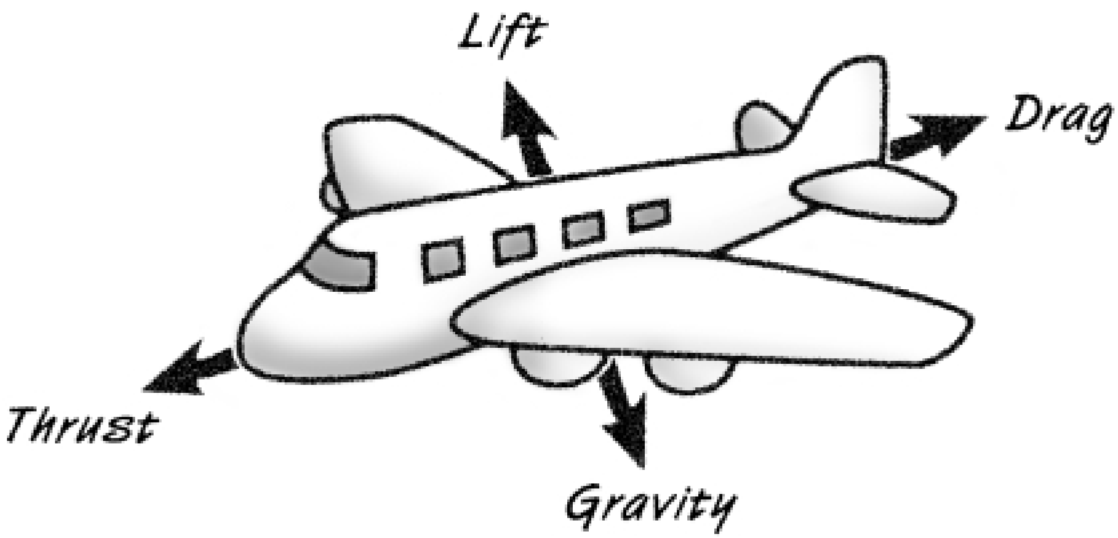
The Four Forces of Flight

An aircraft in straight and level flight is acted upon by four forces: *lift, gravity, thrust,* and *drag.* The opposing forces balance each other; lift equals gravity and thrust equals drag.

Any inequality between thrust and drag, while maintaining straight and level flight, will result in acceleration or deceleration until the two forces again become balanced.



Drag: The air resistance that tends to slow the forward movement of an airplane.

Gravity: The force that pulls all objects towards the earth.

Lift: The upward force that is created by the movement of air above and below a wing. Air flows faster above the wing and slower below the wing, creating a difference in pressure that tends to keep an airplane flying.

***Thrust:* The force that moves a plane forward through the air. Thrust is created by a propeller or a jet engine.**

Foamie Flyer

OBJECTIVE: Investigating the principle of thrust.

PROBLEM: Does the amount of thrust affect the Foamie Flyer's flight?

MATERIALS: Foam paper plates (full size), scissors, masking tape, large paper clips, rubber bands, non-bendable straws, rulers and copies of Blackline 1 for each student.

BACKGROUND: Thrust is the force that moves a plane through the air. Because airplanes fly in a three-dimensional environment, the following terms refer to the various directions an airplane can move:

Pitch—to move the nose of the airplane up or down

Roll—to tilt one wing up and the other wing down

Yaw—to point the nose of the airplane left or right while remaining level with the ground

Bank—to tilt the airplane inward while making a turn

Airplanes, including even the Foamie Flyer, use a variety of "control surfaces" to change the speed and direction in which they fly. These control surfaces include:

Ailerons—movable sections, hinged on the rear edge of the wing near the wingtip, that cause the airplane to roll

Flaps—movable sections, hinged on the rear of the wing, that can be lowered to increase lift and drag during takeoff or landing

Stabilizer—the vertical stabilizer is the upright portion of the airplane tail, while the horizontal stabilizer is the small wing usually located on the back of the airplane.

MANAGEMENT:

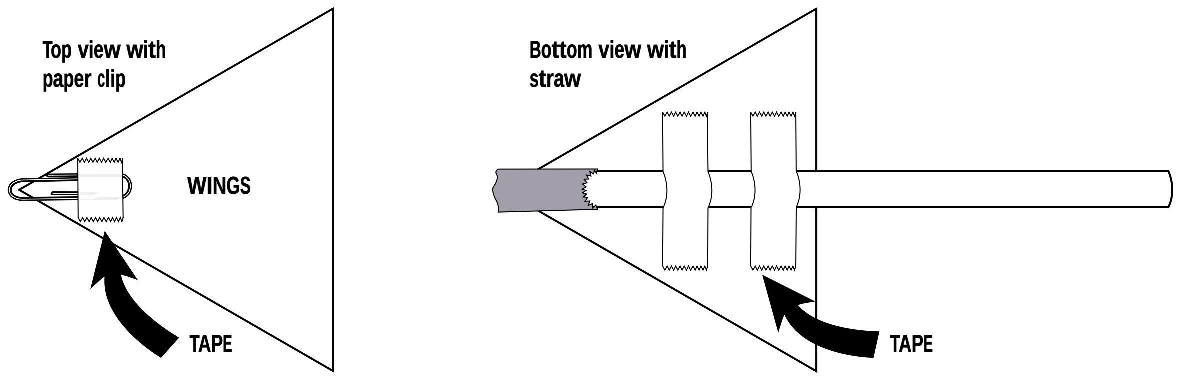
1. 45–60 minutes
2. Students will build their own flyer.
3. When launching the flyers, form groups of 3 or 4 so that all students are not launching at the same time.
4. This is an outdoor activity.
5. Foamie Flyers must be launched away from other children.
6. Save the unused parts of the plate for the extension activities.

WORD BANK: *thrust, lift, gravity, drag, wings, nose, fuselage, ailerons, flaps, pitch, roll, yaw, bank*

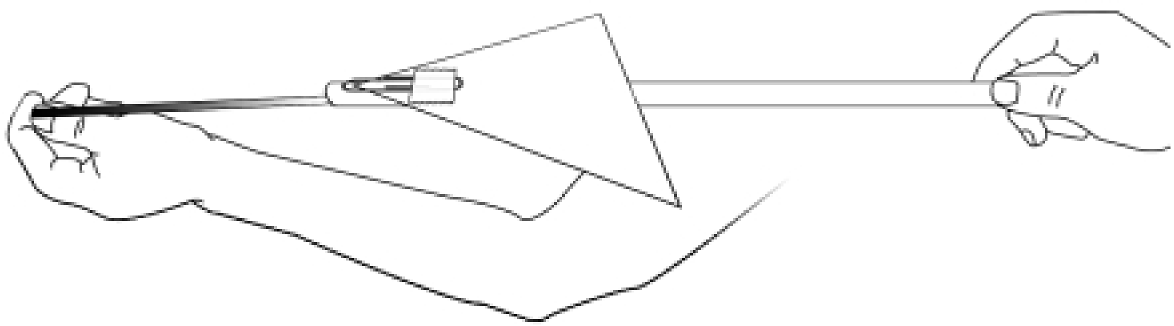
PROCEDURE:

1. Give each child the materials.
2. Instruct students to fold back the top three centimeters of the straw and insert the rubber band into the fold.
3. Fold the straw over the rubber band and secure the end with masking tape. This creates the launcher for the flyer.
4. Instruct students to cut a triangle out of the foam plate from the flat inverted side of the plate. A good size to start with is 13 cm x 13 cm x 13 cm (equilateral triangle).

5. Tape the paper clip to the top of the foam wings. Then, tape the wings to the top of the launcher so that it extends slightly over the tip.



6. Hook the rubber band around the tip of your thumb and pull back on the opposite end of the flyer. Release the straw and the flyer will fly forward.



