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It's the Last Straw!

Topics
Measurement/Force and motion

Key Question
How far will your loop airplane fly?

Learning Goals
Students will:
- fly loop planes,
- measure and record flights in meters and convert those measures to centimeters,
- record data on a bar graph,
- make alterations to the plane in order to achieve longer distances, and
- draw conclusions as to what factors make for better flights.

Guiding Documents
Project 2061 Benchmarks
- *The scale for a graph or drawing makes a big difference in how useful it is.*
- *Measurement instruments can be used to gather accurate information for making scientific comparisons of objects and events and for designing and constructing things that will work properly.*

NRC Standards
- *The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.*
- *If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.*

*Common Core Standards for Math**
- *Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit. (4.MD)*
- *Convert like measurement units within a given measurement system. (5.MD)*

Math
Measurement
  length
  conversion of units
Averaging
Graphing

Science
Physical science
  force and motion
  testing variables

Integrated Processes
Observing
Comparing and contrasting
Collecting and recording data
Interpreting data
Controlling variables
Drawing conclusions

Materials
Drinking straws, one per plane
Transparent tape
Metric measuring tapes (see *Management 3)*
Student pages

Background Information

This integrated activity finds its roots in STEM education. **S**cience (force and motion), **T**echnology (use of tools), **E**ngineering (structural problem solving), and **M**athematics (measurement and measurement conversion) are rolled into an engaging investigation using loop planes.

Thanks to the forces of lift and thrust, this rather unusual object actually does move through the air much like a paper airplane. The fact that the loop planes change positions indicates that motion has occurred. All forces have a magnitude and a direction. As students throw the loop planes, their force of thrust (magnitude—how much of a force) carries it forward (direction). Soon the gravity and air resistance, called drag, (forces opposing lift and thrust) overcome the plane and it falls to the ground (direction). Once on the ground, motion stops because all forces are balanced.

Students will all begin with the same plane construction. They will make trial flights to discover the best method of launching their planes before actually making measured flights. Once measured flights are made and data collected and analyzed, students will make modifications, testing one variable of their choice at a time. Finally, conclusions will be made as to what they think makes the planes fly the farthest distance.

Distances will be measured with the included meter tapes. When these are copied on different colors and placed end-to-end, students will be able to visually distinguish where one meter ends and the other begins. This approach makes it each for students to count and record measurements in meters and then to quickly

convert those measures by counting by hundreds because there are 100 centimeters to a meter.

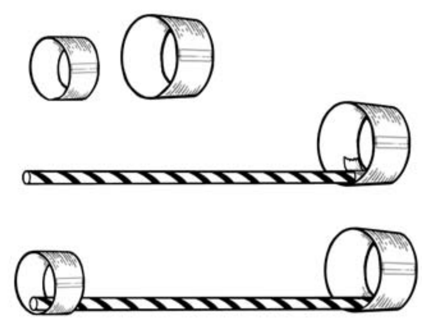
Management

1. Each student will build a plane according to the pattern. Students can work in small groups to collect their data.
2. Establish several areas around the room or in an all-purpose room where students can fly their loop planes. Place masking tape down for a starting line.
3. Copy the meter tapes on various colors of paper. Each student will need to construct a meter tape. These should be positioned on the floor at each flying area with the zero ends near the masking tape. Have students assemble these meter tapes prior to doing the lesson. The meter tapes can be laminated for year-long usage.
4. Allow 40-50 minutes for the initial portion of this activity. Further time should be provided for the testing of variables and the drawing of conclusions.
5. Students will use the aviation alphabet to identify their planes. You will need to project this page for student reference as they are constructing their planes. If desired, make up a sheet where students can register their planes with the FAA (you). This provides a way to identify planes that are being flown at inappropriate times.
6. Prepare a loop plane prior to doing the activity. Be sure to include the plane's identification on the back loop. This plane will be used to introduce the activity.
7. Each student will need one drinking straw, the loops A and B, and small pieces of tape.
8. For *Part Two* of this lesson, have supplies of straws, paper, etc., available for students to test. Various tests that students might choose include: testing other weights of paper loops (card stock vs. copy paper), using larger or smaller loops, weighting the planes with paper clips, using more loops, etc. Students will be making their own data recording page(s) for this part.

