uniform for all students and not part of the design challenge. If this is done, have the students describe the assembly using relative location words such as over, under, in front, behind, etc.

Depending on the age of students and the instructional method, one propeller assembly (half-gallon jug with hub mechanism) for the class will be sufficient. A benefit of using Tinkertoys is that blades can be placed and removed easily, while the assembly can be reused as often as necessary, including year to year.

plane fly. To test the force of pushed air, or wind, a creased sheet of paper will be placed in front of the propeller. The farther away the paper can be blown over, the more wind is being created. The propeller will be powered by gravity – the string with the spool(s) on the back of the propeller will be wound around the rod and released (Appendix B). The students can control:

a. The number of blades on the propeller.
b. The angle of the blades on the propeller.
c. The number of Tinkertoy spools used as weights on the back of the propeller.

8. Instruct student groups to discuss how many blades they want to include on the propeller, how much they should be angled, and how many weights they want to use. Have students draw a picture of what they want their propeller to look like. Check student drawings.
9. Have students attach their propeller blades to the hub and add the weights to the string by removing the string from the end of the rod, threading the spools onto the string, and reattaching the string to the rod.
10. As student groups are ready, have them bring their propellers to the testing area. Set the jug on the table so the side of the jug with the propeller hub is at 0" and the string with weights is hanging over the edge of the table. Stand the paper so it opens toward the propeller with the corner created by the fold at the desired measurement. Have students predict whether the paper will be blown over. The goal is to find out how far away from the propeller the paper needs to be in order to stay standing.
11. Release the weight and record the results. Students should record the distance and success/failure.
    a. If students are successful at the first distance, move the paper farther away and try again. Repeat until the paper does not fall.
    b. If students are unsuccessful at the first distance, move the paper closer and try again. Repeat until the paper falls.
12. In a whole group, have student groups share the longest distance at which their propeller blew the paper over and the distance at which the propeller did not blow the paper over. Explain to students that this is called the failure point because the propeller was no longer able to produce enough force to blow the paper over.

Using a digital camera to document students' designs will help them remember what they did and inform changes, especially if students are sharing a single hub assembly.

Citizenship note: It is important to emphasize that engineers and scientists, like the Wright brothers, use their failures as tools to help them make their designs better. Point out the difference between the original Wright Flyer and the aircraft we see today. Explain that these changes were made in response to failures in early designs. Encourage students to make positive comments to one another during the discussions.

13. Have students present their designs to the class. As a class, discuss the similarities and differences between different groups' designs. Have students share their thoughts and insights about the propellers they created. Record responses on chart paper.

Day 3:

1. Review the list of thoughts and insights as well as procedures from the previous day.
2. Arrange all the propellers, with data sheets from the previous day, around the room in such a way that there is plenty of space between them. In their work groups, allow students time to view other groups' work.
    a. Students in pre-k and kindergarten should count the number of blades and weights used in different designs and compare whether they used more or less in their own design.
    b. Students in first and second grade should collect class data on a table and create a bar graph that displays each design's failure point.
3. Allow all groups a chance to improve their designs. They should draw another picture of what they want to do, create their improved propellers, and test them. Be sure students record their data.
4. As a class, discuss the changes that were made to the different designs during today's lesson, and the successes and failures the students experienced. Have students share what they learned.

Day3, step 2: Older students can carry a notebook or whiteboard around to make notes about others' work. Younger students should discuss what they see at each location. A piece of paper could also be placed beside each propeller for groups to leave comments. If students shared a single hub, be sure to take pictures and print them for this activity.

Have pre-k and kindergarten also describe the shapes they see – rectangles, circles, etc.

In general, as outlined in the Common Core ELA standards, students in pre-k and kindergarten should be able to answer questions on Bloom's lower levels with prompting and support. Students in first and second grade should be able to answer questions into Bloom's higher levels.

Day 4

1. Show students the front cover of <u>My Brothers' Flying Machine: Wilbur, Orville, and Me</u> by Jane Yolen, illustrated by Jim Burke. Ask students to make predictions about what will happen in the selection.
2. Read the book to the class. Pause to ask various grade and comprehension level-appropriate questions during the reading of this text. Focus on main events from the Wright brothers' lives, especially those during childhood and those related to the development of propellers.
3. Help students identify that receiving "the bat" was an event that inspired the Wrights' interest in flying. Explain that Dunbar's mother enjoyed the poems she heard read by the family for which she worked while a slave. Because of her love of poetry, she felt it

important for her children to read. This inspired Paul to begin reading and writing poetry at age six. (http://www.nps.gov/daav/historyculture/paullaurencedunbarslifestory.htm).

4. Read selections from Jump Back, Honey: the Poems of Paul Laurence Dunbar.
5. Have students choose something they want to be when they grow up and write about who or what inspires them. Collect their writings to form a class book, or compile them into "articles", modeling late 1800s newspaper styles similar to what the Wright brothers printed. These can be typed and set to look more "antique." This can be done easily on http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html

For pre-k and kindergarten students, this can be a shared writing, with each student dictating a sentence. The sentences can be typed into a class poem.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Paul Laurence Dunbar biography: http://www.poetryfoundation.org/bio/paul-laurence-dunbar

Newspapers from Wright era: http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers

School photo with Orville Wright and Paul Laurence Dunbar: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg

Propeller information: http://wrightstories.com/propeller-design-demonstrates-the-genius-of-the-wright-brothers/

My Brothers' Flying Machine: Wilbur, Orville, and Me by Jane Yolen, illustrated by Jim Burke; ISBN 0-316-97159-6; 2003.

Jump Back Honey: the Poems of Paul Laurence Dunbar by Paul Laurence Dunbar, illustrated by Ashley Bryan and Brian Pickney; ISBN 0786805730, 1999

Extensions:

Using hand-held, battery-operated fans and toy cars, attempt to attach the fans to the cars to make the cars move. Constraints could include making sure the fan blades can turn, the battery compartment is accessible, and the cars remain under control.

Examine a boat or submarine propeller along with propellers from airplanes. Compare and contrast the shapes and functions of each.

Locate photographs of propeller designs throughout time. Use the photographs to create a timeline.

Invite a park ranger from Dayton Aviation Heritage National Historical Park to visit your classroom.

References/Works Cited:

Paul Laurence Dunbar information from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/historyculture/paullaurencedunbarslifestory.htm

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm, and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Catapults

Grade Levels: PK-2

Summary & Purpose:

This catapult lesson is one of four lessons for pre-school through second grade students to study the Wright brothers and Paul Laurence Dunbar. Students will learn that it takes force to make an object move, and that the amount of force affects how much something moves. Students will experiment with adjusting variables in order to change an outcome, and will learn to persevere in solving problems. Students will consider the importance of a catapult to launching early Wright airplanes. Students will use their new knowledge to launch an object from a catapult and hit a target.

While catapult design is a limited field of study, this unit will address multiple science, social studies, math, and language arts standards. Students will learn that objects can be moved using mechanical force, and that force is required to move an object. This lays a foundation for students to explore simple machines and types of energy in later grades. Most of all, students will be exposed to a rich, positive learning experience which will encourage further exploration and foster a love of learning.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park consists of six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. Huffman Prairie Flying Field Interpretive Center displays the history of the Wright brothers' work after 1903, including their use of catapults. The brothers flew, tested and improved their planes at Huffman Prairie Flying Field. The field includes a replica of their catapult, a replica of a hangar used for storing their airplane, and information panels that discuss their work at the site. The Wright Company operated the first flying school, the Wright School of Aviation, at Huffman Prairie Flying Field. One hundred nineteen pilots, including three women, trained to fly at the flying field.

Essential Questions & Enduring Understandings:

1. **What makes things move?** An object moves when a force pushes or pulls on it.

2. **How can we change how far a catapult throws an object?** Changing the number of rubber bands (the force pulling on the arm of the catapult) or the length of the arm (the distance the arm has to travel) will change how far an object (the projectile) flies.

3. How does the engineering design process help a person solve a problem? The engineering design process helps a person organize their thoughts and ideas, think of possible solutions, and test those possibilities until an acceptable solution is reached.

Lesson Overview:

Day 1	View videos on catapults Discuss new information Learn about the engineering design process
Day 2	Explore the use of rubber bands as catapults Test catapult design variables Record and discuss data
Day 3	Review data Redesign and test catapults; record data Discuss student learning

Vocabulary:

catapult – a kind of machine that is used to propel objects

engineering design process – the steps an engineer or person takes to solve a problem involving science and math

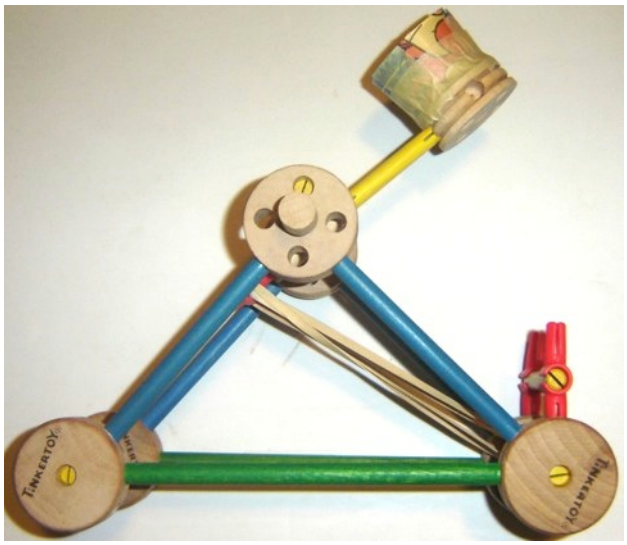
projectile – an object that is thrown into the air by force

variable – something that can be changed during a scientific experiment that will affect the outcome of the experiment

Materials:

For the class:

- Chart paper
- Sticky notes
- Tinkertoy catapult (Appendix C)



  - 4 – Blue rods
  - 4 – Yellow rods
  - 4 – Round spools – 1 center circle
  - 3 – Round spools – 5 center circles
  - 3 – Red connector clips
  - 2 – End caps
  - 1 – Coupling
  - 1 – Paper cup (4 oz.)
  - 3-5 – Rubber bands
- 1—Bag mini marshmallows
- 1 – Bucket
- Engineering design process poster (EDP) (Appendix A)

For each student team (2-3 students):

- 1-2 Cotton balls (for each student)
- 1-2 Rubber bands (for each student)
- Tinkertoy rods (2 of each color: orange, red, blue, green, yellow)

Tinkertoys can be ordered a la carte from the Hasbro website, in order to reduce the cost of buying full sets with pieces unnecessary to the design.

The bucket was chosen as a target that will catch a projectile landing in it, rather than letting it bounce or roll away. A cardboard box, punch bowl, or anything else that will catch a marshmallow will serve the same purpose.

- 1 – Ruler
- Copies of catapult diagram
- Tape measure (optional)

Background Information:

In order to achieve lift, the Wright brothers relied on headwinds. Through extensive experimentation, they concluded that headwinds of 11.8-14.9 mi/h (19-24 km/h or 5.3-6.7 m/s) would be needed to obtain lift for their glider. When the brothers were ready to attain flight, they decided that it was imperative they transport their machine to a location that offered more consistent headwinds than their hometown of Dayton, Ohio, provided. Therefore, they transported their flying machine components by train and boat to Kill Devil Hills, North Carolina.

At Kill Devil Hills they succeeded achieving pilot-controlled flight on a glider in 1902 and the first powered flight on December 17, 1903. To launch the machine, they used a combination of human power and headwinds, by running their flying machine down a single rail that was as long as 60 feet (18.29 m) for speed; headwinds then lifted the machine into the air. When returning to Dayton, Ohio they used Huffman Prairie, a cow pasture, to continue experimenting with a flying machine, but were not as successful due to continual battles with inconsistent wind speeds and changing wind direction. In 1904, they decided to rig a catapult to launch the machine down the rail. A 1,600-pound (726 kg) weight supported by a derrick, or tower, pulled the machine down the rail with enough speed to launch it into the air. On September 20, 1904, two weeks after first using the catapult, Wilbur completed their first circle and flew 4,080 feet (1.24 km) in approximately 1 minute 35 seconds. Dayton's inconsistent winds were no longer an obstacle to making flight practical; the catapult made it possible for the Wrights to fly anytime, anywhere without dependence on wind.

Catapults were developed long ago as engines of war, used to launch increasingly heavier projectiles at enemies from increasingly greater distances. The Wright brothers transformed a weapon of war into a catalyst for human flight.

Procedures:

Day 1:

1. Show the video "The Wright Brothers in Flight" at http://www.youtube.com/watch?v=q3beVhDiyio Point out the pyramidal structure with

the falling object seen behind the plane during takeoffs. Have students hypothesize about what that structure is.

2. Introduce the word catapult. Explain that a catapult is a kind of machine that is used to throw objects. Ask students which object the catapult in the video was throwing.
3. Explain that the Wright brothers used a catapult to launch their airplanes as they conducted flight tests at Huffman Prairie in Dayton, Ohio. However, catapults have been used for many other purposes throughout history.
4. Show students the video of the pumpkin catapult competition at http://matrix.static.nationalgeographic.com/video/places/culture-places/sports/us_catapultpumpkins/
5. Record student observations on a KWL chart – students should notice that some catapults were bigger than others and that some were like guns while others were like slingshots.
6. Introduce students to the Engineering Design Process (EDP). Display the EDP poster (Appendix A) and explain that when engineers need to solve a problem involving science and math, they work through different steps as they find the best solution to the problem.
    a. Question – Find out as much as you can about the problem.
    b. Think – Imagine different ways to solve the problem.
    c. Design – Choose one of your ideas, collect materials, and put it together.
    d. Test – Try your idea and see if it worked.
    e. Solution – If you did not solve the problem the first time, ask more questions and go through all the steps again.
7. Inform students that over the next two days, they will be using the engineering design process to help them find a way to launch mini marshmallows into a bucket.

There are various alternate forms to the KWL. Choose what is most familiar and appropriate for your grade level.

If possible, enlarge the EDP poster and display throughout the project. This process can also be used in other science and math activities. Students would benefit from repeated exposure to this process.

Depending on space, you could have students try to throw and launch their mini marshmallows into the target bucket used in the lesson.

Day 2:

1. Remind students about the catapults they saw on the video from Day 1.
2. Pass out cotton balls to each student. Have students stand in a line and throw their cotton balls as far as they can. Have students retrieve the cotton balls.
3. Distribute a rubber band to each student. Show them how to stretch the rubber band between their forefingers and thumb, put the cotton ball on the rubber band, and shoot it. Have students shoot their cotton balls with the rubber bands. Introduce the word **projectile** at this time.

4. Collect cotton balls and rubber bands as students return to their seats. Pass out Tinkertoy rods to pairs of students. Instruct them to examine the rods and describe their differences. Older students should use rulers to measure the pieces and record the measurements on a chart or graph.
5. Show students the model catapult (see the diagram in Materials section). Explain that there are components of the catapult that can be changed easily. Also, explain the way in which different components will affect how far the catapult will launch an object.
6. Demonstrate how to change the arms of the catapult and how to add rubber bands. Introduce the word **variable**. Explain that the length of the arm and the number of rubber bands are the variables that can be changed during this project.
7. Explain their design goals:
    a. Students will shoot a mini marshmallow 15 feet into a bucket.
    b. Catapult arms must be pulled all the way down to the yellow bar and released.
8. Explain how to operate the Tinkertoy catapult and model its use by launching a mini marshmallow.
9. Have students individually make a prediction about which color of rod should be used as the arm and how many rubber bands should be used to reach the target.
10. Form teams by placing students in pairs to compare their predictions, and explain how they made their choice.
11. Hand out appropriate grade-level Data Collection Chart (Appendix D, E, or F) for each pair to mark which variables they will test first.
12. Provide time and space for teams to test their plans.
    a. Each team will insert the rod of their choice into the catapult and attach the chosen number of rubber bands.
    b. Pull the catapult arm all the way back, aim, and release.
    c. Optional: Allow each team to complete up to three attempts of the same design (do not allow changes at this point).
13. Write each team's trial results on a class chart, record all changes in variables, including number of rubber bands and color of rod. Record the distance travelled by each shot. Students can use tape measures to measure whether the marshmallow was too short or too long from the target area (Appendix E or F depending on student level).

Younger students can measure distances to the closest whole number and circle whether their marshmallow landed too short or too far from the target (Appendix D).

Day 3:

1. Review the chart of catapult launch trials from the previous day.
2. Compare and contrast results based on changed variables. Encourage students to look for patterns.

3. Instruct each team to follow the previous procedures to sketch, build, and test a new design plan based on knowledge gained from initial testing results. Optional: Allow students to make up to three attempts.
4. Record the results of each trial on another chart. Hold a class discussion about the new results and compare them to the results on the initial chart.
5. Direct teams to follow the same procedure in creating a third design. Optional: Allow students to make up to three attempts. Chart the results, discuss the results, and compare to the previous results.
6. As a class, revisit the KWL chart and record student insights and learning (under L).
7. As appropriate for individual grade level, instruct students to write an informational text (a few sentences) about the project. Explain that they should include results, how and why adjustments were made (variables were changed) to the original design, and what they learned throughout the process.

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

Ancient Engineering Series – Catapults:
http://www.catapults.info

First Flight: The Story of the Wright Brothers by Caryn Jenner; ISBN 0-7894-9541-4; 2003.

Airborne: A Photobiography of Wilbur and Orville Wright by Mary Collins; ISBN 0-7922-6957-8; 2003.

First to Fly: How Wilbur and Orville Wright Invented the Airplane by Peter Busby, paintings by David Craig; ISBN 0-375-81287-3; 2002.

Extensions:

Have students design their own catapult using materials other than Tinkertoys.

Have multiple targets placed at varying distances. See which student pairs are able to hit more than one target.

Locate photographs of catapult designs throughout time. Use the photographs to create a photo timeline.

Invite a park ranger from Dayton Aviation Heritage National Historical Park to visit your classroom.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

The Engineering Design Process poster was developed at the Dayton Regional STEM Center in Dayton, Ohio http://www.daytonregionalstemcenter.org

Paul Laurence Dunbar

Grade Levels: PK-2

Summary & Purpose:

This Paul Laurence Dunbar and printing process lesson is one of four lessons for pre-school through second grade students to study the Wright brothers and Paul Laurence Dunbar. Students will learn about the relationship between Paul Laurence Dunbar and the Wright brothers, the history of printing and publishing, the techniques and technologies used for printing and publishing, and how the printing press and later printing technologies have affected daily life. Students will experience poems written by Dunbar as well as other period poems, specifically selections about the "Goops," stories Orville and Wilbur Wright read to their nieces and nephews to teach them about good manners.

This unit will address language arts and social studies standards. Students will learn about historical events that have changed society, respond to literature in writing, and publish their writing for a wider audience.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park commemorates, among other things, the history of Orville and Wilbur Wright's printing business and Paul Laurence Dunbar's literary successes. At the Wright-Dunbar Interpretive Center, visitors will find significant information on both the Wrights' printing business and Paul Laurence Dunbar. The center displays many of Dunbar's literary works as well as a restored Wright brothers' print shop and a printing press similar to one the Wright brothers operated. The Dunbar House, a house originally purchased by Dunbar for his mother, and the house where he passed away in 1906, became a state memorial in 1938, the first to publicly honor an African American. At the Dunbar House visitors will find significant information about and artifacts from Paul Laurence Dunbar's life.

Essential Questions & Enduring Understandings:

1. **How have changes in printing changed society?** The invention of the printing press made books and literature more accessible to everyone. Modern printing techniques have made all kinds of printed material easy for anyone to get and read. More people are able to read and write because of these inventions.

2. **What made Paul Laurence Dunbar so important?** Dunbar was the first widely-known African American writer. He was able to write the way people speak. He travelled all over sharing his writings.

3. **How can we write poems?** Using the right words and sharing what we think and feel is what it takes to write poetry.

Lesson Overview:

Day 1	View the book, *Jump Back Honey, the Poems of Paul Laurence Dunbar* Read poetry Write poems
Day 2	Learn about relationship between Dunbar and the Wright brothers Model the differences between different printing methods View modern newspaper printing video
Day 3	Read "The Goops and How to Be Them" Learn about writing for an audience Write and publish reports in a class newspaper

Vocabulary:

dialect – a special way that a certain group of people speak

printing press – a tool that allows people to print pages of text quickly by setting letters in a form, adding ink, and pressing paper on it

publishing – printing something for others to see or read

rhyme – words that have similar sounding endings

Materials:

- Stamp and ink
- Computer
- Paper and pencils

Background Information:

As entrepreneurs, Orville and Wilbur Wright became business partners in 1889 when they opened their printing shop. They edited and published newspapers, and printed advertising and news circulars for customers. They also printed an African American newspaper, the *Dayton Tattler*, written and edited by Paul Laurence Dunbar. In 1899 the Wright brothers sold their printing business so they could experiment with flying.

Paul Laurence Dunbar and Orville Wright were classmates and acquaintances at Dayton Public School's Central High School. Dunbar was the editor of the high school newspaper, *High School Times.* When Dunbar decided to publish a newspaper, the *Dayton Tattler,* for Dayton's African American community, he asked Orville and Wilbur to print it for him. Unfortunately, the newspaper did not last long, and they only printed three editions. He began creating poetry at the age of six, reciting poetry publicly at the age of twelve, publishing at the age of fourteen, and selling his first book of poetry at the age of twenty. Dunbar is credited as being the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers.

Procedures:

Day 1:

1. Show students the book *Jump Back Honey, the Poems of Paul Laurence Dunbar*. Page through and allow students to view the pictures. Discuss the differences in fashion between then and now.
2. Read two poems from the book. Choose one in dialect and one in standard English. Discuss the differences between the two. Discuss the big ideas/topics of the poems.
3. Have students identify rhyming words in the poems.
4. Have students write poems. For younger students, choose a topic and have each child give a line about that topic to create a class poem.

Day 2:

1. Discuss the relationship between Paul Laurence Dunbar and the Wright brothers.
    a. Dunbar and Orville Wright went to Central High School together in Dayton, Ohio.
    b. Dunbar published a newspaper called *The Tattler,* or *Dayton Tattler*, which was published from December 1890 to January 1891 and printed by the Wright brothers.
2. Read selections from The Story of Writing and Printing, focusing on the pages of the printing press and modern printing. Discuss how the changes in printing have affected modern life. Have students hypothesize about the time it took to publish things before the printing press, after the printing press, and after the modern computer printers.
3. Show students a rubber stamp with a phrase written on it. Show students how to ink the stamp on a stamp pad and press it on a piece of paper.
4. Divide the class into 3 groups.
    a. Give the first group paper and pencils and have them write the phrase as many times as they can in 3 minutes.
    b. Give the second group the stamp and have them stamp the phrase as many times as they can in 3 minutes.
    c. Put the third group on the computer and have them type the phrase once, then use copy and paste to make as many digital copies as possible in 3 minutes.
5. Discuss the results with the students. Discuss the effects of being able to make perfect copies in faster and faster ways (increased availability, decreased prices, more widespread literacy, etc.).
6. Show students a video of a newspaper printing house. http://www.youtube.com/watch?v=q2RU4d9xu5k

Day 3:

1. Read students another poem by Dunbar. Read a few pages from Goops and How to Be Them by Gelett Burgess.
2. Discuss the audiences for whom these works were written. (Dunbar wrote for adults, Burgess for children.) Discuss the purpose of each work. (Entertainment for Dunbar, education for Burgess.)
3. As a class, set the purpose and audience for writing a report about what students learned regarding literature and the printing process.
4. Allow students time to write, edit, and rewrite their reports. For younger students, this can be done as a shared writing activity.

5. Publish the reports and poems in a class newspaper. This can be done easily on http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

Excerpts from the Dayton Tattler:
http://dbs.ohiohistory.org/africanam/nwspaper/tattler.cfm

Biographies of Paul Laurence Dunbar:
http://www.poetryfoundation.org/bio/paul-laurence-dunbar
http://en.wikipedia.org/wiki/Paul_Laurence_Dunbar

Full version of Goops and How to Be Them by Gelett Burgess: http://www.books.google.com (search the title of the book)

The Story of Writing and Printing by Anita Ganeri

Extensions:

Have students make stamps from potatoes, rubber blocks, or foam. Use the stamps to create patterns and pictures to display in the classroom.

Invite a park ranger from Dayton Aviation Heritage National Historical Park to visit your classroom.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Dayton Aviation Heritage National Historical Park
Alignment of Standards for Pre-K through Second Grade

	Flying Machines	Propellers	Catapults	Printing Process and Paul Laurence Dunbar
Science				
PK – Weather changes every day.	X	X	X	
PK – Objects and materials are described by their properties.	X	X	X	
K – Weather changes are long-term and short-term.	X	X	X	
K – Objects and materials can be sorted and described by their properties.	X	X	X	
1 – Objects can be moved in a variety of ways, such as straight, zigzag, circular and back and forth.	X	X	X	
2 – The atmosphere is made up of air.	X	X	X	
2 – Forces change the motion of an object.	X	X	X	

Social Studies				
PK.2. People develop an awareness of their personal histories.	X	X	X	X
PK.4. Relative location can be described by words such as *up, down, over, under, here, there, front, back, behind* and *in front.*	X	X	X	
K.1. Time can be measured.	X			
K.2. Personal history can be shared through stories and pictures.	X		X	X
K.5. Terms related to direction and distance, as well as symbols and landmarks, can be used to talk about the relative location of familiar places.		X		
K.6. Models and maps represent places.	X	X		
1.1. Time can be divided into categories (e.g., months of the year, past, present and future).	X	X	X	X
1.2. Photographs, letters, artifacts and books can be used to learn about the past.	X	X	X	X
1.3. The way basic human needs are met has changed over time.			X	X
1.4. Maps can be used to locate and identify places.	X	X		
1.5. Places are distinctive because of their physical characteristics (land forms and bodies of water) and human characteristics (structures built by people).	X			
2.1. Time can be shown graphically on calendars and timelines.	X		X	X
2.2. Change over time can be shown with artifacts, maps, and photographs.	X			X
2.3. Science and technology have changed daily life.	X	X	X	X

2.4. Biographies can show how peoples' actions have shaped the world in which we live.	X	X	X	X
2.5. Maps and their symbols can be interpreted to answer questions about location of places.	X	X		
2.13. Information displayed on bar graphs can be used to compare quantities.	X	X	X	

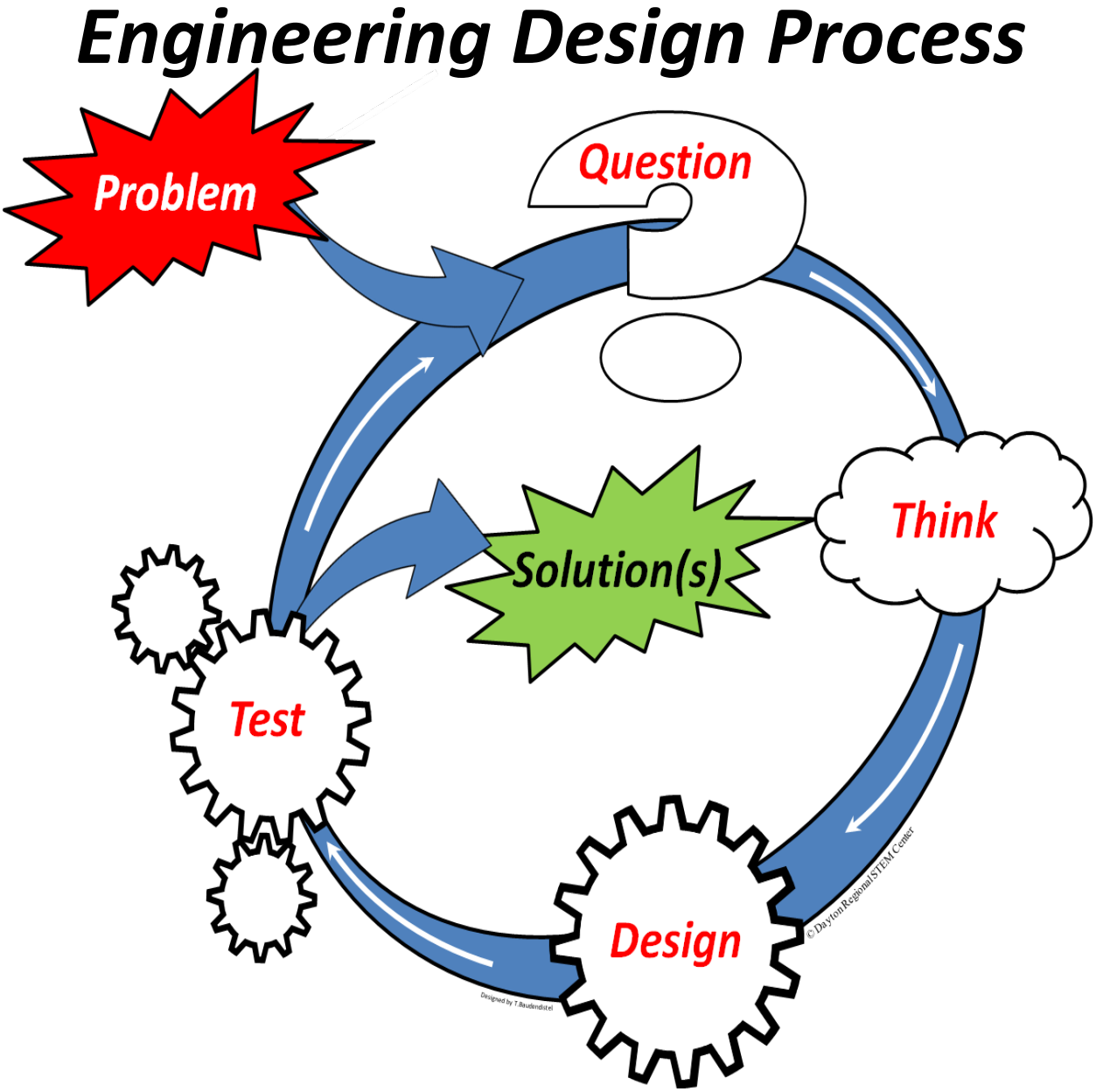
Mathematics				
PK.CC.5. Understand the relationship between numbers and quantities; connect counting to cardinality.		X	X	
PK.CC.6. Identify whether the number of objects in one group is greater than, less than or equal to the number of objects in another group up to 10.		X	X	
PK.MD.1. Describe measurable attributes of objects, such as length or weight. Sort, order and classify by one attribute.		X	X	
PK.G.1. Describe objects in the environment using names of shapes and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind and next to.	X	X	X	
K.CC.5. Count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array, or a circle, or as many as 10 things in a scattered configuration; given a number from 1–20, count out that many objects.		X	X	
K.CC.6. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies.		X	X	
K.MD. 1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.		X	X	
K.MD.2. Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter.		X	X	
K.G.2. Correctly name shapes regardless of their orientations or overall size.		X	X	
1.MD.2. Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.	X	X	X	
1.MD.4. Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.	X	X	X	
2.MD.1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.	X	X	X	
2.MD.3. Estimate lengths using units of inches, feet, centimeters, and	X	X	X	

meters.				
2.MD.4. Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.	X	X	X	
2.MD.9. Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units.	X	X	X	
2.MD.10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.	X	X	X	

English Language Arts				
K.RI.1. With prompting and support, ask and answer questions about key details in a text.	X	X	X	X
K.RI.3. With prompting and support, describe the connection between two individuals, events, ideas in a text.	X	X	X	X
K.RI.6. Name the author and illustrator of a text and define the role of each in presenting the ideas or information in a text.	X	X	X	X
K.RL.3. With prompting and support, identify characters, settings, and major events in a story.	X	X	X	X
K.W.1. Use a combination of drawing, dictating, and writing to compose opinion pieces in which they tell a reader the topic or the name of the book they are writing about and state an opinion or preference about the topic or book (e.g., My favorite book is . . .).		X	X	X
K.W.2. Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.	X	X	X	X
K.SL.1. Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups.	X	X	X	X
K.SL.2. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood.	X	X	X	X
K.SL.3. Ask and answer questions in order to seek help, get information, or clarify something that is not understood.	X	X	X	X
1.RL.3. Describe characters, settings, and major events in a story, using key details.	X	X	X	X
1.RI.1. Ask and answer questions about key details in a text.	X	X	X	X
1.RI.3. Describe the connection between two individuals, events, ideas, or pieces of information in a text.	X	X	X	X
1.RI.6. Distinguish between information provided by pictures or other illustrations and information provided by the words in a text.	X	X	X	X
1.W.1. Write opinion pieces in which they introduce the topic or name the book they are writing about, state an opinion, supply a reason for the		X	X	X

opinion, and provide some sense of closure.				
1.W.2. Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.	X	X	X	X
1.SL.1. Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.	X	X	X	X
1.SL.2. Ask and answer questions about key details in a text read aloud or information presented orally or through other media.	X	X	X	X
1.SL.3. Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood.	X	X	X	X
2.RI.1. Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.	X	X	X	X
2.RI.3. Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.	X	X	X	X
2.RI.6. Identify the main purpose of a text, including what the author wants to answer, explain, or describe.	X	X	X	X
2.RL.3. Describe how characters in a story respond to major events and challenges.	X	X	X	X
2.W.1. Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., because, and, also) to connect opinion and reasons, and provide a concluding statement or section.	X	X	X	X
2.W.2. Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section.	X	X	X	X
2.SL.1. Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.	X	X	X	X
2.SL.2. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.	X	X	X	X
2.SL.3. Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.	X	X	X	X

Appendix A – Engineering Design Process



Question – Find out as much as you can about the problem.

