Target

Lesson 5

Lesson Reference: NASA at http://connect.larc.nasa.gov/connect_bak/pdf/flightd.pdf and a CAP ACE academic lesson

Objectives:

- Students will define and demonstrate roll, pitch, and yaw.
- Students will experiment with surface controls to adjust flight paths.
- Students will convert fractions to decimals.
- Students will calculate percentages and determine probability from data.

National Standards:

Math

- Number and Operations
  - Work flexibly with fractions, decimals, and percents to solve problems
- Understand and apply basic concepts of probability
  - Use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations
- Communication
  - Organize and consolidate mathematical thinking through communication
- Connections
  - Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
  - Recognize and apply mathematics in contexts outside of mathematics
- Representation
  - Create and use representations to organize, record, and communicate mathematical ideas

Science

- Unifying Concepts and Processes
  - Evidence, models, and explanation
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science
  - Motions and forces
  - Transfer of energy
- Content Standard E: Science and Technology
  - Abilities of technological design

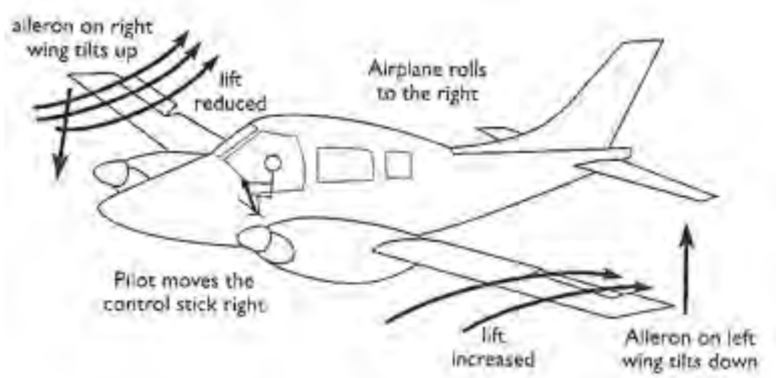
ISTE NETS Technology Standards

- Creativity and Innovation
  - Use models and simulations to explore complex systems and issues
- Communication and Collaboration
  - Develop an understanding of engineering design
- Critical Thinking, Problem Solving, and Decision Making

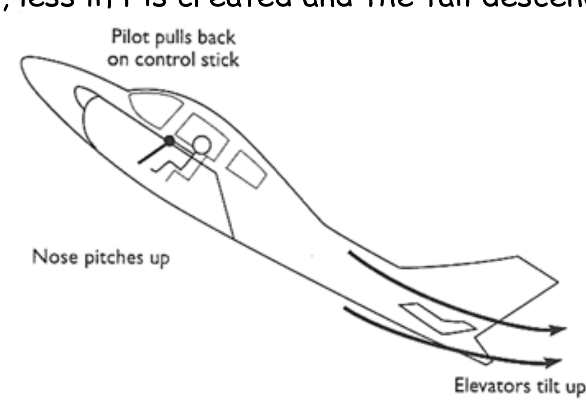
Background Information: (from NASA Quest at http://quest.arc.nasa.gov/aero/planetary/atmospheric/control.html)

An airplane has three control surfaces: ailerons, elevators and a rudder. These control surfaces affect the motions of an airplane by changing the way the air flows around it.

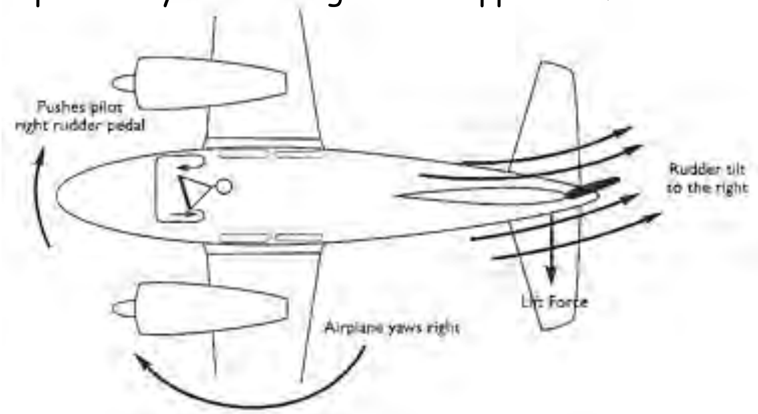
The ailerons are flap-like structures on the trailing edge of the wings - one on each side. When the pilot moves the control stick to the right, the right aileron will tilt up and the left aileron will tilt down. This will cause the airplane to roll to the right. When the pilot moves the control stick to the left, the left aileron tilts up, the right aileron tilts down and the airplane rolls to the left. This happens because as the aileron tilts downward (effectively increasing camber) more lift is created and the wing rises. As it tilts upward, less lift will be created and the wing will lower. If the wing of one side of the airplane rises and the other descends, the airplane will roll towards the side with the decrease in lift.