Procedure

Part One

1. Show the students the loop plane you made. Tell them that they are going to make these planes. Ask the *Key Question* and state the *Learning Goals*.
2. Invite students to guess how many meters they think this plane will fly. As they contribute their guesses, ask them how they would convert these meter measures to centimeters. [multiply by 100 since there are 100 centimeters in one meter]
3. Tell students that everyone will construct their loop plane in the same manner. They will then determine the lengths of the flights, recording their measurements in both meters and centimeters. After the data have been graphed, students will have the opportunity to modify their planes by changing one variable at a time.
4. Distribute a straw, loop patterns, and tape to each student.
5. Project the aviation alphabet and go through the directions for identifying the planes. Ask students why they think words are used instead of letters when pilots and call tower personnel are talking. [It is easy to confuse letter names. For example, *d* sounds like *b,* and *s* sounds like *f*.] Direct students to write their plane's identification on the larger of the two loops, the rear wing.
6. Show students how to form and tape the two loops. Then have them place a small piece of tape over the one end of the straw. Tell them to stick this end of the straw into one of the loops until the end of the straw is even with the outer edge of the loop. Direct them to press the ends of the tape onto the loop. Have them do the same thing with the other end of the straw. Both loops should be oriented the same direction on the straw.



7. Establish the rules for fair measurement. Students will need to decide whether to measure the distance at which the plane touches the ground or where it stops. They will also need to decide whether to measure at the front of the plane or at the rear.
8. Take the students to the areas where they will make their test flights.
9. Allow time for collecting and recording data.
10. Discuss the forces on the planes and why they don't stay up forever. [We provide the force of thrust when we throw the loop plane. After a while, the plane slows and descends to the ground because air resistance and gravity overcome the force of thrust.]
11. Compare results as a class and go over the *Connecting Learning* questions.

Part Two

1. Tell students that they will be allowed to change one thing about their planes, but all the rest of the variables must be kept the same. Discuss the purpose in testing one variable at a time. [If more than one variable is changed, it is difficult

to determine what actually changed the length of the flight.

2. Inform students that they will need to use their own paper to describe the changes in their planes that they want to test. Encourage them to make a data table and graph that resemble those used in *Part One*.
3. Allow time for students to test their newly developed planes.
4. As a class, discuss which changes made for longer flights and which did not.
5. Have students write a paragraph that describes their findings.

Connecting Learning

Part One

1. What was your longest flight? How long was it?
2. Who had the longest flight in the class? What do you think made this plane go the furthest?
3. How did the bar graph help you analyze data?
4. What was the force you used to make your plane fly? [Thrust, we threw it forward.]
5. How did you know that motion occurred? [The plane changed position. It went forward and then down.]
6. Why is it important that we all started with the same basic plane?
7. How were you about to convert the measurements from meters to centimeters?
8. What modifications would you like to make to your plane?
9. What are you wondering now?

Part Two

1. What modification did you make to your plane?
2. Was it successful in making it go further? Explain.
3. Which modification in the class made the greatest difference in distance of flight?
4. Why is it important to change only one variable at a time? [to know which variable is causing the change]
5. What are some of the variables that you kept the same?
6. Why is it important to record data? [to compare results]
7. What are you wondering now?

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Key Question

How far will your loop airplane fly?

Learning Goals

Students will:

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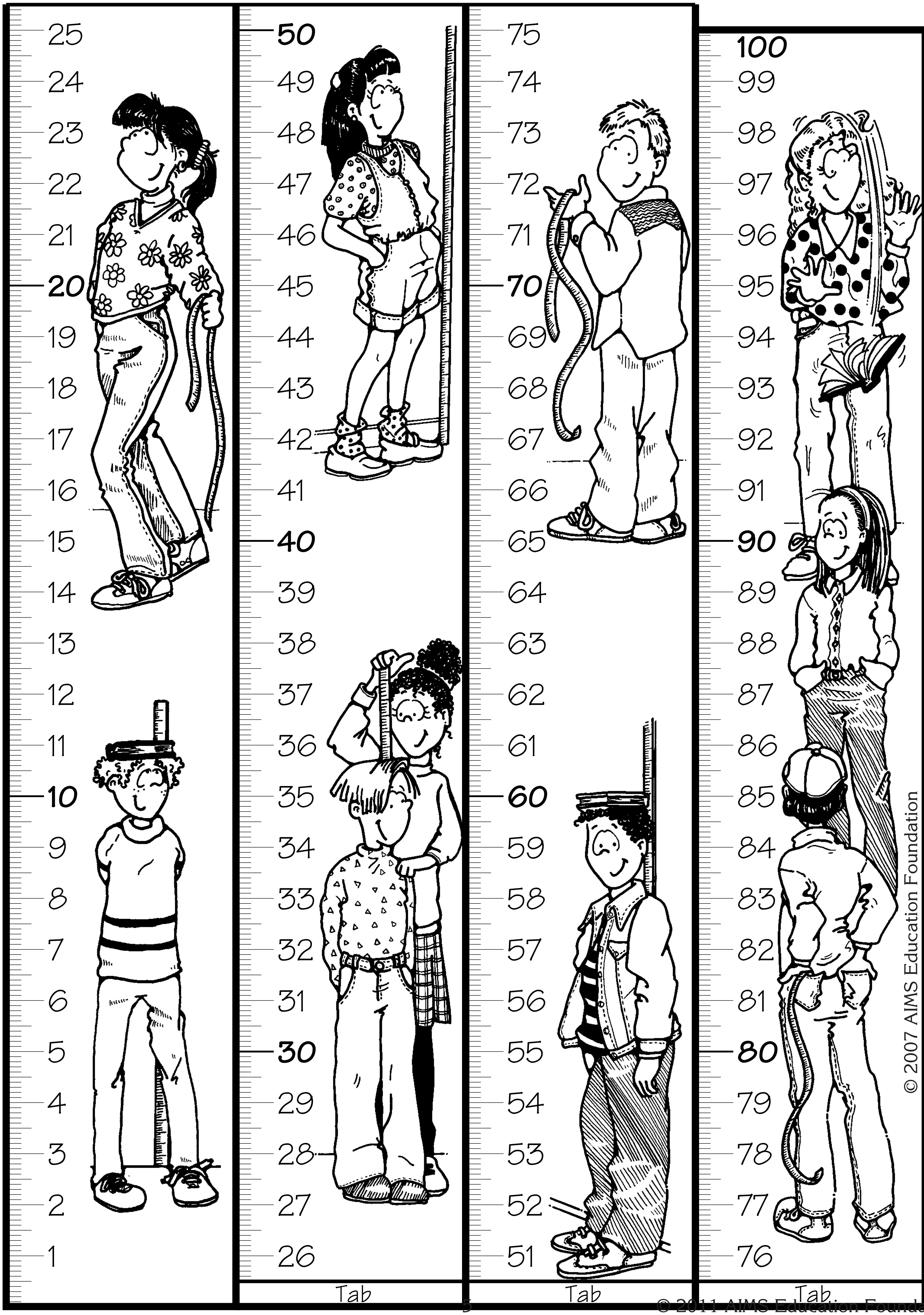
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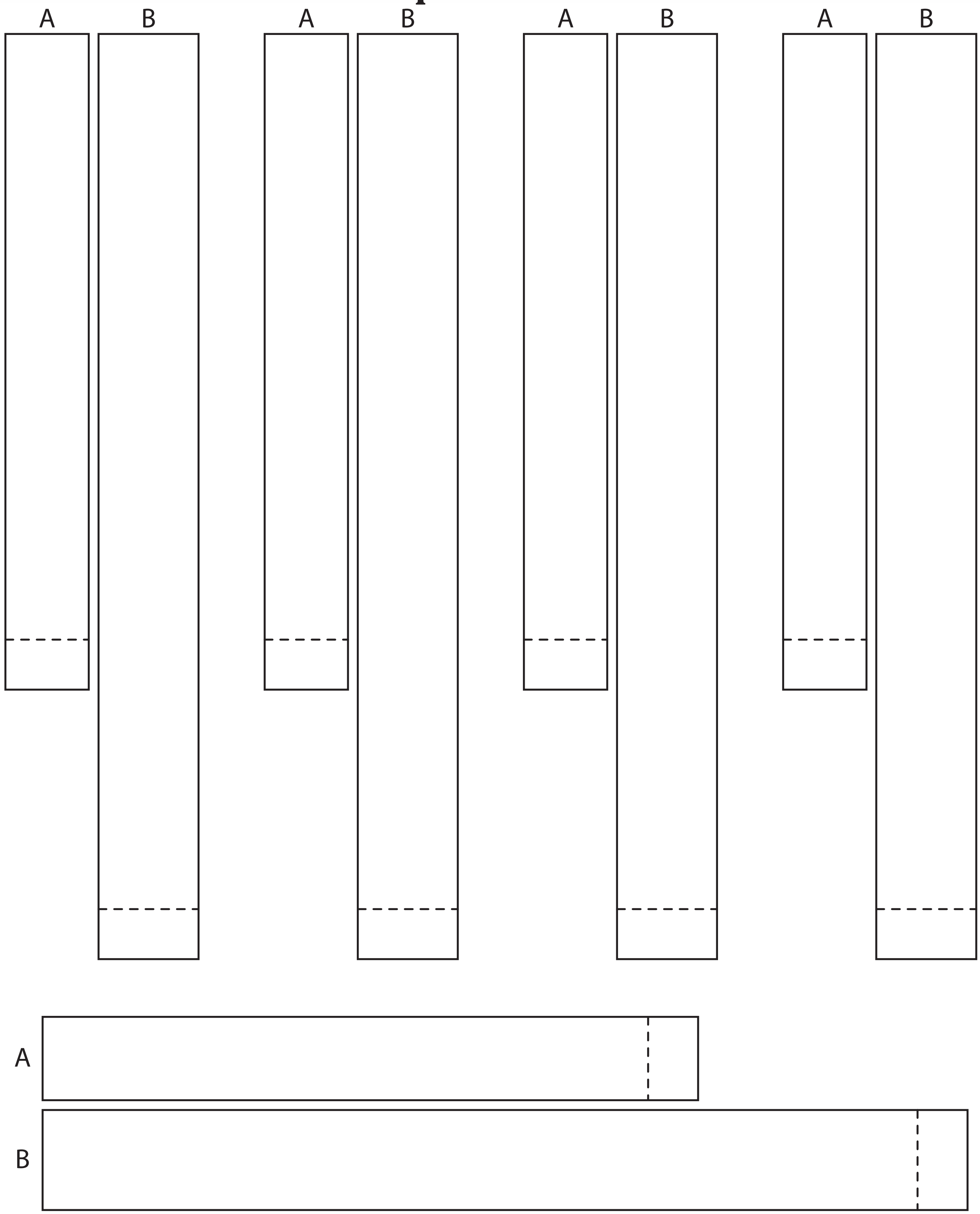
Loop Patterns