Think – Imagine different ways to solve the problem.

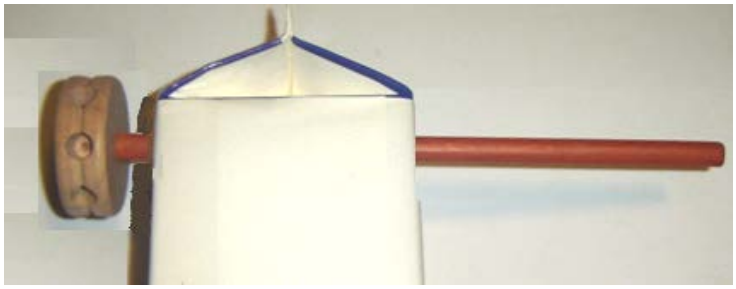
Design – Choose one of your ideas, collect materials, and put it together.

Test – Try your idea and see if it worked.

Solution – If you did not solve the problem the first time, ask more questions and go through all the steps again.

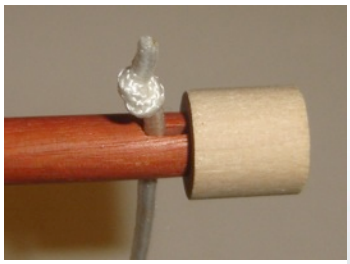
Appendix B – How to Assemble a Tinkertoy Propeller

1. Make a hole near the top of opposite sides of the carton. Make it just big enough to slide the Tinkertoy rod through, while allowing it to spin easily. Measure to make sure the holes are level. Push the orange Tinkertoy rod through the center hole of the spool. Push the rod through both holes of the carton.



2. Tape a red rod onto an index card to make a blade. Make as many as needed.

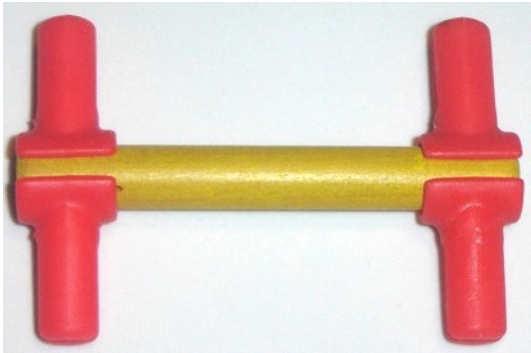
3. Tie a knot in one end of the string. Slide it into the slot at the opposite end of the orange rod. Place an end cap over the end of the rod. Tie one spool onto the end of the string. Other spools can be added by removing the end of the string from the top, sliding the spool on, and replacing the string and end cap.

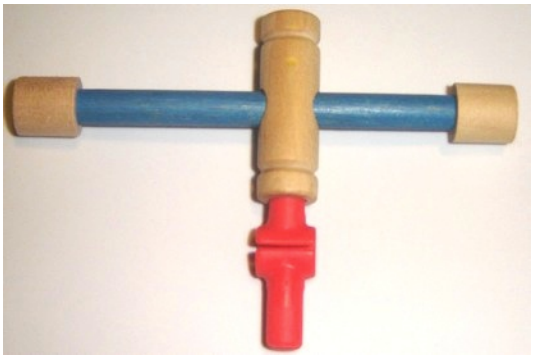


4. Blades can be inserted into the spool as shown. Students will determine how many and at what angle they will be inserted. Students will also determine how many spools need to serve as a counterweight to power the propeller.

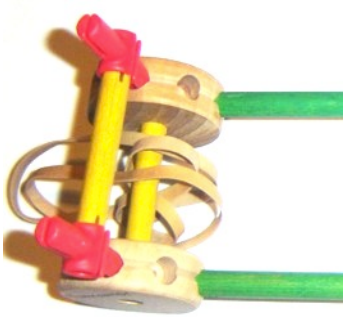
Appendix C – How to Assemble the Tinkertoy Catapult

1. Assemble the components as shown below:



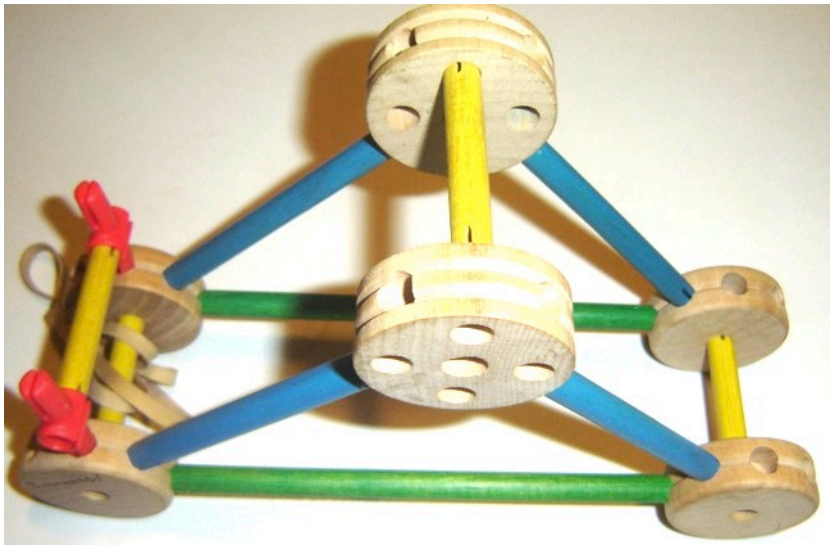


2. Cut the paper cup around the middle so it is approximately one inch tall before taping it to the 5-hole spool. This will make it easier to launch the marshmallows.



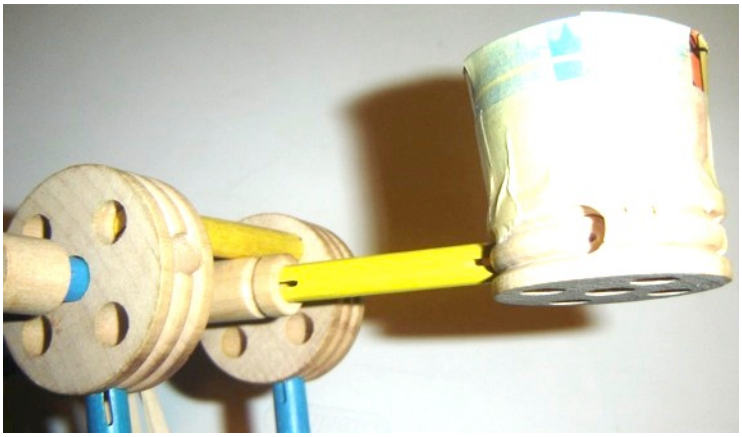
3. Attach the two red connector clips and yellow rod just above the rubber bands. This will let students know how far back to pull the catapult arm.

4. Connect the two 5-hole spools with the yellow rod and connect the blue rods to the base assembly. The triangle structure makes this structure strong and durable.



5. At the top of the triangle structure, through the center holes in the 5-hole spools, slide in the blue rod and the coupling assembly. Be sure the top of the coupling faces back toward the rubber bands and the slit on the red connector clip faces away from the rubber bands. This will allow you to connect and disconnect the rubber bands easily.

6. Attach the spool with the cup to the coupling with a rod of any color.



The rod that holds the cup and the number of rubber bands are the variables that the students will test. Teach students how to manipulate those variables.

Appendix D – Data Collection Chart (basic)

Testing Variables – Too Short or Too Far

*For each variable tested, circle **too short** or **too far**.*

	1 rubber band	2 rubber bands	3 rubber bands	4 rubber bands
Yellow rod	too short too far	too short too far	too short too far	too short too far
Blue rod	too short too far	too short too far	too short too far	too short too far
Red rod	too short too far	too short too far	too short too far	too short too far
Green rod	too short too far	too short too far	too short too far	too short too far
Orange rod	too short too far	too short too far	too short too far	too short too far

Appendix E – Data Collection Chart (medium)

Testing Variables – Too Short or Too Far

Record results for each variable combination tested.

	1 rubber band	2 rubber bands	3 rubber bands	4 rubber bands
Yellow rod				
Blue rod				
Red rod				
Green rod				
Orange rod				

Appendix F – Data Collection Chart (advanced)

Testing Variables – Too Short or Too Far

Record the distance from the target for each combination of variables.

Third through Fifth Grade

Flying Machines

Grade Levels: 3-5

Summary & Purpose:

This flying machine lesson is one of four lessons for third through fifth grade students to study the Wright brothers and Paul Laurence Dunbar. This section may be taught alone or with any other sections chosen by the instructor. Students will learn the history of flying machines, from the first hot air balloons to modern airplanes. Students will learn about the contributions of various historical figures, especially Orville and Wilbur Wright, and engage in a "First in Flight" debate. They will explore several types of flying machines, analyzing the positive and negative aspects of each, and use the engineering design process to safely land their prototype flying machines.

The field of aeronautics and the questions about flight are vital to the age in which we live. Therefore, this unit will address multiple science, social studies, math, and language arts standards as students explore aeronautics. Students will learn about how the weather changes and why those changes were so important to the first flight. Students will explore forces and energy. Resources will be used to research the past and represent events on timelines.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. The Wright-Dunbar Interpretive Center houses some artifacts and replicas from the earliest Wright Flyers, including a model of the first Wright Flyer engine. The Huffman Prairie Flying Field Interpretive Center highlights the history of flight from the first flight to the modern era of air travel. At the Huffman Prairie Flying Field Interpretive Center, visitors will find various models of planes, videos, and hands-on exhibits of flight. They will also experience a flight simulator modeled after an early military Wright Flyer. The Huffman Prairie Flying Field includes a replica of a hangar and a catapult similar to those utilized by the Wright brothers. Signs and placards throughout the park sites also give a rich and detailed history of flight.

Essential Questions & Enduring Understandings:

1. **How does a heavier-than-air flying machine work?** Air takes up space and has mass. Faster moving air is less dense than slower moving air. When the air under a flying machine is denser than that on the top, the machine is lifted by air. This is achieved by curving the wing on the top (camber) so that air moves faster over the top of the machine than it does along the bottom.

2. **How can a human's force be exerted in order to provide energy that moves an object?** The muscles in a human body contract in order to throw, push, or pull an object. The energy from the muscles is transformed from the human to the object, causing the object to move.

Lesson Overview:

Day 1	Introduce history of flight, including first flight pictures Discuss first in flight View Wright brothers' "Inventing Flight" story Discuss debate about first state in flight
Day 2	Present design challenge View "The Quest for Flight" video to explore the principles of flight Plan design
Day 3	Build and test flying machine Record results
Day 4	Redesign and test again

Vocabulary:

camber – the curve of a wing

energy transformation – the change of energy from one form to another

dirigible – a type of flying machine that used lighter-than-air gasses inside a giant balloon

drag – a force pushing against an object moving through the air

flying machine – anything created by humans to help them fly

glider – a type of flying machine that does not have an engine

lift – to bring something up off the ground

pilot – a person who flies a flying machine

thrust – a force that pushes an object forward

weather – the conditions of wind, precipitation, and temperature outside

Materials:

For the class:

- 1 - Hula hoop

Suggested materials for student teams to choose from:

- Balsa wood
- Poster board
- File folder
- Tissue paper
- Egg carton and/or meat tray foam
- Thin sheet of cardboard
- Play dough
- Popsicle sticks
- Glue
- Masking tape
- Tape measure
- Stopwatch
- Marshmallow passenger
- Paper

Use readily available materials. Students will surprise you with their ability to design something that flies and meets their challenge.

Background Information:

Over the past 600 years, various people have made attempts at flight with various levels of success. Leonardo da Vinci designed flying machines from 1485-1500, but never attempted to build or fly any such machines. The first flying machine was a hot air balloon, flown by the Montgolfier brothers in 1783. In 1849, in a glider designed by George Cayley, a 10-year-old boy made short hops in the air. In 1890, Clement Ader made a short, powered hop in the air in a flying machine, but the flight was neither sustained nor controlled. From 1891-1896, a German man named Otto Lilienthal made numerous flights in his gliders until he died in an 1896 crash. Orville and Wilbur Wright learned from many of these people as they designed the first

successful powered, heavier-than-air, practical flying machine. The debate over "First in Flight" involves many of these people.

Procedures:

Day 1:

1. Engage students in a discussion about who was first to fly. Students will most likely answer that the Wright brothers were first. View photos of early flying machines: https://www.google.com/search?q=early+flying+machines&client=gmail&rls=gm&tbm=isch&tbo=u&source=univ&sa=X&ei+soASPv4GoDA&ved=OCCsQsAQ&biw=1231&bih=875
2. Post the following dates and ask students if after viewing the photos and dates, they think the Wright brothers or others were first to fly.
   1783 – First person flies in hot air balloon
   1852 – First person flies in a dirigible (blimp)
   1853 – First person flies in a glider
   1903 – Wright brothers' first flight in Kitty Hawk, North Carolina
   1904 – Wright brothers fly in Dayton, Ohio

3. View and discuss "Inventing Flight" video: http://video.thinktv.org/video/1504588618/
4. Show students pictures of Ohio and North Carolina license plates. Ask students to share their thoughts on the slogans "Birthplace of Aviation" and "First in Flight."

Day 2:

1. Divide the class into teams of 3-4 students and introduce the engineering design process: http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A)
2. Present students with the engineering challenge of constructing a flying machine (Appendix B). Also show students materials available for their design.

Flight challenges listed are suggestions; you may think of challenges that are more suitable to your students and classroom logistics.

3. Assign each team a different flight challenge: longest distance, safest landing, ability to land on a specific target, ability to turn (bank) in a specified direction, or ability to fly through a hoop.
4. Show students the following video clips about the principles of flight: "The Quest for Practical Flight" http://www.nps.gov/featurecontent/daav/quest/index.html Have them

take notes about problems the Wright brothers encountered and how they solved each problem in order to achieve successful flight (Appendix C).

5. Have students share and discuss their notes with their team as they brainstorm and record ideas for constructing their own flying machine successfully.
6. Guide students in deciding which data is most important to measure and record in order to show if their team is successful in completing their assigned challenge (i.e., for ability to land on a specified target, they could record whether the flying machine landed on the target or not and the distance from the target the machine landed). Have them draw columns for each form of data they will record on the table in Appendix B.
7. Ask students what will provide the energy to power their flying machine. They should understand that their muscles will power it by providing a force which is transformed from their body's energy to the machine, thus causing the machine to achieve motion.
8. Direct teams to discuss design possibilities and sketch a design plan.

Because each team will have a unique challenge, their collected data will be unique as well. This is great practice for them to decide what information is important when designing an experiment.

If students are able to test their flying machines as they work, they will be more successful. Consider reserving time in the gym or taking students outside.

Day 3:

1. Distribute materials and instruct students to begin building their flying machine.
2. Provide room for teams to test their machine throughout the design process.
3. Explain to them that based on their initial tests, they will need to choose one variable to change before testing again. Discuss possible variables to change.
4. Inform students that engineers research and collaborate with each other as they complete projects. Therefore, they too should observe other teams' flight tests and learn from them.

Day 4:

1. Allow time for students to test and modify their flying machines once more.
2. Hold a flight symposium in which each team shares their design challenge with the class, explains their flying machine design, describes the results of their tests, and demonstrates how their machine works.
3. After the symposium, allow time for teams to discuss their successes and failures throughout the design process and decide how they could improve the design if given a chance to start over.

Social Studies and Language Arts Integration:

Social Studies:

1. Instruct teams to research and begin a flight timeline that includes the history of flight along with several other major historical events beginning with the first flying glider and ending at the present day.
2. Direct teams to compile their research and write a newspaper article about the Wright brothers' successful flight, and how aviation has advanced since then.
3. Direct students to also write a newspaper article reporting information about their team's design, data, successes, failures, and suggestions for future improvements. Then explain how flying machines are able to fly through the air.

Language Arts:

1. Instruct students to write newspaper articles using their research from social studies and data from science.
2. Have students take on the role of Orville or Wilbur and write a letter to their father or sister, Katharine, about the problems they faced and how they solved them.
3. Have students write a letter to their own families about the problems they faced throughout the flying machine design process and how they solved them.

The following three assignments can be jigsawed within the team. Each team member is responsible for completing one section. After articles are finished, the team can convene to share their information. Finally, they should take time to edit each other's articles before publishing into the final newspaper.

Resources:

Engineering design process: http://www.daytonregionalstemcenter.org/engineering-design-process/

"Inventing Flight" video: http://video.thinktv.org/video/1504588618/

News clippings of Wright brothers: http://www.paperlessarchives.com/wbscrapbooks.html

Photos of early flying machines: https://www.google.com/search?q=early+flying+machines&client=gmail&rls=gm&tbm=isch&tbo=u&source=univ&sa=X&ei+soASPv4GoDA&ved=OCCsQsAQ&biw=1231&bih=875

"The Quest for Practical Flight" video:
http://www.nps.gov/featurecontent/daav/quest/index.html

Extensions:

Take a field trip to Dayton Aviation Heritage National Historical Park.

Invite a ranger from Dayton Aviation Heritage National Historical Park to visit your classroom and present the design challenge to students.

Invite families and a park ranger from Dayton Aviation Heritage National Historical Park to attend a design symposium. If you are completing several of the design challenges in this guide, hold the symposium as a culminating activity after all lessons are completed.

Hold a design challenge family night for students to complete the challenges again with their families. Engineers, after all, do continue to improve their initial designs.

Display photos of airplanes throughout history and analyze them for design changes over time.

References/Works Cited:

Wright Brothers information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Propellers

Grade Levels: 3-5

Summary & Purpose:

This propeller lesson is one of four lessons for third through fifth grade students to study the Wright brothers and Paul Laurence Dunbar. This section may be taught alone or with any other sections chosen by the instructor. Students will learn that wind is moving air, and that it can occur naturally or through human effort. Students will explore propellers, which transform mechanical and/or electrical energy into wind energy to create propulsion. Students will use the engineering design process to develop a propeller design.

While propeller design is a limited field of study, this unit will address multiple science, social studies, math, and language arts standards. Students will learn that forces cause changes in an object's motion. They will also learn that potential energy is stored in an object, and when released is transformed into kinetic energy, or motion. This lays the foundation for the study of Newton's Laws of motion in later grades.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. At the Huffman Prairie Flying Field Interpretive Center, located at the top of Wright Brothers Hill, overlooking Huffman Prairie, as well as at the Wright-Dunbar Interpretive Center, visitors will find helpful information on propellers. The centers provide examples of the innovations in propeller design made by Orville and Wilbur Wright as well as the developments made after their involvement in the field of aviation ended. Models and descriptions of some of the propellers can also be found at the Huffman Prairie Flying Field Interpretive Center.

Essential Questions & Enduring Understandings:

1. **How does force cause an object to speed up or slow down?** Forces cause changes in an object's motion. If an unbalanced force acts on an object, it will either increase or decrease its speed. If an object is not moving, all the forces acting on it are equal, so the object remains at rest. This motion, or speed, can be calculated by dividing distance by time (s = d/t).

2. **How can the potential energy in a rubber band be transformed into kinetic energy to create motion?** When a rubber band is stretched, it has stored, potential, energy. When it is released, the stored energy is transformed into kinetic energy, or the energy of motion.

A common misconception is that if an object is not moving, there are no forces acting upon it. Forces of friction, gravity, air pressure, etc. are constantly acting upon objects. When all forces are balanced, the object is at rest.

Lesson Overview:

Day 1	Explore propellers Present design challenge Silently view available materials Sketch individual propeller design plan
Day 2	Teams discuss individual design plans Teams choose and sketch a team design plan Begin propeller construction
Day 3	Complete construction Test, redesign, test again Record test data
Day 4 (optional)	Attach propellers to flying machines Test, redesign, test again Record test data

Vocabulary:

blade – an arm of a propeller or windmill

hub – the center of a propeller or windmill where the blades attach

kinetic energy – the energy an object has when in motion

potential energy – the energy of a system that is stored

propeller – a device that spins in order to push air

properties – characteristics that define an object

propulsion – the process of pushing an object forward

shaft – a spinning bar used to move an object such as a propeller

thrust – a pushing force

wind – moving air; this occurs in nature as a result of the sun heating the surface of the Earth

Materials:

For each student team (3-4 students):

- 2-4 – 20 Gauge wire, 9 ½" pieces (propeller blades)
- 2-4 – K'nex standard rods, dark blue, 2 ¼" (propeller blades)
- 1 – Box plastic wrap
- 1 – Hand-powered toy helicopter
- Stopwatch

For each propeller hub and shaft (at least one per class) (Appendix D):

- Craft wire, 6" sections precut (1 per propeller blade)
- 3 – Large paperclips
- 1– Package 7" rubber bands (file folder rubber bands work well)
- 2 – 20 gauge wire, 17" pieces (used for support)
- 1 – 50 lb. fishing line, ~10' piece

Hand-powered toy helicopters can be purchased from Dayton Aviation Heritage National Historical Park, your local hobby shop, or online.

K'nex parts may be purchased individually at the following website: http://www.knex.com/Shop/home.php?cat=339

- 1 – Lightweight tubing, 8 ¾" piece (shower curtain rod cover, found at home improvement stores, works well)
- 1 – Bottle super glue
- 6 – K'nex standard rod, dark blue, 2 ¼"
- 1 – K'nex standard circular connector, white
- 2 – K'nex standard connectors, blue
- 3 – K'nex standard connectors, dark grey

Background Information:

Orville and Wilbur Wright came to understand that a propeller works like a rotary wing. As the propeller spins, it generates thrust by creating a low-pressure area in front of the propeller and a high-pressure area behind. This makes the air move backward, pushing the plane forward at the same time. The airfoil shape of the propeller, the speed at which it spins, and other factors affect the efficacy of the propeller.

Procedures:

Prior to Day One:

1. Build the propeller hub and shaft as shown (Appendix D). If possible, build more than one to allow for more testing and modification time.
2. Prepare fishing line by hanging it taut at a slight downward angle across an area of the classroom where it will not be disturbed. Attach the ends to objects that will remain stationary during use. Be sure students are able to reach the fishing line.

Day 1:

1. Show the video "The Wright Brothers in Flight" at http://www.youtube.com/watch?v=q3beVhDiyio. Have students record their observations about what is creating propulsion to push the plane through the air.
2. Think-Pair-Share: Activate prior knowledge by having students record what they know about propellers and how they push, or propel, a plane (2-3 minutes). Instruct them to share thoughts with a partner and record any additional ideas gained through discussion (3 -5 minutes). Then ask students to share ideas with the class while additional ideas gained through sharing are recorded (Appendix E).
3. Give each team a hand-powered helicopter toy to fly and observe outside or in a gym. Demonstrate how the toy works and discuss safety rules. Allow students to explore with the

helicopters for a few minutes while recording their observations about how propellers work.

4. Allow time for student teams to analyze the toy helicopter and decide why they think the Wright brothers chose to add propellers to their flying machine (Appendix E).
5. Show students a map of Dayton, Ohio with the locations of the Wright Cycle Company shop and Huffman Prairie marked. Discuss that Orville and Wilbur Wright built a wind tunnel in Dayton, Ohio to test lift and wing design as it reacts to varying wind conditions. Throughout their testing, the brothers discovered that a propeller designed similarly to a wing would provide thrust. In search of greater wind speed, they travelled to Kitty Hawk, North Carolina to test their flying machines.
6. Distribute a map of the United States; have students use the map scale for calculating the distance the brothers traveled to test their flying machines.

Divide the class into teams of 3-4 students. Introduce the engineering design challenge, and review the engineering design process: http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A).

Day 2:

1. Review the engineering design challenge requirements. Show students the wire and plastic wrap and explain that they will make a wire frame and stretch the plastic over it to create propeller blades.
2. Give each student a rubber band and elicit ideas about how a rubber band can be used as energy to make something move. Discuss the potential energy stored in the rubber band when it is stretched. Let go of the rubber band and discuss that when the rubber band's potential energy is released, it is transferred to kinetic energy as it achieves motion.
3. Show students the hub mechanism and explain how propeller blades will be attached. Have students individually sketch how they think the propellers should be shaped and angled to achieve maximum thrust.
4. Instruct students to share individual propeller design plan sketches with their group and synthesize their sketches into a single design.

Although the Cycle Shop located in Dayton, Ohio is one of the brothers' five original shops, it is not the *location where they designed and built their Flyers. The Flyers were designed and built at their 1127 West Third Street location in Dayton. In 1936 Henry Ford acquired this shop and moved it to his museum in Dearborn, Michigan with Orville's support.*

Individually thinking about designs and materials silently allows those that would not normally offer input an opportunity to creatively problem solve and have a voice in ideas for final team design.

Final design choice can be one of the member's presented ideas, or a combination of ideas.

Remind teams this is a time to listen to each member's thoughts. They should understand that each team member's ideas are valuable to the final team design.

5. Have teams collaborate on a final team design.
6. Distribute materials and instruct teams to begin assembly. Remind them to continue following the engineering design process.

Day 3:

1. Allow teams time to complete their propeller design. Remind them to continue following the engineering design process.
2. Instruct teams to test their propellers by attaching them to the hub of the propeller mechanism. They should begin by winding the propeller 100 times before letting it go. Results and modification ideas should be recorded (Appendix F). You may need to instruct students in how to use a stopwatch to measure flight times.
3. Inform students that engineers research and collaborate with each other as they complete projects. Therefore, they too should observe other teams' propeller tests and learn from them.
4. Explain to students that based on their initial tests, they will need to choose one variable to change before testing again. Discuss possible variables to change, such as: number of propeller blades, size of blades, angle or shape of blades, number of times to twist rubber bands, etc.
5. After all teams have tested and modified their propellers, hold a speed competition between groups. Have each team measure distance traveled as well as time taken to travel the distance. Then, calculate speed by dividing distance by time. The team with the greatest speed wins the competition.

Day 4: (if this lesson is taught following the flying machine lesson)

1. Instruct students to attach their propellers to the flying machines constructed in the previous lesson (Flying Machines).
2. Monitor students as they test and modify the plane with propeller attachment. Record data.

Demonstrate how to count the number of times the propeller is wound (possibly each time your finger pushes one of the blades toward the floor).

Citizenship note: It is important to emphasize that engineers and scientists, like the Wright brothers, use their failures as tools to help them make their designs better. Point out the difference between the original Wright Flyer and the aircraft we see today. Explain that these changes were made in response to failures in early designs. Encourage students to make positive comments to one another during the discussions.

Take pictures for students to use in their newspapers.

Social Studies and Language Arts Integration:

Social Studies:

1. Instruct teams to begin a timeline about the history of flight including several other major historical events from the first flying glider to the present. If this lesson is used in conjunction with other lessons, instruct teams to research the history of the propeller and make a timeline about the use of propellers to add to the timeline.
2. Direct teams to compile their research and write a newspaper article about the Wright brothers' first use of the propeller, and how the propeller has changed since then.
3. Direct teams to write an article reporting information about their team's design, data, successes, failures, and suggestions for future improvements, along with an explanation of how an aircraft propeller works.

These three asignments can be jigsawed within the team. Each team member is responsible for completing one section. After articles are finished, the team can convene to share their information. Finally, they should take time to edit each other's articles before publishing into the final newspaper.

Language Arts:

1. Ask students to write newspaper articles using their research from social studies and data from this lesson.
2. Have students take on the role of Orville or Wilbur and write a narrative about their decision to use a propeller and how the propeller helped their flying machine successfully fly.

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

Newspapers from Wright era:
http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers

Extensions:

Take a field trip to Dayton Aviation Heritage National Historical Park.

Invite a ranger from Dayton Aviation Heritage National Historical Park to visit your classroom and present the design challenge to students.

Invite families and a park ranger from Dayton Aviation Heritage National Historical Park to attend a design symposium. If you are completing several of the design challenges in this guide, hold the symposium as a culminating activity upon completion of the lessons.