The elevators are also flap-like structures that are mounted on each side of the horizontal stabilizer. As an airplane flies in its proper orientation and level to the horizon the pilot uses the elevator to control the pitch of the nose. That means the elevator controls the nose's motion of up and down. When the pilot pushes the control stick forward, the elevators tilt downward -this is called pitching down. When the pilot pulls the control stick back, the elevators tilt upward, the tail goes down and the fuselage pitches nose-up. When the elevator tilts downward more lift is created (like the ailerons) and the tail rises. When the elevator tilts upward, less lift is created and the tail descends.



The rudder is located on the vertical fin. The rudder controls the motion of yaw. Yaw causes the airplane's nose to move sideways to the left or right. The two rudder pedals are located at the pilot's feet. When the pilot pushes on the right rudder pedal, the rudder tilts to the right and the airplane yaws nose-right. When the pilot pushes on the left rudder pedal, the rudder tilts to the left and the airplane yaws nose-left. Again this is due to lift. However, the direction of this lift force is different than the lift force that causes the airplane to ascend. When the rudder tilts to the right, more lift is created on the right, which lifts or pushes the vertical stabilizer to the left. This, in turn, causes the airplane to yaw nose-right. The opposite motion occurs when the rudder tilts to the left.



The thinner the atmosphere the slower the reaction of the airplane to its control surfaces. Airplanes flying at fast speeds in the lower atmosphere react more quickly to a change in the control surfaces than airplanes flying at extremely high altitudes at the same speed. That's because there are fewer air molecules to disturb. This becomes even more important when flying airplanes on planets with atmospheres that are less dense than Earth's atmosphere.

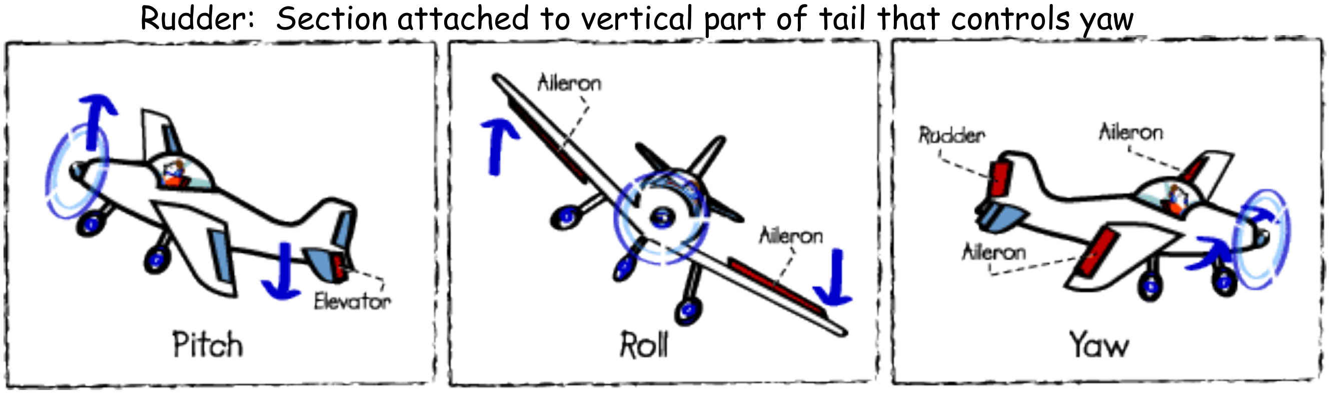
In summary (from http://spacedaycert.donet.com/media/documents/SpaceDayToolkit.pdf)

