



iSTEM. The Science of Flight & Motion

Introduction to Careers, Education & The Science of Flight and Motion

Story: How Bat & Flying Squirrel Got Their Wings

What Do You Think? Newton's Laws of Motion

Explore More (Resources)

Activity 1: Newton's First Law: Inertia

Activity 2: The Forces of Flight: Drag

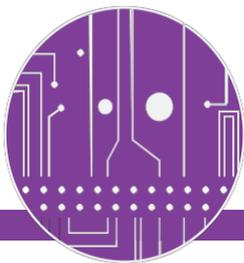
Activity 3

Part 1: Thinking About Weight and Gravity

Part 2: Become a Paper Helicopter Engineer

Activity 4: Make and Race Your Own Balloon Rocket

Take It Home! Balloon and Straw Experiment



iSTEM ■ Motion and Flight

Information • Science • Technology • Engineering • Mathematics



People have always understood that flight was possible from observing birds, but it took thousands of years for humans to actually figure out how to take flight. In order for humans to understand how to construct flying machines, and to understand how the moon stayed in the sky and moved around the earth, we needed to understand motion, gravity, force and other scientific ideas. The study of these concepts is a part of a field of science called, Physics. In this unit we will focus on flight and motion, but there are many, many other areas in **Physics** to explore.

Motion makes the world go 'round and the moon and. . . . In fact, motion makes lots of things go. When we think of motion we often think of cars, bicycles, kids running, basketballs bouncing and airplanes flying. Motion is the changing of position or location.

Careers/Jobs Related to Motion and Flight

- Air Traffic Controller
- Astrophysicist
- Automobile Manufacturer
- Design Engineer
- Electronics Engineer
- Mathematician
- Automotive Engineer
- Astronaut
- Structures Engineer
- Aircraft Mechanic
- Mathematics and Physics Teacher
- Physicist
- Materials Engineer
- Research Assistant
- Astronomer
- Satellite Missions Analyst
- Aerospace Engineer
- Test Engineer

Work and Research Areas

Engineering: Designing and constructing aircraft, and the science of aircraft, spacecraft, automobiles and other vehicles

Aerospace Jobs: Astronauts, pilots, air traffic control specialists, technicians, researchers, engineers

Government jobs: NASA (National Aeronautics and Space Administration), NHTSA (National Highway Traffic Safety Administration), DOT (Department of Transportation), Military

Education in Arizona after High School

Associate Degree (2 years after high school): Aviation Technology, Pima Community College

Bachelor's Degree (4-5 years after high school): Engineering (Aerospace, Industrial Mechanical and Materials Science), University of Arizona, Arizona State University in Phoenix and Embry-Riddle Aeronautical University in Prescott. Embry-Riddle also offers Aeronautical Science, Aeronautics, Air Traffic Management, Applied Meteorology, Aviation Environmental Science and Space Physics

Master of Science (6-7 years after high school): Engineering: Aerospace, Industrial Mechanical and Materials Science), University of Arizona and Arizona State University

Ph.D. (Doctor of Philosophy)(8-10 years after high school): Engineering (Engineering specializations in Aerospace, Mechanical Engineering and Materials Science), University of Arizona



Cmdr. John Herrington- Astronaut, Chickasaw Nation
First enrolled tribal member to fly in outer Space 2002

"American Indians were very careful scientists. They learned important facts about objects in the sky and used them to tell time, to predict the changes of the seasons, and to use maps. Today, American Indian scientists help us learn more about the sky and galaxy. In fact, Native Americans have known for thousands of years that there was a black hole located through the center of the bowl in the big dipper. NASA discovered it just a few years ago."

—Cmdr. John Herrington, Chickasaw Nation

Find out more about physics on the **EXPLORE MORE!** page. 



How Bat & Flying Squirrel Got Their Wings

A Cherokee Nation legend

Long ago, the animals sent a message to the birds. "Let us have a big ball game. We will defeat you in a big ball game."

The birds answered, "We will meet you. We will defeat you in a big ball game."

So the plans were made. The day was set. At a certain place, all the animals gathered, ready to throw the ball to the birds in the trees.

On the side of the animals were the bear, the deer, and the turtle. The bear was heavier than the other animals. He was heavier than all the birds put together. The deer could run faster than the other animals could.

The turtle had a very thick shell. So the animals felt sure that they would win the game.

The birds, too, felt sure that they would win.

On their side were the eagle, the hawk, and the great raven. All three could fly swiftly. All three had far seeing eyes. All three were strong and had sharp beaks that could tear.

In the treetops the birds smoothed their feathers. Then they watched every movement of the animals on the ground below them. As they watched, two small creatures climbed up the tree toward the leader of the birds.