Hold a design challenge family night for students to complete the challenges again with their families. Engineers, after all, do continue to improve their initial designs.

Display photos of propellers throughout history and analyze them for design changes over time.

Explore propellers further by taking apart items containing propeller-type blades (such as battery operated fans). Attach the blades to propel toys that do not normally use propellers.

Examine the propellers from a boat or submarine and the propellers of an airplane. Compare and contrast the shapes and functions of each.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Catapults

Grade Levels: 3-5

Summary & Purpose:

This catapult lesson is one of four lessons for third through fifth grade students to study the Wright brothers and Paul Laurence Dunbar. This section may be taught alone or with any other sections chosen by the instructor. This lesson focuses on using observations and inferences to solve problems. Students will observe, research, and compare the aircraft catapults first used by the Wright brothers with those currently used on aircraft carriers to observe the similarities and differences of catapults developed at different periods in history. Students will work collaboratively in teams using the engineering design process to design, build, and modify a working prototype. The lesson will force them to work within time, material, and distance constraints. Teams will record testing data, explain how to improve their designs to meet the given constraints, and make modifications based on their explanations. Students will organize their gathered information through the creation of a timeline and presentation. Using data collected throughout the process, they will create a newspaper to send to Dayton Aviation Heritage National Historical Park explaining in detail their process in determining how catapults are able to launch a flying machine.

While catapult design is a limited field of study, this unit will address multiple science, social studies, math, and language arts standards. Students will learn that objects can be moved using mechanical force, and that force is required to move an object. This lays a foundation for students to explore simple machines and types of energy in later grades.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park consists of six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. Huffman Prairie Flying Field Interpretive Center displays the history of the Wright brothers' work after 1903, including their use of catapults. The brothers flew, tested and improved their planes at Huffman Prairie Flying Field. The field includes a replica of their catapult, a replica of a hangar used for storing their airplane, and

information panels that discuss their work at the site. The Wright Company operated the first flying school, the Wright School of Aviation, at Huffman Prairie Flying Field. One hundred nineteen pilots, including three women, were trained to fly at the flying field.

Essential Questions and Enduring Understandings:

1. **How can energy be transformed or transferred?** Energy can be transformed from stored (potential) energy to movement (kinetic). Energy is transferred from one form to another and one location to another.

2. **How are scaled models helpful in solving problems?** Scaled models are measured as a fractional part of full-sized measurements. Models help solve problems by reducing material use and time when experimenting. Problems and mistakes can easily be fixed on a scale model before building the actual full-size, more costly object.

3. **How can forces be controlled in order to accomplish a specific task?** Adjusting the amount of potential energy stored in a system (such as a catapult) directly affects the amount of force exerted by that system. Adjusting other variables such as speed and distance allow a catapult to perform in a consistent manner.

Lesson Overview:

Day 1	View videos and record observations Present challenge Silently view available materials Sketch an individual catapult design plan
Day 2	Teams discuss individual design plans Teams choose a design plan Teams sketch a design Begin catapult construction
Day 3	Complete construction Test, redesign, test again Record test data

Vocabulary:

catapult – slingshot; launching device

design – prepare sketches or plans to form something

engineer – a person who uses a process to research and apply scientific knowledge in order to solve a problem

innovate – to make changes in anything

invent – to create something new

kinetic energy – the motion of a system when stored energy is released

potential energy – the energy of a system that is stored

projectile – a launched, thrown, or propelled object, such as a ball

process – an organized system used to solve a problem

Materials:

Per student (for Day 1 exploration):

- 1 - Cotton ball
- 1 - Rubber band

Use readily available materials. Students will surprise you with their ability to design something that flies and meets their challenge.

Suggested materials for student teams to choose from:

- 2 - Straws
- 4 - Popsicle sticks or tongue depressors
- 1 - Paint stick
- Masking tape, 50 cm
- 2 - Index cards, cardboard, or cardstock
- String, 1 m
- 1 - Paper cup
- 1 - Plastic spoon or plastic soda bottle lid
- 4 - Rubber bands
- 2 - Marshmallows or cotton balls
- 2 - Paper clips

- 1 - Target (could use a coffee filter)
- Tape measure (meters)
- Engineering design process poster
- Copies of appendices

Background Information:

In order to achieve lift, the Wright brothers relied on headwinds. Through extensive experimentation, they concluded that headwinds of 11.8-14.9 mi/h (19-24 km/h or 5.3-6.7 m/s) would be needed to obtain lift for their glider. When the brothers were ready to experiment with flight, they decided that it was imperative they transport their machine to a location that offered more consistent headwinds than their hometown of Dayton, Ohio provided. Therefore, they transported their flying machine components by train and boat to Kill Devil Hills, North Carolina.

At Kill Devil Hills, they experimented with pilot-controlled flights in gliders in 1900, 1901 and in 1902. To launch their gliders, they used a combination of human power and headwinds. In 1903, they added an engine to their glider to provide power and propellers to provide thrust. The plane was now too large to use human power, so the brothers would incorporate a track for the plane to travel. Using a modified bicycle hub, the plane travelled down a 60-foot (18.29 m) single rail. On December 17, 1903, they achieved the first powered flight. When returning to Dayton, Ohio they used Huffman Prairie, a cow pasture, to continue experimenting with the airplane, but were not as successful due to continual battles with inconsistent wind speeds and changing wind direction. In 1904, they decided to rig a catapult to launch the airplane down the rail. A 1,600-pound (726 kg) weight supported by a derrick, or tower, pushed the airplane down the rail with enough speed to launch it into the air. On September 20, 1904, two weeks after first using the catapult, Wilbur completed their first circle and flew 4,080 feet (1.24 km) in approximately 1 minute 35 seconds. Dayton's inconsistent winds were no longer an obstacle to making flight practical; the catapult made it possible for the Wrights to fly anytime, anywhere without dependence of wind.

Catapults were developed long ago as engines of war, used to launch increasingly heavier projectiles at enemies from increasingly greater distances. The Wright brothers transformed a weapon of war into a catalyst for human flight.

Procedures:

Day 1:

1. Activate prior knowledge by opening a discussion regarding the Wright brothers and catapult uses.
2. Divide students into teams of 3-4 students.
3. Allow time for students to explore the purpose of catapults by experimenting with cotton balls. Have them first throw the cotton ball, then launch it with a rubber band. Explain that the rubber band is acting as a catapult launching the cotton ball.
4. Discuss potential and kinetic energy and have students identify when the rubber band has potential energy and when it has kinetic energy.
5. Distribute and explain the catapult observations handout (Appendix G).
6. Instruct students to complete the handout as they view the following series of videos. If you do not pause or stop the video, it will continue to play several videos regarding aircraft catapults.

   "Strange Planes: Origin of the Modern Catapult"
   http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm.
   "ENG Aircraft carrier catapult"
   http://www.youtube.com/watch?v=gLVQE2Ml9z8
   "Electromagnetic Catapult"
   http://www.youtube.com/watch?v=27k6pH5sZ5M
7. Introduce and explain the engineering design process: http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A).
8. Present students with the scenario and design challenge (Appendix H).
9. Place materials available for catapult construction on each team's table. Request that students not talk to each other about materials or design ideas. This will give each student time to brainstorm and create their own design plan without influence from others.
10. Instruct students to make a list of materials and begin sketching their design ideas. Sketches can be completed for homework.

Day 2:

1. Allow students time to discuss individual design plans and ideas. Remind teams this is a time to listen and understand each member's design plan ideas. They should understand that each team member's ideas are valuable to the final team design.
2. Instruct teams to collaborate about their ideas to choose and sketch a final team design.

3. Distribute materials to each team and allow time to begin the design challenge. Remind them to continue following the engineering design process.
4. Inform students that engineers research and collaborate with each other as they complete projects. Therefore, they too should observe other teams' catapult tests and learn from them.
5. Observe to ensure teams are testing their designs, recording results, and modifying designs until they are able to land the marshmallow in or near the target as they complete the challenge handout (Appendix H).

Take pictures throughout the building and testing so students can add them to their newspapers.

Day 3:

1. Display photos of catapults used in ancient times. Discuss their uses and how the Wright brothers modified the designs to fit their needs. Have student teams make a plan for modifying their original designs to better fit their needs.
2. Continue with the design challenge, allowing time for teams to test, modify, and retest their catapults.

Social Studies and Language Arts Integration:

Social Studies:

The following three assignments can be jigsawed within the team. Each team member is responsible for completing one section. After articles are finished, the team can convene to share their information. Finally, they should take time to edit each other's articles before publishing into the final newspaper.

1. Instruct teams to research the history of the aircraft catapult and add to their flight timeline started in previous sections. If this is the first or only lesson chosen by instructor, instruct teams to begin a timeline about the history of flight along with several other major historical events beginning with the first flying glider and ending with present day.
2. Direct teams to compile their research in order to write a newspaper article about the Wright brothers' first use of the catapult, and how the catapult has changed since then.
3. Also, direct them to write an article reporting information about their team's design, data, successes, failures, suggestions for future improvements, and explanation of how an aircraft catapult works.

Language Arts:

1. Ask students to write newspaper articles using their research from social studies and data from this lesson.
2. Have students take on the role of Orville or Wilbur and write a narrative about their decision to use a catapult and how the catapult helped their flying machine successfully fly.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Engineering design process http://www.daytonregionalstemcenter.org/engineering-design-process/

"Electromagnetic Catapult" http://www.youtube.com/watch?v=27k6pH5sZ5M

"ENG Aircraft carrier catapult" http://www.youtube.com/watch?v=gLVQE2Ml9z8

"Strange Planes: Origin of the Modern Catapult" http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm

Extensions:

Take a field trip to Dayton Aviation Heritage National Historical Park.

Invite a ranger from Dayton Aviation Heritage National Historical Park to visit your classroom and present the design challenge to students.

Invite families and a park ranger from Dayton Aviation Heritage National Historical Park to attend a design symposium. If you are completing several of the design challenges in this guide, hold the symposium as a culminating activity upon completion of the lessons.

Hold a design challenge family night for students to complete the challenges again with their families. Engineers, after all, do continue to improve their initial designs.

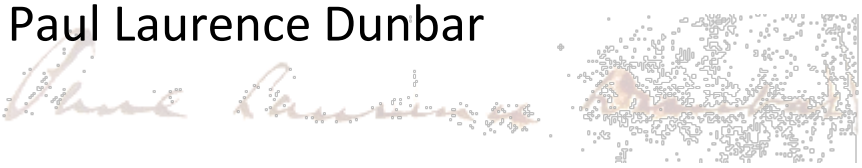
Display photos of airplanes throughout history and analyze them for design changes over time.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch and Wilbur and Orville Wright: A Handbook of Facts by Wright Research Committee.

The Engineering Design Process poster was developed at the Dayton Regional STEM Center in Dayton, Ohio. http://www.daytonregionalstemcenter.org.

Paul Laurence Dunbar



Grade Levels: 3-5

Summary & Purpose:

This Paul Laurence Dunbar and printing process lesson is one of four lessons for third through fifth grade students to study the Wright brothers and Paul Laurence Dunbar. This lesson integrates well with the three-part study of flight lessons or may be taught alone. Students will learn about the changes made over time in written text. Students will analyze Paul Laurence Dunbar's poetry, and model their own poetry after Dunbar's poetry.

This unit will address multiple social studies and language arts standards. Students will learn that life has not always been the way they see it, but that inventions and innovations have changed the world in which we live. Students will learn how to interpret a piece of poetry to infer what the poet meant by his or her words. They will then choose descriptive, vivid words to convey their own thoughts about a topic in poetry form.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park commemorates, among other things, the history of Orville and Wilbur Wright's printing business and Paul Laurence Dunbar's literary successes. At the Wright-Dunbar Interpretive Center, visitors will find significant information on both the Wrights' printing business and Paul Laurence Dunbar. The center displays many of Dunbar's literary works as well as a restored Wright brothers' print shop and a printing press similar to one the Wright brothers operated. The Dunbar House, a house originally purchased by Dunbar for his mother, and the house where he passed away in 1906, became a state memorial in 1938, the first to publicly honor an African American. At the Dunbar House visitors will find significant information about and artifacts from Paul Laurence Dunbar's life.

Essential Questions & Enduring Understandings:

1. **How do technological innovations cause change in a community over time?** Technological innovations provide more convenient methods for doing things. This creates change in a community by creating opportunity for new innovations and opportunities.

2. **Why does our point of view about a piece of writing differ from others and from the author?** Because everyone has unique life-experiences, each individual will interpret the meaning of a piece of literature based on these experiences.

3. **How can an author's choice of words influence our interpretation of a piece of literature?** An author's word choice influences the reader by painting a picture in our minds. The more descriptive and vivid the words are, the clearer picture they create. Therefore, the reader is better able to interpret the writer's meaning and feeling about their piece.

Lesson Overview:

Day 1	Display image stamped on paper Discuss life before, and after the printing press Discuss digital media as an innovative way to print Hold printing press challenge
Day 2	Introduce Paul Laurence Dunbar Listen to and discuss *Toast to Dayton* (Appendix J) Begin analyzing the poem
Day 3	Complete analyzing Begin individual poem brainstorming
Day 4	Complete individual rough draft and editing
Day 5	Publish poem in newspaper format

Vocabulary:

cause – interest or welfare of something

consecrate – to honor something with respect

decked – decoratively dressed

desert – leave behind

diadem – crown

duty – respectfulness

ebb – flow back (antonym of flow)

fate - ruin

gracious – very kind

hail – cheer or welcome

interpret – to find the meaning of something

loyalty – faithful

nay – no

printing press – a machine used to print text

revere – to treat something with respect (synonym of venerate)

righteous – upright, wonderful

sublimest – greatest

toast – to honor someone or something

veneration – a feeling of respect

welfare – happiness, well-being

Materials:

- Rubber stamp with words (i.e., “great job”, “sign and return”...)
- Ink pad
- Computer
- Pen and paper

Background Information:

As entrepreneurs, Orville and Wilbur Wright became business partners in 1889 when they opened their printing shop. They edited and published newspapers, and printed advertising and news circulars for customers. They also printed an African American newspaper, the *Dayton Tattler*, written and edited by Paul Laurence Dunbar. In 1899 the Wright brothers sold their printing business so they could experiment with flying.

Paul Laurence Dunbar and Orville Wright were classmates and acquaintances at Dayton Public School's Central High School. Dunbar was the editor of the high school newspaper, *High School Times.* When Dunbar decided to publish a newspaper, the *Dayton Tattler,* for Dayton's African American community, he asked Orville and Wilbur to print it for him. Unfortunately, the newspaper did not last long, and they only printed three editions. He began creating poetry at the age of six, reciting poetry publicly at the age of twelve, publishing at the age of fourteen, and selling his first book of poetry at the age of twenty. Dunbar is credited as being the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers.

Procedures:

Day 1:

1. Stamp a piece of paper with an image from each stamp students will use (1/3 of the students will each need a stamp).
2. Activate prior knowledge by asking: "How were multiple copies of a flyer, book, magazine, etc. printed in order to share with several people?" Elicit responses about hand copying them and how tedious and time-consuming the process must have been.
3. Discuss change in the printing and publishing process. Display photos of the Wright brothers' print shop (Appendices M and N).
4. Ask students how most of our information is presently published. Elicit digital media technologies.
5. Divide class into three groups and assign each group a different printing method. Allow a few minutes for them to practice.
   Group 1: each student handprints one of the stamp images using a pen and paper.
   Group 2: each student uses an inkpad to stamp the image on a sheet of paper.
   Group 3: each student uses a computer to create the image on the screen.

Students will print the same image: one by hand, one by stamp and inkpad, and one by computer: copy and paste. Therefore, each student that is completing the handwritten and computer printing should stamp the image onto an index card for reference.

6. After students have had a few minutes to practice their assigned type of printing, hold a printing contest. Instruct students to "print" as many copies of their image as possible in ten minutes.
7. Set a timer for ten minutes. Have them count their number and discuss the results with the other students doing the same image.
8. Discuss how innovations have made it easier to share information. Ask students to provide other examples of how innovations have provided more conveniences.
9. Show students a video of a newspaper printing house. http://www.youtube.com/watch?v=q2RU4d9xu5k

Day 2:

1. Introduce Paul Laurence Dunbar by displaying Dayton's Central High School Senior Class of 1890 photo: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg
2. Compare the photo to modern day class photos. Elicit discussion about their observations of the photo. Point out that Paul Laurence Dunbar and Orville Wright are both in the photo and explain that while they attended school together they became acquaintances.
3. Investigate Paul Laurence Dunbar's literary accomplishments: http://www.poetryfoundation.org/bio/paul-laurence-dunbar
4. Explain that Dunbar was the editor of his high school newspaper, *High School Times*. Also, that when Dunbar decided to publish a newspaper, the *Dayton Tattler,* for Dayton's African American community, he asked the Wrights to print it for him.
5. Display photos of the Wright brothers' newspapers including the *Dayton Tattler*: http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers Discuss their printing style as well as the type of articles they included.
6. Inform students that Paul Laurence Dunbar was a famous poet and the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers.
7. Display Dunbar's poem, *Toast to Dayton* (Appendix J).
8. Think-Pair-Share: Have students think about the meaning of the poem by interpreting each stanza using the graphic organizer (Appendix K). This can be completed for homework.

Day 3:

1. Allow time for students to review their interpretation, then have them discuss with a partner. Next, instruct students to share some of their interpretations with either a larger group or with the class.
2. Instruct students to complete the *Toast to Dayton* analyzing and brainstorming sheet (Appendix L).

Day 4:

1. Explain to students that they will now create their own poem based on their recorded responses on the analyzing and brainstorming sheets.
2. Conference with individual students as they write their rough draft to ensure understanding.
3. Have students begin peer editing when they finish their rough draft.

Have students share pieces of their poem throughout the writing session. This helps others generate ideas, especially when they are experiencing writer's block.

Day 5:

1. Complete editing.
2. Instruct students to publish their poems in newspaper format. The following link can be used as a template for creating newspapers: http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html.
3. Ask students if they would rather publish multiple copies of their poem and newspaper by handwriting them, using a printing press, or by telling the printer how many to print. Review how publishing has changed and become more convenient over time.

Social Studies Integration:

1. Add the history of the printing press and of Paul Laurence Dunbar's life to the timeline and newspaper created in flight study lessons. If these have not been created, direct students to create a timeline and a newspaper that incorporate the history of the printing press and the lives of the Wright brothers and Paul Laurence Dunbar. The following interactive website is very helpful: http://www.nps.gov/featurecontent/daav/timeline/main.html
2. Discuss the changes in media, aviation, and society over time due to the innovativeness of the Wright brothers. Paul Laurence Dunbar is credited as being the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers. Discuss how Paul Laurence Dunbar's literature opened doors for African American writers.

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

Paul Laurence Dunbar biography: http://www.poetryfoundation.org/bio/paul-laurence-dunbar

Newspaper template from Read Write Think website: http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html

Photos of the Wright brothers' newspapers: http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers

School photo with Orville Wright and Paul Laurence Dunbar: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg

Interactive timeline: http://www.nps.gov/featurecontent/daav/timeline/main.html

Extensions:

Continue to study Paul Laurence Dunbar by interpreting other literary pieces and using them as a model.

Interpret one of Dunbar's dialect poems. Have students interview a family member about a topic and write a poem using the same language pattern and vocabulary their family member uses.

References/Works Cited:

Paul Laurence Dunbar information taken from http://www.poetryfoundation.org/bio/paul-laurence-dunbar

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Dayton Aviation Heritage National Historical Park
Alignment of Standards Third through Fifth Grade

	Flying Machines	Propellers	Catapults	Printing Process and Paul Laurence Dunbar
Science				
3 – Earth's nonliving resources have specific properties.	X	X	X	
3 – Earth's resources can be used for energy.	X	X	X	
4 – Energy can be transformed from one form to another or can be transferred from one location to another.	X	X	X	
5 – The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.	X	X	X	

Social Studies				
3.1. Events in local history can be shown on timelines organized by years, decades and centuries.	X	X	X	X
3.2. Primary sources such as artifacts, maps and photographs can be used to show change over time.	X	X	X	X
3.3. Local communities change over time.	X	X	X	X
3.4. Physical and political maps have distinctive characteristics and purposes. Places can be located on a map by using the title, key, alphanumeric grid and cardinal directions.	X	X	X	X
3.7. Systems of transportation and communication move people, products and ideas from place to place.	X	X	X	X
3.15. Both positive and negative incentives affect people's choices and behaviors.	X	X	X	X
4.1. The order of significant events in Ohio and the United States can be shown on a timeline.	X	X	X	X
4.2. Primary and secondary sources can be used to create historical narratives.	X	X	X	X
4.8. Many technological innovations that originated in Ohio benefited the United States.	X	X	X	X
4.9. A map scale and cardinal and intermediate directions can be used to describe the relative location of physical and human characteristics of Ohio and the United States.	X	X	X	X
4.10. The economic development of the United States continues to influence and be influenced by agriculture, industry and natural resources in Ohio.	X	X	X	X

4.22. Tables and charts help people to understand information and issues. Tables organize information in columns and rows. Charts organize information in a variety of visual formats (pictures, diagrams, graphs).	X	X	X	X
4.23. Entrepreneurs organize productive resources and take risks to make a profit and compete with other producers.	X	X	X	X
5.1. Multiple-tier timelines can be used to show relationships among events and places.	X	X	X	X
5.4. Globes and other geographic tools can be used to gather, process and report information about people, places and environments. Cartographers decide which information to include in maps.	X	X	X	
5.5. Latitude and longitude can be used to make observations about location and generalizations about climate.	X	X	X	
5.6. Regions can be determined using various criteria (e.g., landform, climate, population, cultural or economic).	X	X	X	X
5.14. The choices people make have both present and future consequences.	X	X	X	X

Mathematics				
3.OA.3. Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.	X	X	X	
4.MD.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb., oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. For example, know that 1 ft. is 12 times as long as 1 in. Express the length of a 4 ft. snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...	X	X	X	
4.MD.2. Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.	X	X	X	
5.NF.6. Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.	X	X	X	

English Language Arts				
3.RL.1. Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.				X
3.RL.4. Determine the meaning of words and phrases as they are used in a text, distinguishing literal from nonliteral language.				X

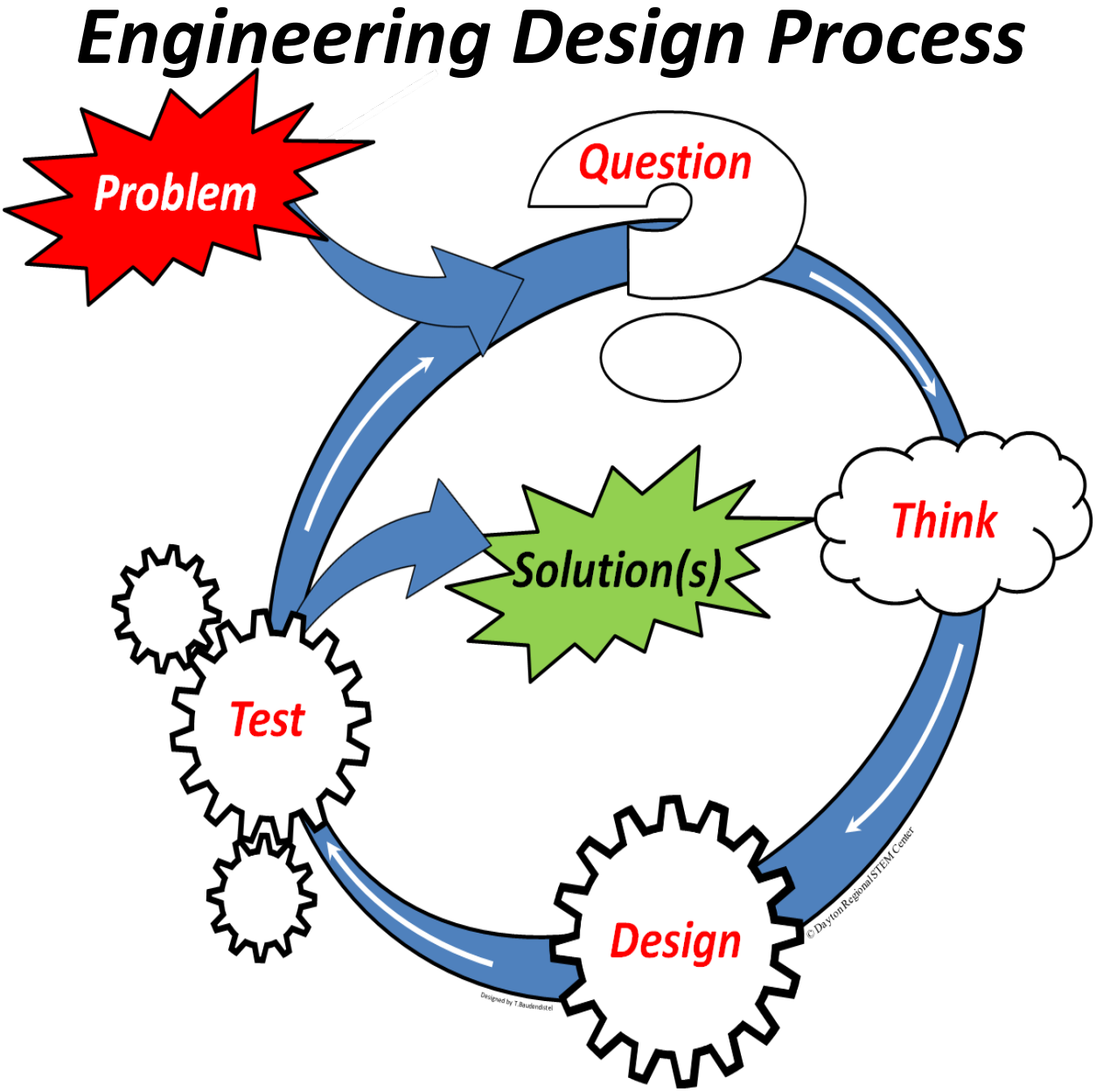
3.RL.5. Refer to parts of stories, dramas, and poems when writing or speaking about a text, using terms such as chapter, scene, and stanza; describe how each successive part builds on earlier sections.				X
3.RL.10. By the end of the year, read and comprehend literature, including stories, dramas, and poetry, at the high end of the grades 2–3 text complexity band independently and proficiently.				X
3.RI.1. Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.				X
3.RI.3. Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.	X	X	X	X
3.RI.4. Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 3 topic or subject area.	X	X	X	X
3.RI.6. Distinguish their own point of view from that of the author of a text.				X
3.RF.3. Know and apply grade-level phonics and word analysis skills in decoding words.				X
3.RF.4. Read with sufficient accuracy and fluency to support comprehension.				X
3.W.1. Write opinion pieces on topics or texts, supporting a point of view with reasons.				X
3.W.2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	X	X	X	
3.W.3. Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.			X	
3.W.4. With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose.	X	X	X	X
3.W.5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.	X	X	X	X
3.W.6. With guidance and support from adults, use technology to produce and publish writing (using keyboarding skills) as well as to interact and collaborate with others.	X	X	X	X
3.W.7. Conduct short research projects that build knowledge about a topic.	X	X	X	
3.W.8. Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.	X	X	X	
3.SL.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.	X	X	X	X
3.SL.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	X	X	X	X
3.L.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening.	X	X	X	X
3.L.4. Determine or clarify the meaning of unknown and multiple-meaning word and phrases based on grade 3 reading and content, choosing flexibly from a range of strategies.				X

3.L.5. Demonstrate understanding of word relationships and nuances in word meanings.				X
4.RL.1. Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.				X
4.RL.2. Determine a theme of a story, drama, or poem from details in the text; summarize the text.				X
4.RL.5. Explain major differences between poems, drama, and prose, and refer to the structural elements of poems (e.g., verse, rhythm, meter) and drama (e.g., casts of characters, settings, descriptions, dialogue, stage directions) when writing or speaking about a text.				X
4.RL.10. By the end of the year, read and comprehend literature, including stories, dramas, and poetry, in the grades 4–5 text complexity band proficiently, with scaffolding as needed at the high end of the range.				X
4.RI.1. Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.				X
4.RI.2. Determine the main idea of a text and explain how it is supported by key details; summarize the text.				X
4.RI.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.	X	X	X	X
4.RI.4. Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.	X	X	X	X
4.RI.7. Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	X	X	X	X
4.RI.8. Explain how an author uses reasons and evidence to support particular points in a text.				X
4.RI.9. Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.	X	X	X	
4.RF.3. Know and apply grade-level phonics and word analysis skills in decoding words.				X
4.RF.4. Read with sufficient accuracy and fluency to support comprehension.				X
4.W.1. Write opinion pieces on topics or texts, supporting a point of view with reasons and information.				X
4.W.2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	X	X	X	
4.W.3. Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.			X	
4.W.4. Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.	X	X	X	X
4.W.5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.	X	X	X	X
4.W.6. With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate	X	X	X	X

4.W.7. Conduct short research projects that build knowledge through investigation of different aspects of a topic.	X	X	X	X
4.W.8. Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.	X	X	X	X
4.W.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.	X	X	X	X
4.SL.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.	X	X	X	X
4.SL.2. Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	X	X	X	X
4.L.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening.	X	X	X	X
4.L.6. Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).	X	X	X	X
5.RL.1. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.				X
5.RL.2. Determine a theme of a story, drama, or poem from details in the text, including how characters in a story or drama respond to challenges or how the speaker in a poem reflects upon a topic; summarize the text.				X
5.RL.4. Determine the meaning of words and phrases as they are used in a text, including figurative language such as metaphors and similes.				X
5.RL.5. Explain how a series of chapters, scenes, or stanzas fits together to provide the overall structure of a particular story, drama, or poem.				X
5.RL.6. Describe how a narrator's or speaker's point of view influences how events are described.				X
5.RL.7. Analyze how visual and multimedia elements contribute to the meaning, tone, or beauty of a text (e.g., graphic novel, multimedia presentation of fiction, folktale, myth, poem).				X
5.RL.10. By the end of the year, read and comprehend literature, including stories, dramas, and poetry, at the high end of the grades 4–5 text complexity band independently and proficiently.				X
5.RI.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.	X	X	X	
5.RI.8. Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).				X
5.RI.9. Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.	X	X	X	
5.RF.3. Know and apply grade-level phonics and word analysis skills in decoding words.				X
5.RF.4. Read with sufficient accuracy and fluency to support				X

comprehension.				
5.W.1. Write opinion pieces on topics or texts, supporting a point of view with reasons and information.				X
5.W.2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	X	X	X	X
5.W.3. Write narratives to develop real or imagined descriptive details, and clear event sequences.			X	
5.W.4. Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.				X
5.W.5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.	X	X	X	X
5.W.6. With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.	X	X	X	X
5.W.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.	X	X	X	X
5.W.8. Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.	X	X	X	X
5.W.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.	X	X	X	X
5.SL.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.	X	X	X	X
5.SL.2. Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	X	X	X	X
5.SL.3. Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence.				X
5.L.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening.				X
5.L.4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies.				X
5.L.5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.				X
5.L.6. Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships (e.g., however, although, nevertheless, similarly, moreover, in addition).	X	X	X	X

Appendix A – Engineering Design Process



Question – Find out as much as you can about the problem.

