Time to Fall?

Michigan Curriculum Framework Connections

SCI.I.1.E.1 — Generate questions about the world based on observation.

SCI.I.1.E.2 — Develop solutions to problems through reasoning, observations, and investigations.

SCI.I.1.E.3 — Manipulate simple devices to make measurements or scientific investigations.

SCI.I.1.E.5 — Develop strategies and skills for information gathering and problem solving.

SCI.I.1.M.1 — Generate scientific questions about the world based on observation.

SCI.I.1.M.2 — Design and conduct science investigations.

SCI.I.1.M.3 — Use tools and equipment appropriate to scientific investigations.

SCI.I.1.M.5 — Use sources of information in support of scientific investigations.

SCI. II.1.E.1 — Develop awareness of the need for evidence in making decisions scientifically.

SCI. II.1.M.1 — Evaluate the strengths and weaknesses of claims, arguments, or data.

SCI. II.1.M.2 — Describe limitations in personal knowledge.

SCI. IV.3.E.1 — Describe or compare motions of common objects in terms of speed or direction.

SCI. IV.3.E.2 — Explain how forces (pushes or pulls) are needed to speed, slow down, stop, or change the direction of a moving object.

SCI. IV.3.E.5 — Manipulate simple mechanical devices and explain how their parts work together.

SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

SCI. IV.3. MS.3 — Describe the non-contact forces exerted by gravity.

Time required

Two 45-minute class periods.

Materials needed for a class of 30 students

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Log and pencils for your class. click here.
- 30 plastic straws
- 1 ball of kite string
- 60 small plastic washers

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the Pilot Logs for taking notes and creating drawings and diagrams.
- Upon entering the exhibit area, have the students sit under the DC-3 airplane suspended over the entry area. Students should be seated so as not to block the entry but be able to see clearly the quotes being projected on the skyline "wall." Have the students focus on the following quote:

  The airplane stays up because it doesn't have time to fall.

  Orville Wright

- Ask the following questions:

  What do you think of this quote?

What do you think keeps the airplane up?

What force or forces would make it fall?

- Ask the students to write their ideas in their Pilot Log. Have the students leave space after their first ideas to draw and take notes while they tour the exhibit. Tell the students they will revisit these same questions as they leave the exhibit.
- Have the students share their ideas with their neighbor and then with the whole group (think, pair, share). Identify any misconceptions, beliefs, or understandings the students may have in order to address the questions later in the lesson.

Explore

- As the students go through the exhibit, remind them of the quote. Have them look carefully at wing designs, propeller designs, materials from which planes are constructed, etc. Remind them to take notes and make diagrams that would help them answer the questions, What keeps the airplane up? What force/s would make it fall?

Explain

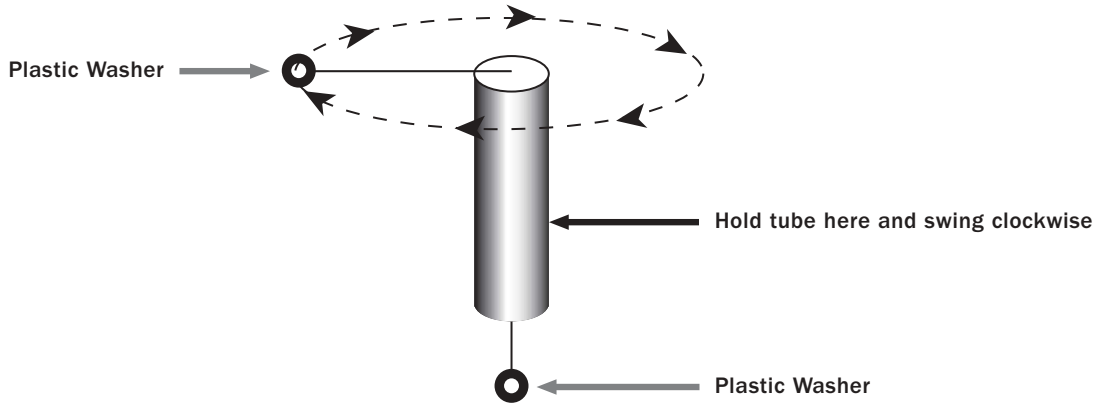
- Upon exiting the exhibit, have the students refer to their Pilot Log and again revisit the quote and questions. Students should express that motors, wind and air keep the airplane up and that gravity would make it fall. If gravity is not given as an answer, then the teacher should check their understanding of the concept of gravity and falling. To demonstrate the pull of gravity, simply drop a pencil and ask why it fell down and not up.
- Explain that gravity is the force that pulls an object downward, toward the center of the Earth. Gravity pulls all objects downward at the same rate, regardless of the size or mass (quantity of matter) of the object. On the moon, an object has the same mass as on Earth, but it weighs less because the moon's gravitational pull is not as great as earth's. Remind them of "weightlessness" they may have seen on the NASA TV channel as astronauts train.
- Ask the students how the moon, stars, and even the space station stay in their orbits. Remind the students that gravity helps to keep things in order in space too. As a human-built satellite circles the Earth, Earth's gravity keeps the satellite from flying off into space. An initial push from a rocket gets the satellite into space. The satellite's orbital speed keeps it in space. At the same time, gravity constantly pulls at the satellite and keeps it going around the Earth. There is an optimum orbital speed a satellite must maintain; otherwise, it is pulled closer and closer to the Earth.