These two creatures were but a little bigger than mice. "Will you let us join in the game?" they asked the leader of the birds. The leader looked at them for a moment. He saw that they had four feet. "Why don't you join the animals?" he asked them. "Because you have four feet, you really belong on their side." "We asked to play the game on their side," the tiny creatures answered. "But they laughed at us because we are so small. They do not want us." *(continued on next page)*

"How the **Bat** and the **Flying Squirrel** Got Their Wings." In Chiltoskey, Mary Ulmer. *Aunt Mary, Tell Me A Story: A Collection of Cherokee Legends and Tales*. Ed. Mary Regina Ulmer Galloway. Cherokee, NC: Cherokee Communications, 1990. pp.79-80.

(How Bat & Flying Squirrel Got Their Wings, continued)

The leader of the birds felt sorry for them. So did the eagle, the hawk, and the other birds. "But how can they join us when they have no wings?" the birds asked each other.

"Let us make wings for the little fellows," one of the birds suggested.

"We can make wings from the head of the drum," another bird suggested.

The drum had been used in the dance the night before. Its head was the skin of a groundhog. The birds cut two pieces of leather from it, shaped them like wings, and fastened them to the legs of one of the little fellows.

Thus they made the first bat.

The leader gave directions. He said to the bat, "When I toss the ball, you catch it. Don't let it touch the ground." The bat caught it. He dodged and circled. He zigzagged very quickly. He kept the ball always in motion, never letting it touch the ground. The birds were glad they had made wings for him.

"What shall we do with the other little fellow?" asked the leader of the birds. "We have used up all our leather in making the wings for the bat." The birds thought and thought.

At last one of them had an idea. "Let us make wings for him by stretching his skin," suggested the eagle. So eagle and hawk, two of the biggest birds, seized the little fellow.

With their strong bills they tugged and pulled at his fur. In a few minutes they stretched the skin between his front feet and his hind feet. His own fur made wings.

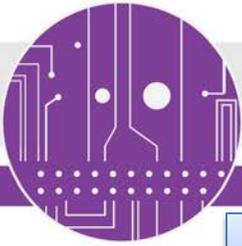
Thus they made the first flying squirrel.

When the leader tossed the ball, the flying squirrel caught it and carried it to another tree. From there he threw it to the eagle. Eagle caught it and threw it to another bird.

The birds kept the ball in the air for some time, but at last they dropped it.

Just before it reached the ground, the bat seized it. Dodging and circling and zigzagging, he kept out of the way of the deer and other swift animals.

At last, the bat threw the ball at the goal and scored. And so he won the game for the birds!



Newton's Laws of Motion

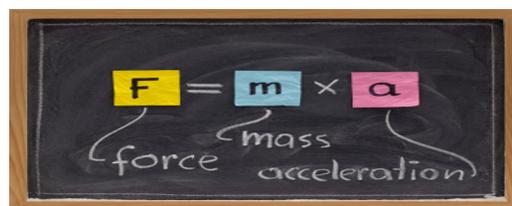
Sir Isaac Newton was a mathematician and scientist (1642-1727) who was the first scientist to explain motion and gravity. He wanted to understand things like, how a bird flies, how a person can stay upright on a bike, and how the moon orbits the earth. His theories (called the Newton's Laws) even explain how a rocket can launch a satellite into space.

According to a famous story, Newton saw an apple fall to the ground and he thought about how the same force which caused the apple to fall also governed the motion of the Moon and the planets. In 1687, Newton published his three **laws of motion**. His three laws explained how, according to western science, the concepts of force and motion work. To understand these things, we need to understand the relationship between **force** and **motion**.

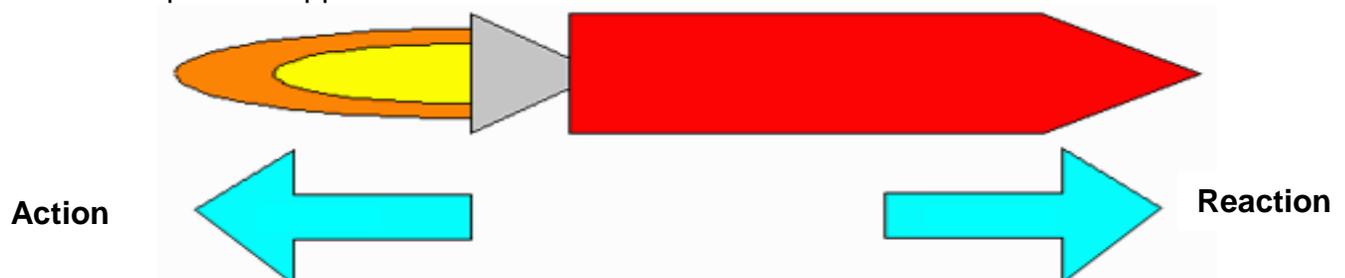
- **1st Law** – If an object is not being pushed or pulled by a **force**, it will either stay still or **move** in a straight line at a constant speed. This law is often called the “**law of inertia**”.