Think – Imagine different ways to solve the problem.

Design – Choose one of your ideas, collect materials, and put it together.

Test – Try your idea and see if it worked.

Solution – If you did not solve the problem the first time, ask more questions and go through all the steps again.

Appendix B - Flying Machines Challenge

Dayton Aviation Heritage National Historical Park has requested your team's assistance in the study of flying machines such as those used by the Wright brothers and those used today. Park rangers have requested this information to help park visitors understand how heavier-than-air flying machines are able to fly through the air. They would like your team to observe and study different flying machines used throughout the process of inventing flight, sketch and build a working prototype of a flying machine using specific materials, compare your flying machine to the Wright brothers' design and others before and after them, and explain how flying machines are able to fly through air.

Your team's goals are:

- To construct a flying machine that will meet your assigned flight challenge (record assigned challenge below)
- Use your notes from video response to help you design a successful flying machine
- Decide what data you will need to collect and record so that you will know if your flying machine has met the challenge
- Analyze data and modify the flying machine based on collected data
- Conduct at least four flight trials

Trial		Modifications Needed
1		
2		
3		
4		

1. How is the energy from your body transformed into energy that is able to provide a force to fly your machine?

_____
_____
_____

2. How did learning about the principals of flight from "The Quest for Practical Flight" video help you construct an effective flying machine?

_____
_____
_____

3. Explain at least two successes you had during your design challenge.

_____
_____
_____

4. Explain one failure you faced during your design challenge. How could you learn from this failure and build a better flying machine?

_____
_____
_____

5. If you were able to complete your challenge again, what would you do differently? Explain your thoughts and reasons in detail.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Appendix C - Video Response

1. Who do you think was the first in flight? Support your answer with details from the pictures, videos, and timeline.

   _____

   _____

   _____

2. What were the Wright brothers' most important contributions to human flight?

   _____

   _____

   _____

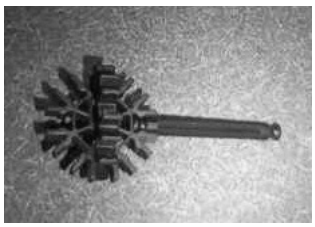
3. Record notes about what made the Wright brothers' flight successful below. Record the problems they faced in the left column, and solutions to the problems in the right column. Use lots of details; your notes will help you complete the design challenge successfully.

Problem	Solution

Appendix D - Propeller Mechanism Building Instructions
(materials listed in the propeller lesson)

Hub and Shaft Instructions (Prebuilt)

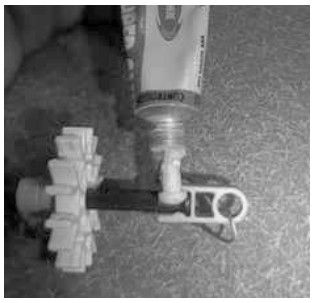
1. Interlock 2 – K'nex standard blue connectors.



2. Connect 1 – K'nex 2 ¼" standard dark blue rod.

3. Slide 2 – K'nex standard dark grey connectors, and 1 – circular white connector onto the dark blue rod. Connect 1 - standard dark grey connector onto the end of the dark blue rod.

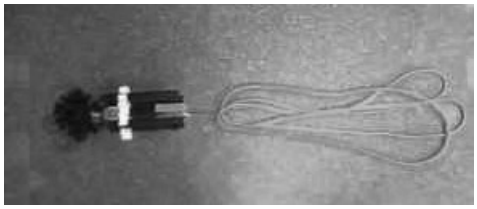
4. Attach 1 – large paper clip to the dark grey connector.



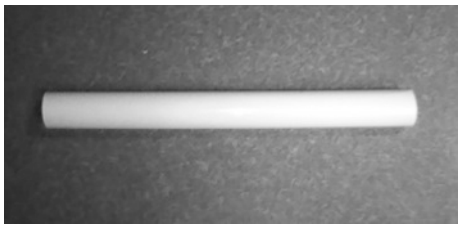
5. Super glue the dark grey connector to the dark blue rod.

6. Super glue the standard blue connector to the dark blue rod.

7. Connect 4 – K'nex 2 ¼" dark blue rods evenly around the white circular connector.



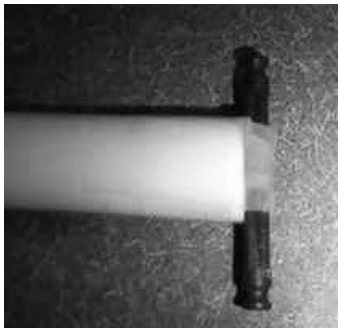
8. Attach 3 – rubber bands to the large paperclip.



9. Cut an 8 ¾" piece of light-weight tubing.

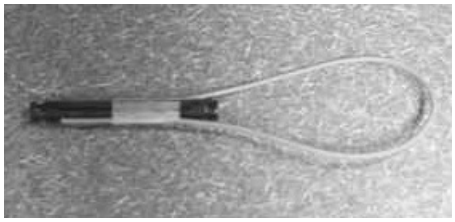
10. Thread rubber bands through the tubing.
Place the K'nex mechanism on top of the tubing.

11. Place 1 – K'nex 8 ¾" dark blue rod through the rubber bands.

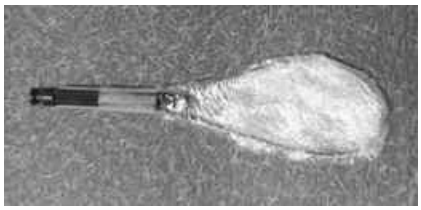


12. Tape the rubber bands to the rod and tubing so that it is unable to move.

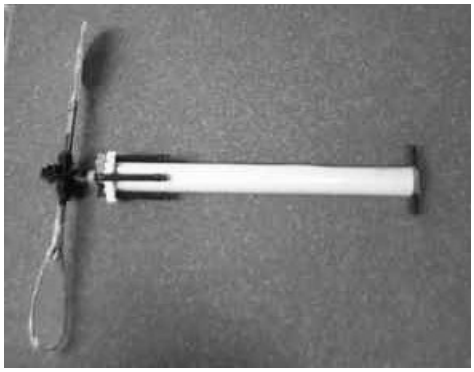
Example of Propeller Blade (Built by Teams)



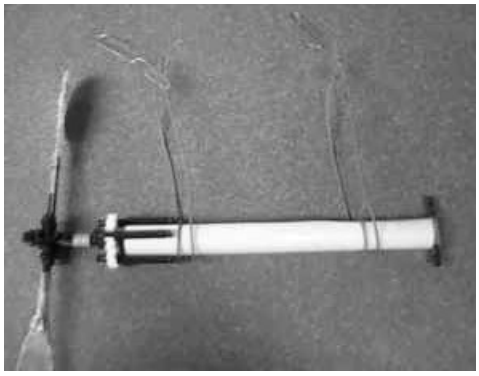
1. Tape 1 – 9 ½" precut wire around 1 –K'nex 8 ¾" dark blue rod. One end of the rod must be left clear in order to attach the propeller to the prebuilt hub.
Each team decides how long to keep the wire, what angle to position it, and if any bends should be placed in it.



2. Wrap the wire with plastic wrap to finalize the propeller blade.



3. Attach each propeller blade to the hub for testing.



4. Wrap 2 – 17" pieces of wire around the tubing. Bend 2 paper clips into hook shapes and attach to the wire.

5. Tautly string 50 lb. fishing line at a slight decline across the room. Use the paper clip hooks to place the mechanism on the fishing line.

6. Have each team connect their propeller to the mechanism, twist the propeller 100 times, let go, observe, and record the results of their test.

Appendix E - Think, Pair, Share

What do you know about how propellers push, or propel, an airplane through the air?

Think (record what you know)	**Pair** (record new knowledge gained or remembered after sharing with a partner)	**Share** (record new knowledge gained or remembered after sharing with the class or group)

Appendix F - Propellers Challenge

Dayton Aviation Heritage National Historical Park has requested your team's assistance in the study of aircraft propellers such as those used by the Wright brothers and those used on more modern aircraft. Park rangers have requested this information to help park visitors understand how propellers push an aircraft through the air. They have requested that your team observe and study the hand-held propeller, sketch and build a working prototype using specific materials, and explain how propellers push aircraft through the air.

Your team's goals are:

- To construct a propeller that will thrust the hub and shaft mechanism across the fishing line with maximum speed and distance
- Record flight data
- Analyze data and modify the propeller based on the data collected
- Conduct at least four flight trials

Trial	Flight Distance	Flight Time	Flight Speed $s = d \div t$	Modifications Needed for Greater Distance
1				
2				
3				
4				

1. Explain how the energy in the rubber band is transferred from potential to kinetic as your propeller creates motion. How is a rubber band able to provide energy to propel an object?
   _____
   _____
   _____

2. How does the number of times the rubber bands are twisted affect your propellers' ability to propel the mechanism? Why would the amount of twists matter?

_____
_____
_____
_____

3. Think about your research and look at your timeline to compare aircraft propellers used throughout history. How have they changed since the time of the Wright brothers? How have they remained the same?

_____
_____
_____
_____

4. The Wright brothers needed a system to propel their flying machine through the air; they solved this problem by creating airplane propellers. How is an airplane propeller like an airfoil, or wing?

_____
_____
_____
_____

5. Not all aircraft today use propellers as their source of thrust, but propellers are used on wind turbines. Think about what you have learned about propellers and their ability to push an object through the air. Using that information, describe how a propeller is able to transform the Earth's natural resource of wind into energy.

_____
_____
_____
_____

6. Is wind a renewable or nonrenewable source of energy? Explain your answer in detail.

_____
_____
_____
_____

Appendix G - Catapult Observations

View several videos of aircraft catapults used throughout history. As you observe the catapults, sketch five of them and record notes about how they launch aircraft into flight. Include the Wright brothers' catapult, the electromagnetic catapult, and three catapults of your choice. Record your observations on the data table below.

Aircraft Catapult	Sketch	Notes
Wright brothers		
Electromagnetic		

Appendix H - Catapult Challenge

Dayton Aviation Heritage National Historical Park has requested your team's assistance in the study of aircraft catapults such as those used by the Wright brothers and those used on modern aircraft carriers. Park rangers have requested this information to help park visitors understand how catapults assist in the takeoff of aircraft. They have requested that your team observe and study video clips of aircraft catapults, sketch and build a working prototype using specific materials, compare your catapult to that of the Wright brothers' design, and explain how catapults are able to successfully launch an aircraft.

Your team's goals are:

- To land a marshmallow onto a target 3 meters (about 10 feet) away from the catapult
- Record launch data
- Analyze data and modify the catapult based on the data collected
- Conduct at least four launch trials
- Continue trials even if launches are successful, and record number of successful launches

If an aircraft is launched with too much or too little force, it will not achieve the necessary lift to fly. Therefore, aircraft catapults must be designed with specific accuracy in launching the plane toward a specific target and distance. Your team's launch goal is for your projectile to land on the target 3 meters (about 10 feet) away from your catapult. Record your data in the table below.

Trial	Launch Distance Did it hit the target?	Modifications Needed to Accomplish the Goal
1		
2		
3		
4		

1. Explain how energy is transformed as you use the catapult to launch a marshmallow. When is there potential, or stored, energy? When is that potential energy transformed to kinetic, or motion energy?

   _____
   _____
   _____

2. Think about your research and look at your timeline to compare aircraft catapults used throughout history. How have they changed since the time of the Wright brothers? How have they remained the same?

   _____
   _____
   _____
   _____

3. What innovations can be made to aircraft catapults to make them better? Explain your ideas.

   _____
   _____
   _____

4. The Wright brothers used the catapult to solve their problem of continually battling wind direction and speed when testing their flying machine. The Navy uses catapults to solve their problem of dealing with limited space on an aircraft carrier for airplane takeoff. What other problems do you think could be solved with a device similar to a catapult? List at least two problems this device could solve and describe how the concept of the catapult would help solve the problem.

   _____
   _____
   _____
   _____
   _____
   _____

How Does Your Catapult Compare to the Wright Brothers' Design?

1. On September 20, 1904 the Wright brothers used their catapult to launch their 1904 Wright Flyer into the air at Huffman Prairie in Dayton, Ohio. Your team's model for testing aircraft launching catapults is a marshmallow. Use a balance to measure the mass and a ruler to measure the length of your marshmallow. Complete the table below to compare your marshmallow to the 1904 Wright Flyer.

Projectile	1904 Wright Flyer	Marshmallow
Mass	760 lbs. (344.73 kg.)	
Length	21.1 ft. (6.43 m.)	

2. Calculate how many times heavier the 1904 Wright Flyer is than your marshmallow.

   _____

3. Calculate how many times longer the 1904 Wright Flyer is than your marshmallow.

   _____

4. Is your marshmallow an accurately scaled model of the 1904 Wright Flyer? Explain in detail why or why not.

   _____

   _____

5. Wilbur flew 4,080 ft. (1,243.58 m) on September 20, completing the first circle. What was your marshmallow's first flight distance? How does the marshmallow's flight distance compare to their flight distance? Explain in detail, including how much greater or less the Wright brothers' first circled flight was than the marshmallow's first flight.

   _____

   _____

6. How did engineering a catapult to launch a marshmallow help you understand the use of catapults to launch aircraft? Explain why it is important for engineers to use scaled models for experimenting before they build the actual object.

   _____

   _____

7. Why do you think engineers use the engineering design process when completing a project? Do you think the Wright brothers used a design process? How did the process help your team create a catapult?

   _____

   _____

   _____

Toast to Dayton

By Paul Laurence Dunbar

Love of home, sublimest passion
That the human heart can know!
Changeless still, though fate and fashion
Rise and fall and ebb and flow,
To the glory of our nation,
To the welfare of our state,
Let us all with veneration
Every effort consecrate.

And our city, shall we fail her?
Or desert her gracious cause?
Nay – with loyalty we hail her
And revere her righteous laws.
She shall ever claim our duty,
For she shines – the brightest gem
That has ever decked with beauty
Dear Ohio's diadem.

Appendix K - Poem Interpretation

Toast to Dayton

By Paul Laurence Dunbar

Vocabulary:

Cause –interest or welfare of something

Consecrate – to honor something with respect (synonym of venerate)

Decked – decoratively dressed

Desert – leave behind

Diadem – crown

Duty – respectfulness

Ebb – flow back (antonym of flow)

Fate - ruin

Gracious – very kind

Hail – cheer or welcome

Loyalty – faithful

Nay – no

Revere – to treat something with respect (synonym of venerate)

Righteous – upright, wonderful

Sublimest – greatest

Toast – to honor someone or something

Veneration – a feeling of respect

Welfare – happiness, well-being

Explain what you think Paul Laurence Dunbar meant in each stanza of his poem, *Toast to Dayton*. Use the vocabulary list to help you.

Toast to Dayton

Stanza	Your Interpretation (What you think Dunbar meant)
Toast to Dayton	
Love of home, sublimest passion That the human heart can know!	
Changeless still, though fate and fashion, Rise and fall and ebb and flow,	
To the glory of our nation, To the welfare of our state,	
Let us all with veneration Every effort consecrate.	
And our city, shall we fail her? Or desert her gracious cause?	
Nay—with loyalty we hail her And revere her righteous laws.	
She shall ever claim our duty,	
For she shines—the brightest gem	
That has ever decked with beauty Dear Ohio's diadem.	

Appendix L - Analyze Poetry and Brainstorm Ideas

1. When Dunbar uses the word "she" who or what is he referring to? How do you know?

_____

_____

2. Paul Laurence Dunbar is creating an image, or painting a picture, of Dayton through his poetry. What image does Dunbar paint in your mind about Dayton? Support your answer with details from the reading selection.

_____

_____

_____

3. Personification is giving something that is not living human qualities. Does Dunbar use personification in *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

_____

4. Strong verbs add excitement to writing. List at least five strong verbs in the poem. For each strong verb you list, also include a weak verb Dunbar could have used.

_____

_____

_____

_____

5. How would the poem have been different had he chosen the weak verbs? Do you think he made the right choice by using strong verbs? Explain your thinking.

_____

_____

_____

_____

6. What is the mood of Dunbar's *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

7. What theme, or controlling idea, is Dunbar communicating through *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

8. Do you think the Wright brothers felt the same way about Dayton? Explain your thinking in detail.

_____

_____

_____

9. In your life, what makes you feel similar to how Paul Laurence Dunbar felt about Dayton? Give several reasons for your feelings about this topic.

_____

_____

_____

10. List at least five **verbs** you would use when talking to someone about your topic. Then find **stronger verb** synonyms to substitute for each of the verbs.

_____

_____

_____

_____

_____

11. List at least ten **adjectives** you would use when talking to someone about your topic. Make the adjectives *million dollar* words by finding synonyms for simple adjectives.

_____

_____

_____

_____

_____

12. Read *Toast to Dayton* again paying attention to Dunbar's writing style. Create a poem about your topic using a style similar to Dunbar's. Be sure to include the strong verbs and million dollar adjectives you listed above.

Appendix M - Composing room of the Wright brothers' 1890-1895 print shop

Appendix N - Second room of the Wright brothers' 1890-1895 print shop

Photo displaying a replica of the foot-powered Prouty press which handled small jobs such as stationery and business cards.

Sixth through Eighth Grade

Flying Machines

Grade Levels: 6-8

Summary & Purpose:

This flying machine lesson is one of four lessons for sixth through eighth grade students to study the Wright brothers and Paul Laurence Dunbar. This section may be taught alone or with any other sections chosen by the instructor. Students will learn the history of flying machines, from the first hot air balloons to modern airplanes. Students will learn about the contributions of various historical figures, especially Orville and Wilbur Wright, and engage in a "First in Flight" debate. In this activity students will research the history of flight, debate the facts among themselves and in the ultimate challenge, each group will fly their own planes for the title of "First in Flight".

The field of aeronautics and the questions of flight are vital to the age in which we live. Therefore, this unit will address multiple science, social studies, math, and language arts standards as students explore aeronautics.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. The Wright-Dunbar Interpretive Center houses some artifacts and replicas from the earliest Wright Flyers, including a model of the first Wright Flyer engine. The Huffman Prairie Flying Field Interpretive Center highlights the history of flight from the first flight to the modern era of air travel. At the Huffman Prairie Flying Field Interpretive Center, visitors will find various models of planes, videos, and hands-on exhibits of flight. They will also experience a flight simulator modeled after an early military Wright Flyer. The Huffman Prairie Flying Field includes a replica of a hangar and a catapult similar to those utilized by the Wright brothers. Signs and placards throughout the park sites also give a rich and detailed history of flight.

Essential Questions and Enduring Understandings:

1. **How is the engineering design process used to design, collaborate, build and test a prototype, and communicate solutions?** The engineering design process is a valuable method in which collaboration with others in order to solve a problem is used to develop and carry out a plan and communicate solutions.

2. **How do tables, charts, graphs and timelines help in understanding information, issues, and changes in history over time?** Tables, charts, graphs and timelines are a tool to help show relationships among events, places, or information.

3. **How do the measurements of scaled models compare to actual objects; and how are scaled models helpful in solving problems?** Scaled models are measured as a fractional part of actual measurements. Models help solve problems by reducing material use and time when experimenting. Problems and mistakes can easily be fixed on a scale model before building the actual full-size, more costly object.

Lesson Overview:

Days 1-3	Discuss "First in Flight" contest Group students heterogeneously and assign inventors Students research and prepare for debate (see Appendix B) Students perform the debate Teams will receive points based on the most convincing argument and best score on the rubric (see Rubric Appendix C)
Days 4-5	Students build timelines of flight beginning in 1000 B.C. with Chinese kites Team with the best score on the rubric receives points towards final score (see Rubric Appendix C)
Days 6-7	Engineering design process (see Appendix A) Build a plane according to instructions Test, collect data on flight time and distance Plane Re-Design Challenge
Day 8	Create and sketch designs individually as homework, then teams discuss individual design plans and choose one Redesign and reconstruct plane Test again, record data (flight time and distance), calculate speed (s=d/t)
Day 9	See Airplane Redesign Rubric Appendix D Make presentation to class explaining what and why changes were made in the plane design and how it affected the results Possibly ask a guest National Park Service ranger to judge Give awards based on total points earned per team

Vocabulary:

aileron – helps to keep the plane steady and assist in banking when making a turn, referred to as roll

Bernoulli's Principle – the law that pressure in a fluid decreases with the rate of flow

design – prepare sketches or plans to form something

drag – a restraining force parallel to the direction of movement; acts against the force of thrust

elevator – points the nose of the plane up or down, referred to as pitch

engineer – a person that designs, constructs or uses a device

force – the capacity to do work or cause physical change; energy, strength, or active power

gravity – the natural force of attraction between any two massive bodies, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them

invent – to create something new

lift – air flowing over and under the wing creates lift which counteracts the force of weight

process – an organized system used to solve a problem

propeller – a machine for propelling an aircraft or boat, consisting of a power-driven shaft with radiating blades that are placed so as to thrust air or water in a desired direction when spinning

propulsion – the act of propelling or the state of being propelled

rotor – a rotating part of an electrical or mechanical device

rudder – the vertical fin that steers the plane right or left, referred to as yaw

speed – distance divided by time; s=d/t

thrust – the force that moves the aircraft forward through the air counteracting the force of drag

weight – the force of gravity on the aircraft that constantly pulls the aircraft towards the ground

Materials:

Each student will need:

- Balsa wood propeller airplane kits
- Cardboard squares, 18”x18”
- Cutting knives
- Wood glue
- Clear tape
- Mini sticky notes
- Tape measure or meter stick
- Stopwatch (per group)
- 2 - Ground stakes (to mark runway distance)

Hand-powered toy airplane kits can be purchased from Dayton Aviation Heritage National Historical Park, your local hobby shop, or online.

Background Information:

There are four main forces exerted on a plane. They are lift, drag, thrust and gravity. Lift causes the plane to rise. Drag is the pull on the plane by the passing air. Thrust is the force that moves the aircraft forward through the air and gravity causes the plane to fall. When all four of these forces are balanced the plane will fly. A plane has many parts that help keep lift, drag, thrust and gravity balanced.

In this activity students build an airplane from a kit then re-design it to see if they can improve its flight. If you use the airplane type suggested in the lesson, the most obvious design change would be on the type of rubber band used to run the propeller, giving the plane more or less thrust.

Over the past 600 years, various people have made attempts at flight with various levels of success. Leonardo da Vinci designed flying machines from 1485-1500, but never attempted to build or fly any such machines. The first flying machine was a hot air balloon, flown by the Montgolfier brothers in 1783. In 1849, in a glider designed by George Cayley, a 10-year-old boy made short hops in the air. In 1890, Clement Ader made a short, powered hop in the air in a flying machine, but the flight was neither sustained nor controlled. From 1891-1896, a German man named Otto Lilienthal made numerous flights in his gliders until he died in an 1896 crash.

Orville and Wilbur Wright learned from many of these people as they designed the first successful powered, heavier-than-air, practical flying machine. The debate over "First in Flight" involves many of these people.

Procedures:

Days 1-3:

1. Activate prior knowledge by opening a discussion regarding the Wright brothers and North Carolina's state motto: "First in Flight". What does it mean? Aren't the Wright brothers from Ohio? Didn't they fly here first? Who else is credited with flying airplanes? Were the Wright brothers really the first to fly?
2. Next explain to students that they are beginning a three part competition to see who the classroom "First in Flight" team will be.

   Part 1 is researching famous aviators with the goal to present student information to the class in a debate.
   Part 2 is creating a timeline about early flights and technological advances.
   Part 3 is an engineering design challenge of building a model plane, testing and improving it, then competing against classmates.

3. Heterogeneously group students in fours, and assign them one of the topics below:

   a. Clement Ader

   b. Otto Lilienthal

   c. Samuel Pierpont Langley

   d. Alberto Santos-Dumont

   e. Wright brothers – Dayton, Ohio

   f. Wright brothers - Kitty Hawk, North Carolina

4. Students will research their inventor, and gather background information on the other inventors with the intention of performing a debate about who was "First in Flight. " Possible website: http://www.ueet.nasa.gov/StudentSite/historyofflight.html. See attached Gathering Grid (Appendix B) as a guide for helping students collect information. Students should also be looking at different airplane designs to begin thinking about the design challenge coming up.
5. Students perform the debate. Teams will receive points based on the most convincing argument and best score on the rubric (Appendix C).

Days 4-5:

1. Instruct teams to research and create a timeline of the history of flight, including any other major historical events beginning in 1000 B.C. with Chinese kites up to 1940. Possible websites include:
   http://www.nps.gov/featurecontent/daav/timeline/main.html
   http://teacher.scholastic.com/activities/flight/timeline.htm
2. Team with the best score receives points towards final score. Show students different types of model flying machines: a paper airplane, a balsa wood glider, a rubber band-powered propeller plane, and a rubber band catapulted glider. Pass them around so all students can examine them.

Day 6:

1. Introduce and explain the engineering design process. http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A). Present students with the design challenge.
2. Explain the activity to the students.
3. Review the four forces of flight (lift, drag, thrust, and gravity).
4. To help students understand plane motion, tape a cross of two strips of paper: one for the fuselage and one for the wings, to the back of each student's hand. With their palms facing down, have students wave their hands up and down, bending only at the wrist; this movement of the plane is called pitch (controlled by the elevator). Next, tilt the hand left and right; this is roll (controlled by ailerons on today's planes). Finally, with the hand palm-side down, bending at the wrist, move the hand from left to right; this is called yaw (controlled by the rudder).
5. Review Bernoulli's Principle using the wing of an airplane. Review the functions of the ailerons, elevators, and rudder. Review the terms pitch, roll, and yaw. Review the speed formula. (Speed = distance/time; s = d/t)
6. Each student group should receive a building kit, cardboard, and a cutting knife.
7. Tape the pattern to the cardboard, and write names on all materials. Follow the instructions for cutting out and assembling the airplane. Store airplanes in a very safe, undisturbed area overnight to allow the glue to dry.

Please remind students of the cautions needed when working with knives. Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the "takeoff" line. Give an "all clear" signal when it is time to fly the planes, and do not allow students to cross the "takeoff" line to retrieve airplanes that have already landed until a "retrieve all planes" signal has been given.

Day 7:

1. The students will do their test flights either inside (gymnasium) or out on a field. Stress to students that observations of the flight path must be accurate in order to make the proper modifications necessary to make it fly straight.

    a. Rotate the propeller clockwise 50 turns, and hold it there.
    b. Hold the plane level.
    c. When the "all clear" signal is given, students will release their planes. The Observers will watch to see if the plane flies straight.
    d. Record observations of the flight path of the plane in the flight log. (Time and distance)
    e. Repeat the trial flight with the propeller rotated clockwise 75 times and 100 times.

2. Record observations about the plane's flight in the flight log for each test flight. As homework, ask students to re-design the plane to improve its flight. Students should write a description and sketch their changes.

Day 8:

1. Allow students time to discuss/share ideas from homework on how to improve the flight of their plane. Remind teams this is a time to listen and understand each members re-design plan ideas. They should understand that each team member's ideas are valuable to the team design. Instruct teams to collaborate about their ideas and choose a final team design.

2. Have teams sketch a detailed team airplane design on Google Sketch Up or with PowerPoint drawing tools. Make modifications to model plane and test. Record data. Calculate speed.

Day 9:

1. See Airplane Redesign Rubric (Appendix D). Students compile data and write a brief report detailing their results before and after

Individually thinking about designs and materials silently allows those that would not normally offer input, an opportunity to creatively problem solve and have a voice in ideas for final team design.

Final design choice can be one of the member's presented ideas, or a combination of ideas.

Google Sketch Up is an online freeware tool used for creating 3D models. If computers are not available, sketches can also be completed using paper and pencil.

Take pictures throughout the building and testing. These can be added to teams' ideas. If plans were hand-drawn, they can be scanned in order to add to their multimedia presentations.

testing. Teacher or guest judge makes awards for "First in Flight" based on total points earned on the project, and may also include awards for longest flight (time or distance), etc.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Dayton Regional STEM Center: http://www.daytonregionalstemcenter.org

Interactive flight: http://www.pbs.org/wgbh/nova/space/pilot-wright-brothers-flyer.html

Scholastic website: http://teacher.scholastic.com/activities/flight/wright/choice1.htm

Timelines website: http://teacher.scholastic.com/activities/flight/timeline.htm

NASA website: http://www.ueet.nasa.gov/StudentSite/historyofflight.html

Extensions:

Schedule a field trip to Dayton Aviation Heritage National Historical Park. Use the Ranger for a Day lesson plan so that students become experts in an area of the park. Have students assume the role of the ranger by leading the tour of their expert section of the park.

Hold an evening Wright Brothers' symposium in order to display student planes and presentations. Invite families to go through the process of building a plane under the same constraints.

Students could design landing gear for the planes.

References/Works Cited:

This lesson is adapted from Project SOAR™: Science in Ohio through Aerospace Resources, Volume I-III. Dayton, Ohio: The National Museum of the United States Air Force and the Air Force Museum Foundation, Inc. 1997-1999.

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm

Propellers

Grade Levels: 6-8

Summary & Purpose:

This propeller lesson is one of four lessons for sixth through eighth grade students to study the Wright brothers and Paul Laurence Dunbar. This section may be taught alone or with any other sections chosen by the instructor. Students will learn that wind is moving air, and that it can occur naturally or through human effort. Students will explore propellers, which transform mechanical and/or electrical energy into wind energy to create propulsion. Students will use the engineering design process to develop the pitch of propeller blades.

While propeller design is a limited field of study, this unit will address multiple science, social studies, math, and language arts standards. Students will learn that forces cause changes in an object's motion. They will also learn that potential energy is stored in an object, and when released is transformed into kinetic energy, or motion. This lays the foundation for the study of Newton's laws of motion.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. At the Huffman Prairie Flying Field Interpretive Center, located at the top of Wright Brothers Hill overlooking Huffman Prairie, as well as at the Wright-Dunbar Interpretive Center, visitors will find helpful information on propellers. The centers provide examples of the innovations in propeller design made by Orville and Wilbur Wright as well as the developments made after their involvement in the field of aviation ended. Models and descriptions of some of the propellers can also be found at the Huffman Prairie Flying Field Interpretive Center.