7. There should be a designated launch starting line. Call groups forward, one at a time, to launch their flyers. Each child should launch the flyer using two different amounts of thrust. They should first pull the nose of the flyer halfway to their elbow and let it fly. Next, they should pull the nose of the flyer all the way to their elbow and let it fly. The group should observe the changes in their flyer's flight and distance. These observations can be recorded on the Student Data Sheet, Blackline 1.

DISCUSSION:

1. Does the amount of thrust affect the Foamie Flyer's flight?
2. What other factors affect how your flyer flew?
3. Why was your flyer successful or unsuccessful?
4. How does the thrust of the Foamie Flyer compare to the thrust of a real airplane?

EXTENSIONS:

1. Students can cut wing flaps and ailerons into the back of the foam wings and observe the changes in flight.
2. Students can alter the weight of the flyer and to observe the changes in flight by adding weight behind the wings with tape or paper clips.
3. Students can use the leftover foam plate parts to add stabilizers and rudders to their flyers and observe changes in flight.
4. Try different size foam wings to observe changes in flight.

Student Data Sheet

Foamie Flyer

Captain: ____________________

1. Did the amount of thrust affect Foamie Flyer's flight?

____

2. What did you observe when using different amounts of thrust to launch your Foamie Flyer?

____

____

3. How differently did the Foamie Flyer fly after modifications were made to the ailerons, flaps, stabilizers or rudder?

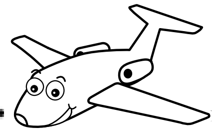
____

____

____

Draw and label a diagram showing how thrust affected the flight of your flyer.

Did You Know?



The Wright Brothers first successfully flew an airplane on Dec. 17, 1903. They discovered that airplanes needed to roll to turn. They invented a system of bending the wings with ropes in order to cause the plane to roll. This system was called wing warping.

Jammin' Jets

OBJECTIVE: To use thrust as the main force while manipulating the design of an aircraft to increase the distance.

PROBLEM: When using thrust to fly a Jammin' Jet, how do changes to the design affect the distance it can travel?

MATERIALS: 2 straws with different diameters, masking tape, scissors, index cards, rulers, tape measures, and a copy of Blackline 1 for each student.

BACKGROUND INFORMATION: Airplane designers try to increase airplane thrust by making more powerful jet engines and propellers.

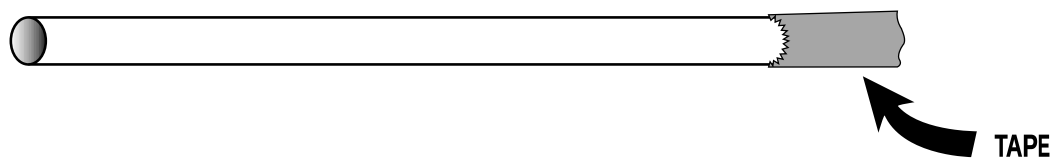
MANAGEMENT:

1. 45–60 minutes
2. Construct the Jammin' Jets individually then work in groups of four to complete the activity.
3. A large open space is required for this activity.
4. Students should be instructed to blow only into their own straw and to launch their jets away from each other.
5. Set up a runway using tape measures for the students to launch their jets.

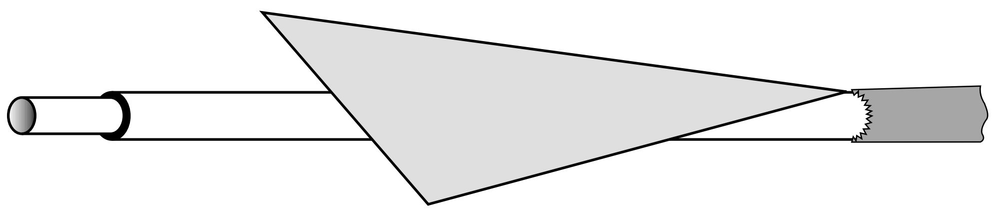
WORD BANK: *thrust, fuselage, wings, nose, stabilize*

PROCEDURE:

1. Hand out materials to each student.
2. Wrap a piece of tape around the front end of the straw with the larger diameter so that the opening is taped shut.



3. Allow the children to experiment by placing wings on different parts of the straw.
4. Insert the smaller straw into the larger straw, leaving an inch at the end of the smaller straw.



5. Demonstrate thrust by blowing into the smaller straw. This projects the jet forward.
6. If the front of the jet rises, wrap some tape near the front of it until it flies level. If the front of the jet falls, wrap some tape around the straw just behind the wings.
7. Students can practice flying the different jets within their group.
8. Choose the best jet and fly three trails recording the distance on the Student Data Sheet.

DISCUSSION:

1. What force was used to propel your Jammin' Jet?
2. Did your jet fly in a straight line?
3. What changes did you make to help your jet fly straighter?
4. What design feature increased the distance?

EXTENSIONS:

1. Students use their best design in a Jammin' Jets rally. The jets can compete against each other to see which one will fly the longest distance.
2. Different levels of thrust can be applied to see how this affects the stability of the plane.

CULMINATING ACTIVITY:

Set up a target (hula-hoop with paper plate inside) and see which jet can land closest to the center of the target by adjusting the amount of applied thrust. Award five points for jets that land in the hula-hoop and ten points for landing on the paper plate.

Student Data Sheet

Jammin' Jets

Captain: ____________________

DISTANCE TRAVELED

Trial 1	Trial 2	Trial 3	Average

Diagram and label your best design.

What changes to the jet's design were most successful?

____

____

Why do you think these changes were successful?

____

____

Balloon Jet

OBJECTIVE: Investigate the principle of thrust.

PROBLEM: What force causes the Balloon Jet to move forward?

MATERIALS: balloon (sausage-shaped works best), straws, spool of fishing line, scotch tape, a copy of Blackline 1 for each group, a copy of Blackline 1 for each student

BACKGROUND INFORMATION: Thrust is the force created by a power source that moves the plane forward — either from a propeller or a jet engine. When the thrust is greater than the drag, a plane moves forward. This activity demonstrates Newton's Third Law of Motion: For every action, there is an equal and opposite reaction. Backward thrust of the air from the balloon produces the forward motion of the balloon.

MANAGEMENT:

1. 45–60 minutes
2. This activity works best with small cooperative groups of 3–4 students.
3. Pieces of fishing line should be cut to the length of the room available.
4. Create one Balloon Jet per group.
5. The class graph can be used for the main activity as well as the extensions.
6. Each group should have a designated "balloon blower" so that the same student always inflates the balloon.

WORD BANK: *thrust, average (mean), launch*

PROCEDURE:

1. Thread fishing line through a straw and attach the ends of the fishing line securely to a wall or other object. The line should be taut.
2. Instruct students to blow up their balloons to the desired size, measure its length and record it on the Group Data Sheet. Pinch off the end of the balloon so that no air is released.
3. Tape the balloon to the straw.
4. The students will release the balloon from the designated starting point.
5. Observe and measure the distance the balloon travels and record it on the Group Data Sheet, Blackline 1.
6. Repeat the procedure two more times with balloons that are inflated to the same size. (Balloons may be a different size for each group.)
7. After the groups have completed the activity and data sheet, compare the results.
8. Each student will then complete his or her own Class Graph, Blackline 2.

DISCUSSION QUESTIONS:

1. What makes the Balloon Jet travel forward?
2. Does the length of the Balloon Jet make a difference as to how far it travels? Why?
3. What else could affect the distance a Balloon Jet will travel?

EXTENSIONS:

1. Students could repeat the activity using different size or shape balloons.
2. The tautness of the line can be altered.
3. The angle of the line can be changed to show the effect of forward thrust.
4. The students can insert different size straws into the opening of the balloon to observe and measure changes in the distance the Balloon Jet travels.

5. Students can find the speed of their Balloon Jet by dividing the distance traveled by the time it took.

CULMINATING ACTIVITY:

Using the variables from the main activity and the extensions, students can work to design a Balloon Jet that will travel the longest distance.

Group Data Sheet

Balloon Jet

Pilots: ____

____

Prediction: We think our balloon jet will travel ____ cm.