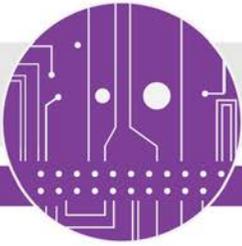


- **2nd Law** – When a **force** acts on an object, the object will start to move, speed up, slow down, or change direction. **Force** equals **mass multiplied by acceleration**.



- **3rd Law** – If you push or pull an object, it will push or pull you to an equal extent. For every action there is an equal and opposite reaction.





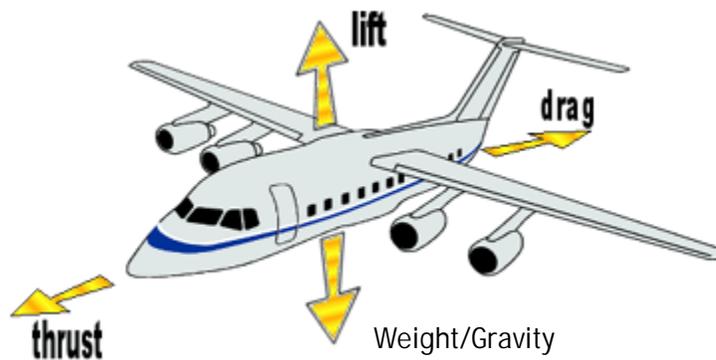
Laws of Motion Related Flight

Sir Isaac Newton proposed three laws of motion in 1665. These Laws of Motion help to explain how a planes flies.

1. If an object is not moving, it will not start moving by itself. If an object is moving, it will not stop or change direction unless something pushes it.
2. Objects will move farther and faster when they are pushed harder.
3. When an object is pushed in one direction, there is always a resistance of the same size in the opposite direction.

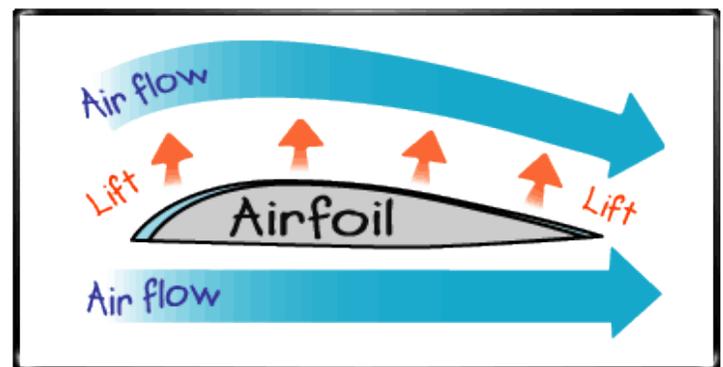
Four forces of flight

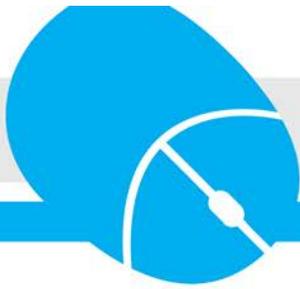
Lift - upward
Drag - backward
Weight/Gravity - downward
Thrust - forward



How Wings Lift the Plane

Airplane wings are shaped to make air move faster over the top of the wing (airflow). When the air moves faster, the pressure of the air decreases. So, the pressure on the top of the wing is less than the pressure on the bottom of the wing. The difference in pressure creates a force on the wing that lifts the wing up into the air (airfoil).





NASA for Students

<http://www.nasa.gov/audience/forstudents/index.html>

Practical Physics—Nuffield Foundation

<http://www.nuffieldfoundation.org/practical-physics/newtons-laws-motion>

MansfieldCT.org—The 4 Forces of Flight

<http://www.mansfieldct.org/Schools/MMS/staff/hand/flight4forcesoverview.htm>

Bureau of Labor Statistics--Becoming an Aerospace Engineer

<http://www.bls.gov/ooh/architecture-and-engineering/aerospace-engineers.htm>

Careers in Aviation and Aerodynamics

http://www.eaa32.org/YoungEagles/Aerospace%20Badge/Aviation_Careers.pdf



What do Aerospace Engineers do?

Aerospace engineers design aircraft, spacecraft, satellites, and missiles. In addition, they test prototypes to make sure that they function according to design.

Aerospace engineers are employed in industries whose workers design or build aircraft, satellites, systems for national defense, or space exploration.

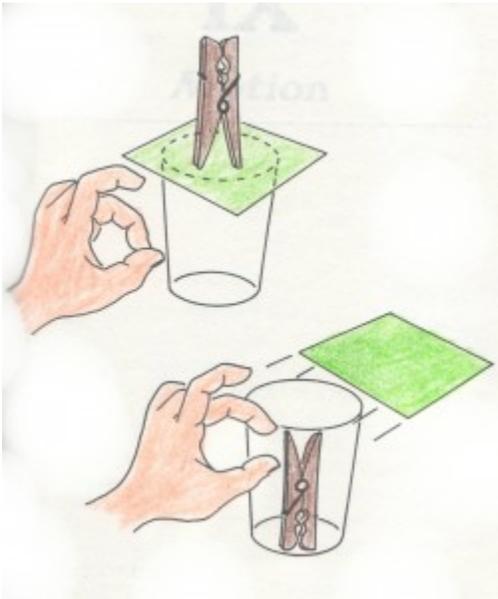
-U.S. Department of Labor





Activity 1: NEWTON'S FIRST LAW OF MOTION: INERTIA

Newton's laws of motion describe the relationship between the **forces** acting on a body and the **motion** of the body.