Essential Questions & Enduring Understandings:

1. **How does force cause an object to speed up or slow down?** Forces cause changes in an object's motion. If an unbalanced force acts on an object, it will either increase or decrease its speed. If an object is not moving, all the forces acting on it are equal, so the object remains at rest. This motion, or speed, can be calculated by dividing distance by time (s = d/t).

2. **How can the potential energy in a rubber band be transformed into kinetic energy to create motion?** When a rubber band is stretched, it has stored, potential, energy. When it is released, the stored energy is transformed into kinetic energy, or the energy of motion.

A common misconception is that if an object is not moving, there are no forces acting upon it. Forces of friction, gravity, air pressure, etc. are constantly acting upon objects. When all forces are balanced, the object is at rest.

Lesson Overview:

Day 1	Engage**:** Build planes Explore propellers Present design challenge Silently view available materials
Day 2	Explore**:** Test plane with standard propeller Collect and record time and distance flown Explain**:** Discuss how changing the propeller blade pitch will affect flight path
Day 3	Explore**:** Affix new propeller to plane, adjust pitch Record data, repeat while using different pitches
Day 4	Elaborate**:** Summarize test results to reach a conclusion and prepare a poster to share results
Day 5	Evaluate**:** Share poster with class to describe what was tested and test results

Vocabulary:

blade – an arm of a propeller or windmill

blade pitch – the angle of attack of the blades of a propeller or helicopter rotor into or out of the wind to control the production or absorption of power

hub – the center of a propeller or windmill where the blades attach

kinetic energy – the energy an object has when in motion

potential energy – the energy of a system that is stored

propeller – a device that spins in order to push air

properties – characteristics that define an object

propulsion – pushing an object

shaft – a spinning bar used to move an object such as a propeller

thrust – a pushing force

wind – moving air; this occurs in nature as a result of the sun heating the surface of the Earth

Materials:

For each student team (3-4 students):

- Stopwatch
- Meter stick or tape measure
- 1 - Hand-powered helicopter toy
- 1 - Adjustable pitch propeller
- 1 – Hand-powered propeller plane

Hand-powered toy helicopters can be purchased from Dayton Aviation Heritage National Historical Park, your local hobby shop, or online.

Background Information:

Orville and Wilbur Wright came to understand that a propeller works like a rotary wing. As the propeller spins, it generates thrust by creating a low-pressure area in front of the propeller and a high-pressure area behind. This makes the air move backward and pushes the plane forward at the same time. The shape of the airfoil on the propeller, the speed at which it spins, and other factors affect the efficacy of the propeller.

Blade pitch or simply pitch refers to turning the angle of attack of the blades of a propeller or helicopter rotor into or out of the wind to control the production or absorption of power. Wind turbines use this to adjust the rotation speed and the generated power. A propeller of a ship uses this effect to control the ship's speed without changing the rotation of

the shaft and to increase the efficiency of streaming fluids. Blade pitch acts much like the gearing of the final drive of a car. Low pitch yields good low speed acceleration (and climb rate in an aircraft) while high pitch optimizes high speed performance and economy. It is quite common in aircraft for the propeller to be designed to vary pitch in flight, optimizing both cruise and takeoff performance.

The design of a propeller, like an airplane, is influenced by many factors, some of which cause contradictions in design. The overall shape is determined by compromise and is largely dependent on the mission to be performed. For low speeds, the propeller blade is usually slender with rounded tips. For high speeds, larger paddle-shaped blades are used or more propeller blades are used.

Read more: http://en.wikipedia.org/wiki/Blade_pitch
http://www.ehow.com/about_6103907_effect-pitch-angle-airplane-thrust.html#ixzz1W9YrcsfV

Procedures:

Day 1:

1. Before the first lesson, find a place where you can set up a wire or string at chest height and 120 feet long. (This was the distance of the Wright brothers' first flight in 1903.) This will be your "runway" for flight testing the planes and propeller changes.
2. Before the first lesson, make a "harness" of hanger wire for the airplane that will suspend it from the "runway". It should be heavy enough to hold the airplane on the runway in a straight line. It should also allow free propeller rotation without interference. You may decide to make several harnesses so some students can be setting up their planes while others are testing.
3. Have students follow directions to assemble planes from kits.
4. Set planes aside for use later in the lesson.
5. Show the video "The Wright Brothers in Flight" at http://www.youtube.com/watch?v=q3beVhDiyio. Have students record their observations about what is creating propulsion to push the plane through the air.
6. Think-Pair-Share: Activate prior knowledge by having students record what they know about propellers and how they push or propel a plane. Instruct them to share thoughts with a partner and record any additional ideas gained through discussion. Then ask students to share ideas with the class while additional ideas gained through sharing are recorded (Appendix E).
7. Give each team a hand-powered helicopter toy to fly and observe outside or in a gym. Demonstrate how the toy works and discuss safety rules. Allow students to explore with the

helicopters for a few minutes while recording their observations about how propellers work.

8. Allow time for student teams to analyze the toy helicopter and their flying machine completed in the previous flight study section. Have them decide why they think the Wright brothers chose to add propellers to their flying machine (Appendix F). If students are not noticing similarities in propellers and wings, guide them to make connections through leading questions.
9. Show students a map of Dayton, Ohio with the locations of the Wright Cycle Company shop and Huffman Prairie marked. Discuss that in search of greater wind speed, Orville and Wilbur Wright travelled to Kitty Hawk, North Carolina to test their flying machines.
10. Distribute a map of the United States; have students use the map scale for calculating the distance the brothers traveled to test their flying machines.
11. Divide the class into teams of 3-4 students, introduce the engineering design challenge, and review the engineering design process: http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A).

Day 2:

1. Give each team a rubber band and elicit ideas about how a rubber band can be used as energy to make something move. Discuss the potential energy stored in the rubber band when it is stretched. Let go of the rubber band and discuss that when the rubber band's potential energy is released, it is transferred to kinetic energy as it achieves motion.
2. Conduct a test flight of the airplanes to collect time and distance data. Instruct students to share ideas about changing the pitch on the propellers. Remind teams this is a time to listen to each member's thoughts. They should understand that each team member's ideas are valuable.

Day 3:

1. Allow teams time to revisit their propeller ideas. Distribute variable pitch propellers and instruct teams to begin testing.
2. Instruct teams to test their propellers by attaching them to the hub of the propeller mechanism. They should begin by winding the propeller 100 times before letting it go. Results and modification ideas should be recorded (Appendix G). Inform students that engineers research and collaborate with each other as they

Encourage students to make positive comments to one another during the discussions.

Citizenship note: It is important to emphasize engineers and scientists, like the Wright brothers, use their failures as tools to help them make their designs better. Point out the difference between the original Wright Flyer and the aircraft we see today. Explain that these changes were made in response to failures in earlier designs.

Take pictures for students to use in their posters.

complete projects. Therefore, they too should observe other teams' propeller tests and learn from them.

3. After all teams have tested and modified their propellers, have each team measure distance traveled as well as time taken to travel the distance. Then, calculate speed by dividing distance by time. Calculate the average (mean) speed for all planes in the class.

Day 4:

1. Summarize test results to reach a conclusion and prepare a poster to share results.

Day 5:

1. Share poster with class to describe what was tested and test results.

Social Studies and Language Arts Integration:

Social Studies:

1. Instruct teams to research the history of the propeller and add to their flight timeline started in previous section. If this is the first or only lesson chosen by instructor, instruct teams to begin a timeline about the history of flight along with several other major historical events beginning with the first flying glider and ending with present day.
2. Direct teams to compile their research and write a newspaper article about the Wright brothers' first use of the propeller, and how the propeller has changed since then.
3. Direct them to also write a newspaper article reporting information about their team's design, data, successes, failures, and suggestions for future improvements. Then explain how a propeller works. They can also write about how a propeller is able to generate energy by use of wind turbines.

If the Social Studies/ELA integration plan is followed, teacher could skip the poster step in favor of the newspaper assessment.

The following assignments can be jigsawed within the team. Each team member is responsible for completing one section. After articles are finished, the team can convene to share their information. Finally, they should take time to edit each other's articles before publishing into the final newspaper.

Language Arts:

1. Write newspaper articles using their research from social studies and data from science.
2. Have students take on the role of Orville or Wilbur and write a narrative about their decision to use a propeller and how the propeller helped their flying machine fly successfully.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Newspapers from Wright era: http://chroniclingamerica.loc.gov/

School photo with Orville Wright and Paul Laurence Dunbar: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg

Adjustable-Pitch Propellers (Part One): http://www.flightlearnings.com/adjustable-pitch-propellers-part-one/607/

Propellers for Model Aircraft: http://www.airfieldmodels.com/information_source/model_aircraft_engines/propellers.htm

Engineering design process http://www.daytonregionalstemcenter.org/engineering-design-process/

Extensions:

Explore propellers further by taking apart items containing propeller-type blades (battery operated fan). Attach the blades to propel toys that do not normally use propellers.

Examine the propellers from a boat or submarine and the propellers of an airplane. Compare and contrast the shapes and functions of each.

Find photographs of propeller designs from different years and analyze them for design changes over time.

Invite a park ranger from Dayton Aviation Heritage National Historical Park to visit your classroom.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

The Effect of a Propeller Pitch Angle on an Airplane Thrust http://www.ehow.com/about_6103907_effect-pitch-angle-airplane-thrust.html#ixzz1W9YrcsfV

More information about propellers
http://en.wikipedia.org/wiki/Blade_pitch
http://www.wright-brothers.org/

"The Wright Brothers in Flight" video at http://www.youtube.com/watch?v=q3beVhDiyio

Catapults

Grade Levels: 6-8

Summary & Purpose:

This catapult lesson is one of four lessons for sixth through eighth grade students to study the Wright brothers and Paul Laurence Dunbar. Students are presented with a scenario in which Dayton Aviation Heritage National Historical Park has requested their help in the study of aircraft catapults such as those used by the Wright brothers and on aircraft carriers. Teams are asked to observe and study video clips of aircraft catapults, sketch and build a working prototype using a propeller-driven toy airplane and other specified materials, and explain how catapults are able to successfully launch a flying machine. They are also asked to research and create a timeline including the development of aircraft catapults beginning with the Wright brothers and ending with present-day aircraft launching systems. Other major historical events that would fit onto the timeline may be included.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park consists of six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. Huffman Prairie Flying Field Interpretive Center displays the history of the Wright brothers' work after 1903, including their use of catapults. The brothers flew, tested and improved their planes at Huffman Prairie Flying Field. The field includes a replica of their catapult, a replica of a hangar used for storing their airplane, and information panels that discuss their work at the site. The Wright Company operated the first flying school, the Wright School of Aviation, at Huffman Prairie Flying Field. One hundred nineteen pilots, including three women, were trained to fly at the flying field.

Essential Questions and Enduring Understandings:

1. **How can observations and inferences be used to solve and explain a problem?** Observation and inference are methods to model what others have accomplished and begin thinking innovatively to improve the model in order to solve a problem.

2. **How is the engineering design process used to design, collaborate, build and test a prototype and communicate solutions?** The engineering design process is a valuable method in which data and inquiry guide the problem-solving process, and in which collaboration with others and communicating solutions are integral parts of the process.

3. **How do tables, charts and timelines help in understanding information, issues, and changes in history over time?** Tables, charts and timelines are tools to help show relationships among events, places, or information.

4. **How can energy be transformed or transferred in order to exert enough force to move an object?** Energy can be transformed from stored (potential) energy to movement (kinetic). Energy is transferred from one form to another and one location to another.

Lesson Overview:

Days 1-2	View videos and record observation Prepare a timeline and presentation
Day 3	Present scenario Silently view available materials Sketch an individual catapult design plan
Day 4	Teams discuss individual design plans Teams choose a design plan Teams sketch a design Begin catapult construction
Day 5	Complete construction Test, redesign, refine, test again Record test data
Day 6	Present to class and possibly park ranger or forward presentations to park

Vocabulary:

catapult – slingshot; launching device

projectile – a launched, thrown, or propelled object, such as a ball

Materials:

Materials can vary. Below are some suggested materials for each team.

- Balsa wood propeller airplane kits
- 2 - Straws
- 4 - Popsicle sticks, craft sticks or tongue depressors
- 1 - Paint stick
- Masking tape, 50 cm.
- 2 - Index cards, cardboard, or cardstock
- String, 1 meter length
- 1 - Paper cup
- 1 - Plastic spoon or plastic soda bottle lid
- 4 - Rubber bands
- 2 - Marshmallows or cotton balls
- 2 - Paper clips
- 1 - Target (could use a coffee filter)
- Tape measure
- Engineering design process poster (Appendix A)
- Copies of appendices

Per student (for Day 1 exploration):

- 1 - Cotton ball
- 1 - Rubber band

Background Information:

In order to achieve lift, the Wright brothers relied on headwinds. Through extensive experimentation, they concluded that headwinds of 11.8-14.9 mi/h (19-24 km/h or 5.3-6.7 m/s) would be needed to obtain lift for their glider. When the brothers were ready to experiment with flight, they decided that it was imperative they transport their machine to a location that offered more consistent headwinds than their hometown of Dayton, Ohio provided. Therefore, they transported their flying machine components by train and boat to Kill Devil Hills, North Carolina.

At Kill Devil Hills, they experimented with pilot-controlled flights in gliders in 1900, 1901 and in 1902. To launch their gliders, they used a combination of human power and headwinds.

In 1903, they added an engine to their glider to provide power and propellers to provide thrust. The plane was now too large to use human power, so the brothers would incorporate a track for the plane to travel. Using a modified bicycle hub, the plane travelled down a 60-foot (18.29 m) single rail. On December 17, 1903, they achieved the first powered flight. When returning to Dayton, Ohio they used Huffman Prairie, a cow pasture, to continue experimenting with the machine, but were not as successful due to continual battles with inconsistent wind speeds and changing wind direction. In 1904, they decided to rig a catapult to launch the machine down the rail. A 1,600-pound (726 kg) weight supported by a derrick, or tower, pulled the machine down the rail with enough speed to launch it into the air. On September 20, 1904, two weeks after first using the catapult, Wilbur completed their first circle and flew 4,080 feet (1.24 km) in approximately 1 minute 35 seconds. Dayton's inconsistent winds were no longer an obstacle to making flight practical; the catapult made it possible for the Wrights to fly anytime, anywhere without dependence on wind.

Catapults were developed long ago as engines of war, used to launch increasingly heavier projectiles at enemies from increasingly greater distances. The Wright brothers transformed a weapon of war into a catalyst for human flight.

Procedures:

Days 1 & 2:

1. Access prior knowledge by opening a discussion regarding the Wright brothers and catapult uses.
2. Divide students into teams of 3-4 students.
3. Allow time for students to explore the purpose of catapults by experimenting with cotton balls. Have them first throw the cotton ball, then launch it with a rubber band. Elicit that the rubber band is acting as a catapult launching the cotton ball.
4. Instruct teams to research and create a timeline of the history of the catapult as an aircraft-launching device. They must also include additional major historical events on the timeline. For example:
   http://autocww.colorado.edu/~blackmon/E64ContentFiles/MilitaryWeapons/Catapult.html
   http://science.howstuffworks.com/transport/engines-equipment/question127.htm
5. Have teams prepare a multimedia presentation of the timeline (PowerPoint, prezi.com, glogster.com).

In this activity students build an airplane from a kit then re-design it to see if they can improve its flight time or distance by launching it from a catapult. If you use the airplane type suggested in the lesson, students will need to be cautious that they don't develop too much thrust or else the plane will be driven into the ground.

Doing the timeline before creating a catapult will help the students generate better ideas for their own design.

Day 3:

1. Distribute and explain the Catapult Video Viewers Guide (Appendices H and J). This is to be completed as they view videos of aircrafts being launched by catapults.
2. Instruct students to complete the handout as they view the following series of videos as directed on the worksheet. http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm
3. Introduce and explain the engineering design process poster (Appendix A). http://www.daytonregionalstemcenter.org/engineering-design-process/
4. Present students with the scenario and design challenge.
5. Students will need to build planes and test them before launching them from catapults. (If this is the case, please allow 2 extra days for building and initial testing and collecting of data.)
6. Place available materials for catapult construction on each team's table. Do not allow students to talk to each other about materials or design ideas. This will give each student time to brainstorm and create their own design plan without influence from others.
7. Instruct students to make a list of materials and begin sketching their design ideas. Sketches may be completed for homework.

Having students think about designs and materials silently allows those that would not normally offer input an opportunity to creatively problem solve and have a voice in ideas for final team design.

Day 4:

1. Allow students time to discuss individual design plans and ideas. Remind teams this is a time to listen and understand each member's design plan ideas. They should understand that each team member's ideas are valuable to the final team design.
2. Instruct teams to collaborate about their ideas and choose a final team design.
3. Have teams sketch a detailed team catapult design on Google Sketch Up or with PowerPoint drawing tools.

Final design choice can be one of the member's presented ideas, or a combination of ideas.

Google Sketch Up is an online freeware tool used for creating 3D models. If computers are not available, sketches can also be completed using paper and pencil.

Day 5:

1. Allow time for each team to review and discuss their team design plan.
2. Distribute materials to each team and allow them to begin the design process. Remind them to continue following the engineering design process.
3. Observe to ensure teams are testing their designs, recording flight time and distance in results column and modifying the design for better accuracy.

Safety: Remind students to be careful when working with sharp objects.

Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the "takeoff" line. Give an "all clear" signal when it is time to fly the planes, and do not allow students to cross the "takeoff" line to retrieve airplanes that have already landed until a "retrieve all planes" signal has been given.

Day 6:

1. Allow time for each team to present their information and demonstrate for the class. Possible rubric for evaluation can be found at Appendix K.
2. Forward presentations and pictures of each team's catapult to a ranger at Dayton Aviation Heritage National Historical Park for feedback and possible use at the park.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Dayton Regional Stem Center: http://www.daytonregionalstemcenter.org

How Stuff Works: http://science.howstuffworks.com/transport/engines-equipment/question127.htm

Wright Brothers Aeroplane Virtual Museum: http://www.wright-brothers.org/

The Historical Marker Database
Photos of catapult at Huffman Prairie:
http://www.hmdb.org/PhotoFullSize.asp?PhotoID=13282
http://www.hmdb.org/marker.asp?marker=4587
Photo of re-enactment of replica Wright Flyer III and catapult at Huffman Prairie Flying Field:
http://static.slugsite.com/wright-catapult-1-big.jpg

Extensions:

Schedule a field trip to Dayton Aviation Heritage National Historical Park. Use the Ranger for a Day lesson plan so that students become experts in an area of the park. Have students assume the role of the ranger by leading the tour of their expert section of the park.

Hold an evening Wright brothers' symposium in order to display student planes and presentations.

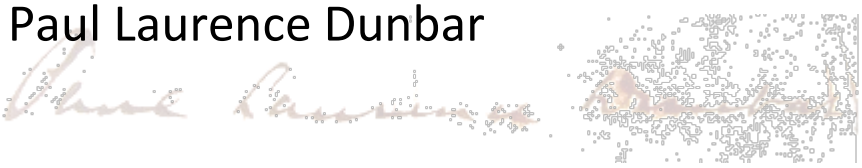
Have students design landing gear for the planes.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

http://autocww.colorado.edu/~blackmon/E64ContentFiles/MilitaryWeapons/Catapult.html

Paul Laurence Dunbar



Grade Levels: 6-8

Summary & Purpose:

This Paul Laurence Dunbar and printing process lesson is one of four lessons for sixth through eighth grade students to study the Wright brothers and Paul Laurence Dunbar. This lesson integrates well with the three-part study of flight lessons or may be taught alone. Students will learn about the changes made over time in written text. Students will analyze Paul Laurence Dunbar's poetry, and model their own poetry after Dunbar's poetry.

This unit will address multiple social studies and language arts standards. Students will learn that life has not always been the way they see it, but that inventions and innovations have changed the world in which we live. Students will learn how to interpret a piece of poetry to infer what the poet meant by his or her words. They will then choose descriptive, vivid words to convey their own thoughts about a topic in poetry form.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park commemorates, among other things, the history of Orville and Wilbur Wright's printing business and Paul Laurence Dunbar's literary successes. At the Wright-Dunbar Interpretive Center, visitors will find significant information on both the Wrights' printing business and Paul Laurence Dunbar. The center displays many of Dunbar's literary works as well as a restored Wright brothers' print shop and a printing press similar to one the Wright brothers operated. The Dunbar House, a house originally purchased by Dunbar for his mother, and the house where he passed away in 1906, became a state memorial in 1938, the first to publicly honor an African American. At the Dunbar House visitors will find significant information about and artifacts from Paul Laurence Dunbar's life.

Essential Questions & Enduring Understandings:

1. **How do technological advances cause change in a community over time?** Technological advances provide more convenient methods for doing things. This creates change in a community by creating opportunity for new innovations and opportunities.

2. **Why does our point of view about a piece of writing differ from others and from the author?** Because everyone has unique life-experiences, each individual will interpret the meaning of a piece of literature based on these experiences.

3. **How can an author's choice of words influence our interpretation of a piece of literature?** An author's word choice influences the reader by painting a picture in our minds. The more descriptive and vivid the words are, the clearer the picture they create. Therefore, the reader is better able to interpret the writer's meaning and feeling about their piece.

Lesson Overview:

Day 1	Display image stamped on paper Discuss life before, and after the printing press Discuss digital media as an innovative way to print Hold printing press challenge
Day 2	Introduce Paul Laurence Dunbar Listen to and discuss *Toast to Dayton* (Appendix L) Begin analyzing the poem
Day 3	Complete analyzing Begin individual poem brainstorming
Day 4	Complete individual rough draft and editing
Day 5	Publish poem in newspaper format

Vocabulary:

cause – interest or welfare of something

consecrate – to honor something with respect (synonym of venerate)

decked – decoratively dressed

desert – leave behind

diadem – crown

duty – respectfulness

ebb – flow back (antonym of flow)

fate - ruin

gracious – very kind

hail – cheer or welcome

interpret – to find the meaning of something

loyalty – faithful

nay – no

printing press – a machine used to print text

revere – to treat something with respect (synonym of venerate)

righteous – upright, wonderful

sublimest – greatest

toast – to honor someone or something

veneration – a feeling of respect

welfare – happiness, well-being

Materials:

- Rubber stamp with words (i.e., "great job", "sign and return"...)
- Ink pad
- Computer
- Pen and paper

Background Information:

As entrepreneurs, Orville and Wilbur Wright became business partners in 1889 when they opened their printing shop. They edited and published newspapers, and printed

advertising and news circulars for customers. They also printed an African American newspaper, the *Dayton Tattler*, written and edited by Paul Laurence Dunbar. In 1899 the Wright brothers sold their printing business so they could experiment with flying.

Paul Laurence Dunbar and Orville Wright were classmates and acquaintances at Dayton Public School's Central High School. Dunbar was the editor of the high school newspaper, *High School Times.* When Dunbar decided to publish a newspaper, the *Dayton Tattler,* for Dayton's African American community, he asked Orville and Wilbur to print it for him. Unfortunately, the newspaper did not last long, and they only printed three editions. He began creating poetry at the age of six, reciting poetry publicly at the age of twelve, publishing at the age of fourteen, and selling his first book of poetry at the age of twenty. Dunbar is credited as being the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers.

Procedures:

Day 1:

1. Stamp a piece of paper with an image from each stamp students will use (1/3 of the students will each need a stamp).
2. Activate prior knowledge by asking: "How were multiple copies of a flyer, book, magazine, etc. printed in order to share with several people?" Elicit responses about hand copying them and how tedious and time-consuming the process must have been.
3. Discuss change in the printing and publishing process. Display photos of the printing press, similar to what the Wright brothers may have used (Appendices O and P).
4. Ask students how most of our information is presently published. Elicit digital media technologies.
5. Divide class into three groups and assign each group a different printing method. Allow a few minutes for them to practice.
   Group 1: each student handprints one of the stamp images using a pen and paper.
   Group 2: each student uses an inkpad to stamp the image on a sheet of paper.
   Group 3: each student uses a computer to create the image on the screen.
6. After students have had a few minutes to practice their assigned type of printing, hold a printing contest. Instruct students to "print" as many copies of their image as possible in ten minutes.

Students will print the same image: one by hand, one by stamp and inkpad, and one by computer: copy and paste. Therefore, each student that is completing the handwritten and computer printing should stamp the image onto an index card for reference.

7. Set a timer for ten minutes. Have them count their number and discuss the results with the other students doing the same image.
8. Discuss how innovations have made it easier to share information. Ask students to provide other examples of how innovations have provided more conveniences.
9. Show students a video of a newspaper printing house. http://www.youtube.com/watch?v=q2RU4d9xu5k

Day 2:

1. Introduce Paul Laurence Dunbar by displaying Dayton's Central High School Senior Class of 1890 photo: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg
2. Compare the photo to modern day class photos. Elicit discussion about their observations of the photo. Point out that Paul Laurence Dunbar and Orville Wright are both in the photo and explain that while they attended school together they became aquaintances.
3. Investigate Paul Laurence Dunbar's literary accomplishments: http://www.poetryfoundation.org/bio/paul-laurence-dunbar
4. Explain that Dunbar was the editor of their high school newspaper, *High School Times*. Also, that when Dunbar decided to publish a newspaper, the *Dayton Tattler,* for Dayton's African American community, he asked the Wrights to print it for him.
5. Display photos of the Wright brothers' newspapers including the *Dayton Tattler*: http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers Discuss their printing style as well as the type of articles they included.
6. Inform students that Paul Laurence Dunbar is a famous poet and the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers.
7. Display Dunbar's poem, Toast to Dayton (Appendix L).
8. Think-Pair-Share: Have students think about the meaning of the poem by interpreting each stanza using the graphic organizer (Appendix M). This can be completed for homework.

Day 3:

1. Allow time for students to review their interpretation, then have them discuss with a partner. Next, instruct students to share some of their interpretations with either a larger group or with the class.
2. Instruct students to complete the *Toast to Dayton* analyzing and brainstorming sheet (Appendix N).

Day 4:

1. Explain to students that they will now create their own poem based on their recorded responses on the analyzing and brainstorming sheets.
2. Conference with individual students as they write their rough draft to ensure understanding.
3. Have students begin peer editing when they finish their rough draft.

Have students share pieces of their poem throughout the writing session. This helps others generate ideas, especially when they are experiencing writer's block.

Day 5:

1. Complete editing.
2. Instruct students to publish their poems in newspaper format. The following link can be used as a template for creating newspapers: http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html
   Poetry can also be added to newspapers created in other flight study lessons.
3. Ask students if they would rather publish multiple copies of their poem and newspaper by handwriting them, using a printing press, or by telling the printer how many to print. Review how publishing has changed and become more convenient over time.

Social Studies Integration:

1. Add the history of the printing press and of Paul Laurence Dunbar's life to the timeline and newspaper created in other flight study lessons. If these have not been created, direct students to create a timeline and a newspaper that incorporate the history of the printing press and the lives of the Wright brothers and Paul Laurence Dunbar. The following interactive website is very helpful:
   http://www.nps.gov/featurecontent/daav/timeline/main.html
2. Discuss the changes in media, aviation, and society over time due to the innovativeness of the Wright brothers. Paul Laurence Dunbar is credited as being the first African American writer to receive attention and praise in the United States, opening doors for a new generation of writers. Discuss how Paul Laurence Dunbar's literature opened doors for African American writers.

Resources:

Dayton Aviation Heritage National Historical Park website: http://www.nps.gov/daav/index.htm

Paul Laurence Dunbar biography: http://www.poetryfoundation.org/bio/paul-laurence-dunbar

Newspaper template from Read Write Think website: http://www.readwritethink.org/classroom-resources/studentinteractives/readwritethink-printing-press-30036.html

Photos of the Wright brothers' newspapers: http://content.daytonmetrolibrary.org/cdm/search/searchterm/Wright%20Brothers%20Newspapers

School photo with Orville Wright and Paul Laurence Dunbar: http://www.libraries.wright.edu/special/dunbar/images/gallery/large/dunbar_wright.jpg

Interactive timeline: http://www.nps.gov/featurecontent/daav/timeline/main.html

Extensions:

Continue Paul Laurence Dunbar study by interpreting other literary pieces and using them as a model.