AVIATION ALPHABET

A	Alpha	N	November
B	Bravo	O	Oscar
C	Charlie	P	Papa
D	Delta	Q	Quebec
E	Echo	R	Romeo
F	Foxtrot	S	Sierra
G	Golf	T	Tango
H	Hotel	U	Uniform
I	India	V	Victor
J	Juliet	W	Whiskey
K	Kilo	X	X-Ray
L	Lima	Y	Yankee
M	Mike	Z	Zulu

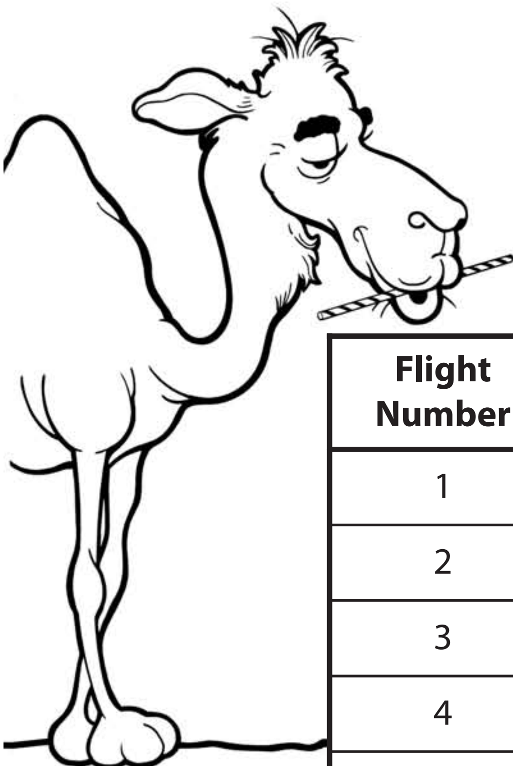
Name your plane. Start your identification with N, which stands for United States, then numbers and letters not to exceed a total of seven.