Extend

- Do the following as a demonstration to the class: Drop a book. Ask the students what happened. They should say that gravity pulled the book down. Hold a book in one hand and a pencil in the other. Ask the students to predict which will hit the floor first when dropped. Drop both at exactly the same time. (This may take practice.) Ask which one hit the floor first and why. Optionally, is to do the same drop from standing on a chair or stair.
- Next, have each student run a length of string (about 1 meter) through a straw and tie a lightweight plastic washer to each end. Make certain the string is securely fastened to the weights. (Use tape if needed. The objects could be dangerous if they fly off.)
- The upper weight/object represents the satellite and the lower weight/object represents gravity. Spin the satellite around. Does the lower object rise up toward the tube or the other spinning weight? Can you spin the satellite so that the lower object remains level and does not move up and down as the satellite spins? It takes practice. To maintain an "orbit," the outward pull caused by the rotation of

the satellite must be balanced by the pull of gravity (the lower weight/object).

- Change the radius of the "orbit" (spin the satellite in a larger circle). Does the satellite have to go faster or slower for the lower object to remain level? Ask the students why.



Evaluate

- Return to the original quote from Orville Wright.
- "The airplane stays up because it doesn't have time to fall." Ask the students to write their response to this quote using at least four examples from either the exhibit or extension activity to support their answer. They may use their Pilot Log and diagrams if they wish.
- Reinforce the concept that it is okay to disagree with a statement from a famous person as long as there is a scientific basis for the disagreement.

References

Susan V. Bosak, *Science Is…A Sourcebook of Fascinating Facts, Projects and Activities (*Markham, Ontario: Scholastic Canada Ltd., 2000), p. 124.

An Aerodynamic Drag Race

Michigan Curriculum Framework Connections

SCI.I.1.E.1 — Generate questions about the world based on observation.

SCI.I.1.E.2 — Develop solutions to problems through reasoning, observations, and investigations.

SCI.I.1.E.3 — Manipulate simple devices to make measurements or scientific investigations.

SCI.I.1.E.5 — Develop strategies and skills for information gathering and problem solving.

SCI.I.1.E.6 — Construct charts and graphs and prepare summaries of observations.

SCI.I.1.MS.1 — Generate scientific questions about the world based on observation.

SCI.I.1.MS.2 — Design and conduct science investigations.

SCI.I.1.M.5 — Use sources of information in support of scientific investigations.

SCI. II.1.E.1 — Develop an awareness of the need for evidence in making decisions scientifically.

SCI. II.1.MS.1 — Evaluate the strengths and weaknesses of claims, arguments, or data.

SCI. II.1.MS.2 — Describe limitations in personal knowledge.

SCI. II.1.MS.5 — Develop an awareness of and sensitivity to the natural world.

SCI. IV.3.E.1 — Describe or compare motions of common objects in terms of speed or direction.

SCI. IV.3.E.2 — Explain how forces (pushes or pulls) are needed to speed, slow down, stop, or change the direction of a moving object.

SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

SCI. IV.3. MS.3 — Describe how the non-contact forces exerted by gravity.

Time required

Two 45-minute class periods.

Materials needed for a class of 30 students (students working in teams of three)

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Logs and pencils for your class. click here.
- 1 quarter per team
- 1 pair of scissors per team
- Several sheets of different types of paper, such as tissue, lens paper, rice paper, 20# paper
- 1 pack of playing cards
- An Aerodynamic Drag Race Work Sheet

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the Pilot Log for taking notes and creating drawings and diagrams.
- After the students have explored a bit with gravity from the lesson *Time to Fall?*, ask them if they could think of a way to make a quarter and paper smaller than the quarter hit the ground at the same time here on Earth. Facilitate the formation of their ideas and list them on chart paper, etc. for the entire class to see.