Interpret one of Dunbar's dialect poems. Have students interview a family member about a topic and write a poem using the same language pattern and vocabulary their family member uses.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Dayton Aviation Heritage National Historical Park
Alignment of Standards Sixth through Eighth Grade

	Flying Machines	Propellers	Catapults	Printing Process and Paul Laurence Dunbar
Science				
6 – There are two categories of energy: kinetic and potential.	X	X	X	
6 – An object's motion can be described by its speed and the direction it is moving.	X	X	X	
7 – Energy can be transferred through a variety of ways.	X	X	X	
8 – Forces between objects act when the objects are in direct contact or when they are not touching.	X	X	X	
8 – Forces have magnitude and direction.	X	X	X	
8 – There are different types of potential energy.	X	X	X	

Social Studies				
6.HIST A – Interpret relationships between events shown on multiple-tier time lines.	X	X	X	X
6.SSSM A – Analyze different perspectives on a topic obtained from a variety of sources.	X	X	X	X
6.SSSM C – Present a position and support it with evidence and citation of sources.	X	X	X	X
7.1. Historians and archeologists describe historical events and issues from the perspectives of people living at the time to avoid evaluating the past in terms of today's norms and values.	X	X	X	X
7.HIST A – Interpret relationships between events shown on multiple-tier time lines.	X	X	X	X
7.SSSM A – Analyze different perspectives on a topic obtained from a variety of sources.	X	X	X	X
7.SSSM C – Present a position and support it with evidence and citation of sources.	X	X	X	X
8.1. Primary and secondary sources are used to examine events from multiple perspectives and to present and defend a position.	X	X	X	X
8.22. Choices made by individuals, businesses and governments have both present and future consequences.	X	X	X	X
8.HIST A – Interpret relationships between events shown on multiple-tier time lines.	X	X	X	X
8.SSSM A – Analyze different perspectives on a topic obtained from a	X	X	X	X

variety of sources.				
8.SSSM C – Present a position and support it with evidence and citation of sources.	X	X	X	X

Mathematics				
6.EE.6. Use variables to represent numbers and write expressions when solving real-world or mathematical problems.	X	X	X	
6.EE.7. Solve real world and mathematical problems by writing and solving equations of the form x+p=q and px=q for cases in which x, p, and q are non-negative numbers.	X	X	X	
6.M.B. Convert units of length, area, volume, mass and time within the same measurement system.	X	X	X	
6.N.F. Apply number system properties when performing computations.	X	X	X	
6.N.B. Compare, order and convert among fractions, decimals and percents.	X	X	X	
6.A.C. Use variables to create and solve equations and inequalities representing problem situations.	X	X	X	
6.A.F. Use representations, such as tables, graphs and equations, to model situations and to solve problems, especially those that involve linear relationships.	X	X	X	
6.A.J. Use formulas in problem-solving situations.	X	X	X	
6.D.B. Interpret data by looking for patterns and relationships, draw and justify conclusions, and answer related questions.	X	X	X	
6.A.L. Analyze functional relationships, and explain how a change in one quantity results in a change in the other.	X	X	X	
6.D.C. Evaluate interpretations and conclusions as additional data are collected, modify conclusions and predictions, and justify new findings.	X	X	X	
6.D.E. Collect, organize, display and interpret data for a specific purpose or need.	X	X	X	
7.M.B. Convert units of length, area, volume, mass and time within the same measurement system.	X	X	X	
7.N.F. Apply number system properties when performing computations.	X	X	X	
7.N.B. Compare, order and convert among fractions, decimals and percents.	X	X	X	
7.A.C. Use variables to create and solve equations and inequalities representing problem situations.	X	X	X	
7.A.F. Use representations, such as tables, graphs and equations, to model situations and to solve problems, especially those that involve linear relationships.	X	X	X	
7.A.J. Use formulas in problem-solving situations.	X	X	X	
7.D.B. Interpret data by looking for patterns and relationships, draw and justify conclusions, and answer related questions.	X	X	X	
7.A.L. Analyze functional relationships, and explain how a change in one quantity results in a change in the other.	X	X	X	
7.D.C. Evaluate interpretations and conclusions as additional data are	X	X	X	

collected, modify conclusions and predictions, and justify new findings.				
7.D.E. Collect, organize, display and interpret data for a specific purpose or need.	X	X	X	
8.M.B. Convert units of length, area, volume, mass and time within the same measurement system.	X	X	X	
8.N.F. Apply number system properties when performing computations.	X	X	X	
8.N.B. Compare, order and convert among fractions, decimals and percents.	X	X	X	
8.A.C. Use variables to create and solve equations and inequalities representing problem situations.	X	X	X	
8.A.F. Use representations, such as tables, graphs and equations, to model situations and to solve problems, especially those that involve linear relationships.	X	X	X	
8.A.J. Use formulas in problem-solving situations.	X	X	X	
8.D.B. Interpret data by looking for patterns and relationships, draw and justify conclusions, and answer related questions.	X	X	X	
8.A.L. Analyze functional relationships, and explain how a change in one quantity results in a change in the other.	X	X	X	
8.D.C. Evaluate interpretations and conclusions as additional data are collected, modify conclusions and predictions, and justify new findings.	X	X	X	
8.D.E. Collect, organize, display and interpret data for a specific purpose or need.	X	X	X	

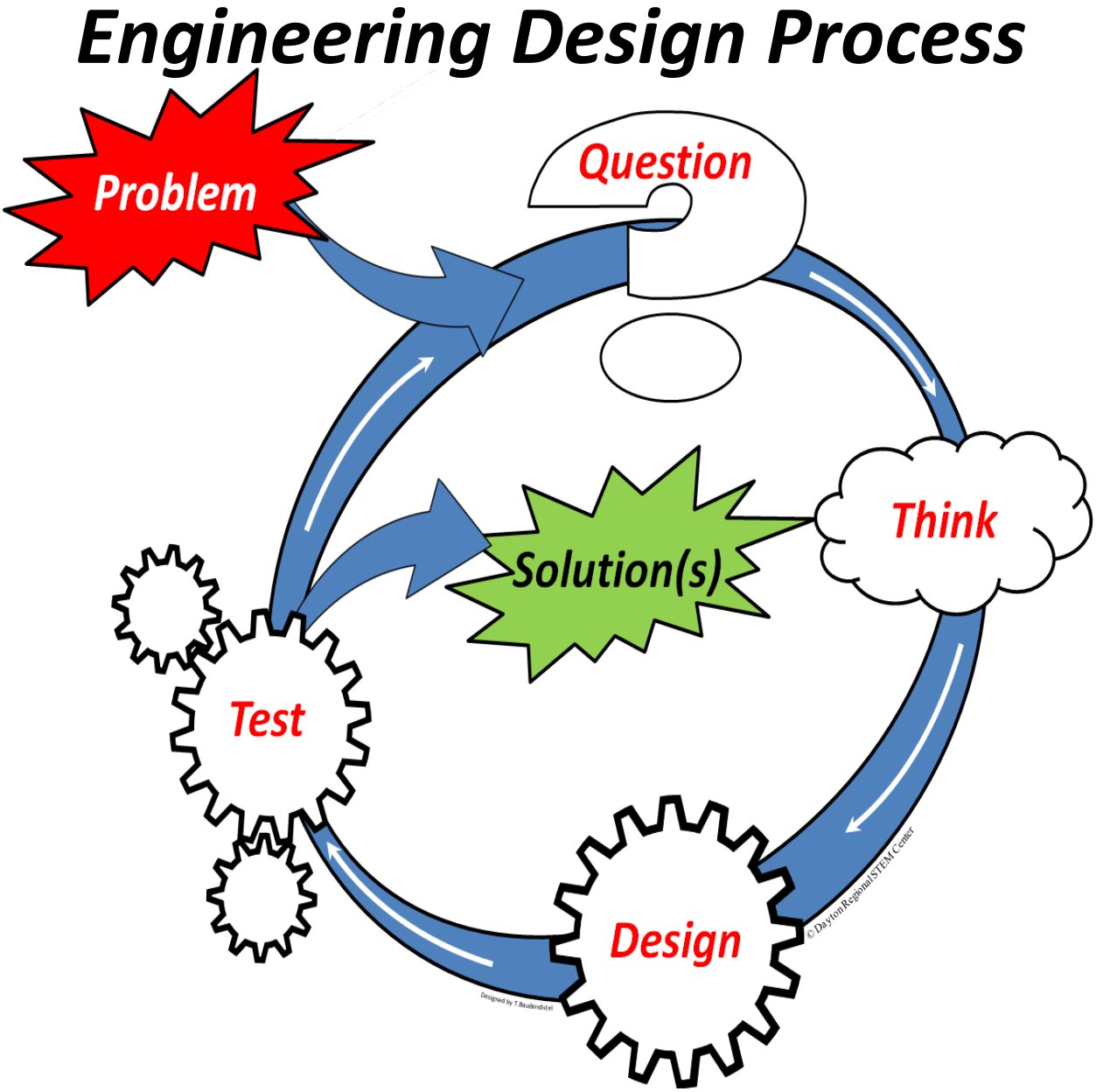
English Language Arts				
6.RPB. Apply effective reading comprehension strategies, including summarizing and making predictions, and comparisons, using information in text, between text and across subject areas.	X	X	X	X
6.RPC. Make meaning through asking and responding to a variety of questions related to text.				X
6.AVA. Use context clues and text structures to determine the meaning of new vocabulary.	X	X	X	X
6.AVB. Infer word meaning through identification and analysis of analogies and other word relationships.				X
6.LTD. Differentiate between the points of view in narrative text.				X
6.ITE. Explain the treatment, scope and organization of ideas from different texts to draw conclusions about a topic.				X
6.ITF. Determine the extent to which a summary accurately reflects the main idea, critical details and underlying meaning of original text.				X
6.ITC. Explain how main ideas connect to each other in a variety of sources.	X	X	X	X
6.ITA. Use text features and graphics to organize, analyze and draw inferences from content and to gain additional information.				X
6.ITB. Recognize the difference between cause and effect and fact and opinion to analyze text.				X
6.WPD. Use revision strategies to improve the overall organization, the clarity and consistency of ideas within and among paragraphs and the logic	X	X	X	X

and effectiveness of word choices.				
6.REE. Communicate findings orally, visually and in writing or through multimedia.	X	X	X	X
6.REB. Locate and summarize important information from multiple sources.	X	X	X	X
6.RED. Acknowledge quoted and paraphrased information and document sources used.	X	X	X	X
6.WAD. Produce informational essays or reports that convey a clear and accurate perspective and support the main ideas with facts, details, examples and explanations.	X	X	X	X
6.WPD. Use revision strategies to improve the overall organization, the clarity and consistency of ideas within and among paragraphs and the logic and effectiveness of word choices.				X
6.REC. Organize information in a systemic way.	X	X	X	X
6.WPH. Prepare writing for publication that is legible, follows an appropriate format and uses techniques such as electronic resources and graphics.	X	X	X	X
6.WPC. Clarify ideas for writing assignments by using graphics or other organizers.	X	X	X	X
6.WPF. Edit to improve fluency, grammar and usage.	X	X	X	X
6.REA. Formulate open-ended research questions suitable for inquiry and investigation and develop a plan for gathering information.	X	X	X	X
6.COA. Use effective listening strategies, summarize major ideas and draw logical inferences from presentations and visual media.	X	X	X	X
6.COF. Give presentations using a variety of delivery methods, visual materials and technology.	X	X	X	X
6.WCA. Use correct spelling conventions.	X	X	X	X
6.WCB. Use conventions of punctuation and capitalization in written work.	X	X	X	X
6.AVF. Use multiple resources to enhance comprehension of vocabulary.	X	X	X	X
7.RPB. Apply effective reading comprehension strategies, including summarizing and making predictions, and comparisons, using information in text, between text and across subject areas.	X	X	X	X
7.RPC. Make meaning through asking and responding to a variety of questions related to text.				X
7.AVB. Infer word meaning through identification and analysis of analogies and other word relationships.				X
7.LTD. Differentiate between the points of view in narrative text.				X
7.ITC. Explain how main ideas connect to each other in a variety of sources.	X	X	X	X
7.ITA. Use text features and graphics to organize, analyze and draw inferences from content and to gain additional information.	X	X	X	X
7.ITF. Determine the extent to which a summary accurately reflects the main idea, critical details and underlying meaning of original text.				X
7.ITB. Recognize the difference between cause and effect and fact and opinion to analyze text.				X
7.ITE. Explain the treatment, scope and organization of ideas from different texts to draw conclusions about a topic.				X

7.REE. Communicate findings orally, visually and in writing or through multimedia.	X	X	X	X
7.WPD. Use revision strategies to improve the overall organization, the clarity and consistency of ideas within and among paragraphs and the logic and effectiveness of word choices.				X
7.REB. Locate and summarize important information from multiple sources.	X	X	X	X
7.RED. Acknowledge quoted and paraphrased information and document sources used.	X	X	X	X
7.WAD. Produce informational essays or reports that convey a clear and accurate perspective and support the main ideas with facts, details, examples and explanations.	X	X	X	X
7.REC. Organize information in a systemic way.	X	X	X	X
7.WPH. Prepare writing for publication that is legible, follows an appropriate format and uses techniques such as electronic resources and graphics.	X	X	X	X
7.WPC. Clarify ideas for writing assignments by using graphics or other organizers.	X	X	X	X
7.REA. Formulate open-ended research questions suitable for inquiry and investigation and develop a plan for gathering information.	X	X	X	X
7.COA. Use effective listening strategies, summarize major ideas and draw logical inferences from presentations and visual media.	X	X	X	X
7.COE. Present ideas in a logical sequence and use effective introductions and conclusions that guide and inform a listener's understanding of key ideas.	X	X	X	X
7.WPF. Edit to improve fluency, grammar and usage.	X	X	X	X
7.WCA. Use correct spelling conventions.	X	X	X	X
7.WCB. Use conventions of punctuation and capitalization in written work.	X	X	X	X
7.AVA. Use context clues and text structures to determine the meaning of new vocabulary.	X	X	X	X
7.AVF. Use multiple resources to enhance comprehension of vocabulary.	X	X	X	X
8.RPA. Apply reading comprehension strategies to understand grade-appropriate texts.	X	X	X	X
8.RPB. Demonstrate comprehension of print and electronic text by responding to questions (e.g., literal, inferential, evaluative and synthesizing).	X	X	X	X
8.WAB. Write responses to literature that extend beyond the summary and support references to the text, other works, other authors or to personal knowledge.	X	X	X	X
8.AVA. Use context clues and text structures to determine the meaning of new vocabulary.	X	X	X	X
8.AVB. Examine the relationships of analogical statements to infer word meanings.	X	X	X	X
8.AVC. Recognize the importance and function of figurative language.				X
8.ITA. Evaluate how features and characteristics make information accessible and usable and how structures help authors achieve their				X

purposes.				
8.ITE. Utilize multiple sources pertaining to a singular topic to critique the various ways authors develop their ideas (e.g., treatment, scope and organization).				X
8.WAE. Write a persuasive piece that states a clear position, includes relevant information and offers compelling evidence in the form of facts and details.	X	X	X	X
8.REB. Evaluate the usefulness and credibility of data and sources.	X	X	X	X
8.WPC. Use revision strategies to improve the style, variety of sentence structure, clarity of controlling ideas, logic, effectiveness of word choices and transitions between paragraphs, passages or ideas.	X	X	X	X
8.WAD. Use documented textural evidence to justify interpretations of literature or to support a research topic.	X	X	X	X
8.WPF. Prepare writing for publication that is legible, follows an appropriate format and uses techniques such as electronic resources and graphics.	X	X	X	X
8.REA. Formulate open-ended research questions suitable for investigation and adjust questions as necessary while research is conducted.	X	X	X	X
8.COA. Use a variety of strategies to enhance listening comprehension.	X	X	X	X
8.COD. Demonstrate an understanding of effective speaking strategies by selecting appropriate language and adjusting presentation techniques.	X	X	X	X
8.COB. Analyze the techniques used by speakers and media to influence an audience, and evaluate the effect this has on the credibility of a speaker or media message.	X	X	X	X
8.COE. Give informational presentations that present ideas in a logical sequence, include relevant facts and details from multiple sources and use a consistent organizational structure.	X	X	X	X
8.COG. Give presentations using a variety of delivery methods, visual displays and technology.	X	X	X	X
8.WCC. Demonstrate understanding of the grammatical conventions of the English language.	X	X	X	X
8.WCA. Use correct spelling conventions.	X	X	X	X
8.WCB. Use correct punctuation and capitalization.	X	X	X	X
8.AVF. Use multiple resources to enhance comprehension of vocabulary.	X	X	X	X

Appendix A – Engineering Design Process



Question – Find out as much as you can about the problem.

Think – Imagine different ways to solve the problem.

Design – Choose one of your ideas, collect materials, and put it together.

Test – Try your idea and see if it worked.

Solution – If you did not solve the problem the first time, ask more questions and go through all the steps again.

Appendix B – First in Flight Debate Gathering Grid

Inventor's Name: _____

The Flyers (Brief biographical information)	
The Flights (When, how high, how far, how fast, how long, powered or not powered?)	
The Aircraft (Weight, structure, power, control)	
What developments in science and technology made it possible?	

Appendix C – First in Flight Debate Rubric

CATEGORY	4	3	2	1
Information	All information presented in the debate was clear, accurate and thorough.	Most information presented in the debate was clear, accurate and thorough.	Most information presented in the debate was clear and accurate, but was not usually thorough.	Information had several inaccuracies OR was usually not clear.
Use of Facts/Statistics	Every major point was well supported with several relevant facts, statistics and/or examples.	Every major point was adequately supported with relevant facts, statistics and/or examples.	Every major point was supported with facts, statistics and/or examples, but the relevance of some was questionable.	Every point was not supported.
Understanding of Topic	The team clearly understood the topic in-depth and presented their information forcefully and convincingly.	The team clearly understood the topic in-depth and presented their information with ease.	The team seemed to understand the main points of the topic and presented those with ease.	The team did not show an adequate understanding of the topic.
Rebuttal	All counter-arguments were accurate, relevant and strong.	Most counter-arguments were accurate, relevant, and strong.	Most counter-arguments were accurate and relevant, but several were weak.	Counter-arguments were not accurate and/or relevant
Presentation Style	Team consistently used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience.	Team usually used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience.	Team sometimes used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience.	One or more members of the team had a presentation style that did not keep the attention of the audience.
Organization	All arguments were clearly tied to an idea (premise) and organized in a tight, logical fashion.	Most arguments were clearly tied to an idea (premise) and organized in a tight, logical fashion.	Most arguments were clearly tied to an idea (premise) but the organization was sometimes not clear or logical.	Arguments were not clearly tied to an idea (premise).
Respect for Other Team	All statements, body language, and responses were respectful and were in appropriate language.	Statements and responses were respectful and used appropriate language, but once or twice body language was not.	Most statements and responses were respectful and used appropriate language, but there was one sarcastic remark.	Statements, responses and/or body language were consistently not respectful.

Total (28) _____

Appendix D – Airplane Redesign Rubric

Building A Structure: Airplane Redesign				
	Group Name: _____			
CATEGORY	4	3	2	1
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Modification/Testing	Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles.	Clear evidence of troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence of troubleshooting, testing or refinement.
Data Collection	Data taken 10 or more times in a careful, reliable manner.	Data taken less than 10 times in a careful, reliable manner.	Data taken less than 5 times in a careful, reliable manner.	Data not taken carefully OR not taken in a reliable manner.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Total (20) _____				

Appendix E – Think, Pair, Share

What do you know about how propellers push or propel an airplane through the air?

Think (record what you know)	**Pair** (record new knowledge gained or remembered after sharing with a partner)	**Share** (record new knowledge gained or remembered after sharing with the class or group)

Appendix F – The Challenge

Dayton Aviation Heritage National Historical Park has requested your team's assistance in the study of aircraft propellers such as those used by the Wright brothers and those used on more modern aircraft. Park rangers have requested this information to help park visitors understand how propellers push an aircraft through the air. They have requested that your team observe and study the handheld propeller, build a working prototype using specific materials, test how pitch affects aircraft flight, compare your propeller to that of the Wright brothers, and explain how propellers push aircraft through the air.

Your team's goals are:

- To construct an airplane
- Record flight data
- Analyze data and modify the propeller pitch based on the data collected
- Conduct at least ten flight trials while adjusting propeller pitch
- Set up the data table similar to one below

Trial	Flight Distance	Flight Time	Flight Speed $s = d \div t$	Modifications Needed for Greater Distance
1				
2				
3				
4				

1. Explain how the energy in the rubber band is transferred from potential to kinetic as your propeller creates motion. How is a rubber band able to provide energy to propel an object?

   _____

   _____

   _____

2. How does the number of times the rubber bands are twisted affect your propellers' ability to propel the mechanism? Why would the amount of twists matter?

_____
_____
_____
_____

3. Think about your research and look at your timeline to compare aircraft propellers used throughout history. How have they changed since the time of the Wright brothers? How have they remained the same?

_____
_____
_____
_____

4. The Wright brothers needed a system to propel their flying machine through the air; they solved this problem by creating airplane propellers. How is an airplane propeller like an airfoil, or wing?

_____
_____
_____
_____

5. Most aircraft today no longer use propellers as their source of thrust, but propellers are used on wind turbines. Think about what you have learned about propellers and their ability to push an object through the air. Using that information, describe how a propeller is able to transform the Earth's natural resource of wind into energy.

_____
_____
_____
_____

6. Is wind a renewable or nonrenewable source of energy? Explain your answer in detail.

_____
_____
_____
_____

Appendix G – Propeller Testing Rubric

Building A Structure: Propeller Testing				
	Group Name: _____			
CATEGORY	4	3	2	1
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Modification/Testing	Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles.	Clear evidence of troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence of troubleshooting, testing or refinement.
Data Collection	Data taken 10 or more times in a careful, reliable manner.	Data taken less than 10 times in a careful, reliable manner.	Data taken less than 5 times in a careful, reliable manner.	Data not taken carefully OR not taken in a reliable manner.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Total (20) _____				

Appendix H – Catapult Video Viewers Guide

Go to: http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm Watch the following videos and answer the questions.

Strange Planes: Origin of the Modern Catapult

1. In 1900, the Wright brothers' gliders were launched using what method?

2. The Wright brothers found that flying machines were unstable but what did they do to change this problem?

3. What year did the Wrights build and fly their first Wright Flyer?

4. The Wrights created a catapult to assist their takeoffs. What did it look like?

Strange Planes: Catapult Planes

1. Which plane was most popular at the end of WWI?

2. As planes were needed to takeoff from ships _____were used before catapults made their appearance.

3. What was the purpose of catapult planes?

4. The US Navy's first aircraft carrier had a catapult driven by _____.

Strange Planes: First Catapults

1. Who first created catapults for WWI seaplanes?

2. How was this first catapult made?

Strange Planes: Steam Catapults

1. What must be artificially increased in a plane to allow it to take off from an aircraft carrier?

2. What are the advantages of having a steam-powered catapult on a ship?

Appendix J – Catapult Video Viewers Guide Answer Key

Go to: http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm Watch the following videos and answer the questions.

Strange Planes: Origin of the Modern Catapult

1. In 1900, the Wright brothers' gliders were launched using what method? *They ran down a hill at Kitty Hawk, North Carolina carrying the glider.*

2. The Wright brothers found that flying machines were unstable but what did they do to change this problem? *Created control systems to fix the instability and created a power system to get it off the ground.*

3. What year did the Wrights build and fly their first Wright Flyer? *1903*

4. The Wrights created a catapult to assist their takeoffs. What did it look like? *It had a large weight attached to a cable and that pulled the plane forward when the weight was dropped.*

Strange Planes: Catapult Planes

1. Which plane was most popular at the end of WWI? *seaplanes*

2. As planes were needed to takeoff from ships *ramps* were used before catapults made their appearance.

3. What was the purpose of catapult planes? *Search for enemy targets, drop bombs, lay smoke, carry messages and aid in anti-submarine screening.*

4. The US Navy's first aircraft carrier had a catapult driven by *a flywheel*.

Strange Planes: First Catapults

1. Who first created catapults for WWI seaplanes? *The British*

2. How was this first catapult made? *The catapult was made using a trolley propelled down a ramp with the plane perched on top.*

Strange Planes: Steam Catapults

1. What must be artificially increased to allow a plane to take off from an aircraft carrier? *Thrust*

2. What are the advantages of having a steam-powered catapult on a ship? *It uses energy sources already on the ship, simple to maintain and cheap to operate. It is adjustable to any weight of plane.*

Appendix K – Catapult Design and Testing Rubric

Building A Structure: Catapult Design and Testing				
	Group Name: _____			
CATEGORY	4	3	2	1
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Modification/Testing	Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles.	Clear evidence of troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence of troubleshooting, testing or refinement.
Data Collection	Data taken 10 or more times in a careful, reliable manner.	Data taken less than 10 times in a careful, reliable manner.	Data taken less than 5 times in a careful, reliable manner.	Data not taken carefully OR not taken in a reliable manner.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Total (20) _____				

Toast to Dayton

By Paul Laurence Dunbar

Love of home, sublimest passion
That the human heart can know!
Changeless still, though fate and fashion
Rise and fall and ebb and flow,
To the glory of our nation,
To the welfare of our state,
Let us all with veneration
Every effort consecrate.

And our city, shall we fail her?
Or desert her gracious cause?
Nay – with loyalty we hail her
And revere her righteous laws.
She shall ever claim our duty,
For she shines – the brightest gem
That has ever decked with beauty
Dear Ohio's diadem.

Appendix M - Poem Interpretation

Toast to Dayton
By: Paul Laurence Dunbar

Vocabulary:

Cause –interest or welfare of something

Consecrate – to honor something with respect (synonym of venerate)

Decked – decoratively dressed

Desert – leave behind

Diadem – crown

Duty – respectfulness

Ebb – flow back (antonym of flow)

Fate - ruin

Gracious – very kind

Hail – cheer or welcome

Loyalty – faithful

Nay – no

Revere – to treat something with respect (synonym of venerate)

Righteous – upright, wonderful

Sublimest – greatest

Toast – to honor someone or something

Veneration – a feeling of respect

Welfare – happiness, well-being

Explain what you think Paul Laurence Dunbar meant in each stanza of his poem, *Toast to Dayton*. Use the vocabulary list to help you.

Toast to Dayton

Stanza	Your Interpretation (What you think Dunbar meant)
Toast to Dayton	
Love of home, sublimest passion That the human heart can know!	
Changeless still, though fate and fashion, Rise and fall and ebb and flow,	
To the glory of our nation, To the welfare of our state,	
Let us all with veneration Every effort consecrate.	
And our city, shall we fail her? Or desert her gracious cause?	
Nay—with loyalty we hail her And revere her righteous laws.	
She shall ever claim our duty,	
For she shines—the brightest gem	
That has ever decked with beauty Dear Ohio's diadem.	

Appendix N – Analyze Poetry and Brainstorm Ideas

1. When Dunbar uses the word "she" who or what is he referring to? How do you know?

_____

_____

2. Paul Laurence Dunbar is creating an image, or painting a picture, of Dayton through his poetry. What image does Dunbar paint in your mind about Dayton? Support your answer with details from the reading selection.

_____

_____

_____

3. Personification is giving something that is not living human qualities. Does Dunbar use personification in *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

_____

4. Strong verbs add excitement to writing. List at least five strong verbs in the poem. For each strong verb you list, also include a weak verb Dunbar could have used.

_____

_____

_____

_____

5. How would the poem have been different had he chosen the weak verbs? Do you think he made the right choice by using strong verbs? Explain your thinking.

_____

_____

_____

_____

6. What is the mood of Dunbar's *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

7. What theme, or controlling idea, is Dunbar communicating through *Toast to Dayton*? Support your answer with details from the selection.

_____

_____

_____

8. Do you think the Wright brothers felt the same way about Dayton? Explain your thinking in detail.

_____

_____

_____

9. In your life, what makes you feel similar to how Paul Laurence Dunbar felt about Dayton? Give several reasons for your feelings about this topic.

_____

_____

_____

10. List at least five **verbs** you would use when talking to someone about your topic. Then find **stronger verb** synonyms to substitute for each of the verbs.

_____

_____

_____

_____

_____

11. List at least ten **adjectives** you would use when talking to someone about your topic. Make the adjectives *million dollar* words by finding synonyms for simple adjectives.

_____

_____

_____

_____

_____

12. Read *Toast to Dayton* again paying attention to Dunbar's writing style. Create a poem about your topic using a style similar to Dunbar's. Be sure to include the strong verbs and million dollar adjectives you listed above.

Appendix O - Composing room of the Wright brothers' 1890-1895 print shop

Appendix P - Second room of the Wright brothers' 1890-1895 print shop

Photo displaying the replica foot-powered Prouty press which handled small jobs such as stationery and business cards.

Ranger for a Day

Dayton Aviation Heritage Trail

Grade Levels: 6-12

Summary & Purpose:

Students, working in groups as park rangers, will plan a tour of the Dayton Aviation Heritage Trail to be presented to other members of the class (acting as the local Chamber of Commerce). At each of the sites, students must present a model demonstrating one facet of the local history.

National Park Connection:

The National Park Service is our nation's Department of History. While many Americans associate the National Park Service with the preservation of natural places, few realize that almost two-thirds of the more than 400 national parks were designated specifically to preserve an important aspect or moment in our nation's history.

Several of these stories are told in the Dayton area: the beginning of the aviation age, the struggle for racial equality, and outstanding contributions to American literature. Dayton Aviation Heritage National Historical Park is the national park preserving Dayton's contribution to our nation's history, and the stories of three Daytonians that helped shape our world. The three exceptional men from Dayton, Ohio: Wilbur Wright, Orville Wright and Paul Laurence Dunbar, found their creative outlet here through accomplishments and failures, and finally success. However, these men offered the world something far greater, they offered the world hope, and the ability to take a dream and make it a reality.

Lesson Overview:

Day 1	Engage students by sharing with them the scenario Present Challenge Break students into groups, assign and explore park sites
Day 2-4	Teams create displays and practice presentations
Day 5	Students make presentations to class and possibly guest ranger
Day 6	Teacher and/or guest evaluate the presentations and decide grant award

Procedures:

1. Teacher reads a mock letter to the students from the Dayton Area Chamber of Commerce explaining the opportunity to obtain a Project Development Grant to increase tourist numbers at the park.
2. Teacher role plays and guides discussion on how to best achieve this goal.
3. Teacher will divide students into groups of 3-4. Each group will choose one of the following sites on the Aviation Heritage Trail:
    - Wright Cycle Company building
    - Wright-Dunbar Interpretive Center – print shop
    - John W. Berry Sr., Wright Brothers Aviation Center at Dayton History at Carillon Park
    - Huffman Prairie Flying Field
    - Huffman Prairie Flying Field Interpretive Center
    - Paul Laurence Dunbar State Memorial
    - Hawthorn Hill
4. Students begin investigating through research and share ideas for an interactive presentation.
5. Each site should be explained/demonstrated by the students as if they were park rangers talking to tourists about their site. Hands-on activities and the use of technology are encouraged. Students/teacher might choose one of the ideas below to illustrate as a part of the demonstration:
    - Wright Cycle Company building
        - a. How did the bicycle influence the creation of airplanes?
        - b. What bike parts ended up on the first airplane?
    - Wright-Dunbar Interpretive Center - print shop
        - a. How did the Wright brothers use the print shop to advertise and sell their bicycles?
        - b. Demonstrate how printing was done during that time.
    - John W. Berry Sr., Wright Brothers Aviation Center at Dayton History at Carillon Park
        - a. What were cameras like at that time?
        - b. Demonstrate how a still camera or motion camera works.
    - Huffman Prairie Flying Field
        - a. Explain how the Wrights developed a dependable, fully-controllable airplane.
        - b. Demonstrate how their catapult worked getting a plane into the air.
    - Huffman Prairie Flying Field Interpretive Center
        - a. Around the memorial, there is information about wings.
        - b. Demonstrate how airfoils work to make things fly.
    - Paul Laurence Dunbar State Memorial
        - a. Dunbar was a true pioneer in African-American literature.
        - b. Demonstrate some of his poetry in a creative format…art, song, acting.
    - Hawthorn Hill
        - a. What Orville Wright called home for nearly 35 years.
        - b. Using living history role play, demonstrate the conversation Orville Wright might have had with Charles Lindbergh when he came to visit.

6. Teachers should allow time so that all members can present a cohesive and organized presentation. Presentations could be made on tri-fold boards or through the use of multimedia.
7. Teachers should set a time limit for presentations (i.e. 5 minutes per site) and develop a rubric for grading (could be peer-graded or self-graded).
8. At the end of the presentations, students or teacher or an independent person (possibly a park ranger from Dayton Aviation Heritage National Historical Park) can award "the grant" to the group that makes the best presentation.