The name of our balloon jet is ____________________.

Diagram and label your balloon jet.

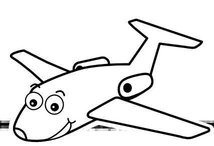
	Distance Traveled			
Balloon Length	**Trial 1**	**Trial 2**	**Trial 3**	**Average Distance**

Conclusion: What forces caused the balloon to move forward on the line?

____

____

Did You Know?



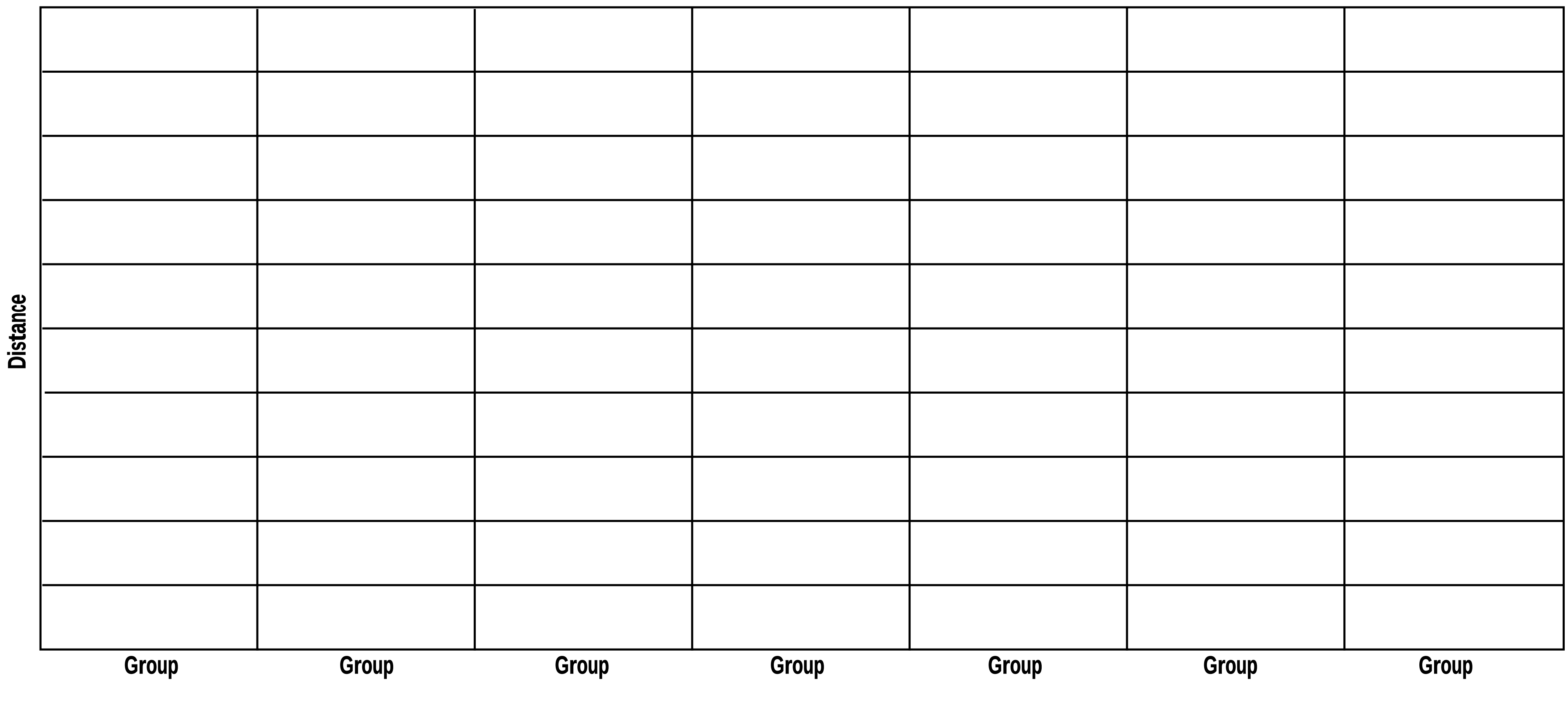
Did you know: Almost all mail traveling farther than 200 miles, as well as airmail, is carried by airplanes.

Class Graph

Balloon Jet

Pilot: ______________________

Title: ______________________



The Four Forces of Flight

An aircraft in straight and level flight is acted upon by four forces: *lift, gravity, thrust,* and *drag.* The opposing forces balance each other; lift equals gravity and thrust equals drag.

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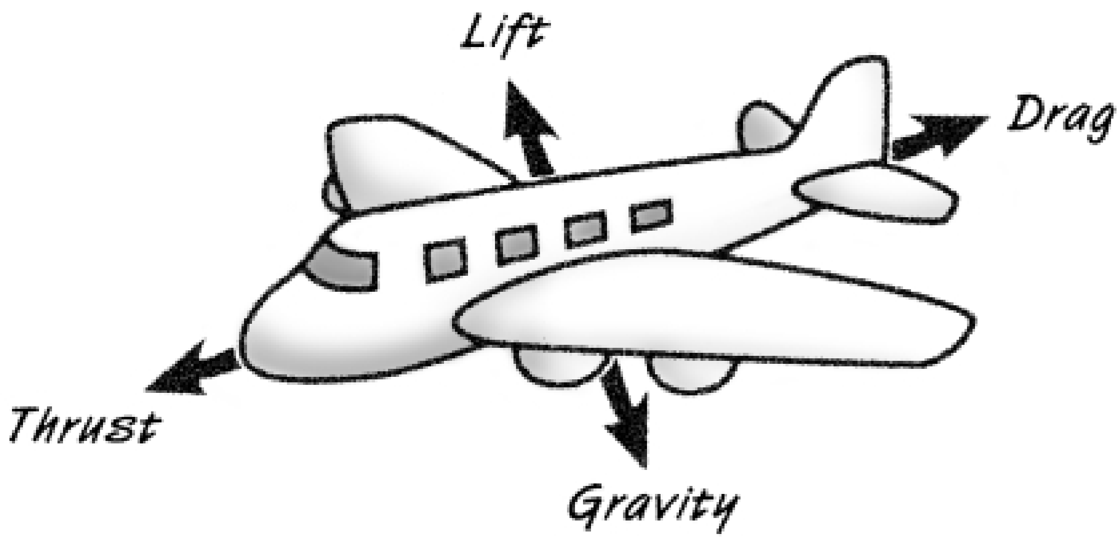


Drag: The air resistance that tends to slow the forward movement of an airplane.

***Gravity:* The force that pulls all objects towards the earth.**

Lift: The upward force that is created by the movement of air above and below a wing. Air flows faster above the wing and slower below the wing, creating a difference in pressure that tends to keep an airplane flying.

Thrust: The force that moves a plane forward through the air. Thrust is created by a propeller or a jet engine.

Gravity Busters

OBJECTIVE: Investigate the principle of gravity combined with lift.

PROBLEM: How does lift work against gravity?

MATERIALS: One blackline per student, scissors, staplers, stopwatches per group

BACKGROUND INFORMATION: Gravity is the force pulling the plane down. When the gravity is stronger than the lift, the plane goes down. Helicopters are really airplanes with moving wings called rotors, which replace the fixed wings and propellers used on an airplane. A helicoptor rises for the same reason an airplane flies: the movement of the air results in a pressure on the bottom of the rotor blades (wings) that is greater than the pressure on the top of the rotor blades (wings).

MANAGEMENT:

1. 45 minutes to an hour
2. This activity works best with small groups of 3–4 students. Each student makes his or her own Gravity Buster.

WORD BANK: *gravity, rotation, rotary wing, weight, pull, aloft, descent, air-traffic controller (a person on the ground who uses radar to track aircraft and radios to direct the movement of aircraft)*

PROCEDURE:

1. Using Blackline 1, construct the Gravity Buster.
2. Within their groups, students test their individual Gravity Busters by standing on a chair and releasing them. Ensure students release rather than throw them. They must be released from the same height each time.
3. After five minutes each group chooses the most effective Gravity Buster for the rest of the activity.