Pilots use different terms to describe the particular ways an aircraft moves forward:

Pitch: Aircraft nose moves up or down
Roll: One wing of aircraft tips up while the other tips down
Yaw: Nose of the airplane moves left or right while remaining level with the ground

Pilots use several control surfaces (moveable sections on the aircraft's surface) to better direct an aircraft's movement. These include:

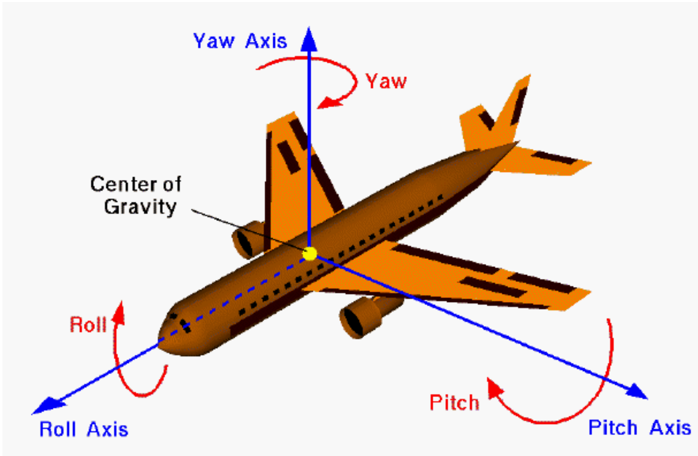
Elevator: Section on horizontal part of tail that controls pitch
Aileron: Section at rear edge of wing near tip that controls roll
Rudder: Section attached to vertical part of tail that controls yaw



Source: NASA at http://www.ueet.nasa.gov/StudentSite/dynamicsofflight.html

Materials:

- 5 pieces of green construction paper
- 5 pieces of blue construction paper
- 5 pieces of yellow construction paper
- 5 pieces of orange construction paper
- 1 piece of red construction paper
- Tape
- Scissors
- Paper airplane
- Data collection sheet



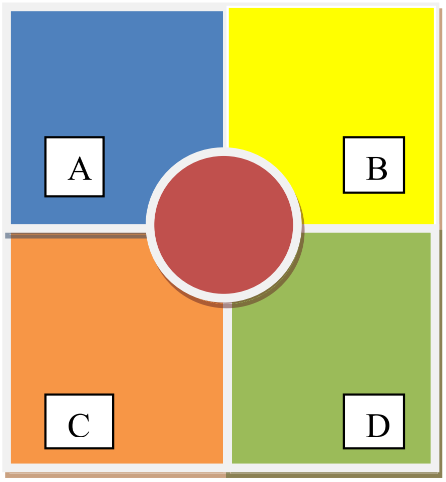
Source: NASA

Optional:

Rather than using paper to construct paper airplanes to use with this activity, you may wish students to construct foam plate gliders (FPGs) using foam plates, masking tape, and pennies. This will allow the ability to experiment with a rudder. The complete directions for constructing the gliders are available online at http://www.modelaircraft.org/education/fpg-9.aspx (AMA web page), courtesy of the Academy of Model Aeronautics (AMA) and Jack Reynolds. (Making the elevons, the moveable control surfaces along the wings that act as the elevators and aeilerons, longer than the pattern indicates for these gliders will improve their flight performance. A construction video is available at the AMA web page and http://www.youtube.com/watch?v=pNtew_VzzWg, but again, make the slits for the elevons farther apart than what is shown.)

Prerequisite:

Students need to understand how to convert fractions to decimals and decimals to percentages. This lesson will provide additional practice towards these math skills in an entertaining and motivating manner.



Prior to engaging in the lesson, ask the students to construct their optimal paper airplane. If they do not know how to make a paper airplane, allow them to research designs on the computer or provide instructions on how to make a "Simple Paper Airplane" included in this lesson. Have the students make the paper airplane for homework and inform them that they will need it during class on the next day.