Materials Needed

- 1 heavy drinking glass
- 1 3x5 index card
- 1 clothespin

Newton's First Law of Motion: This law describes **inertia**, which means a body will stay at rest (still) or continue at a constant velocity (speed) unless acted upon by an external force.

Example of the inertia of an object at rest: You can remove a paper from beneath a standing clothespin and the pin will fall into the container beneath it.

Activity Directions: Place an index card over the mouth of a heavy drinking glass. Stand a clothespin on top of the card so that it is centered over the glass. Quickly and forcefully thump the card straight forward with your finger. You want only to hit the card and you want the card to move in a horizontal direction. 

What's Happening Here? The clothespin falls straight into the glass about half of the time; the other half of the time it flips over landing upside down in the glass. Your finger applies **force** to the card, **moving** it forward. The card quickly **moves** out from under the clothespin and the pin falls straight down due to the pull of **gravity**. If you do not hit the card straight forward and/or it is not hit with enough **force**, the card pulls the bottom of the pin forward and gravity pulls the top of the pin down, causing the pin to flip before it lands.

**Materials Needed**

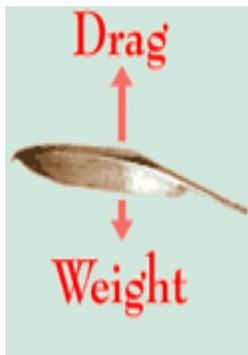
- 1 River Rock
- 1-2 Sheets of paper
- 1 Feather

Activity 2: The Forces of Flight: Drag*Fast Fall, Slow Fall*

1) **Try this!** Drop a stone and a feather from the same height. **What happens?**

The stone reaches the ground before the feather. That's because of the **drag**, or resistance of the air.

This is a vertical drop:



The stone falls quickly because the **drag** of the air is small (compared to its **weight**). **Drag** has a much greater effect on the fall of the feather.

Can you guess why that might be?

Two astronauts tried a similar experiment (using a hammer) on the Moon, where there is no air.

What do you think they found? Share your ideas with your mentor.

Drag is a force which tries to slow down anything moving through the air. Another name for this **force** is **air resistance**.

2) **Try this!** A sheet of paper falls slowly through the air, like a feather. How can you make a sheet of paper fall more quickly? Investigate ways of making a sheet of paper fall as quickly as possible.

3) **Try this!** Stones fall quickly through the air. How can you make a stone fall more slowly? Investigate ways of making a stone fall as slowly as possible.

JOURNAL IT!

From your investigations, write or draw what you have found out about the force called **drag**. Log your findings in your **Science Journal**. Share your findings with your mentor!



Activity 3: Part I: Thinking about Weight and Gravity

The pull of the Earth's **gravity** keeps us on the ground. The Earth is massive (it has a large mass), so the pull of its **gravity** is strong.

- 1) **Show your mentor:** What would it be like to move around, if the Earth's **gravity** were twice as strong?

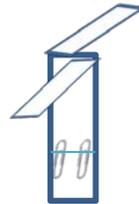
The Moon is much smaller than the Earth.

- 2) **Explain to your mentor:** What would it be like to walk on the Moon?

The pull of the Earth's **gravity** makes you heavy. Its force on you is called your **weight**.

- 3) **Use your imagination:** What would it be like if the Earth had no **gravity**? Share your ideas about the relationship between **weight** and **gravity** with your mentor.

Part II: Become a Paper Helicopter Engineer



Activity Directions:

- 1) Use the **Paper Helicopters** cut-outs on the next page. Cut on solid lines, fold on dotted lines and add two paper clips to create the prototype paper helicopter shown.

Materials Needed

- Construction paper, printer paper, tissue paper, foil, or...
- Scissors
- Paperclips
- Helicopter template

- 2) Explore the effect of changing some or all of these characteristics of your helicopter.

- **Material:** Use construction paper, card stock, tissue paper, foil, waxed paper, or...
- **Rotor Blades:** Change the length, width, number, shape, or.....
- **Helicopter Body:** Change the length, width, shape, or.....
- **Weighting System:** Use more or fewer paperclips, place paper clips in other locations, or use smaller or larger paper clips, use something else as a weight, or.....