Explore

- Taking the ideas from the list generated, divide the class into groups of three students. Have each group try one idea. Assign members of the group to jobs: recorder, observer, experimenter, etc. Tell the groups that they have 15 minutes to try their idea at least five times and then gather their results into a brief presentation to share with the class.
- It is rare that the teams cannot make the quarter and slip of paper hit the ground at the same time. If a team succeeds, give them all credit that is due. Then demonstrate to the entire class how it can be done, using vocabulary like gravity, weight, friction, and drag to reinforce their discovery. If they do not find a way, then simply do this demonstration for them using correct vocabulary.
- To accomplish this, put the paper on top of the quarter making certain that no corners of the paper are sticking out over the edge of the quarter. Press the paper down on the quarter, so that there is as much contact between the two surfaces as possible. The idea is to keep air from moving under the paper and lifting it from the quarter. Drop the quarter and paper together, ensuring that the coin remains horizontal as it falls.
- Also, putting the paper under the coin generally works because the coin presses down on the paper as both fall to the ground. The paper-under-coin approach is a little harder to set up. The finger must be removed from the paper quickly so the drop can occur without shifting the paper's position under the coin.

Explain

- Air exerts friction on objects moving through it. The amount of air resistance, or drag, depends on the shape of an object and the object's speed. Streamlining and smoothing surfaces reduces drag. A slip of paper flutters to the ground slowly because drag acts against the force of gravity. Drag also affects a falling coin, but the coin's weight counteracts the drag. If the slip of paper is placed properly on top of the coin, the coin shields the paper from the effects of motion through the air. The paper and coin then reach the ground at the same time. If there were no air (as on the moon), all objects dropped from the same height would reach the ground at the same time.
- Ask the students to return to their Logs and find an example of drag and the effect of surfaces found in the exhibit. In the Record Breakers section, they should have noted the display with retractable gears and the difference of speed when the gears were down versus up. Visit the website at http://wright.grc.nasa.gov/airplane/tunnlint.html referenced in the *Wing It* lesson that also focuses on the concept of drag.

Extend

- Have students use the library or Internet to learn about specific personalities or events they encountered in the exhibit *Heroes of the Sky*.

Evaluate

- Tell the students that thrust is the force that gives a bird or airplane forward motion and gets air moving over a wing. Air constantly rubbing against the surface of the wing causes air resistance or drag. Drag is the force that slows a flyer down. Have the students watch the following demonstration and then answer the questions including diagrams.
- Have one member of the student team hold a piece of construction paper vertically between their hands so the thumbs point toward the ceiling. Have them hold their arms out straight and start to spin to the

left. Spinning provides thrust and gets the construction paper moving. After they are spinning, have them drop their left hand from the vertical hold on the paper. Ask the students why the paper does not fall. What is holding it to their hand? Have them predict and explain what would happen if they stop spinning. Finally ask them if they could spin faster without the paper. Why or why not?

References

Susan V. Bosak, *Science Is…A Sourcebook of Fascinating Facts, Projects and Activities (*Markham, Ontario: Scholastic,Canada Ltd., 2000), p. 34.

Mary K. Carson, and Laura D'Argo. *The Wright Brothers for Kids: How They Invented the Airplane with 21 Activities for Exploring the Science and History of Flight (*Chicago: Chicago Review Press, 2003),pp. 32-33.

Wing it!

Michigan Curriculum Framework Connections

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SCI. IV.3.E.2 — Explain how forces (pushes or pulls) are needed to speed, slow down, stop, or change the direction of a moving object.

SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

SCI. IV.3. MS.3 — Describe the non-contact forces exerted by gravity.

Time required

Three 45-minute class periods.

Materials needed for a class of 30 students (students working in teams of four)

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Logs and pencils for your class. click here.
- Various pictures of birds in flight
- 1 pack of 4x6 index cards
- Tape
- Paper punch
- Metric ruler
- 1 package of plastic straws
- 1 package of plastic pickup sticks or large paper clips
- 1 hair dryer per team
- 1 chunk of Styrofoam or modeling clay per team
- Access to the Internet for images of birds in flight and wind tunnel site

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the *Heroes of the Sky* Pilot Log for taking notes and creating drawings and diagrams.
- Ask the students, "Have you ever watched a bird flying high in the sky making large circles? Have you ever watched birds flying in close formations, diving after each other, or even fighting?" Certainly each student can relate an incident from their own experience. Perhaps a student has his or her own pet bird. They may be able to relate why they have

to clip the bird's wings so it will not fly. Next, ask them if they have ever noticed the shape of bird wings. Diagram several shapes based on the students' observations or thoughts.