4. Each group is assigned a job:
   Timer, Recorder, Pilot, Air-traffic controller (boss)
5. The pilot drops the Gravity Buster three times. The timer will start at release and stop at landing. The recorder records each trial time on the Group Data Sheet, Blackline 2.
6. Add one staple to the bottom of the Gravity Buster and repeat step #5.
7. Add two additional staples to the bottom of the Gravity Buster and repeat step #5.
8. Complete the Group Data Sheet. Share and discuss results.
9. Have students create a graph, Blackline 3, using the class data.

DISCUSSION QUESTIONS:

1. How does lift work against gravity?
2. Why did your group choose the winning Gravity Buster?
3. How did the staples affect the Gravity Buster?
4. How does this activity show how a helicopter stays in the air?
   Answer: When lift is stronger than gravity, the craft stays up.

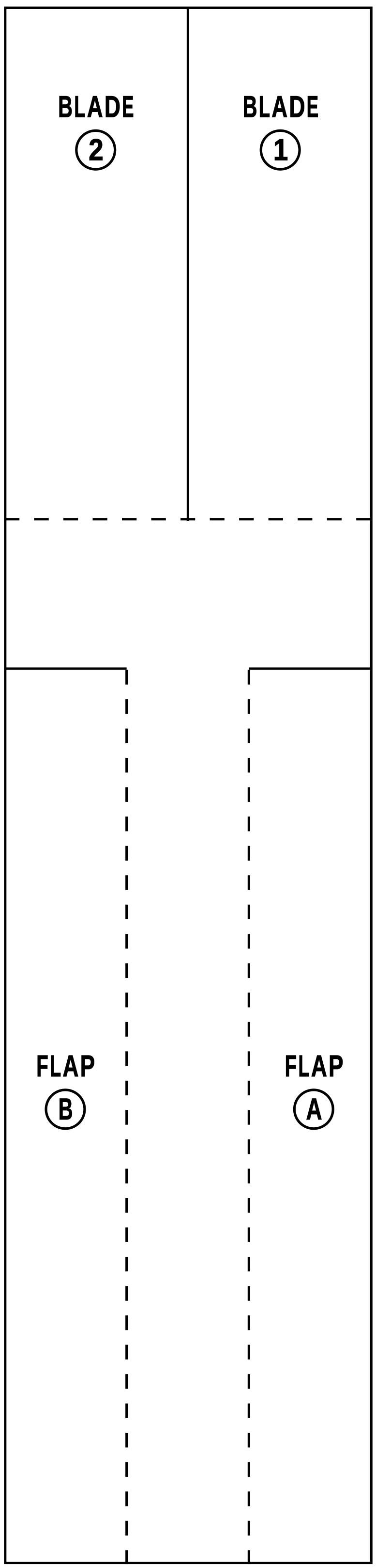
EXTENSIONS:

1. Construct Gravity Busters out of different materials and/or designs.
2. Change the heights at which it's dropped.
3. Add or remove weight.

CULMINATING ACTIVITIES:

Using the extension knowledge have the students improve their Gravity Busters and let them drop!

Gravity Busters



To construct:

1. Cut along the solid lines.
2. Fold along the dashed lines.
3. Fold Flap A in to the center. Then fold Flap B over Flap A.
4. Fold Blade 1 back and Blade 2 forward.

Group Data Sheet

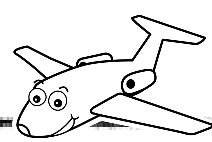
Gravity Busters

Pilots: ______________________

____

	Descent Time: Seconds from Release to Landing			Average Time (in seconds)
Weight Added	Trial 1	Trial 2	Trial 3	
No Staples				
1 Staple				
3 Staples				

Did You Know?

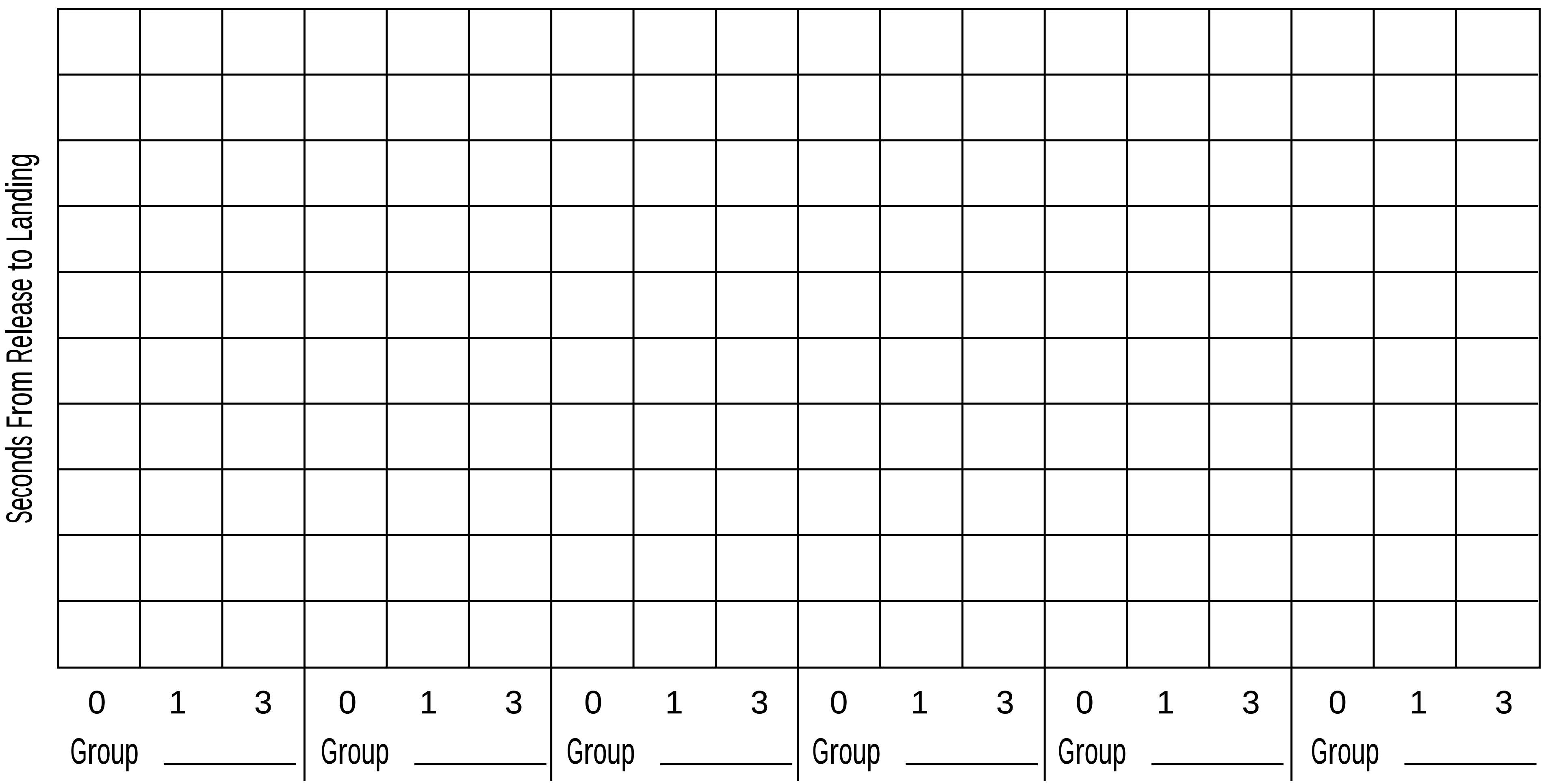


Did you know: Gravity is the force that pulls everything to the center of the earth. This is why thrown objects and jumping people always end up back on the ground.