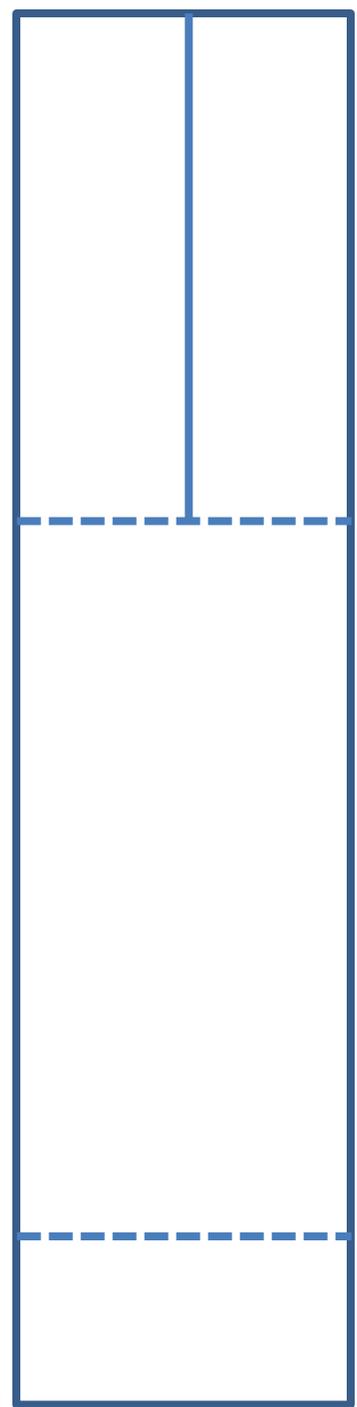
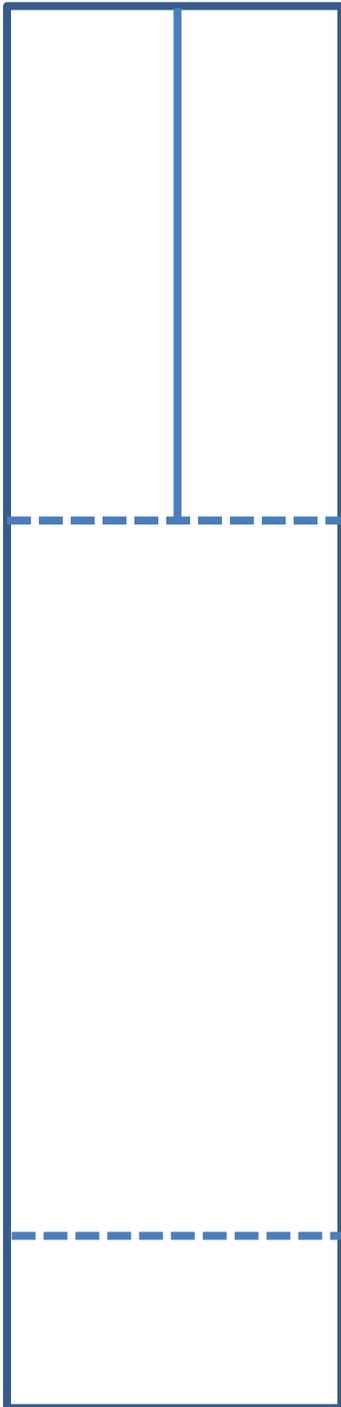
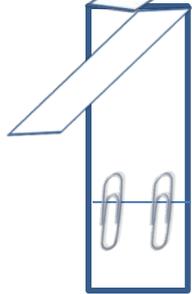
JOURNAL IT!

What is your definition of a “GOOD” paper helicopter?” Share your best design and explain its features to your mentor. Write about it or draw it in your **Science Journal**.



Activity 3: Paper Helicopters

———— = CUT
----- = FOLD





Activity 4: Make and Race Your Own Balloon Rocket

Energy source, friction, drag and Newtonian Principle's Third Law **"to every action there is an equal and opposite reaction."**

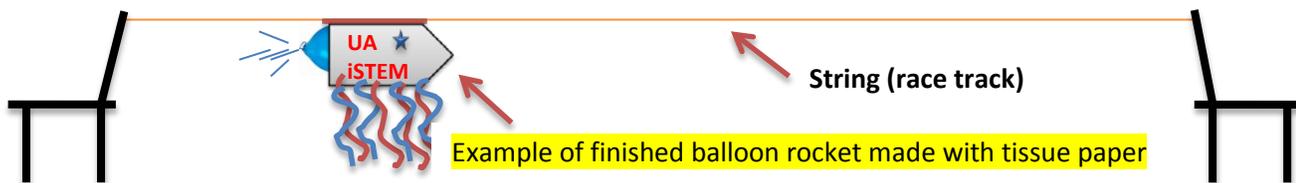
Rocket engines are reaction engines. A rocket engine is throwing mass in one direction and benefiting from the reaction that occurs in the other direction as a result. When you blow up a balloon and let it go so that it flies all over the room, you have created a rocket engine. In this case, what is being thrown are the air molecules inside the balloon. Many people believe that air molecules don't weigh anything, but they do. When molecules are thrown out the nozzle of a balloon, the rest of the balloon reacts in the opposite direction. Blast off!