- Next have the students get their *Heroes of the Sky* Pilot Log in which they have made notes and diagrams during their visit to the *Heroes of the Sky*: *Adventures of Early Flight* exhibit. Have them observe carefully the shapes of airplane wings. Have them diagram them in all views in their logs. What do they look like from the front, side, and rear? Are all wings the same or do they differ? Why might they differ?

Explore

- Upon returning to the classroom, have the students share their observations of wing diagrams. Draw their observations on chart paper and post them around the room.
- Explain to the students that a wing does have a special shape. It has to resist the pulling downward force that gravity puts on it by creating the upward force of flight called lift.
- Give each team of three or four students a 4x6 index card, tape, a paper punch, scissors, a plastic drinking straw, two plastic pickup sticks or two large unbent metal paper clips, a chunk of Styrofoam or modeling clay, and a hair dryer.
- Have the teams fold the card in half and tape the top half of the card to the bottom half of the card so that about 6 mm of the bottom shows. This is a wing shape—it should not be flat on both the top and bottom.
- Have the students use the paper punch and put two sets of holes in the thickest part of the wing. Next have them cut the straw into two pieces each 5 cm long each and put the pieces into the holes through the wing. Set the wing on the Styrofoam or modeling clay base and slip a plastic pickup stick or unbent paper clip through each of the mini-straws into the base.
- Holding the hairdryer as steadily as possible in one position at a time, use it to move air over the wing to create lift. The wing will climb up the plastic pickup stick or unbent paper clip when air movement creates lift. Have the students try it both ways: with the flat surface on the bottom and on the top. Also have them try the wing with the thinnest surface closest to the hairdryer, and then the thickest. Have the students record which position creates the most lift.

Explain

- Air may seem invisible and difficult to feel, but, in fact, air is all around us. It takes up space and has weight. The weight of air pushing down on the Earth is called air pressure. Daniel Bernoulli discovered that when air speeds up, its pressure drops; thus, fast moving air has less pressure than slower moving air.
- Have the students go to the wing position at which the wing climbed highest on the plastic pickup sticks or unbent paper clips. The wing should have been higher or thicker closest to the hair dryer and the back of the wing should be thinner. Because of this shape, the air sliding down over the top of the wing speeds up as it goes and drops in pressure. The higher pressure air below the wing now pushes up on the wing creating lift. Most, but not all, of a wing's lift is created by this difference in air pressure.
- Lift is the force that pulls an airplane off the ground. Gravity, acting on the airplane's weight, pulls it back down. That's why kites, hang gliders and birds have lightweight materials in their structures. It is why the Wright brothers chose light-

weight wood and cloth when building their flyer. The less weight there was, the weaker the force of gravity, and the more lift was possible.

- A wing can create lift only if it is moving through the air. The force that pushes a bird or an airplane forward through the air is called thrust. An airplane's propeller gives it thrust, as do the forward flapping wings of a bird.

Extend

- Have the students search on the Internet for examples of materials that are used in the construction of flying machines. What are some of the factors that need to be considered when selecting these materials? Have the students share their findings in a brief presentation.
- Wilbur and Orville didn't understand why their larger 1901 wing didn't provide the lift they expected. To find out why, they built their own wind tunnel and conducted almost 200 tests of wing shapes and combinations. The wind tunnel tests showed how air flowed over the airplane wing and what effect the wing's shape had on the amount of lift the airplane could generate. Conduct these same tests in the same kind of wind tunnel at the following site: http://wright.grc.nasa.gov/airplane/tunnlint.html

Evaluate

- Ask the students to diagram a wing and show what each surface does when it is thrust through the air. Have them describe how this wing works to lift into the air.

References

Mary K. Carson and Laura D'Argo, *The Wright Brothers for Kids: How They Invented the Airplane with 21 Activities for Exploring the Science and History of Flight (*Chicago: Chicago Review Press, 2003), p. 31.

Designing a Glider

Michigan Curriculum Framework Connections

SCI.I.1.E.1 — Generate questions about the world based on observation.

SCI.I.1.E.2 — Develop solutions to problems through reasoning, observations, and investigations.

SCI.I.1.E.3 — Manipulate simple devices to make measurements or scientific investigations.

SCI.I.1.MS.1 — Generate scientific questions about the world based on observation.

SCI.I.1.MS.2 — Design and conduct science investigations.

SCI.I.1.MS.3 — Use tools and equipment appropriate to scientific investigations.

SCI.I.1.M.5 — Use sources of information in support of scientific investigations.