Class Graph

Gravity Busters

Pilot: ____________________



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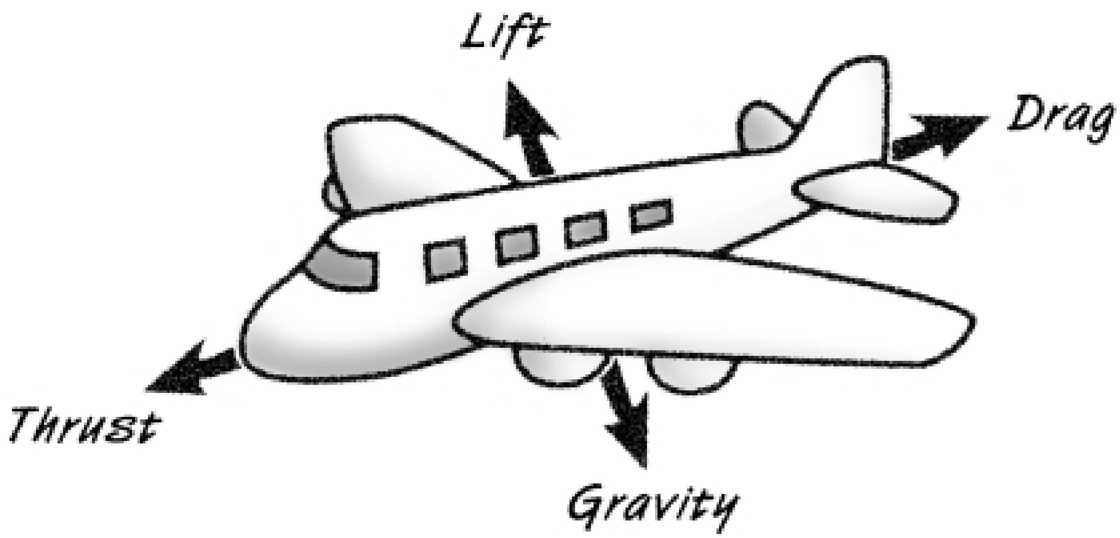

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Thrust: The force that moves a plane forward through the air. Thrust is created by a propeller or a jet engine.

Paratrooper's Away!

OBJECTIVE: Investigate the principle of drag.

PROBLEM: How does a parachute create drag for a falling object?

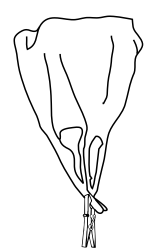
MATERIALS: Each pair of students needs one plastic grocery bag (with handles), one clothespin (or a large paperclip), and a copy of Blackline 1.

BACKGROUND INFORMATION: Drag is the force that acts against the forward movement of an airplane and slows it down. All moving objects experience drag.

MANAGEMENT:

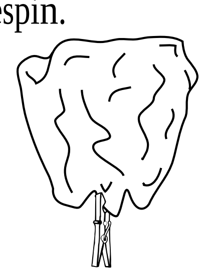
1. 30 minutes
2. This activity should be done in pairs.
3. Allow the pairs to take turns dropping the parachutes.
4. Students will get more height if they stand on chairs.

WORD BANK: *drag, parachute, weight, descent, streamline, observation, paratrooper (a soldier trained to jump from an airplane and be lowered slowly to the ground using a parachute), drag chute (a parachute used to slow down an airplane or other object that tavels through the air)*

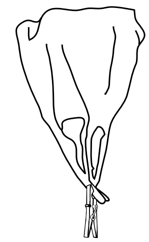


PROCEDURE:

1. Bring the handles of the grocery bag together and secure with a clothespin.
2. First, the students drop the parachute from a chair-standing height. With the grocery bag first crumpled up, observe the decent of the clothespin. Note: make sure the clothespin drops first.



3. Next, students open up the parachute fully and drop it from the same height. Observe the descent of the clothespin.
4. The students should experiment with the two different ways of dropping the clothespin.
5. The students will record their observations on the Paratrooper Data Sheet, Blackline 1.



DISCUSSION:

1. How does a parachute create drag for a falling object?
2. What were the differences they observed between the two drops?
3. How does drag affect the flight of an airplane?
4. Would increased weight require a larger parachute? Why?

EXTENSIONS:

1. Have the students try different sized parachutes.
2. Have the students add different weights.
3. Drop the parachutes from different heights.

CULMINATING ACTIVITY: Paratrooper Target Drop

Students can compete by creating parachutes that land accurately on a bullseye target.

Paratrooper Data Sheet

Paratrooper's Away!

Paratroopers: ______________________________

Diagram and label the two parachute drops.

Closed Chute	Open Chute

How does a parachute create drag for a falling object? Write your observations.

____

____

____

____

Drag Racers

OBJECTIVE: Investigate the force of drag on a moving object.

PROBLEM: How does a drag-chute affect the speed of student runners?

MATERIALS: garbage bags (large, heavyduty bags work best), tape, stopwatch, and copy of Blackline 1 for each group

BACKGROUND INFORMATION: This activity lets students to feel the force of drag. Airplanes are designed to be sleek so that drag is reduced, allowing easier movement through the air.

MANAGEMENT:

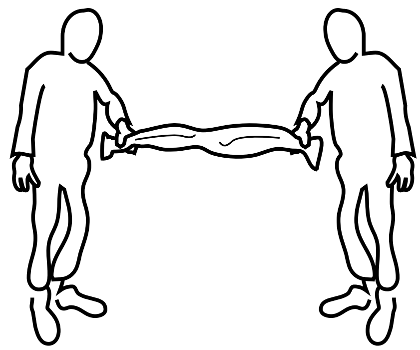
1. 45–60 minutes
2. Students should work in groups of four taking turns running and timing.
3. Construct the drag-chutes in the classroom. Running will take place outside on a marked 20–30 meter "runway."
4. Garbage bag drag-chutes should be at least one square meter. (This might require taping bags together. If so, make sure seams are solid — no holes!)

WORD BANK: *drag, drag-chute, meter, runway, sleek, aerodynamic, speed, resistance, pull*

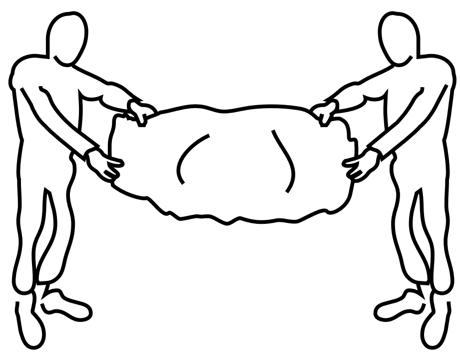
PROCEDURE:

1. Each group will make their garbage bag drag-chute. To do this, cut along one side and the bottom of the bag. This will make one flat sheet. Make sure it is at least one square meter. If it is not, tape another bag to it.

2. Two students run from the starting line, side by side, holding the drag-chute that is rolled up between them. The timers say "Go," the students run to the finish, and the timers stop the watch. Record the time on the record log, Blackline 1.



3. The same two students now repeat the run with the drag-chute unfurled. The timers instruct the students to "Go", then stop the watches at the finish. Record time on the Record Log.



4. The timers should now switch places with the runners. Repeat the procedure.
5. The group then completes the Record Log, Blackline 1.

DISCUSSION:

1. Explain what is was like running with the drag-chute closed compared to when it was open.
2. What force caused you to slow down?
3. Do you think a larger drag-chute would cause you to run even slower? Why?
4. How are airplanes designed to keep the force of drag in mind?

EXTENSIONS:

1. Complete more trials by running longer distances, using smaller or larger drag-chutes, or using different drag-chute materials.
2. Two students with a drag-chute can race two students without drag-chutes.

CULMINATING ACTIVITY:

Allow the students to design original drag-chutes, naming their teams. Then conduct a class drag race derby!

Record Log

Drag Racer

Racers: ____

____

	Time without Dragchute	Time with Dragchute
Racers 1 and 2		
Racers 3 and 4		

How did the drag-chute affect the speed of your race?