Activity Directions:

Materials Needed

- two chairs, string, tissue paper, scissors, glue
- 1 balloon, clothespin, straw, tape, markers
- light weight decorations like tinsel and glitter, measuring tape

- 1) Extend a string 10 to 15 feet across a room. Tie one end to a chair and tape the other end to another chair. This will provide your Balloon Rocket's path of trajectory.



- 2) Blow up a balloon to a medium to large size, measure around the fattest part (Write down your measurement—you will use this measurement in designing your tissue paper rocket). Twist the end of the balloon three or four times in either direction to ensure that no air will be released before the experiment is ready to begin. You don't want to tie the end of the balloon in a knot. Instead, you will want to **secure this twisted end of the balloon with a clothespin** to make certain it does not unravel. When you release the clothespin, this will allow the twist you have made to unravel and allow the air to escape. Consequently, the balloon will take off and rocket along the string as the air is released.

- 3) Cut two pieces of tissue paper about the same length as the balloon and a little more than half as wide. Cut the front ends to a point and glue them together on the sides and front so it's like an envelope. Decorate it with few pieces of tinsel or marker designs, and **fringe** over the twisted end, by making small cuts with your scissors.

- 4) Tape the straw to the top of your rocket (the long way).

Tissue paper cut in half and glued together is the body of your rocket

- 5) Check to see that your **balloon fits into your rocket**---if not, let some air out.

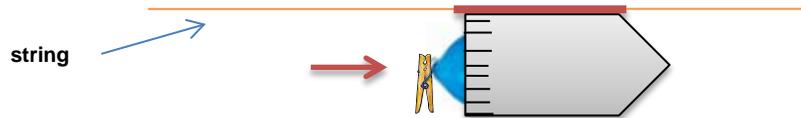
(Continued on next page)





(Activity 4: Continued)

- 6) Put the **string through the straw** (which is now taped to the balloon envelope) and pull the line tight, tying the end of the string to the back of the other chair. Pull the chairs apart to tighten the string. Now your Balloon Rocket is suspended from a tight line or track.



- 7) When you are ready, remove the clothespin! See how far along the string your rocket blasts! To race someone else, simply set up another string between the two chairs and have two people go at once.

JOURNAL IT!

This experiment demonstrates Newton's Third Law of Motion as **every action has a reaction**. In this case, by removing the clothespin and allowing the twisted end to unravel, it allows the air to release out of the balloon from one end. The **reaction** of this is the rocket shooting in the other direction. This experiment also allows you to make inferences and predictions as well as observing and analyzing the results of the experiment.

1. Does the shape of the balloon influence how far (**distance**) or fast the rocket travels (**velocity**)?
2. Does the length of the straw affect how far (or fast) the rocket travels?
3. Does the type of string affect the distance rocket travels? (try fishing line, nylon string, cotton string, etc.)
4. Does the angle of the string affect how the velocity of the rocket?





Activity 5: Make An Airplane Do Tricks!

Is your airplane going to be a Soaring Eagle or a Clumsy Penguin?

Materials Needed

- Paper
- Paperclips—large and small

Activity Directions

Can you make a paper airplane that twists and turns when you throw it?

- 1) Try making a few designs (see the attached samples)
- 2) Use small and large paperclips on various parts of your paper airplane to make it twist and turn.
- 3) Now, try using the paperclips to make your plane fly straight the farthest!

Experiment with placing paperclips:

On the nose of your plane...

On each wing ---or just on one wing...

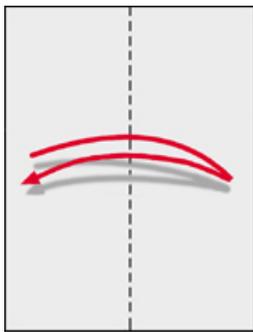
On the tail...

JOURNAL IT!

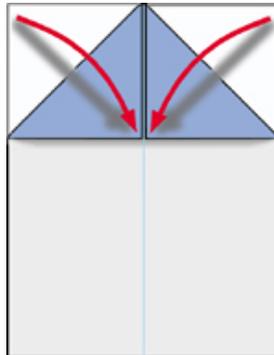
- 1) Write or draw what you found!
- 2) Explain to your mentor how you created your favorite airplane!



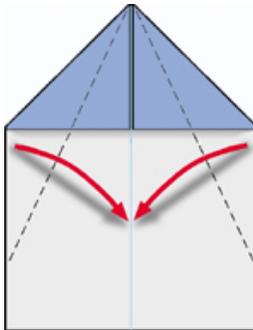
Basic Dart: Folding Instructions



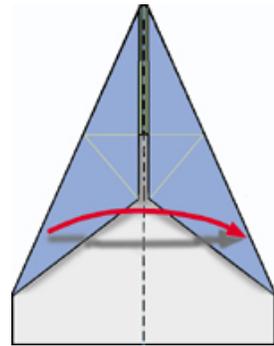
Step 1



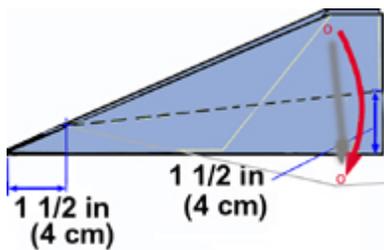
Step 2



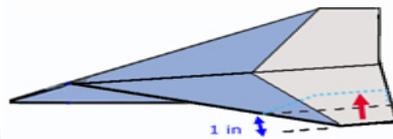
Step 3



Step 4



Step 5



Step 6

Step 1.