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

Ninth through Twelfth Grade

Flying Machines

Grade Levels: 9-12

Summary & Purpose:

This flying machine lesson is one of two lessons for ninth through twelfth grade students to study the Wright brothers. This section may be taught alone or with any other sections chosen by the instructor. Students will learn about the contributions of various historical figures, especially Orville and Wilbur Wright, and engage in the "First in Flight" contributions these people made to aviation. They will learn about the past and future efforts of flight and aircraft designs, as well as the forces of flight and how to calculate the glide slope aspect ratio. Students will then be issued a challenge to make a shoebox fly.

Students will research the dynamics and forces of flight; apply their understanding of flight to the design, construction, and test flight of a shoebox glider; collect measurements and calculate glide slope aspect ratios and provide a visual and oral summary of their design and test solutions. Students will explore different types of flying machines, analyzing the positive and negative aspects of each, and will use the engineering design process to land model flying machines safely.

The field of aeronautics and the mystery of flight are vital to the age in which we live. This unit will address multiple science, social studies, math, and language arts standards as students explore this topic. Students will learn about force and energy.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park encompasses six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. The Wright-Dunbar Interpretive Center houses some artifacts and replicas from the earliest Wright Flyers, including a model of the first Wright Flyer engine. The Huffman Prairie Flying Field Interpretive Center highlights the history of flight from the first flight to the modern era of air travel. At the Huffman Prairie Flying Field Interpretive Center, visitors will find various models of planes, videos, and hands-on exhibits of flight. They

will also experience a flight simulator modeled after an early military Wright Flyer. The Huffman Prairie Flying Field includes a replica of a hangar and a catapult similar to those utilized by the Wright brothers. Signs and placards throughout the park sites also give a rich and detailed history of flight.

Essential Questions & Enduring Understandings:

1. **Identify the four forces experienced by all things that fly?** A glider uses thrust, drag, lift, and gravity (weight) during flight.

2. **How does the Bernoulli Principle relate to airplane flight?** If air moves faster on one side of an object, the air pressure decreases and the object will move in the direction of the faster moving air. This is how wings create lift and why the objects in this experiment move in the direction of the faster air.

3. **What does a glide slope ratio indicate?** The relationship between horizontal distance and a change in altitude, or the rate of descent.

4. **Using your research skills and applying your knowledge of flight dynamics, can you design a shoebox to fly?**

Lesson Overview:

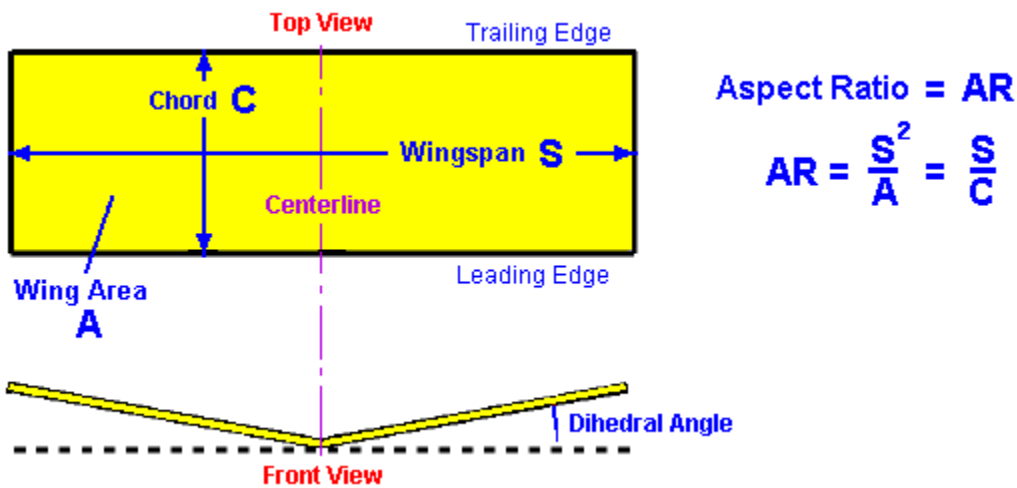
Day 1	Introduce history of flight, including "The Wright Stuff" video
Day 2	Investigate Bernoulli's Principle
Day 3	Discuss Newton's Third Law
Day 4	Engineering design process (Appendix A) Build and test paper airplanes
Day 5	Build, test, collect data on the shoebox glider Create a broadcast for use on the TV News

Pre-requisite Skills:

Students should have some introductory knowledge of numeracy and algebra, including simplifying radicals, combining like terms, factoring, and the FOIL method. Students should also understand quadratic equations. Students should be able to calculate the x and y intercepts and the vertex of a parabola, and then be able to graph accordingly.

Aspect Ratio is a measure of how long and slender a wing is from tip to tip. The aspect ratio of a wing is defined to be the square of the span divided by the wing area and is given the symbol **AR**.

The formula for a rectangular wing is simplified as: the ratio of the span to the chord length, as shown on the figure below.



Wing dihedral refers to the angle of wing panels as seen in the aircraft's front view. Dihedral is added to the wings for roll stability; a wing with some dihedral will naturally return to its original position if it is subject to a briefly slight roll displacement.

Most large airliner wings are designed with dihedral. On the contrary, the highly maneuverable fighter planes have no dihedral. In fact, some fighter aircraft have the wing tips lower than the roots, giving the aircraft a high roll rate.

Vocabulary:

aerodynamics - a field of fluid dynamics that studies how gases, including air, flow and how forces act upon objects moving through air

aeronautics - the science of flight; the study of how and why airplanes fly

airfoil – parts of an airplane, such as wings, tail surfaces, and propellers, whose shapes control stability, direction, lift, thrust

air pressure - the force exerted by air on an area

aspect ratio – the length of a wing divided by the width (cord)

Bernoulli's Principle - states, "as a fluid's speed increases, the pressure within the fluid decreases," therefore, the pressure on top of an airfoil must be less than the pressure below

dihedral – the angle at which the wings of an airplane are vertically inclined

drag - the resistance caused by the shape of an object and its movement through the air

fluid - any substance where the molecules move around freely; can be a gas or liquid

force - a push or pull on an object

fuselage – the basic structure of the airplane to which all the other parts are attached

glider – a type of flying machine that does not have an engine

glide slope ratio – the horizontal distance divided by the change in altitude

gravity – the natural force of attraction between any two massive bodies, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them

lift – the upward force that opposes the pull of gravity

thrust - the force developed by a propeller or jet engine that drives an airplane through the air

Materials:

For each student team:

- Paper
- Hair dryer
- Scissors
- Assorted balloons (1 per size per triad)
- Fishing line, approximately 40 feet per triad
- Poles, beams or structures, suitable to tie line on
- 2 - Plastic straws (per triad)
- Styrofoam coffee cup (per triad)

- Masking tape
- Meter stick or tape measure
- String
- Small paper clips
- Ruler
- Grid paper, cm
- Balsa wood gliders or paper airplanes

Background Information:

Over the past 600 years, various people have made attempts at flight with various levels of success. Leonardo da Vinci designed flying machines from 1485-1500, but never attempted to build or fly any such machines. The first flying machine was a hot air balloon, flown by the Montgolfier brothers in 1783. In 1849, in a glider designed by George Cayley, a 10-year-old boy made short hops in the air. In 1890, Clement Ader made a short, powered hop in the air in a flying machine, but the flight was neither sustained nor controlled. From 1891-1896, a German man named Otto Lilienthal made numerous flights in his gliders until he died in an 1896 crash. Orville and Wilbur Wright learned from many of these people as they designed the first successful powered, heavier-than-air, practical flying machine.

The debate over "First in Flight" involves many of these people. The debate also stretches from Dayton, Ohio, where the Wright brothers designed, built, and studied all facets of their flying machines, to Kitty Hawk, North Carolina, where the Wrights tested their designs and made the first flights.

Procedures:

All paper airplane gliders have a natural speed and angle at which they will steadily glide down to the ground. Fly them too slowly, and the nose will drop and the plane will dive. Fly them too fast, and the nose will rise and the plane will climb or stall.

The greater the height from which a plane is launched, the farther the plane has to drop before it hits the ground.

To compare paper airplane performance fairly, one must take into account the height from which the plane was launched. Computing the plane's glide slope ratio will accomplish this task. Each different paper airplane has a different glide ratio.

The glide ratio is the distance a plane flew divided by the height (rise) from which it was launched (run), hence, the name glide slope ratio (rise/run). Comparing glide ratios eliminates

the advantage a tall person gets by launching a plane from higher above the ground, and makes it possible for people of various heights to compete equally.

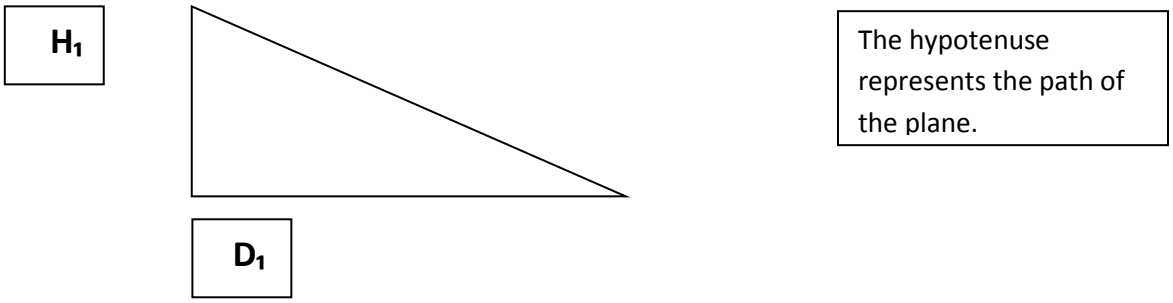
Calculating Glide Ratios

The glide ratios can be found by dividing the distance a plane flew by the height from which that plane was launched.

Here, **D** represents the distance the plane flew, **H** represents the launch height, and **G** represents the glide ratio. Using these letters, here's the equation for calculating glide ratio:

$$D \div H = \boldsymbol{G}$$

The greater *G* is, the better a flying machine glides!



Day 1:

1. Show the video "The Wright Stuff." At the conclusion of the movie, lead the students in a brief discussion of the film. Have the students take notes on the people and events that are discussed.
2. Ask students "Who were the first people to fly?" Students with prior knowledge will likely answer that the Wright brothers were the first people to fly. Tell students the answer will depend on what "fly" means.
3. Divide the class into small groups for the research portion of the lesson. The groups should be comprised of 5-6 students of varying academic abilities.
4. Each group will be assigned one of the following subjects:

    a. Wilbur Wright
    b. Orville Wright
    c. Katharine Wright
    d. Kitty Hawk, North Carolina
    e. the Wright Flyer
    f. the Wright Cycle Company

5. Allow time to research the subjects. Internet access and library access are needed. The goal of the research is the creation of a PowerPoint presentation.
6. Encourage the students to find pictures, images, and stories they want to share with the class.

Day 2:

1. Demonstrate Bernoulli's Principle as a class. Tape a sheet of paper to the edge of a tabletop and then fold it over to get the "airfoil" shape. Use a hair dryer and point the airflow toward the leading edge of the paper. The paper will rise just as it does when you blow on it. Try taping a penny to the underside of the back of the paper airfoil. If not done correctly, the paper will lift the penny from the table. Try two pennies.
2. Issue the Bernoulli Lab Worksheet (Appendix B) to students. Ask them to read and predict the answers to the questions. Then, perform the experiment to verify their predictions.

    a. The Paper Tent - have the students make a paper tent by folding a piece of paper (lengthwise). Students should predict what will happen when they blow into the tent. Will it appear to get larger, will it remain unchanged, or will it bend down toward the table? Make sure the students notice that the tent flattens. This is because the air moving through the inverted V has less pressure, so the higher pressure on the outside of the paper tent flattens the paper. Have the students record their prediction in the space provided on the Bernoulli Lab Worksheet.
    b. Moving Balloons - as a class demonstration, blow up two balloons. You may want to attach a string to each one. The balloons must be the same height. Have a student hold the two balloons together. Ask the class to predict what will happen when they blow between the two balloons. Have students record their prediction in the space provided on the Bernoulli Lab Worksheet. Hold the balloons up by their neck so they are hanging loosely about 4-6 inches apart. Blow hard between them. Like magnets attracting each other, the two balloons will come together just like in the paper V experiment earlier. Students should complete the Bernoulli Lab Worksheet and discuss the results.

Day 3:

1. Discuss Newton's third law of motion with the class.
2. Show the following video clip: http://www.wonderhowto.com/how-to-master-newtons-third-law-motion-with-nasa-329433/
3. Run fishing line through the straws.
4. Tie the ends of the fishing lines to fixed objects on the other side of the room so the line is parallel to the ground.
5. Blow up the balloons.
6. Hold the end of the balloons so no air escapes.
7. Tape the first balloon to a straw.

8. Slide the Styrofoam cup hoop over the end of the balloon.
9. Tape a second balloon to the straw.
10. Position the front of the second balloon into a Styrofoam cup hoop so that it fills the hoop and compresses against the tail end of the first balloon, making it airtight.
11. Slide the balloons to the launching end of the fishing line.
12. Let go of the end of the balloon.
13. Have student teams complete 3 launches and enter their data onto worksheet (Appendix C).
14. Discuss the following questions:
    a. In the flight of the balloon, what was the action?
    b. What was the reaction?
    c. How does this relate to Newton's Third Law?
    d. How does the size and shape of the balloon affect the distance of its flight?
    e. Do bigger balloons have greater or less velocity than smaller balloons? Answers should be based on your experiment. Encourage speculation.
    f. If you used coarse twine instead of fishing line, how would this affect the flight of the balloon? Highlight the role of friction in creating drag.

Day 4:

1. Set up a runway where you will test paper airplanes. Use masking tape or chalk to mark the ground in 50-cm increments. Label each increment: zero cm (start line), 50 cm, 100 cm, and so on. Your testing ground should be at least 10 meters (1000 cm) long.
2. To begin this lab, you may want to have all groups create the same type of paper airplane. http://www.bestpaperairplanes.com You can suggest that they try different designs. The websites below provide templates and directions for creating several paper airplanes. http://www.amazingpaperairplanes.com/Simple.html or http://www.funpaperairplanes.com/
3. Introduce and explain the engineering design process. http://www.daytonregionalstemcenter.org/engineering-design-process/ (Appendix A)
4. After students have made a paper airplane, have each group select someone in the group to throw their paper airplane. Use string to measure the distance from the ground to the top of that person's shoulder. This distance will be their launch height because airplanes are launched from shoulder height.
5. Once students have had the opportunity to practice with their paper airplanes and make appropriate adjustments, you may have students begin to collect data in order to complete the challenge worksheet (Appendix D).
6. If time permits, you may have groups select another paper airplane design to test.

7. Issue the shoebox challenge so that students can begin to gather materials to create their shoebox glider.

Day 5**:**

1. This activity is based on the original NASA Educational Project titled, "Can a Shoebox Fly?" http://www.nasa.gov/pdf/469325main_5-12ShoeboxEducatorGuide.pdf
   This lab may take two or three class periods depending upon length of your class. For this lab you will need a larger space for students to fly their shoebox glider.
2. Issue the Shoebox Challenge (Appendix E) to the students. Read over the Shoebox Challenge Worksheets (Appendices F and G) with the students.
3. You may want to create a shoebox glider as a model or show students the NASA website. The opening page has several examples of the shoebox glider.
4. Students will create a news broadcast for use on the TV News for one of the following events:
   a. Five people watch the brothers toss a coin to see who will be the first to fly. Wilbur wins. The flight is a 3½-second hop.
   b. Wilbur gives exhibition flights in France and sets a world flight record of 1½ hours.
   c. Orville and Lieutenant Selfridge crash while testing a plane for the Army Signal Corps. Lieutenant Selfridge is killed and Orville receives a broken leg and cracked ribs.
   d. Explain why the Wright brothers chose Kitty Hawk, North Carolina for their first flight.
   e. Explain how Bernoulli's Principal is related to the shoebox glider.
   f. Explain how the four forces of flight affect your shoebox glider.
   g. Explain how Newton's third law of motion influenced your shoebox glider. (Include the action, reaction and the thrust.)

Presentations should be no more than 3-5 minutes and should include pictures and illustrations and interesting facts/information. You may want to conduct a lottery to determine which groups are assigned the topics.

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

News clippings of Wright brothers' articles:
http://www.paperlessarchives.com/wbscrapbooks.html

The Beginners Guide to Aerodynamics http://www.grc.nasa.gov/WWW/K-12/airplane/bga.html

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm

The Bishop's Boys: A Life of Wilbur and Orville Wright by Tom D. Crouch, 1989.

The Wright Brothers: A Biography by Fred C. Kelly, 1943. Reprinted by Dover 1989.

How We Invented the Airplane: An Illustrated History by Orville Wright, edited by Fred C. Kelly, 1953.

Miracle at Kitty Hawk: The Letters of Wilbur and Orville Wright, edited by Fred C. Kelly, 1951, reprinted 1996.

Wilbur and Orville: A Biography of the Wright Brothers by Fred Howard, 1998.

Kitty Hawk and Beyond: Wright Brothers and Early Years on Aviation: A Photographic History by Ronald Geibert and Patrick B. Nolan, 1990.

Catapults

Grade Levels: 9-12

Summary & Purpose:

This catapult lesson is one of two lessons for ninth through twelfth grade students to study the Wright brothers. Students are presented with a scenario in which Dayton Aviation Heritage National Historical Park has requested their help in the study of aircraft catapults such as those used by the Wright brothers and on aircraft carriers. Teams are asked to observe and study video clips of aircraft catapults, sketch and build a working prototype using specified materials, and explain how catapults are able to successfully launch a flying machine. They are also asked to research and create a timeline including the development of aircraft catapults beginning with the Wright brothers and ending with present-day aircraft launching systems. Other major historical events that would fit onto the timeline may be included.

National Park Service Connection:

Dayton Aviation Heritage National Historical Park consists of six sites around the city of Dayton, Ohio. This national park, among other things, commemorates the history of flight from Orville and Wilbur Wright's first attempts at flight until Wilbur Wright's death in 1912 and the sale of the Wright Company in 1915. Huffman Prairie Flying Field Interpretive Center displays the history of the Wright brothers' work after 1903, including their use of catapults. The brothers flew, tested and improved their planes at Huffman Prairie Flying Field. The field includes a replica of their catapult, a replica of a hangar used for storing their airplane, and information panels that discuss their work at the site. The Wright Company operated the first flying school, the Wright School of Aviation, at Huffman Prairie Flying Field. One hundred nineteen pilots, including three women, were trained to fly at the flying field.

Essential Questions & Enduring Understandings:

1. **What shape does a projectile take?** Parabolic

2. **What is air resistance? How does air resistance affect a projectile?** Air resistance, or friction of the air molecules acting on the projectile, will slow the acceleration of the object. The parabolic path will have a shorter horizontal distance than it would ideally (without air resistance).

3. **What is the best angle in which to release a projectile if you want it to travel the farthest distance?** 45 degrees

4. **Identify the various forms of energy involved in the catapult.** The forms of energy are: potential energy stored in the rubber band or springs; kinetic energy of the arm; kinetic energy of the marshmallow; friction energy in the catapult mechanism; air friction of the ball as it is moving through the air; increased motion energy of the air molecules as the ball strikes and accelerates them; potential energy of the gravitational field as the ball rises and falls back to Earth; compression energy as the ball crashes into the Earth, deforming both the ball and the Earth; and heat energy as the Earth is warmed up a little.

Lesson Overview:

Day 1	Present scenario and design challenge View videos and record observations Conduct research on catapults Prepare a timeline for a presentation
Day 2	Brainstorm on design Choose design
Day 3	Teams design and build a catapult Test and refine the design Use catapult model to explain Newton's Laws Graph and record the correlation between angle (force) and distance traveled (acceleration)
Day 4	Find the equation of the curve of best fit formed by a projectile from an algebraic approach and using quadratic regression
Day 5	Present findings to class

Pre-requisite Skills:

Students should have some introductory knowledge of numeracy and algebra, including simplifying radicals, combining like terms, factoring, and the FOIL method. Students should also understand quadratic equations. Students should be able to calculate the x and y intercepts and the vertex of a parabola, and then be able to graph accordingly.

Newton's Laws of Motion

Sir Isaac Newton (1642 – 1727) was a brilliant mathematician, astronomer and physicist. Newton studied a wide variety of phenomena during his lifetime, one of which included the motion of objects and systems. Based on his observations he formulated Three Laws of Motion which were presented in his masterwork Philosophiæ Naturalis Principia Mathematica in 1686.

- Newton's First Law – An object at rest will remain at rest and an object in motion will remain in motion at a constant speed unless acted on by an unbalanced force (such as friction or gravity). This is also known as the law of inertia.
- Newton's Second Law – An object's acceleration is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the applied net force. Newton's Second Law can be expressed as: F = ma
- Newton's Third Law – For every action there is an equal and opposite reaction.

Newton's work on developing the laws of motion led him to formulate the Law of Universal Gravitation. The law states that two bodies attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The following equation is used to calculate the force of gravity with which an object is attracted to the Earth: FG = mg
where m = mass of the object; and g = the acceleration of gravity 9.8 m / s2

Vocabulary:

catapult - slingshot; launching device

elastic potential energy - energy stored in elastic materials as the result of their stretching or compressing. Elastic potential energy can be stored in rubber bands, bungee cords, trampolines, springs, an arrow drawn into a bow, etc.

gravitational potential energy - energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object.

kinetic energy - energy an object has when in motion

potential energy - energy of a system that is stored

projectile – a launched, thrown, or propelled object, such as a ball

trajectory – the path of a projectile through space

Materials:
Materials can vary. Below are some suggested materials for each team.

One set of materials for each group of students:

- 20 Plastic drinking straws
- 20 Unsharpened pencils
- 20 Popsicle sticks
- 10 Rubber bands
- 5 Toothpicks
- 5 Paperclips or craft wire
- Masking tape
- String
- Scissors
- 5 Metal washers
- Small piece of cloth
- Meter stick or measuring tape
- Marshmallows
- Cotton balls
- Ping pong balls
- Pie tin or paper plate

Background Information:

In order to achieve lift, the Wright brothers relied on headwinds. Through extensive experimentation, they concluded that headwinds of 11.8-14.9 mi/h (19-24 km/h or 5.3-6.7 m/s) would be needed to obtain lift for their glider. When the brothers were ready to experiment with flight, they decided that it was imperative they transport their machine to a location that offered more consistent headwinds than their hometown of Dayton, Ohio provided. Therefore,

they transported their flying machine components by train and boat to Kill Devil Hills, North Carolina.

At Kill Devil Hills, they experimented with pilot-controlled flights in gliders in 1900, 1901 and in 1902. To launch their gliders, they used a combination of human power and headwinds. In 1903, they added an engine to their glider to provide power and propellers to provide thrust. The plane was now too large to use human power, so the brothers would incorporate a track for the plane to travel. Using a modified bicycle hub, the plane travelled down a 60-foot (18.29 m) single rail. On December 17, 1903, they achieved the first powered flight. When returning to Dayton, Ohio they used Huffman Prairie, a cow pasture, to continue experimenting with the machine, but were not as successful due to continual battles with inconsistent wind speeds and changing wind direction. In 1904, they decided to rig a catapult to launch the machine down the rail. A 1,600-pound (726 kg) weight supported by a derrick, or tower, pulled the machine down the rail with enough speed to launch it into the air. On September 20, 1904, two weeks after first using the catapult, Wilbur completed their first circle and flew 4,080 feet (1.24 km) in approximately 1 minute 35 seconds. Dayton's inconsistent winds were no longer an obstacle to making flight practical; the catapult made it possible for the Wrights to fly anytime, anywhere without dependence on wind.

Over 2000 years ago, the Greeks and Romans did not know about gunpowder, yet were able to hurl projectiles over a large distance using kinetic energy storage devices. Through the years, some modifications were made to increase the accuracy and throwing distance of these machines. The first two types of throwing machines were the catapult and the ballista. The catapult started out as a large cross bow to shoot oversized arrows at an enemy. The ballista was about 10 times larger than a catapult and threw large stones.

The ballista's design consists of two pieces of wood, each fastened at one end to a torsion device rotating about a more or less horizontal axis. The free ends of the wooden pieces are connected together with a rope. The projectile to be thrown is held by the connecting rope used as a sling.

When most people think of the catapult, they are actually thinking about an onager. The strange name is derived from a wild donkey kicking with its hind legs. The onager (or gone, mangonel, or nag) was typically a single spar held in a more or less vertical position by a torsion device rotating around a horizontal axis. The projectile was located in either a pocket at the top end of the spar or in an attached sling.

The choice of the Middle Ages was a trebuchet. This device used gravity instead of torsion springs to provide propulsion energy. The theory is simple: put a large weight at the short end of a lever arm and put the projectile in some kind of basket at the other end of the

lever. The velocity of the projectile can become quite large when the ratio of the lengths of the lever arms is great.

The catapult is still in use today, although radically different from those used long ago. The modern catapult is used to launch aircraft from the deck of an aircraft carrier. The aircraft carrier catapult uses steam as a source of energy to push a piston along a linear track in the aircraft carrier's deck. The piston pushes the aircraft and accelerates the plane up to flying speed in a very short distance.

This project is a hands-on activity that will reinforce many physics concepts such as: friction (air resistance); projectile motion; angles of projection; velocity; acceleration; inertia; gravity; and Newton's Laws. Students will also collect trajectory data and use technology to predict a quadratic curve of best fit and use the equation of a parabolic path to investigate the horizontal and vertical position over an interval. Teams will complete a PowerPoint presentation to act as a visual journal of their work during the design process.

Procedures:

Days 1 & 2:

1. Access prior knowledge by opening a discussion regarding the Wright brothers and catapult uses.
2. Present students with Catapult Design Challenge (Appendix J).
3. Introduce the engineering design process (Appendix A). http://www.daytonregionalstemcenter.org/engineering-design-process/
4. Instruct students to research the history of the catapult as an aircraft-launching device and create a timeline. Include additional major historical events on the timeline. http://autocww.colorado.edu/~blackmon/E64ContentFiles/MilitaryWeapons/Catapult.html http://science.howstuffworks.com/transport/engines-equipment/question127.htm
5. Divide students into teams of 2-3 students. Explain that students must develop their own working catapult from everyday items. Teams will prepare a multimedia presentation of their work (PowerPoint, prezi.com, glogster.com).
6. Instruct students to complete the worksheet (Appendix K) as they view the following series of videos. http://videos.howstuffworks.com/discovery/32444-strange-planes-origin-of-the-modern-catapult-video.htm

Day 3:

1. Place available materials for catapult construction on each team's table.

2. Students develop a plan for their catapult. Teams agree on materials they will need and begin sketching their design ideas. Remind teams this is a time to listen and understand each member's design plan ideas. They should understand that each team member's ideas are valuable to the final team design. Teams choose a final design and construct catapult.
3. Allow time for students to explore the purpose of catapults by experimenting with appropriate objects such as cotton balls, marshmallow, ping pong balls, etc. Chalk stubs work well and leave a mark, which helps with measurements.

Day 4:

1. Review Newton's Laws/ Bernoulli's Principle. Review the terms pitch, roll, and yaw. Review the speed formula: (Speed = distance/time; s = d/t)
2. Using their catapult models, student teams will explain Newton's Laws. Students should record their results measuring both the distance the projectile was launched as well as the distance the projectile landed from the target. Teams should record their measurements using the Catapult Launch Data Worksheets (Appendix L).
3. If students have difficulty measuring the height of the projectile, have them launch the catapult parallel to a wall. Use a piece of masking tape to mark the high point on the wall, then use the meter stick or measuring tape to measure the height.
4. Observe to ensure teams are testing their designs, recording flight time and distance in results column and modifying the design for better accuracy.

Day 5:

1. Allow time for each team to present their information and demonstrate their PowerPoint presentation for the class.
2. Teams complete the evaluation/reflection worksheet (Appendix M).

Resources:

Dayton Aviation Heritage National Historical Park website:
http://www.nps.gov/daav/index.htm

First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Dayton Regional Stem Center http://www.daytonregionalstemcenter.org

How Stuff Works http://science.howstuffworks.com/transport/engines-equipment/question127.htm

Wright Brothers Aeroplane Virtual Museum http://www.wright-brothers.org/

The Historical Marker Database
Photos of catapult at Huffman Prairie
http://www.hmdb.org/PhotoFullSize.asp?PhotoID=13282
http://www.hmdb.org/marker.asp?marker=4587
Photo of re-enactment of replica Wright Flyer III and catapult at Huffman Prairie Flying Field
http://static.slugsite.com/wright-catapult-1-big.jpg

Extensions:

Build a wall of paper cups of a given height and challenge teams to design a catapult that can launch a marshmallow over it. Teams can also design a catapult that can launch a marshmallow through the wall with the goal of knocking down the greatest number of cups.

References/Works Cited:

Wright brothers' information taken from the Dayton Aviation Heritage National Historical Park's website http://www.nps.gov/daav/index.htm and First Flight: The Wright Brothers and the Invention of the Airplane by Tom D. Crouch.