____

____

Why do you think the drag-chute affected your race?

____

____

Find the difference in speed between your race without the drag-chute and with the drag-chute:

Racers 1 and 2 ________________________________

Racers 3 and 4 ________________________________

What A Drag!

OBJECTIVE: Investigate the principle of drag.

PROBLEM: Does drag affect the flight of an airplane?

MATERIALS: Balloons (sausage-shaped works best), straws, scotch tape, paper plates (8-1/2" diameter)

BACKGROUND INFORMATION: This activity is similar to the Balloon Jet activity but emphasizes how drag slows down the jet.

MANAGEMENT:

1. 45–60 minutes
2. This activity works best with small cooperative groups of 3–4 students.
3. Cut pieces of fishing line to the length of the room available.
4. Create one Balloon Jet per group.
5. Each group should have a designated "balloon blower" so that the balloon is always blown up by the same student.

WORD BANK: *thrust, drag, average (mean), launch*

PROCEDURE:

1. Thread the fishing line through the straw and attach the ends of the fishing line securely to a wall or other object. The line should be taut.
2. Instruct the students to blow up their balloons to the desired size, measure the length, and record it on their Group Data Sheet. Pinch off the end of the balloon so that no air is released.

3. Tape the balloon to the straw.
4. The students will release the balloon from the designated starting point.
5. Observe and measure the distance the balloon travels and record it on the Group Data Sheet.
6. Repeat the procedure two more times keeping the balloon the same size. (Balloons may be a different size for each group.)
7. Repeat procedures 2–6, adding a paper plate to the front of the jet. (Be sure plate does not get caught on line)
8. After all groups have completed the activity and Group Data Sheet, compare the results.
9. Each student will then complete his or her own Class Graph.

DISCUSSION QUESTIONS:

1. Which jet went a shorter distance? Why?
2. Why is it important for an aircraft to have less drag?
3. How are aircrafts designed to overcome drag?
4. Would weight affect the flight of your jet in the same way?

EXTENSIONS:

1. Use different sized plates for drag.
2. Use different shapes for drag.
3. Use different amounts of weight for drag.

CULMINATING ACTIVITY:

Have students share information about their jets, explaining the drags used and their observations.

Group Data Sheet

What A Drag!

Pilots: ____

____

PREDICTION:

We think our Balloon Jet without drag will travel ______cm.

We think our Balloon Jet with drag will travel ______cm.

The name of our Balloon Jet is______________________________

Diagram and label your Balloon Jet.

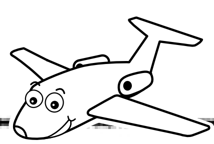
	Distance Traveled							
	Trial 1		Trial 2		Trial 3		Average Distance	
Balloon Length	No Drag	Drag	No Drag	Drag	No Drag	Drag	No Drag	Drag

CONCLUSION: Explain how drag affects the flight of an airplane.

____

____

Did You Know?

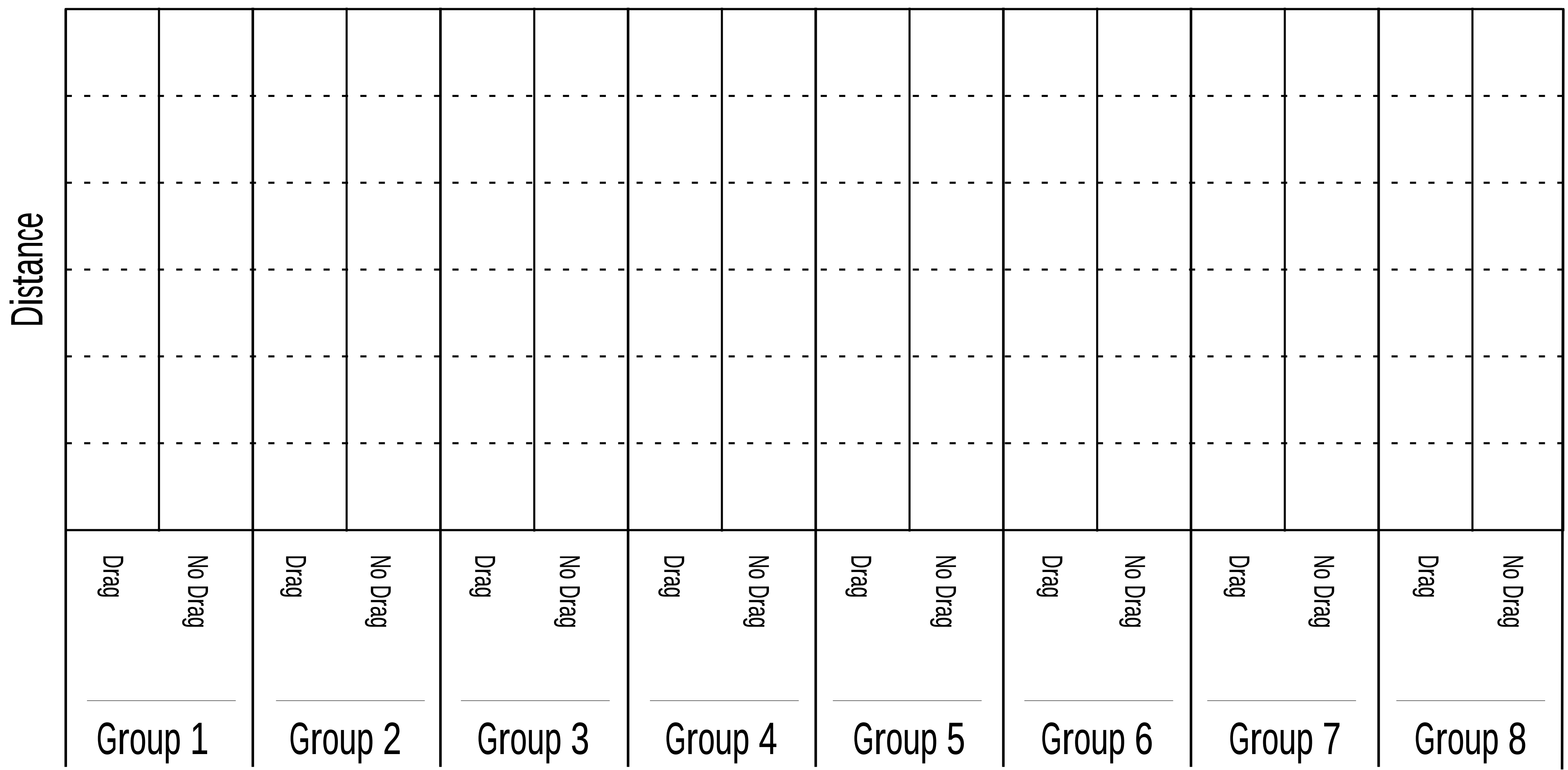


Did you know: Airplanes imitate birds in order to land. Both extend their wings and flaps to provide more lift at low speeds and to add drag to slow them down.

Class graph

What A Drag!