Use a sheet of 8 1/2-by-11 inch paper. Fold the paper in half lengthwise and run thumbnail along the fold to create it sharply. Now, unfold the paper.

Step 2

Fold down the top corners as indicated by the arrows.

Step 3

Fold the two edges toward the center line, as indicated.

Step 4.

Make a valley fold in half. Turn the plane 90 degrees as shown in figure of Step 5.

Step 5

Create a wing crease that begins at the nose as shown.

Step 6.

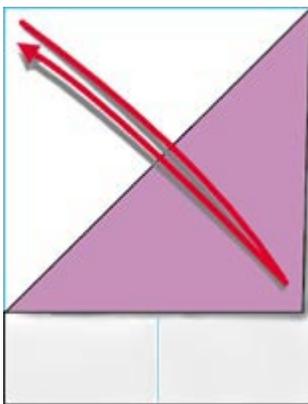
Form 3-dimensional shape as shown in figure. The Basic Dart is complete. Bend up the tailing edge of the wings for lift if it has a tendency to nose-dive.



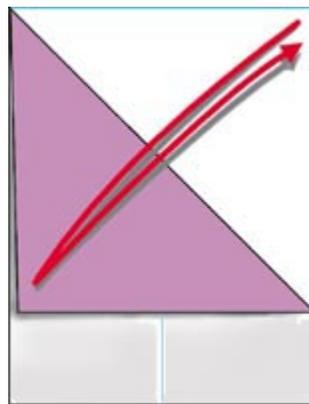
Airliner 717



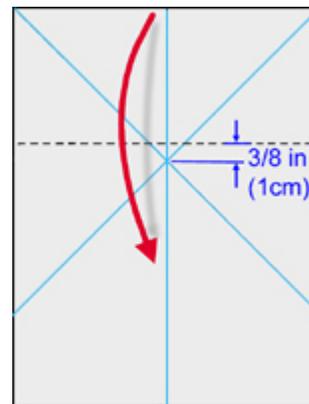
Folding Instructions



1. Crease and unfold the center crease, then bring the top left-hand corner across to the right-hand edge and crease. Then unfold.

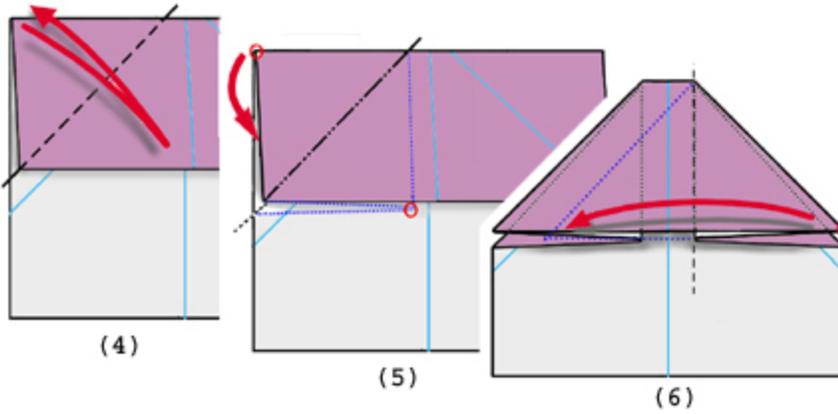


2. Bring the top right-hand corner across to the left-hand edge and crease, then unfold.



3. Make a mark $\frac{1}{2}$ " (or 1cm) above the point where the diagonal creases cross. Fold down along the dotted line as shown.