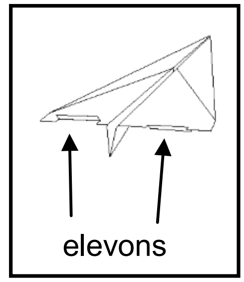
Have 5 target areas set up before class begins the next day. To make the targets, attach 4 different colored pieces of construction paper together using tape to make a large rectangle. Cut out a large red circle or square and place it in the middle of the 4 pieces of construction paper to act like a bull's-eye. Label the colored squares: A, B, C, and D.

Lesson Presentation:

1. Engage the students by having them show off their paper airplanes. Ask if anyone wants to share their individually engineered airplane with the class. Allow the students to showcase their aeronautical vehicle.
2. Next, inform the students that they will be using their paper airplane, along with science and math, to determine how effectively they can hit a target.
3. Before the students begin, review with them the ways that an airplane can travel, besides just forward. This may be new information or it may be recall of a prior lesson. Adjust the level of information accordingly, making sure to highlight pitch, yaw, and roll. Use the paper airplane to demonstrate pitch, yaw, and roll. (Tip: You can use a plastic straw to represent each imaginary axis mentioned below.)
    - Pitch: Tell the students to imagine a line running through the plane from wingtip to wingtip. If the airplane rotates up or down on this imaginary line, it is pitching. Holding the wings level, pitch the nose up (move the nose up and the tail will go down). Tell the students that when the nose goes up, the plane is pitching upward. Tip the nose down and inform the students that when the nose of the plane goes down, the tail will pitch up and the plane is said to be pitching down. Have the students demonstrate pitch with you.
    - Yaw: Tell the students to imagine a vertical line stabbing the plane right in its midsection. If the plane twists left or right along this imaginary axis, it is yawing. Have the students picture a swivel chair. Turn the nose of the airplane to the left and inform them that this is an example of yawing to the left. Repeat the demonstration yawing to the right. Have the students demonstrate yaw with their paper airplane.
    - Roll: Tell the students to imagine an imaginary horizontal line running through the nose of the airplane to the back end of the plane. If the airplane rotates left or right on this imaginary line, it is rolling. Demonstrate roll by tipping one wing down which will make the opposite wing automatically go up. Make sure to keep the fuselage (body) of the airplane in the same place. Again, ask the students to demonstrate roll.
4. To ensure that the students fully understand pitch, yaw, and roll, have them demonstrate the three movements with their paper airplane as you call out the movement. For example, when you say pitch, the students should pitch the nose of their airplane up and down. Additionally, you can reach your kinesthetic learners by having the students move their bodies accordingly. Have them roll by leaning at their waist to the left or right. Pitch can be shown by bending forward or backward at the waist. Finally, yaw can be illustrated by having them spin on one foot to the left or right, like you would turn in a swivel chair.
5. Get more specific and have the students orient their planes appropriately. Use the terms: pitch up, pitch down, yaw left, yaw right, roll left, roll right.

6. Inform or remind the students that an airplane has control surfaces or moveable sections on the airplane's surface that affect how the plane moves. The rudder, aileron, and elevator move to make the plane yaw, roll, and pitch respectively. (See background information for more details).

7. Instruct the students to make 2 small cuts a few centimeters apart at the rear of each wingtip. Tell them that these movable parts are called elevons because they are a combination of the elevators and the ailerons. (See background information.) Show the students that they can bend the elevons slightly up or down and that this will change the flight path of their airplane. (Teachers: You have the option of letting the students experiment with moving the elevons and seeing how the plane reacts, or if time is a factor, you can provide specific instructions. For example, if the plane is pitching down or flying low, slightly bend both elevons up and the plane will move up. If it is flying too high, do the opposite and pitch the elevons down. If the students have one elevon up and one down, it will cause the airplane to roll left or right.) Ask the students which control surface is missing (rudder) as well as which motion the will not be able to control (yaw).