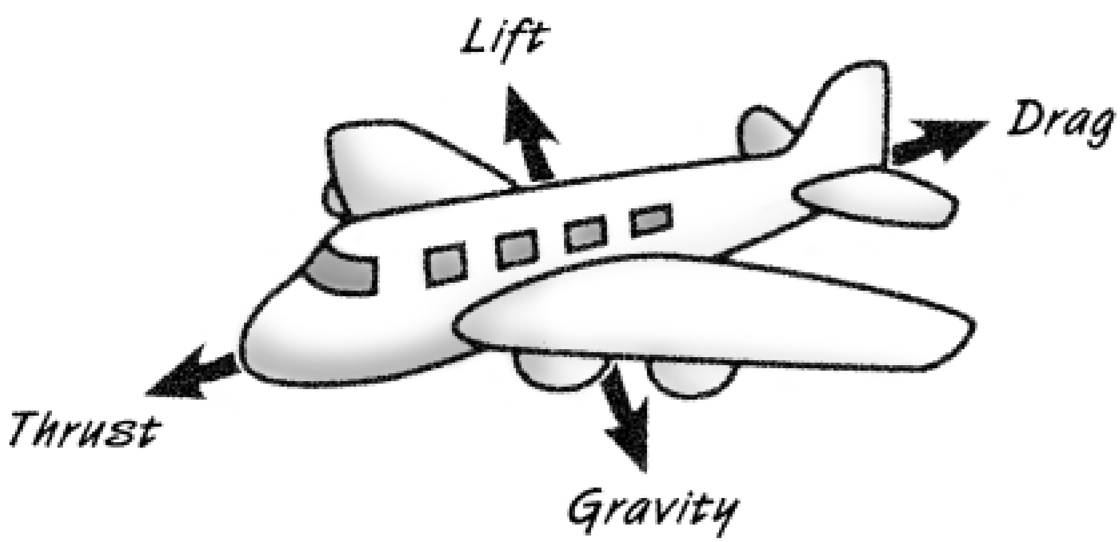
Captain: ______________________________



The Four Forces of Flight

An aircraft in straight and level flight is acted upon by four forces: *lift, gravity, thrust,* and *drag.* The opposing forces balance each other; lift equals gravity and thrust equals drag.

Any inequality between thrust and drag, while maintaining straight and level flight, will result in acceleration or deceleration until the two forces again become balanced.



Drag: The air resistance that tends to slow the forward movement of an airplane.

Gravity: The force that pulls all objects towards the earth.

***Lift:* The upward force that is created by the movement of air above and below a wing. Air flows faster above the wing and slower below the wing, creating a difference in pressure that tends to keep an airplane flying.**

Thrust: The force that moves a plane forward through the air. Thrust is created by a propeller or a jet engine.

An UpLIFTing Adventure

OBJECTIVE: Investigate the principle of lift.

PROBLEM: How does the design of the airplane affect the lift?

MATERIALS: several 8-1/2 x 11 sheets of paper for each student, a stopwatch, and copy of Blackline 1a and 1b for each pair

BACKGROUND INFORMATION: Lift is created by the shape of the wing, which makes the air pressure above the plane's wing less than the pressure below. This causes the plane to lift upward. When the lift is greater than gravity, the plane goes up.

MANAGEMENT:

1. 45–60 minutes
2. Students work in pairs. While one student pilots the plane, the other times the flight.
3. This activity works best outdoors or in a large indoor area.

WORD BANK: *lift, descent, ascent, landing, aloft, design, fuselage, wing, nose, elevators, rudder*

PROCEDURE:

1. Each pair constructs the two different designs of airplanes. (See Blacklines 3 and 4)
2. One pilot will fly his or her design at the timer's signal.
3. The timer starts at release and stops at landing.

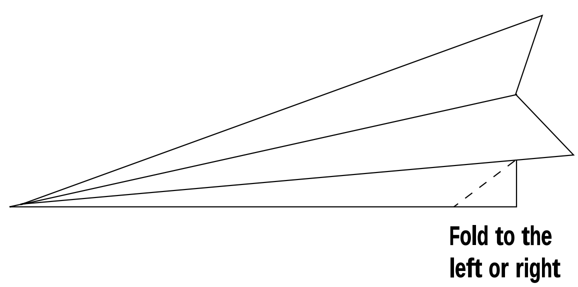
4. Each trial is recorded on the Pilot's Logs, Blacklines 1a and 1b.
5. This procedure is completed five times for each plane.
6. Complete the Flight Data Sheet, Blacklines 1a and 1b.
7. Share and discuss the results. Calculate the class average for each design.
8. Have students create a graph on Blackline 2 using this class data.

DISCUSSION QUESTIONS:

1. How does the design of the airplane affect the lift?
2. What features of the plane kept it aloft the longest?
3. What features of the plane kept the plane from staying aloft?
4. How does this activity show how a plane stays aloft?

EXTENSIONS:

1. Students can add elevators to their planes and observe changes in flight.
2. Students can add rudders by folding the base of the fuselage.



CULMINATING ACTIVITY:

Challenge students to design an airplane that will remain aloft the longest.

Pilot's Log Flight Data Sheet

—An UpLIFTing Adventure—

Captains: ____

____

We think plane number ________ will stay aloft the longest.

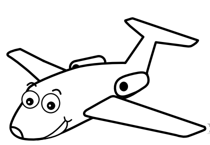
Here are our reasons:

Airplane #1

Flight #	Time Aloft
1	
2	
3	
4	
5	

Average Time Aloft: _____________

Did You Know?



Did you know: Airplane wings are curved on top because scientists observed that the curved shape of a bird's wing helped lift the bird into the air.