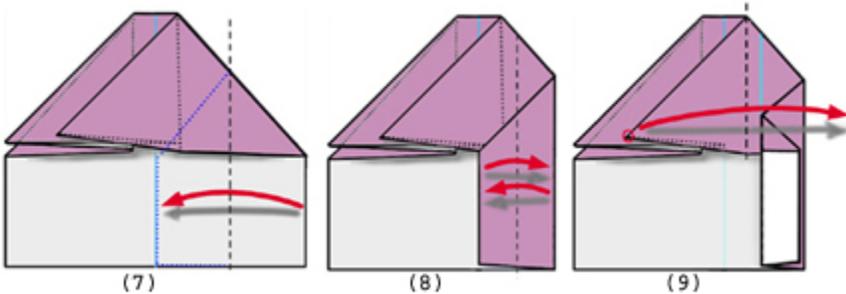




4. Fold the top left-hand corner along the existing crease and unfold.

5. Push down the left top corner between top and base sheets.

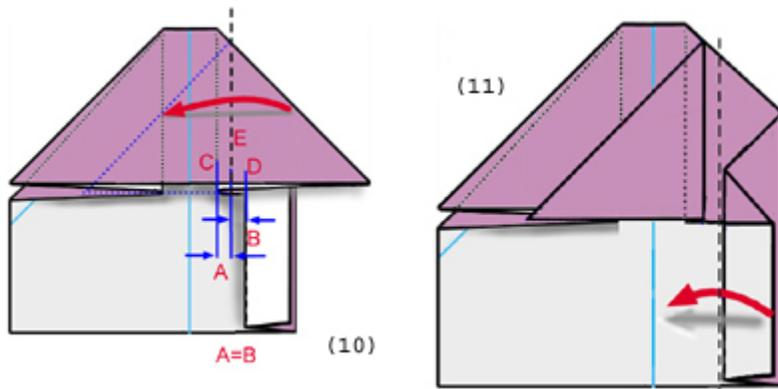
6. Repeat step 5 and step 6 for the right-hand side. Then flip the top right-side wing to the left side.



7. Fold the right side edge to the center crease.

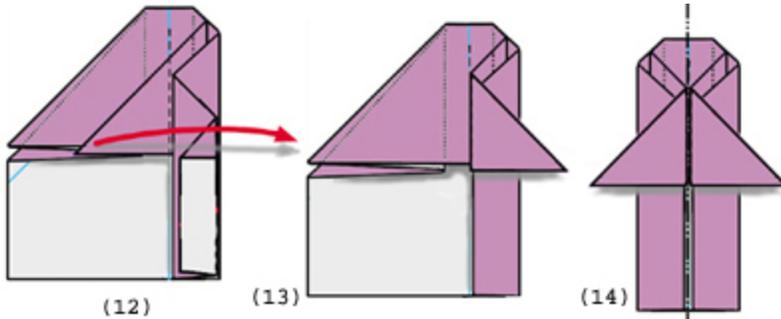
8. Fold back to the right side edge.

9. Swing the top wing toward right side.



10. Crease line E that becomes the center between line C and D. Swing the right wing to the left.

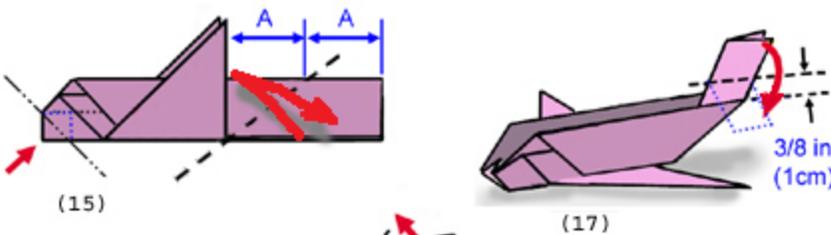
11. Fold the right side edge to the center crease.



12. Swing the top wing toward right side.

13. Repeat steps 6-12 for left-hand section.

14. Mountain fold the paper in half.



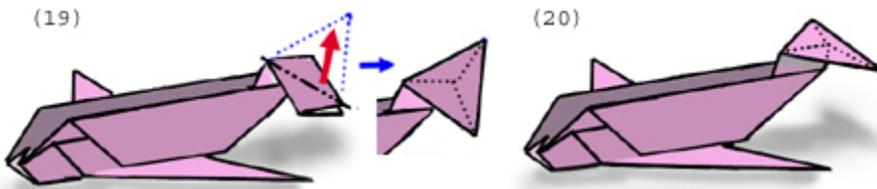
15. Push in the front bottom part to make a sharp nose. Create a diagonal line X. Note A=B



16. Push in the tail section.

17. Crease a line parallel with body that is 3/8 inch apart.

18. Fold and unfold diagonally for the tail wings.



19. Pull out the top part of tail while pushing in the center edge,

20. Rotate the tail wings 90 degrees. Final model looks like this.





Balloon and Straw Experiment: Newton Law III (Action-Reaction)

Objective: Make a balloon spin with a bendy straw



Materials Needed

- balloon
- bendy straw
- rubber band
- scissors

Activity Directions:

- 1) First, cut about two inches off the bottom of the bendy straw.
- 2) Next, blow up a balloon. Put the opening of the balloon around the bottom of the straw. Hold onto the balloon and straw so that you don't let any air out.
- 3) While holding the balloon and straw, wrap a rubber band around the balloon so that the balloon stays in place.
- 4) Then, bend the top of the straw, put the balloon on the table, let it go, and watch what happens.

What's happening here?

In order for the air to get out of the balloon, the air has to turn the corner in the bendy straw. When the air turns the corner, **it pushes on the straw and the straw pushes back on the air**. The straw then pushes on the balloon and look what happens to the balloon.

What do you think will happen if you change the direction that the straw points?