8. Distribute the data collection sheet and divide the students into 5 groups. Inform the students that they will line up in front of the target area, which is the construction paper taped to a wall. The students should be instructed to take turns throwing their airplane toward the red bull's-eye. After each toss, they will move to the back of the line and make a tally mark on their data sheet in the correct box to indicate where the nose of their airplane hit the target area. For example, if they toss it and it hits the "B" area of the target, they should place an "X" on their data sheet exactly where the plane hit in that "B" box. Tell the students that they have 7 times (or another amount determined by the teacher to use in fractions) to toss the plane at the target. Once all of the throws have been completed, the students should answer the remaining questions on the Data Collection Form. Provide an example of how to fill in the chart by throwing the plane and marking the results on a chart drawn on the board if necessary.

9. Position groups in their assigned target area and let them begin. Make sure that the targets are spaced out around the room for safety. Students need to be aware of others and warned in advance of the consequence should they intentionally hit another student with their plane.

10. Depending on time, allow the students to discuss the results documented on their data sheet. Talk about who has the best aim.

11. Have the students explain how they used math and science to determine how well they can hit a target with a paper airplane. Topics of discussion can include how the scientific method was utilized; Newton's laws of motion (inertia, F=MA, action/reaction); using math by counting and creating percentage of accuracy; and even how important it is to have specific information in science. For example, it is

better to say, "I can hit the bull's-eye with 65% accuracy," than to say, "I am good at hitting a target with a paper airplane."

Summarization:
Ask the students to summarize what they learned in today's lesson. The students should explain pitch, yaw, and roll, in addition to being able to demonstrate the movements with their paper airplane. Make sure to emphasize that science and math helped to explain the experiments and to provide a better understanding of what happened during the lesson. Also, remind students that they can improve their target skills through practice; furthermore, practice will also help the students in the area of math. The more they practice at anything in life, the better they will become.

Career Connection: (from http://stemcareer.com/topcareers/ and http://www .onetonline.org/)

Aerospace Engineer – engineering duties to include designing, constructing and testing aircraft, missiles, and spacecraft. Sample job titles include Aerospace Engineer, Flight Test Engineer, Design Engineer, Systems Engineer, Structures Engineer, Test Engineer, Aeronautical Engineer, Aerospace Stress Engineer, Avionics Engineer, and Flight Systems Test Engineer.

Air Traffic Controller – control air traffic on and within a vicinity of an airport according to established procedures and policies to expedite and ensure flight safety. Sample job titles include Air Traffic Control Specialist (ATCS), Air Traffic Controller, Certified Professional Controller (CPC), Air Traffic Controller (Enroute Option), and Air Traffic Controller (Tower Option).

Scientist – plan, direct, or coordinate activities in such fields as life sciences, physical sciences, research and development in these fields. Sample job titles include Natural Science Manager, Water Team Leader, Fisheries Director, Health Sciences Manager, Laboratory Manager, Natural Resources Planner, Research and Development Director, Coastal Management Planner, Environmental Manager, Mineral and Aggregate Resources Planner.

Pilot – pilot and navigate the flight of fixed-wing, multi-engine aircraft usually for the transport of passengers and cargo. Must have pilot certificate and rating for aircraft type used. Sample job titles include Airline Captain, First Officer, Pilot, Airline Pilot, Check Airman, Co-Pilot, Airline Transport Pilot, and Commuter Pilot.

Evaluation:

- Data Collection Form
- Teacher observation

Lesson Enrichment/Extension:

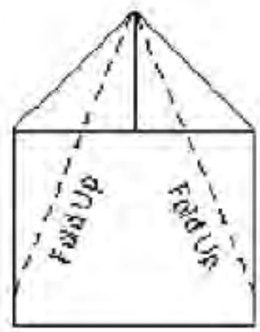
- Have the students figure the overall percentage of girls hitting the target versus boys hitting the target.
- Have the students create a graph to illustrate their data (pie graph/bar graph).
- Complete the included NASA worksheet(s): Flight Direction Challenge Point.
- Challenge the students to create their own Flight Direction Challenge Point worksheet based on their personal data from the Data Collection Form.
- Repeat the lesson by having the students throw a different number of times to increase work with fractions, decimals, and percentages.
- If using the foam plate glider, have students complete the activity sheet available at http://www.modelaircraft.org/education/fpg-9.aspx. (Click "Activity Sheet.")