SCI. II.1.E.1 — Develop an awareness of the need for evidence in making decisions scientifically.

SCI. II.1.MS.1 — Evaluate the strengths and weaknesses of claims, arguments, or data.

SCI. II.1.MS.2 — Describe limitations in personal knowledge.

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SCI. IV.3.E.1 — Describe or compare motions of common objects in terms of speed or direction.

SCI. IV.3.E.2 — Explain how forces (pushes or pulls) are needed to speed, slow down, stop, or change the direction of a moving object.

SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

Time required

Five 45-minute class periods.

Materials needed for a class of 30 students (students working in teams of four)

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Log s and pencils for your class. click here.
- Access to the Internet for paper airplane construction plans at http://www.TheHenryFord.org/museum/heroes/paperairplane/default.asp
- 5 sheets of 8.5 inch x 11 inch 20 pound paper per team
- 1 stopwatch per team
- 1 pair of scissors per team
- 1 meter stick or tape measure per team
- 1 ruler per team
- 1 roll of tape per team

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the Pilot Log for taking notes and creating drawings and diagrams.
- An airplane moves in three directions; it has three axes of motion. It moves left and right, which is called yaw; up and down, which is called pitch; and side to side as it tilts and balances, which is called roll. Ask the students if they could compare the axes of motion while riding a bicycle to the movements of a plane.
- A bicycle moves right and left (yaw) and tips over (roll). On stunt bikes used today, the front wheel of

the bicycle is pulled up to increase the pitch for various stunts. Students should be able to relate to the sensations their own bodies go through as they are riding(i.e., leaning into a turn, changing weight distribution, etc.). See if a student who has a stunt bicycle and is skilled can demonstrate several stunts. The other students can analyze the stunt as to what axes of motion are being displayed while the stunt is being performed on the playground.

- Visit the following websites for demonstrations of pitch, roll and yaw:
  http://www.grc.nasa.gov/WWW/Wright/airplane/pitch.html
  http://www.grc.nasa.gov/WWW/Wright/airplane/roll.html
  http://www.g rc.nasa.gov/WWW/Wright/airplane/yaw.html

Explore

- Ask the students if they remember the paper airplanes they built while visiting the *Heroes of the Sky: Early Adventures in Flight* exhibit.Have students build their own basic paper airplane first and put their name on it so it can be identified. Visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/paperairplane/default.asp for instructions for building a basic paper airplane. You may wish to make award certificates for each category of competition and have students decorate their planes.
- Divide the class into teams of four each. Explain to them that they will be competing as a team, BUT that each of their individual scores will be combined and averaged for a team score during half of the competition. Give each team a stopwatch, scissors and meter stick or tape measure. Tell them that they can modify their airplane if needed for the different categories of competition which are:
  - Duration Aloft
  - Distance
  - Accuracy in Hitting a Target
  - Aeronautical Stunts (upward or downward loops and turns around a specific object).
- The airplanes must be hand launched. Participants are allowed three launches in each category and then results are recorded. After the entire team's data has been recorded, the average is determined and team scores can be posted. This competition may be more easily done in the hall, gym or cafeteria. Each category is worth 25 points. Ties are permissible. Scoring instructions are below. The highest team score for the entire event is 100 points. Competition may be done over several days.

  Duration Aloft

  Use a stopwatch to determine the length of time a plane stays in the air so that flights can be more spectacular. Launches can be made from a high place like the top step of a flight of stairs, stage in the cafeteria or bleachers in the gym. Planes can be expected to fly five to 10 times farther than the height from which they are launched. The team with the longest average length of flight receives 25 points, the next longest receives 20 points, the third longest 15 points and so on.

  Distance

  Measure the straight-line distance from the launch spot to the landing spot. This should be demonstrated to the class prior to competition. Space should also be provided so that students are not interfering with each other. The team with the longest average flight receives 25 points, the next longest receives 20 points, the third longest 15 points, and so on.
- Before the next category of competition, have the students select the one airplane they wish to use to compete in the next two categories. Also, have them select one student to launch the plane each trial. Remind them what the next two categories are and tell them that if they wish to modify their design in

anyway or build another type of plane they only can do it after the accuracy competition. They can also do the modification only after they have explained to the teacher what they wish to do and why.

Accuracy in Hitting a Target

Place a chair five meters from the launching point. A plane that hits the target automatically receives 25 points for the team. Planes that land within predetermined distances of the target receive lower scores (e.g., planes within 0.5 meter of the target receives 20 points, within 1.5 meter 15 points, etc.).