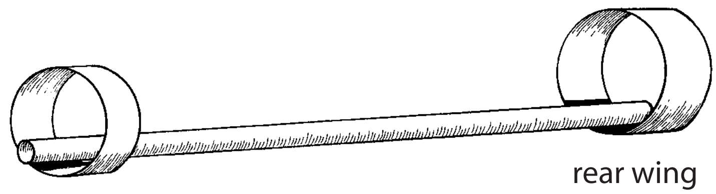
Example **N 952 – SM** **N 231 BC**

November 952 Sierra Mike **November 231 Bravo Charlie**

It's the Last Straw!

Cut out the patterns given for the strips. Form them into loops, and tape them to the ends of your straw as shown. Print your name or the plane's name on the rear wing.

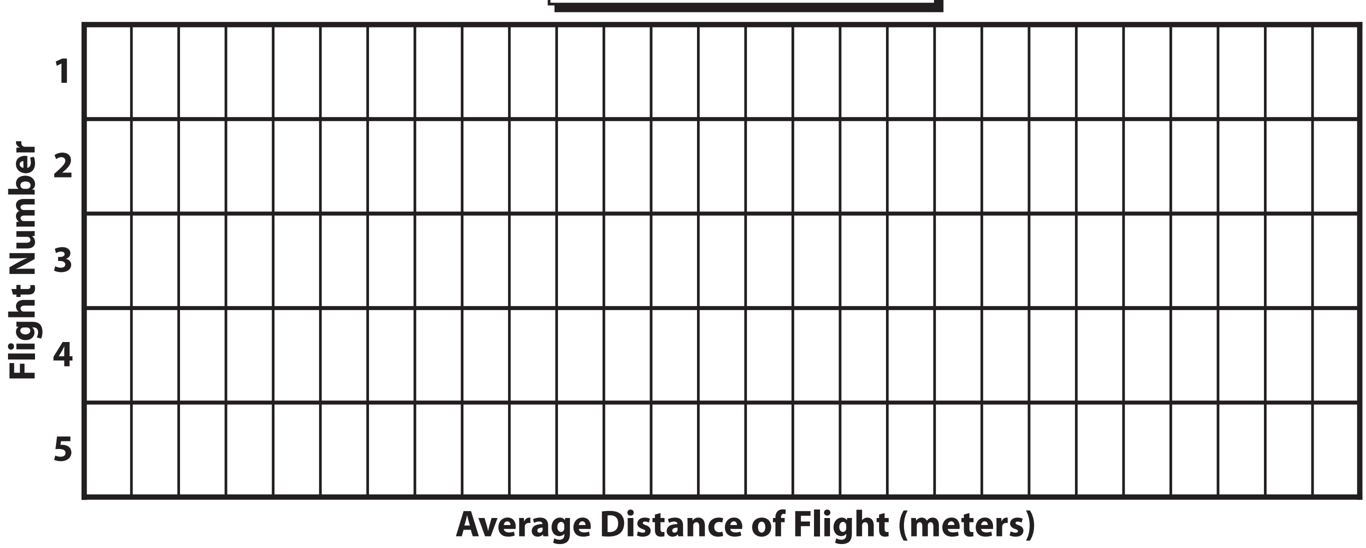




Make five test flights. For each, measure the distance flown in meters, and record in both meters and centimeters.

Flight Number	Distance Flown (meters)	Distance Flown (centimeters)
1		
2		
3		
4		
5		
Total		
Average		

Flight Distance Graph



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Connecting Learning

Part One

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Connecting Learning

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7. How were you about to convert the measurements from meters to centimeters?

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9. What are you wondering now?

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Part Two

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2. Was it successful in making it go further? Explain.

3. Which modification in the class made the greatest difference in distance of flight?

4. Why is it important to change only one variable at a time?

5. What are some of the variables that you kept the same?

It's the Last Straw!

Connecting Learning

6. Why is it important to record data?

7. What are you wondering now?