Associated Websites:

- Dynamics of Flight: provides more background information and graphics http://www.ueet.nasa.gov/StudentSite/dynamicsofflight.html
- How a Plane is Controlled with Animations http://www.allstar.fiu.edu/aero/fltmidcont.htm
- Amazing Paper Airplanes http://www.amazingpaperairplanes.com/Simple.html
- World Record Paper Airplane Story and Design http://www.paperplane.org/
- Create a Graph Website http://nces.ed.gov/nceskids/index.asp
- Additional Paper Airplane Lessons http://teams.lacoe.edu/documentation/projects/math/airplane_sites.html
- Take Off with Paper Airplanes http://www.teachengineering.org/view_lesson.php?url=http://www.teachengineering.org/collection/cub_/lessons/cub_airplanes/cub_airplanes_lesson06.xml

SIMPLE PAPER AIRPLANE

1



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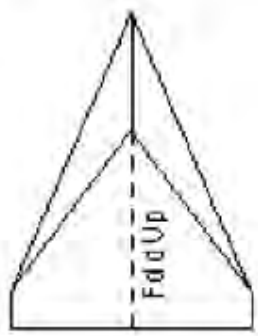

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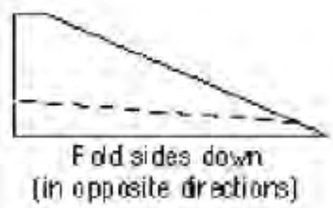

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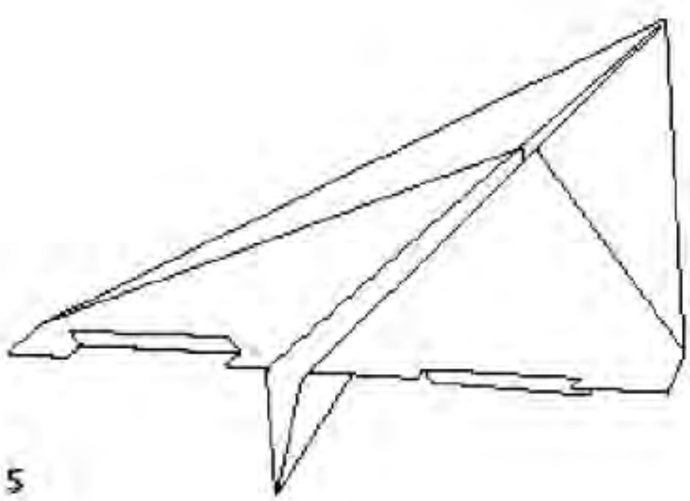