Aeronautical Stunts:

Again, each team will have to compete with the one plane they have selected for the accuracy competition. This plane may be modified as previously described. Only one student should be selected to launch the plane. A judge needs to be selected, perhaps a building engineer, administrator or teacher. Each plane will be launched three times, and the judge will award points for the stunt. This category can be run two ways: participants can describe what they plan to do and be judged on whether they accomplish their goal, or a judge can instruct participants on what stunt(s) the planes must perform.

- After each event, post the team scores so the students can easily determine a total. If this competition takes place over several days, expect that students will try to launch their own planes outside class to discover what is needed to accomplish the requirements for each category. This can easily lead to the explanations for why alterations are needed.

Explain

- Characteristics that help a plane fly a long distance may not make it capable of many stunts. As the students experiment with paper airplanes, they will gain insights into the problems that airplane pioneers had to overcome and the things that modern flight crews must know. For example, weight is important in both paper airplanes and full-sized planes. When a real plane is loaded, it can carry only a certain amount of weight. The weight must also be loaded so that the plane is balanced—not too much weight in the nose or tail.

Extend

- Have the students go back to the website http://www.TheHenryFord.org/museum/heroes/paperairplane/default.asp and assign each team to make a different plane this time. Have them repeat at least one of the competition categories. Is success a result only of the type of plane in a category or is it also the way the plane is launched? What do flaps cut in the wing (ailerons) do for the flight? If the ailerons are tipped up? Or down? What happens if you bend the wing tips up? What happens if you curve the wings (cambering)?
- Have the students search the Internet for websites such as http://www.bestpaperairplanes.com/ or http://www.josephpalmer.com/planes/Airplane.shtml for stunt flyers, blunt nose flyers, the Barnaby, the Air Scorpion, or the Super Zoomer aircraft, all of which have been flown in the International Paper Airplane Competition. Have the students construct the aircraft from the provided directions and compare their flight patterns.

Evaluate

- Assign each team a specific goal (flight of 15 meters, downward loop, circles, straight flight, etc.). Give the team their equipment (paper, ruler, tape, and scissors.) Allow them 20 minutes to build their plane and test fly it at least three times before they fly it for their performance assessment.

References

Susan V. Bosak, *Science Is…A Sourcebook of Fascinating Facts, Projects and Activities.* (Markham, Ontario: Scholastic Canada Ltd., 2000), p. 331.

Propel It

Michigan Curriculum Framework Connections

SCI.I.1.E.1 — Generate questions about the world based on observation.

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SCI.I.1.E.5 — Develop strategies and skills for information gathering and problem solving.

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SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

SCI. IV.3. MS.3 — Describe how the non-contact forces exerted by gravity.

SCI. IV.3. MS.5 — Design strategies for moving objects by application of forces, including the use of simple machines.

Time required

Two 45-minute class periods.

Materials needed for a class of 30 students (students working in teams of three or four)

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Logs and pencils for your class. click here.
- 1 meter of thick thread or light string per team
- 1 piece of plastic bottle 5 inches x 1/2 inch wide per team
- 1 piece of light weight cardboard 2 inches x 3 inches per team
- 1 unsharpened pencil with an eraser per team
- 1 thumbtack per team
- 1 ruler per team
- Tape
- Scissors
- 1 permanent marker per team
- 8 Wright Bat #5220 from Midwest Products Co. per class @ $34.99 (prices subject to change) www.midwestproducts.com or 1.800.348.3497
- 16 pack of Easy Spins #52101 from Midwest Products Co. @ $9.99 (prices subject to change) www.midwestproducts.com or 1.800.348.3497
- Propel It Work Sheet

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the Pilot Logs for taking notes and creating drawings and diagrams.

- Ask the students to refer to their *Heroes of the Sky* Pilot Log entries from their visit to the *Heroes of the Sky: Adventures in Early Flight* exhibit. What did they record concerning propellers? If their entries are weak or lacking, refer to the website http://www.TheHenryFord.org/museum/heroes/home.asp. Have the students look carefully at each planes propellers. What are their shapes? Are they curved? Flat? What is their primary function? Record all their responses on chart paper in the front of the classroom for future reference.