Dayton Aviation Heritage National Historical Park
Alignment of Standards Ninth through Twelfth Grade

	Flying Machines	Catapults
Science		
9.PS.21. Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.	X	X
9.PS.22. Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.	X	X
9.PS.23. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. (F net=ma. Note that weight is the gravitational force on a mass.)	X	X
9.PS.24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.	X	X
9.PS.25. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).	X	X
9.PS.26. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., atomic theory, quantum theory and Newtonian mechanics).	X	X
9.ST.1.Describe means of comparing the benefits with the risks of technology and how science can inform public policy.	X	X
9.ST.2. Identify a problem or need, propose designs and choose among alternative solutions for the problem.	X	X
9.ST.3. Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.	X	X
9.SI.1. Distinguish between observations and inferences given a scientific situation.	X	X
9.SI.3. Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.	X	X
9.SI.5. Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.	X	X
9.SI.6. Draw logical conclusions based on scientific knowledge and evidence from investigations.	X	X
9.SWK.2. Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.	X	X
9.SWK.3. Demonstrate that reliable scientific evidence improves the ability of scientists	X	X

to offer accurate predictions.		
9.SWK.5. Justify that scientific theories are explanations of large bodies of information and/or observations that withstand repeated testing.	X	X
9.SWK.6. Explain that inquiry fuels observation and experimentation that produce data that are the foundation of scientific disciplines. Theories are explanations of these data.	X	X
9.SWK.7. Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge.	X	X
9.SWK.8. Illustrate that much can be learned about the internal workings of science and the nature of science from the study of scientists, their daily work and their efforts to advance scientific knowledge in their area of study.	X	X
10.ST.1. Cite examples of ways that scientific inquiry is driven by the desire to understand the natural world and how technology is driven by the need to meet human needs and solve human problems.	X	X
10.ST.2. Describe examples of scientific advances and emerging technologies and how they may impact society.	X	X
10.SI.2. Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.	X	X
10.SI.3. Use mathematical models to predict and analyze natural phenomena.		
10.SI.4. Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.	X	X
10.SI.5. Explain how new scientific data can cause any existing scientific explanation to be supported, revised or rejected.	X	X
10.SWK.1. Discuss science as a dynamic body of knowledge that can lead to the development of entirely new disciplines.	X	X
10.SWK.2. Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.	X	X
10.SWK.3. Recognize that science is a systematic method of continuing investigation, based on observation, hypothesis testing, measurement, experimentation, and theory building, which leads to more adequate explanations of natural phenomena.	X	X
11.ST.1. Identify that science and technology are essential social enterprises but alone they can only indicate what can happen, not what should happen. Realize the latter involves human decisions about the use of knowledge.	X	X
11.ST.4. Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.	X	X
11.SI.1. Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.	X	X
11.SI.2. Evaluate assumptions that have been used in reaching scientific conclusions.	X	X
11.SI.3. Design and carry out scientific inquiry (investigation), communicate and critique results through peer review.	X	X
11.SI.4. Explain why the methods of an investigation are based on the questions being asked.	X	X
11.SI.5. Summarize data and construct a reasonable argument based on those data and	X	X

other known information.		
11.SWK.1. Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).		
11.SWK.2. Apply scientific inquiry to evaluate results of scientific investigations, observations, theoretical models and the explanations proposed by other scientists.	X	X
11.SWK.3. Demonstrate that scientific explanations adhere to established criteria, for example a proposed explanation must be logically consistent, it must abide by the rules of evidence and it must be open to questions and modifications.	X	X
11.SWK.7. Explain how theories are judged by how well they fit with other theories, the range of included observations, how well they explain observations and how effective they are in predicting new findings.	X	X
12.PS.5. Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.	X	X
12.PS.9. Describe how gravitational forces act between all masses and always create a force of attraction. Recognize that the strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.	X	X
12.ST.1. Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.	X	X
12.ST.2. Describe how new technologies often extend the current levels of scientific understanding and introduce new areas of research.	X	X
12.ST.3. Research how scientific inquiry is driven by the desire to understand the natural world and how technological design is driven by the need to meet human needs and solve human problems.	X	X
12.ST.4. Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.	X	X
12.SI.1. Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.	X	X
12.SI.2. Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).	X	X
12.SI.4. Create and clarify the method, procedures, controls and variables in complex scientific investigations.	X	X
12.SI.5. Use appropriate summary statistics to analyze and describe data.	X	X
12.SWK.1. Give examples that show how science is a social endeavor in which scientists share their knowledge with the expectation that it will be challenged continuously by the scientific community and others.	X	X
12.SI.2. Evaluate scientific investigations by reviewing current scientific knowledge and the experimental procedures used, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence and suggesting alternative explanations for the same observations.	X	X
12.SI.3. Select a scientific model, concept or theory and explain how it has been revised over time based on new knowledge, perceptions or technology.	X	X
12.SI.5. Describe how individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies, hundreds of people may work together on major scientific questions or technical	X	X

problem).		
12.SI.7. Describe the current and historical contributions of diverse peoples and cultures to science and technology and the scarcity and inaccessibility of information on some of these contributions.	X	X
12.SI.9. Recognize the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"	X	X
12.SI.11. Research how advances in scientific knowledge have impacted society on a local, national or global level.	X	X

Social Studies		
9-10.SSSM A. Evaluate the reliability and creditability of sources.	X	X
9-10.SSSM B. Use data and evidence to support or refute a thesis.	X	X
9-10.RH/SS3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.	X	X
9-10.RH/SS7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.	X	X
9-10.RS/TS3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.	X	X
9-10.RS/TS4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.	X	X
9-10.RS/TS7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.	X	X
9-10.GEO B. Analyze geographic changes brought about by human activity using appropriate maps and other geographic data.	X	X
9-10.WH/SS/S/TS2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	X	X
9-10.WH/SS/S/T6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	X	X
11-12.SSSM D. Work in groups to analyze an issue and make decisions.	X	X
11-12.RH/SS7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.	X	X
11-12.RS/TS3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	X	X
11-12.RS/TS4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.	X	X
11-12.RS/TS7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	X	X

11-12.WH/SS/S/TS2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	X	X
11-12.WH/SS/S/TS6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.	X	X

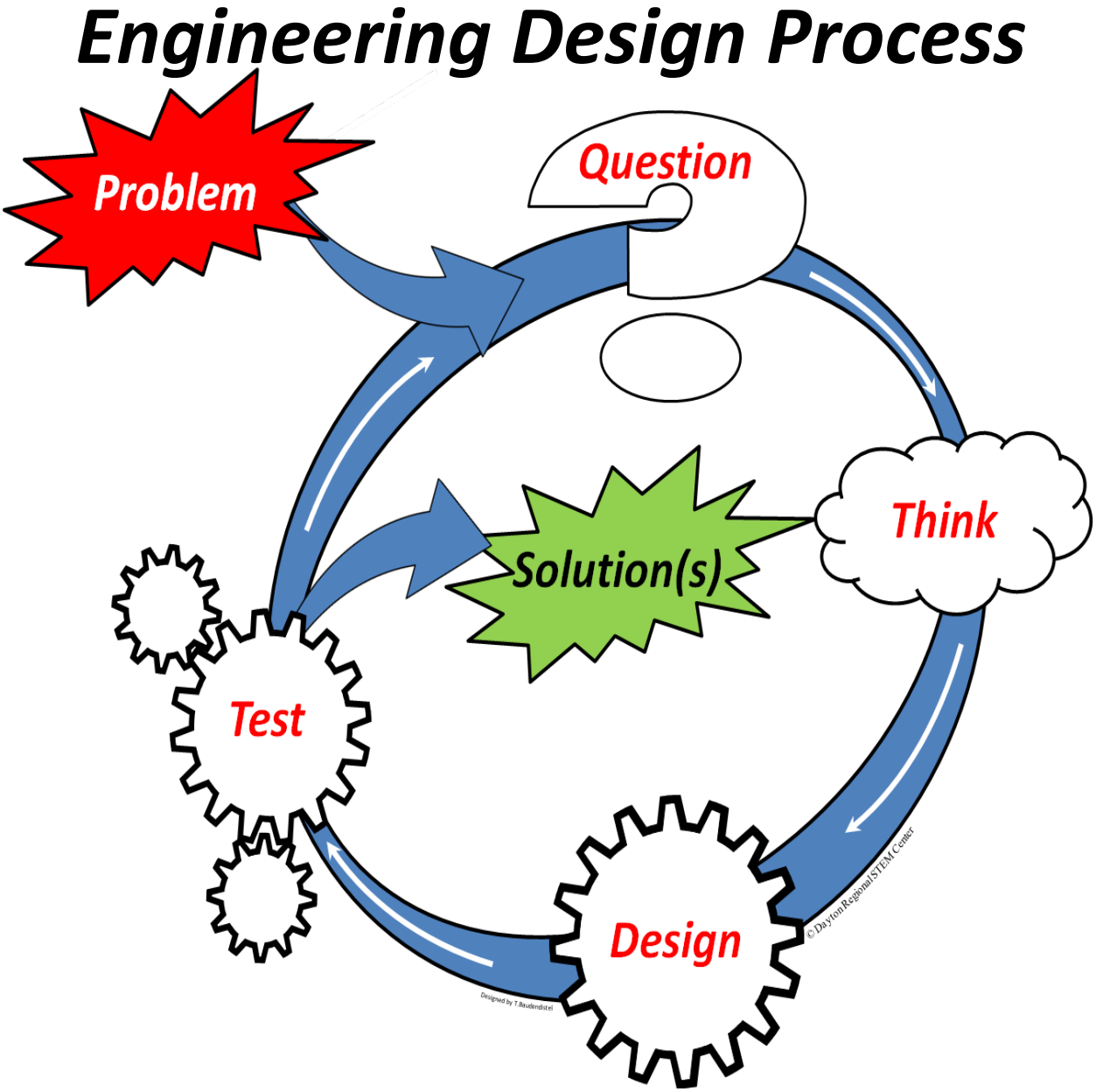
Math		
9-10.M.A. Solve increasingly complex non-routine measurement problems and check for reasonableness of results.	X	X
9-10.A.D. Use algebraic representations, such as tables, graphs, expressions, functions and inequalities, to model and solve problem situations.	X	X
9-10.A.F. Solve and graph linear equations and inequalities.	X	X
9-10.A.H. Solve systems of linear equations involving two variables graphically and symbolically.	X	X
9-10.A.C. Translate information from one representation (words, table, graph or equation) to another representation of a relation or function.	X	X
9-10.A.J. Describe and interpret rates of change from graphical and numerical data.	X	X
9-10.G.A. Formally define geometric figures.	X	X
9-10.GH. Establish the validity of conjectures about geometric objects, their properties and relationships by counter-example, inductive and deductive reasoning, and critiquing arguments made by others.	X	X
9-10.G.C. Recognize and apply angle relationships in situations involving intersecting lines, perpendicular lines and parallel lines.	X	X
9-10.G.I. Use right triangle trigonometric relationships to determine lengths and angle measures.	X	X
9-10.M.D. Use proportional reasoning and apply indirect measurement techniques, including right triangle trigonometry and properties of similar triangles, to solve problems involving measurements and rates.	X	X
9-10.M.B. Use formulas to find surface area and volume for specified three-dimensional objects accurate to a specified level of precision.	X	X
9-10.M.E. Estimate and compute various attributes, including length, angle measure area, surface area and volume, to a specified level of precision.	X	X
9-10.D.B. Evaluate different graphical representations of the same data to determine which is the most appropriate representation for an identified purpose.	X	X
9-10.D.E. Evaluate the validity of claims and predictions that are based on data by examining the appropriateness of the data collection and analysis.	X	X
9-10.D.K. Make predictions based on theoretical probabilities and experimental results.	X	X
9-10.D.I. Design an experiment to test a theoretical probability, and record and explain results.	X	X
9-10.P.E. Use a variety of mathematical representations flexibly and appropriately to organize, record and communicate mathematical ideas.	X	X
9-10.P.F. Use precise mathematical language and notations to represent problem situations and mathematical ideas.	X	X
9-10.P.G. Write clearly and coherently about mathematical thinking and ideas.	X	X
9-10.P.H. Locate and interpret mathematical information accurately, and communicate	X	X

ideas, processes and solutions in a complete and easily understood manner.		
11-12.P.E. Use a variety of mathematical representations flexibly and appropriately to organize, record and communicate mathematical ideas.	X	X
11-12.M.A. Explain differences among accuracy, precision and error, and describe how each of those can affect solutions in measurement situations.	X	X
11-12.M.B. Apply various measurement scales to describe phenomena and solve problems.	X	X
11-12.M.D. Solve problem situations involving derived measurements; e.g., density, acceleration.	X	X
11-12.G.A. Use trigonometric relationships to verify and determine solutions in problem situations.	X	X
11-12.P.H. Use formal mathematical language and notation to represent ideas, to demonstrate representations systems, and to formulate generalizations.	X	X
11-12.P.J. Apply mathematical modeling to workplace and consumer situations, including problem formulation, identification of a mathematical model, interpretation of solution within the model, and validation to original problem situation.	X	X
11-12.D.A. Create and analyze tabular and graphical displays of data using appropriate tools, including spreadsheets and graphing calculators.	X	X
11-12.D.C. Design and perform a statistical experiment, simulation or study; collect and interpret data; and use descriptive statistics to communicate and support predictions and conclusions.	X	X
11-12.P.C. Assess the adequacy and reliability of information available to solve a problem.	X	X
11-12.P.D. Select and use various types of reasoning and methods of proof.	X	X
11-12.P.F. Use precise mathematical language and notations to represent problem situations and mathematical ideas.	X	X
11-12.P.I. Communicate mathematical ideas orally and in writing with a clear purpose and appropriate for a specific audience.	X	X
11-12.P.G. Understand the difference between a statement that is verified by mathematical proof, such as a theorem, and one that is verified empirically using examples of data.	X	X
11-12.P.A. Construct algorithms for multi-step and non-routine problems.	X	X
11-12.P.B. Construct logical verifications or counter-examples to test conjectures and to justify or refute algorithms and solutions to problems.	X	X

English Language Arts		
9-10.L.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	X	X
9-10.R.I.7. Analyze various accounts of a subject told in different mediums (e.g., a person's life story in both print and multimedia), determining which details are emphasized in each account.	X	X
9-10.SL.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.	X	X

9-10.SL.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.	X	X
9-10.SL.5. Make strategic use of digital media (e.g., graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	X	X
9-10.W.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	X	X
11-12.R.I.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.	X	X
11-12.SL.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.	X	X
11-12.SL.2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informal decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.	X	X
11-12.W.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.	X	X

Appendix A – Engineering Design Process



Question – Find out as much as you can about the problem.

Think – Imagine different ways to solve the problem.

Design – Choose one of your ideas, collect materials, and put it together.

Test – Try your idea and see if it worked.

Solution – If you did not solve the problem the first time, ask more questions and go through all the steps again.

Appendix B – Bernoulli Lab Worksheet

Name: _____ Date: _____

Part A: The Paper Tent

Directions: Circle the correct answer.

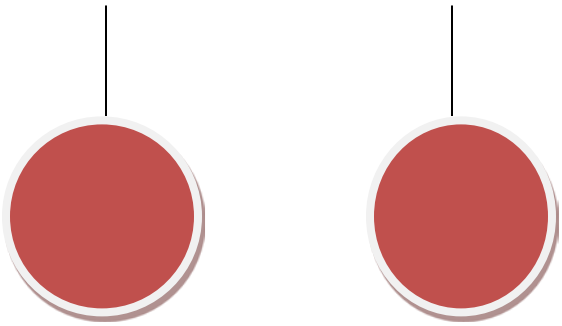
1. When I blow through the paper tent, the air velocity will be greater on the **(inside/outside)** of the tent.

2. My hypothesis is that the paper tent walls will move **(in/out /up)** when I blow through the tent.

3. Bernoulli's Principle states that as air moves faster over a surface, the pressure exerted on the surface **(increases/decreases).**

Part B: Moving Balloons

Directions: Which way will the balloons move when you blow between them? Draw arrows on the balloon diagram below to indicate which direction the balloons will move.



Write an explanation of what happened in the two experiments above and why.

_____

_____

_____

_____

_____

Appendix C – Rocket Balloons & Newton's Third Law

Name: _____ Date: _____

Directions: In your group, answer the following.

1. Record your balloon flight distances below.

- _____
- _____
- _____

Group Average: _____

2. Explain which measure of central tendency best represents the data and why?

_____
_____
_____

3. How did Newton's third law of motion influence your rocket balloon?

_____
_____
_____

4. In the string balloon experiment, describe what is the action and what is the reaction?

_____
_____
_____

5. How does the shape and size of a balloon influence the velocity or acceleration of the string balloon rocket?

_____
_____

6. How is this similar to a real jet engine?_____
_____
_____

Appendix D – Paper Airplane Glide Ratio Challenge Worksheet

Your team's goals are:

- To construct a paper airplane from www.bestpaperairplanes.com or design your own
- Test your design by measuring the glide ratio
- Make three test flights for your airplane and record the distances
- Average the distance of the three flights to determine how well your airplane flew
- Use your average glide ratio to determine the flight path of your paper airplane

Trial Number	Distance (D) cm	Launch (H) cm	Glide Ratio (G)
1			
2			
3			
Average			

Round your answers to the nearest tenth.

Assume that the side of each square on the grid represents 50 cm in the real world. Draw a mark on the vertical side of the grid to show your launch height.
Draw a mark on the horizontal side of your grid to show the average distance your plane flew.
Connect these two marks to make a right triangle (a triangle with a 90- degree angle).
The height of the triangle is your launch height. The base of the triangle is the average distance of your plane's flight.
The hypotenuse, the longest side of the triangle, shows the approximate flight path of your plane.

1. Which of your planes flew best? _____
_____

2. Why do you think this plane flew better than the other design?
_____
_____

Appendix E - The Shoebox Challenge

The purpose of this challenge is to design a glider shoebox. In this challenge you will be required to work as a member of a team and engage in creative problem solving. You will need to accomplish the following tasks to complete the challenge successfully:

- Determine and gather materials necessary to construct your glider
- Determine how to launch your glider in a consistent way
- Obtain the most efficient glide slope ratio possible

Aerospace engineers must consider elements of the design in their work (criteria and constraints). Criteria are standards or requirements that must be included in the design**.** For example: your glider must be able to land without damage to itself, include efficient materials, and glide to at least 3 meters.

Constraints are things that limit the design of the glider. For example, cost, time, size and available resources to build or fly the glider.

Shoebox Glider Criteria:

1. The glider must fly forward at least three meters.

2. The glider must demonstrate an efficient positive glide slope ratio. The larger the glide slope, the better, as long as the other criteria and constraints are followed.

3. The glider must not break upon landing.

4. The glider's glide slope and aspect ratios must be determined.

Shoebox Glider Constraints:

1. The glider must include an intact shoebox in its design.

2. There are no material constraints.

Appendix F - The Shoebox Challenge Glider Ratios Worksheet

Name: _____ Date: _____

Directions: Using the shoebox glider you created, record each measurement to the nearest tenth of a centimeter.

(Aspect Ratios)

Wing

Chord _____ cm Length _____ cm Aspect Ratio _____:_____

Shape _____ Area _____ cm²

Vertical stabilizer

Width _____ cm Length _____ cm

Shape _____ Area _____ cm²

Ratio of vertical stabilizer area to wing area _____:_____

Horizontal stabilizer

Width _____ cm Length _____ cm

Shape _____ Area _____ cm²

Ratio of horizontal stabilizer area to wing area _____:_____

Fuselage

Length _____ cm

Ratio of fuselage length to wing chord _____:_____

(Glider Slope Ratio)

Trial Number	Distance (D) cm	Launch (H) cm	Glide Ratio (G)
1			
2			
3			
Average			

Round your answers to the nearest tenth.

Create a graph to represent the glide ratio data. Explain what the graph means.

Appendix G - The Shoebox Challenge Flight Log Worksheet

Distance of Flight (m)	Time Aloft (sec)
Trial 1	
Trial 2	
Trial 3	
Average Distance:	**Average Time:**

1. Create a line graph by plotting the average velocity at each time (x-axis is time and y-axis is average velocity) for each member of your group. Use graph paper, making sure to properly label and plot your data.

2. What is velocity? _____

3. Explain the curve (shape) of your line graph.
   _____
   _____

4. From your line graph, was your velocity constant while you did the activity? Explain.
   _____
   _____

5. What is acceleration?
   _____
   _____

6. Calculate your acceleration.
   _____
   _____

7. Are you accelerating or decelerating? Is your acceleration/deceleration constant?
   _____
   _____

Appendix H - Rubric for Shoebox Challenge

Names: _____

Tasks	Points	Comments
Glider built and tested	/40	
Original design	/10	
Glide slope calculated	/10	
Aspect ratio calculated	/10	
Team work	/20	
Time constraints met	/10	

Appendix J – Catapult Design Challenge

Your team of engineers has been given the challenge to design a catapult out of everyday items. The catapult should be designed to launch a projectile (marshmallow, cotton ball, etc.) to land as far away from the catapult as possible. The catapult that can launch the projectile the greatest distance is the winner!

- Rubber bands may not be used to power the arm of the catapult

1. Meet as a team and discuss the problem you need to solve.
2. Develop and agree on a design for your catapult.
3. Determine what materials you will need.
4. Draw your design in the box below. Indicate the description and number of parts you plan to use.

5. Build your catapult.
6. Test your catapult by launching a projectile (marshmallow, cotton ball, etc.) and landing it in the pie plate.
7. Observe your launches and make necessary revisions.
8. Observe the other teams' launches.

Appendix K – Catapult Video Worksheet

Start with the information available from the suggested videos, then search the web for more answers, if needed.

Name: _____

1. What simple machines are at work in a catapult?

   _____

   _____

2. How did the invention of catapults change warfare?

   _____

   _____

3. Name 5 types of ancient catapults. Make a chart which will give a brief description (or even a picture); describe their uses, and list their advantages and disadvantages.

4. How did subsequent warfare advances make catapults obsolete?

   _____

   _____

5. Aside from entertainment and hobbies, how are catapults still in use today?

   _____

   _____

6. What is Newton's second law of motion?

_____

_____

7. Why is Newton's second law of motion important if you want to catapult an object a certain distance?

_____

_____

Appendix L - Catapult Launch Data Worksheet

Name: _____ Date: _____

Directions: Your team will do several launches and measure the highest point on the parabola and the point where the object lands. The diagram on the data sheets shows where to take the measurements to get the *x*, *y* values for the three points. Record your data on the three Launch Data Sheets.

Recall that $y = ax^2 + bx + c$ is a quadratic equation in standard form. You will use the data collected to create quadratic equations like the one shown. After you have taken data for three launches, use the projectile motion quadratic equation to solve for initial velocity to see how powerful your catapult is.

Your team's goals:

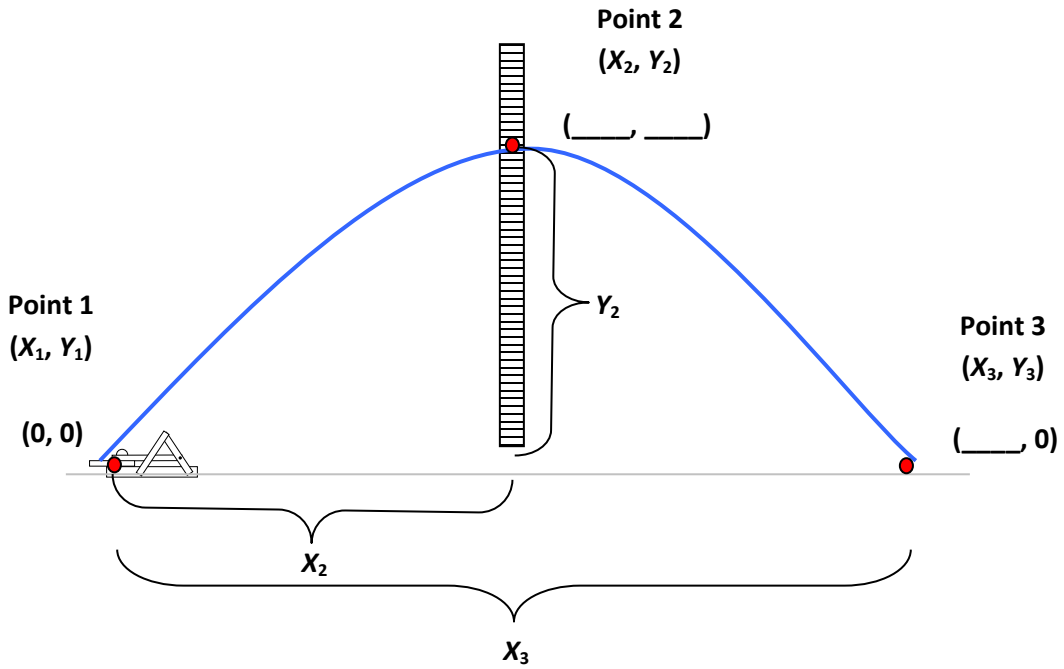
- Make sure that all measurements are taken in the same units.
- Have everyone in the group doing something to help save time. Designate a person for each of these tasks:
    - launch the object
    - measure the highest point of the parabola and the distance of this point from the launch point
    - measure the distance from the starting point to the place where the object lands
    - record data

- Hold a measuring tape or meter stick near the middle of the parabola so you can measure the highest point of the arc and the distance of this point from the launch point when the object is launched.
- Mark the spot where the object lands with masking tape and measure the distance from the launch point.
- The person launching the object should give a count-down to help their partners get ready.
- Be very careful while measuring and recording your data.

Launch 1 Data Sheet

Object launched: _____

Launch the "projectile" and take measurements for X_2, Y_2, and X_3.



Note: Since the curve is probably not exactly a parabola, the high point will not occur at the half-way mark. That is, $X_2 \neq \frac{1}{2} X_3$

Fill in the table with data from your three points and the time.

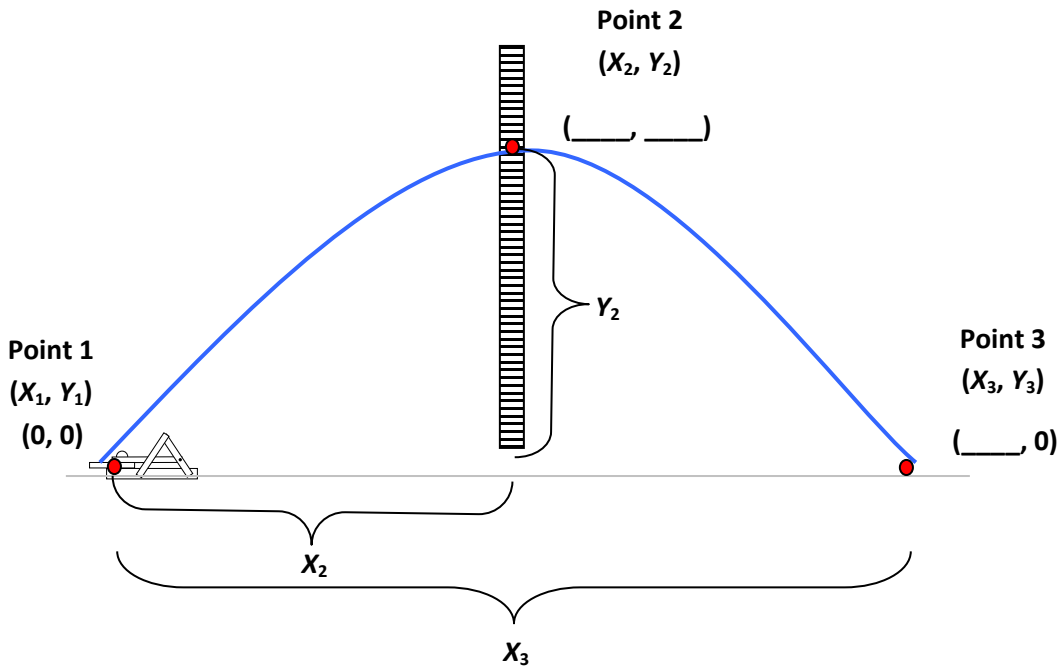
Point 1	X_1 = **0 cm**	Y_1= **0 cm**
Point 2	X_2 =	Y_2=
Point 3	X_3 =	Y_3=
Time (s)	*at* X_1=	*at* X_3=

Using the data collected, write the quadratic equation of the parabolic motion and determine the initial velocity in feet or meters per second.

Launch 2 Data Sheet

Object launched: _____

Launch the "projectile" and take measurements for X_2, Y_2, and X_3.



Note: Since the curve is probably not exactly a parabola, the high point will not occur at the half-way mark. That is, $X_2 \neq \frac{1}{2} X_3$

Fill in the table with data from your three points and the time.

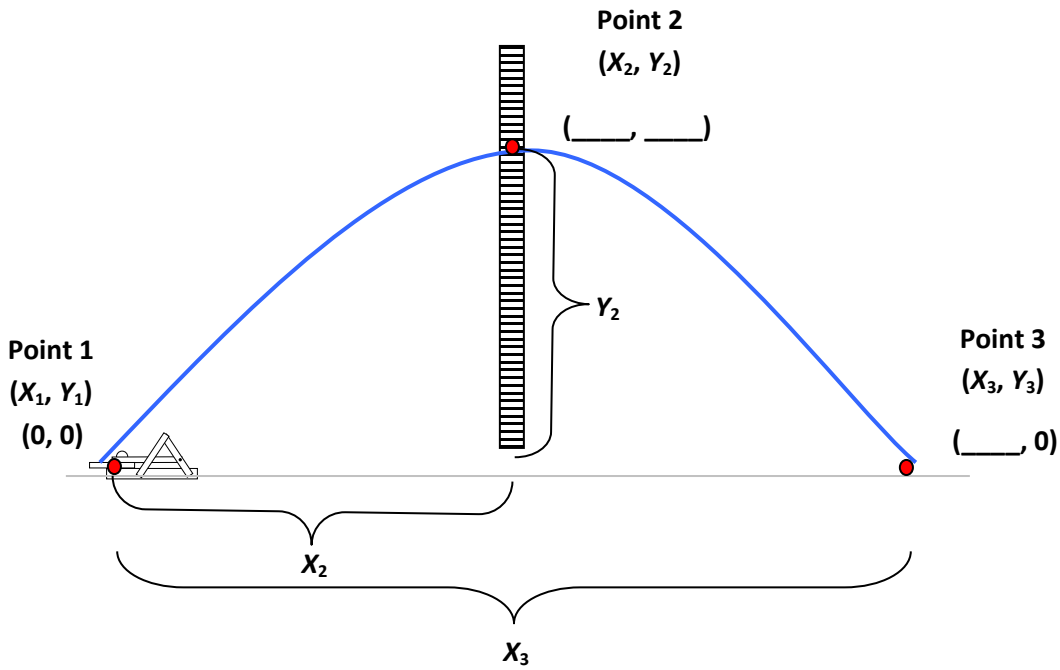
Point 1	X_1 = **0 cm**	Y_1= **0 cm**
Point 2	X_2 =	Y_2=
Point 3	X_3 =	Y_3=
Time (s)	*at* X_1=	*at* X_3=

Using the data collected, write the quadratic equation of the parabolic motion and determine the initial velocity in feet or meters per second.

Launch 3 Data Sheet

Object launched: _____

Launch the catapult and take measurements for X_2, Y_2, and X_3.



Note: Since the curve is probably not exactly a parabola, the high point will not occur at the half-way mark. That is, $X_2 \neq \frac{1}{2} X_3$

Fill in the table with data from your three points and the time.

Point 1	X_1 = **0 cm**	Y_1= **0 cm**
Point 2	X_2 =	Y_2=
Point 3	X_3 =	Y_3=
Time (s)	*at* X_1=	*at* X_3=

Using the data collected, write the quadratic equation of the parabolic motion and determine the initial velocity in feet or meters per second.

Appendix M - Evaluation/Reflection Worksheet

Name: _____ Date: _____

1. What did you learn about the velocities of different projectiles? Why did some projectiles go farther than others?

2. How could you improve upon your catapult design if given the opportunity?

3. Was there a part of the lab where you had to use your/your teammates' personal judgement/common sense? If so, where, and what did you ultimately decide?

4. How do you think this lab could be applied to the real world of engineering design? Be creative here.