5

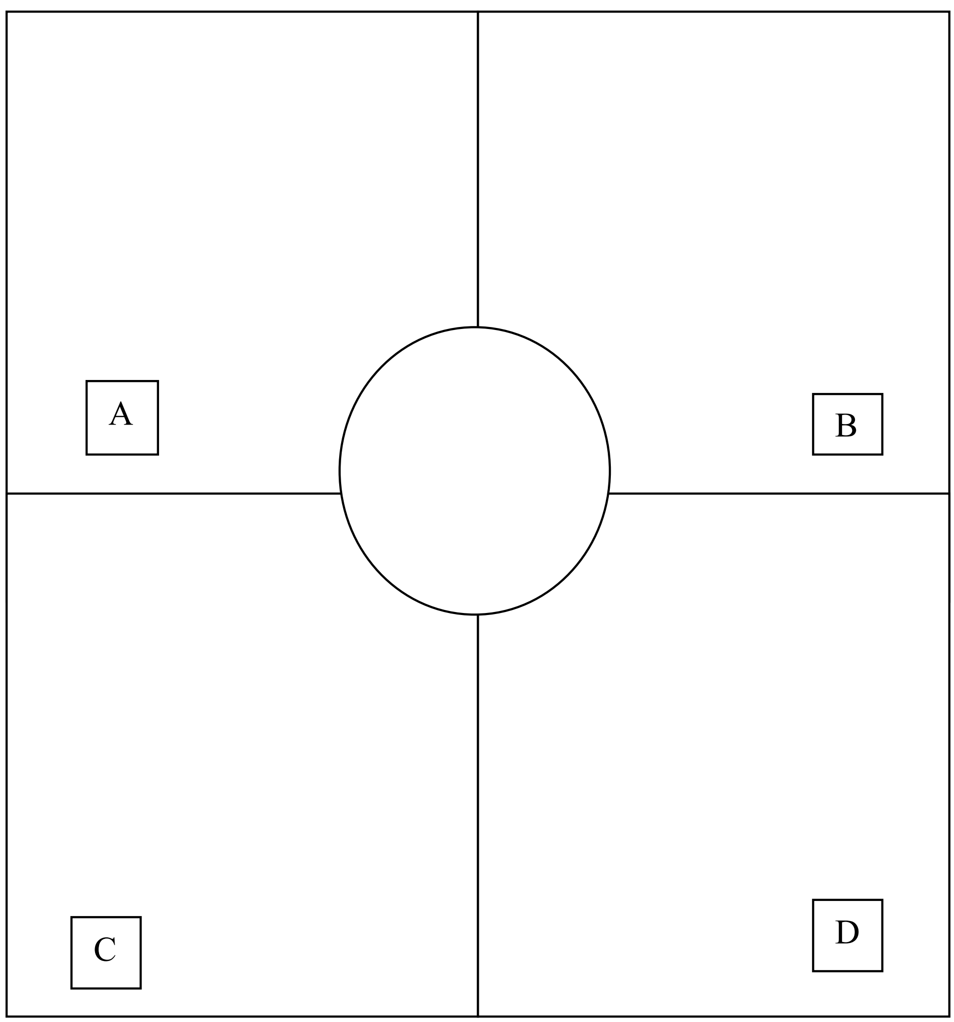
Name: ______________________________

Target Data Collection Form

Total number of times that you were instructed to toss the airplane:

____

After you toss your airplane, make sure to place an "X" in the corresponding area inside of the section (A, B,C, or D) to indicate where your airplane hit on the target. Repeat after each throw.



Total in each section (should add up to the total throws)

A:_____ B:_____ C:_____ D:_____ Bull's-eye:______

Complete the chart below using the data from the front side.

	# of times plane hit this area	Total # of times you threw the plane	Write a fraction for # of times you hit this area	Write a decimal for number of times you hit this area	What % of the time did you hit this area?
A					
B					
C					
D					
Bull's-eye					

Which section did the plane hit the most? _______ the least? ______

Did you notice any patterns? Explain why you think the patterns occurred.

____

____

____

How can you tweak your airplane to better hit the target? What would the adjustment do to the flight pattern?

____

____

____

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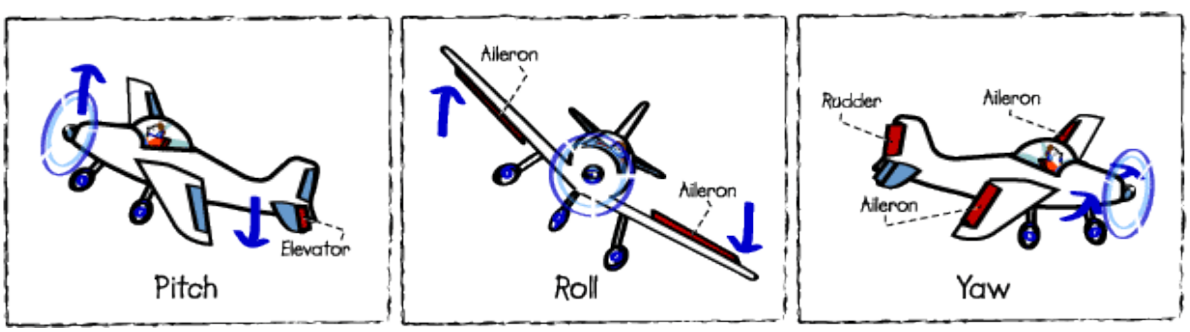
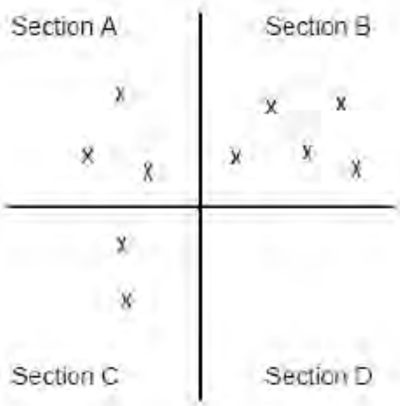