Explore

- Students will build their own propellers and try to fly them to determine the effects of shape and curvature. To build a simple flying apparatus, they will need the supplies listed in the Materials section.
- Wrap the cardboard rectangle lengthwise around the pencil to form a loose tube. The tube should be loose enough so that the pencil can spin inside it. Tape the tube so it keeps its shape.
- Next, use the ruler and marker to draw a rectangle that measure 12.7 cm x 1.3 cm on a flat part of the plastic bottle. Carefully cut out the rectangle. If this is too time consuming, cut these out for the students prior to the activity. Have the students find the midpoint of the propeller by drawing lines connecting opposite corners of the rectangle. Where the lines cross is the midpoint, push the thumbtack through the midpoint of the propeller and, grabbing both ends of the propeller, twist the right end upward and the left side downward. Attach the propeller to the top of the pencil by pushing the thumbtack into the eraser. If the propeller slides around between the thumbtack and the eraser, wrap a piece of tape over them to hold it securely. Have the students start wrapping the string around the pencil about halfway up the shaft of the pencil.
- Wrap the string up the pencil tightly and smoothly leaving 5 to 7.5 cm of unwrapped string at the top. This becomes the pull end. Place the pencil inside the cardboard tube while carefully holding onto the pull end of the string. Gently hold the tube in one hand and pull the string with the other. Pull quickly with force but smoothly. The pencil should be pulled up out of the tube by the pull of the propeller. Have the students try again for at least three trials and record their results, however successful. Have the students compare their results with others. What worked best? Why? Have the students modify their flying top until successful.
- OR have the students in teams of two assemble the Easy Spin propeller (ordering information above). Have each team fly their Easy Spin at least three times recording the time aloft. Have each team compare their results with other teams as to time aloft and the angle of the propellers. Is there any correlation? Why?

Explain

- A propeller is actually a twisted wing designed so that when an engine rotates it, the propellers produce a force similar to lift but aimed in a forward direction. This force (thrust) pulls an airplane through the air so that its wings can develop lift and holds the airplane aloft. A propeller works because the blades have a thin edge, like a knife; the propeller "cuts" through the air. Propeller blades are also at an angle so that as they "cut" the air, they push it backward. When air is pushed back, it gives a little thrust forward. This thrust enables the airplane to go forward, take off, and fly. Propellers also can be used for when landing a plane. The pilot throws a switch that changes the angle of the propeller blades. Instead of pushing the air backwards the blades push air forward, and the air helps to slow down the plane.

Propel It continued

Extend

- Obtain an Easy Spin from the same supplier. Have the students compare the Easy Spin to their propellers. Why is the twisting of the propeller so important? How does the Wright Bat fly? How does it differ from your pencil flyers? How is it the same as your pencil flyers?
- Obtain a Wright Bat from Midwest Products Co., Inc. www.midwestproducts.com or 1.800.348.3497. Available in an eight-pack for $34.99. Do not discard the box; note the instructions on the side dealing with the simple demonstration concerning wing warping.

Evaluate

- Ask the question, "The Wright Flyer had two propellers. Were the two propellers positioned so the propellers would turn in the same direction or in opposite directions when powered? What is your hypothesis? Why?"

References

Mary K. Carson and Laura D'Argo, *The Wright Brothers for Kids: How They Invented the Airplane with 21 Activities for Exploring the Science and History of Flight*. (Chicago: Chicago Review Press, 2003), pp. 4.

Let's Put It All Together

Michigan Curriculum Framework Connections

SCI.I.1.E.1 — Generate questions about the world based on observation.

SCI.I.1.E.2 — Develop solutions to problems through reasoning, observations, and investigations.

SCI.I.1.E.3 — Manipulate simple devices to make measurements or scientific investigations.

SCI.I.1.E.5 — Develop strategies and skills for information gathering and problem solving.

SCI.I.1.MS.1 — Generate scientific questions about the world based on observation.

SCI.I.1.MS.2 — Design and conduct science investigations.

SCI.I.1.MS.3 — Use tools and equipment appropriate to scientific investigations.

SCI.I.1.MS.5 — Use sources of information in support of scientific investigations.

SCI. II.1.MS.1 — Evaluate the strengths and weaknesses of claims, arguments, or data.

SCI. II.1.MS.2 — Describe limitations in personal knowledge.

SCI. II.1.MS.5 — Develop an awareness of and sensitivity to the natural world.

SCI. IV.3.E.5 — Manipulate simple mechanical devices and explain how their parts work together.

SCI. IV.3. MS.1 — Qualitatively describe and compare motion in two dimensions.

SCI. IV.3. MS.2 — Relate motion of objects to unbalanced forces in two dimensions.

SCI. IV.3. MS.3 — Describe the non-contact forces exerted by gravity.

SCI. IV.3. MS.5 — Design strategies for moving objects by application of forces, including the use of simple machines.

Time required

One 45-minute class period

Materials needed for a class of 30 students (students working in teams of three or four)

- *Heroes of the Sky* Pilot Log
  To request *Heroes of the Sky* Pilot Logs and pencils for your class. click here.
- 8 Sky Streak model airplane kits attached pattern (available from hobby shops such as Riders Hobby Shop at http://www.riders.com/)
- Propeller from "Propel It" investigation or a 13 cm commercially-obtained propeller
- Permanent marker
- Internet accessibility to http://wright.nasa.gov to download the Beta test version of WrightSIM is obtained from Re-Living the Wright Way. System requirements: 700 MHz processor, 256 RAM, and 180 MB free space, NVIDIA Geforce 2 (32 MB), ATI Radeon (32 MB) or comparable video card is necessary. A 3-D joystick or game pad is recommended.
- For evaluation, 1 plastic straw per student
- Tape measure
- 2 strips of paper (2 cm x 24 cm and 1.5 cm x 18 cm) per student

Engage

- Prior to visiting the Museum, visit The Henry Ford website at http://www.TheHenryFord.org/museum/heroes/home.asp and preview the exhibit with the students. Review with them what your expectations will be while visiting the exhibit.
- Pick up and distribute *Heroes of the Sky* Pilot Logs and pencils. When your students visit the *Heroes of the Sky*: *Adventures in Early Flight* exhibit, use the Pilot Logs for taking notes and creating drawings and diagrams.

- Ask the students to recall and review with you the investigations they have done concerning flight. The students may first want to look at their *Heroes of the Sky* Pilot Logs as they reflect. As they mention their investigations, write them on flip chart paper to post in the classroom during this next investigation. As they gather their observations, ask them to summarize what they have learned from each one. Try to find and clarify any misconceptions that may remain.
- Ask the students what type of flight they have not investigated yet. The answer should be "powered flight." Continue probing by asking them what could be the source of the power—jet fuel, av fuel, solid rocket fuel, perhaps a rubber band?

Explore

- Divide the class into new teams of four, keeping in mind that this investigation requires attention to detail (model building). Have each team obtain a Sky Streak model kit and, following the included instructions, construct their own model. Once completed, have one student launch three times to determine length of flight and time aloft. Subsequent explorations could include the effects of weight the addition of paperclips, position of the weight, and position of the rudder.
- Hold the airplane in your hand so that the propeller is facing you. Wind the propeller clockwise no more than 15 turns. Continue to hold the airplane in one hand along the rod and the propeller in the other hand. Find an open area and gently toss it into the air releasing of the plane and propeller at the same time. Powered flight…at last.
- If you want the students to build their own planes, instructions for constructing a balsa or Styrofoam airplane can be found on pp. 138-140 in: Carson, Mary K. and D'Argo, Laura. *The Wright Brothers for Kids: How They Invented the Airplane with 21 Activities for Exploring the Science and History of Flight*. Chicago: Chicago Review Press, 2003.

Explain

- The rubber band provides the power for the flight as it unwinds. If the rubber band is wound too tightly, it may break the place where the staple is placed on the rod. If the rudder is not tight, then flight may not be straight. Have the students try to alter their powered airplane with fewer twists of the rubber band. Ask if they think there may be a difference in rubber bands. Competition rubber bands can be obtained from local hobby shops.

Extend

- Ask the students if any of them have made model planes and would be willing to share their experiences.
- Radio-controlled model plane flying is quite popular. Have the students search the Internet and find a local club.
- Finally, ask the students if they could even imagine what it would feel like to fly the Wright Flyer. Capture their responses and encourage their descriptions and imagination. Prior to this activity register and receive your free WrightSIM Beta test version at the Re-Living the Wright Way (http://wright.nasa.gov). This WrightSIM contains a realistic flight model of the Flyer, mimics the aerodynamics of the actual Flyer, and contains 3-D models of Kitty Hawk terrain and weather conditions. Students can view statistics at the end of each flight (flight time, distance flown, height achieved, and airspeed) along with a comparison of the same statistics from the Wright brothers' best flight in 1903. Integrated math activities are also provided by grade-level groups. Video card is necessary.

A 3-D joystick or game pad . The best thing is that

Let's Pull It All Together continued

students can do this at home with their parents. When using this, forward any comments and suggestions to Carol.Galica@grc.nasa.gov.

Evaluate

Give each student a plastic straw, a strip of paper 2 cm x 24 cm, a strip of paper 1.5 cm x 18 cm, and tape. Tell them their assessment task is to use these materials to construct an airplane that will fly at least 15 meters and to explain what each part of their airplane is doing. Give them 15 minutes for construction and test flights. They will demonstrate this to the teacher individually as a performance assessment.