Source: NASA at http://www.ueet.nasa.gov/StudentSite/dynamicsofflight.html

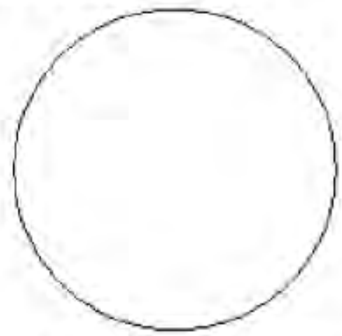
CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (5-8)

McINTOSH STUDENTS' FLIGHT DATA

Flight Results



Create a pie graph to represent the flight results on the left.



Section A—Green Section B—Red
Section C—Yellow Section D—Blue

1. Which section of the target did the McIntosh Team's planes hit the most? The least?
   MOST: Section ________ LEAST: Section __________
2. What patterns do you notice in the data for their airplanes?
   ____
   ____
   ____
3. Of the 10 landings, how many were in section A? In section B? In section C? In section D?
   Section A:_____ Section B:______ Section C:______ Section D:______
4. Discuss how the number of landings in a section can be expressed with either a fraction or decimal. Organize the data in the displayed table.

Area	No. of Landings	Total Flights	Fraction	Decimal
Section A		10		
Section B		10		
Section C		10		
Section D		10		

5. Color the circle graph to summarize landing results for each section of the sample data.

Source: http://connect.larc.nasa.gov/connect_bak/pdf/flightd.pdf

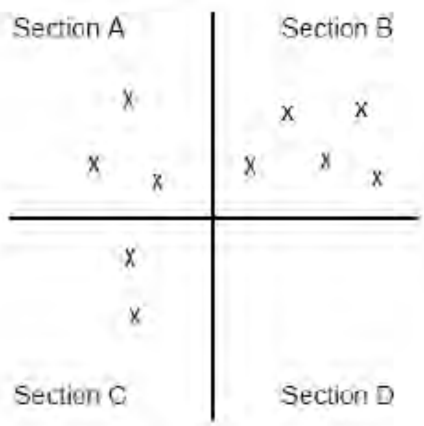
ANSWER KEY

Program 1 Flight Director

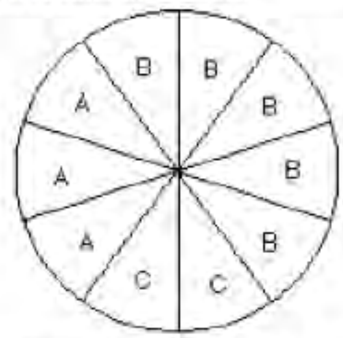
CHALLENGE POINT WORKSHEET ANSWER KEY
INTERMEDIATE LEVEL (5-8)

McINTOSH STUDENTS' FLIGHT DATA

Flight Results



Create a pie graph to represent the flight results on the left.



Section A—Green Section B—Red
Section C—Yellow Section D—Blue

1. Which section of the target did the McIntosh Team's planes hit the most? The least?
   MOST: Section B LEAST: Section D

2. What patterns do you notice in the data for their airplanes?

   ____

   ____

   ____

3. Of the 10 landings, how many were in section A? In section B? In section C? In section D?

   Section A: 3 Section B: 5 Section C: 2 Section D: 0

4. Discuss how the number of landings in a section can be expressed with either a fraction or decimal. Organize the data in the displayed table.

Area	No. of Landings	Total Flights	Fraction	Decimal
Section A	3	10	3/10	.30
Section B	5	10	5/10	.50
Section C	2	10	2/10	.20
Section D	0	10	0/10	.00

5. Color the circle graph to summarize landing results for each section of the sample data.

Source: http://connect.larc.nasa.gov/connect_bak/pdf/flightd.pdf

Source: CAP