Pilot's Log Flight Data Sheet

— An UpLIFTing Adventure —

Airplane #2

Flight #	Time Aloft
1	
2	
3	
4	
5	

Average Time Aloft: ______________

1. Which plane had the highest average time aloft?

____

2. What features of the plane lead to longer time aloft?

____

____

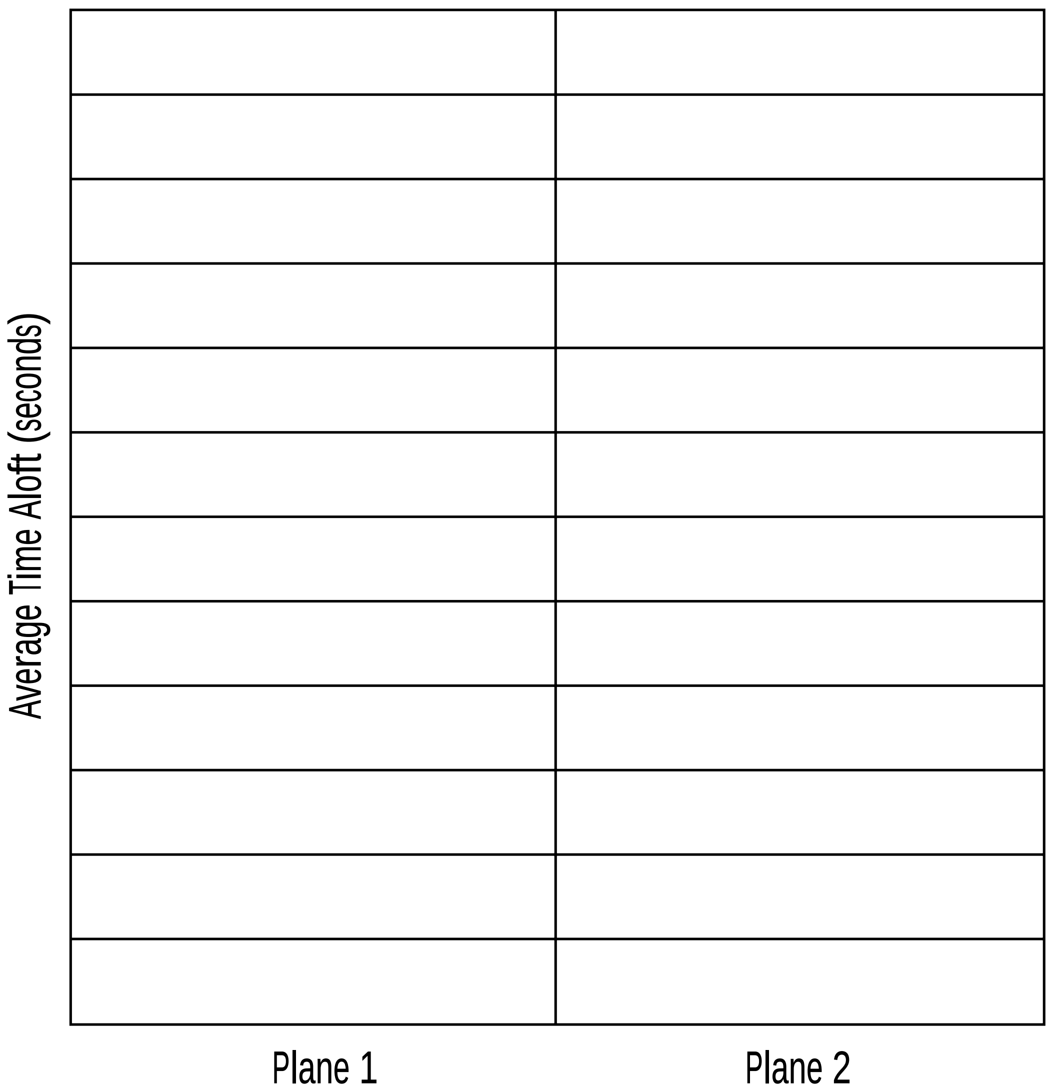
Class Graph

— An UpLIFTing Adventure —

Captains: ____

____

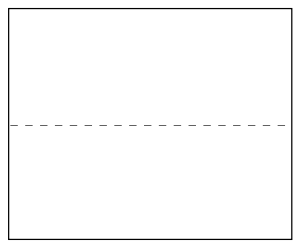
Title: ____



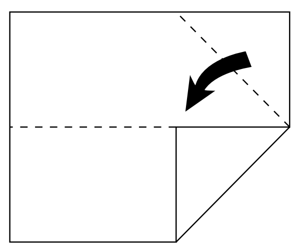
Paper Plane Model # 1

— An UpLIFTing Adventure —

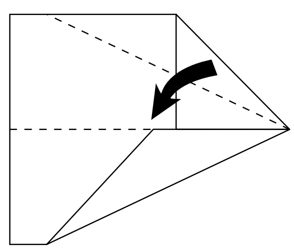
1. Take an 8-1/2 x 11" sheet of paper, fold it in half lengthwise and open it flat again.



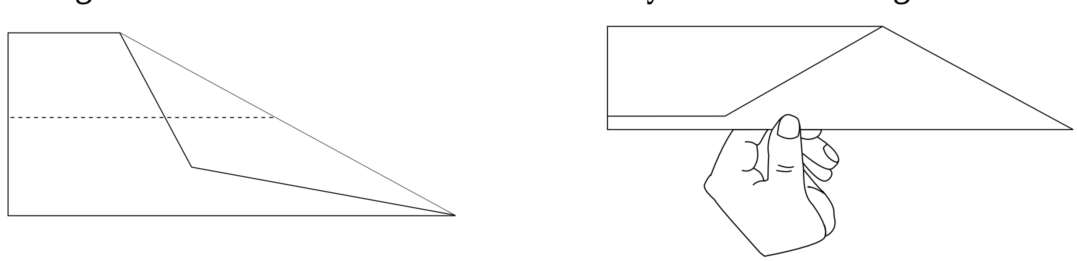
2. Fold the top two corners to the centerline.



3. In the same manner, fold the corners again to the centerline.



4. Fold back the sides along the original fold line, plain sides together. Fold down the sides half way down the wing.

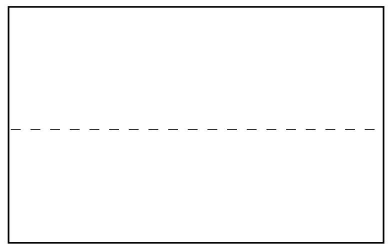


5. Hold the plane underneath and launch with a hard forward thrust.

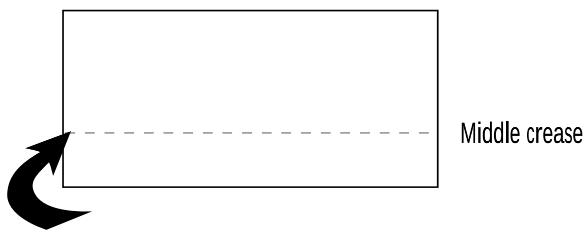
Paper Plane Model #2

— An UpLIFTing Adventure —

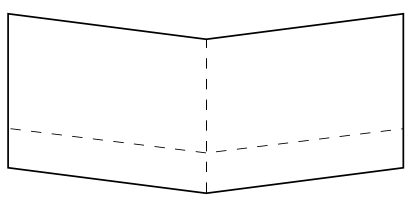
1. Fold an 8-1/2 x 11” piece of paper lengthwise and open it.



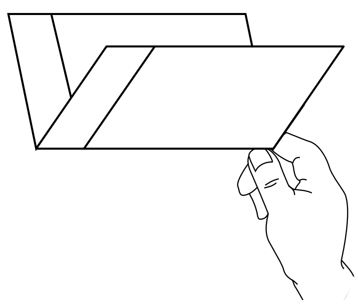
2. Fold the bottom edge to the middle crease. Fold it again making four thicknesses.



3. Crease the folded part at its mid point, causing a slight angle in the wing.



4. Hold at the back of the wing and launch with a gentle forward thrust.



Fearless Flyers

OBJECTIVE: Investigate the principle of lift.

PROBLEM: How does the design of an airplane affect its ability to perform stunts?

MATERIALS: several sheets of 8-1/2 x 11” paper, scissors, scotch tape, design pattern Blackline 1 for each student

BACKGROUND INFORMATION: This activity uses Bernoulli’s principle of lift. The shape of the wing (airfoil) causes air to move faster over the top of the wing. The faster the air moves, the less the air presses down on the wing. Because the wing is flat on the bottom, the air pressure is greater under the wing. This creates lift.

MANAGEMENT:

1. 60 minutes
2. Divide class into small groups (3–4 students).
3. This activity requires a large open space.

WORD BANK: *lift, thrust, gravity, drag, climb, bank, loop, boomerang, design, stunt, aerobatics, dive*

PROCEDURE:

1. Hand out the Fearless Flyers Data Sheet to each group.
2. Have the teams work together to design planes that will successfully perform the specified stunts on the Data Sheet, Blackline 1.
3. Individually, students draw diagrams of an airplane that completed a stunt and answer the questions on the design sheet (Blackline 2). Students do not have to write about their own plane.

DISCUSSION QUESTIONS:

1. How does the design of an airplane affect its ability to perform stunts?
2. Was there more than one design that could complete the same stunt?
3. Which design was affected most by gravity? Drag?
4. Did the amount of thrust affect the way your airplanes flew?
5. What happens when drag becomes greater than lift?

EXTENSIONS:

1. Add weight (paperclip) to different points on the fuselage. Observe and discuss the results.
2. Vary the size and weight of the paper.

CULMINATING ACTIVITY: Air Jam

Each group performs their stunts for the rest of the class.

Data Sheet

Fearless Flyers

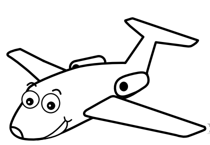
Stunt Pilots: ______________________________

____

Can your team design planes that will perform the following stunts?

	Affirmative	**Negative**
Fly Straight	______	______
Dive	______	______
Bank Left	______	______
Bank Right	______	______
Climb	______	______
Boomerang	______	______
Loop	______	______
Double Loop	______	______

Did You Know?



Did you know: Aircraft engineers design planes with a sleek, trim shape so that they will cut through the air. Planes with low drag need less engine power to fly and have better flight performance.

Design Sheet

Fearless Flyers

Stunt Design Engineer: ________________________________

*Stunt Performed:*____________________________________

How did your team design the airplane to perform this stunt?

____

____

____

Why do you think this design caused the airplane to perform the stunt?

____

____

Draw and label a diagram of the stunt plane performing its stunt.

Plane name: ____

Loop-to-Loop AdVENNtures

OBJECTIVE: Compare two designs of loop airplanes, observing the four forces of flight.

PROBLEM: How are loop-planes and tube-planes similar and different? (design, flight patterns, etc.)

MATERIALS: one straw, design patterns, Blacklines 1 and 2, scotch tape, 8 -1/2 x 8-1/2” paper for each student

BACKGROUND INFORMATION: The loops cause enough lift to keep the plane in the air. As it descends, the top part of the loop catches the air and helps the plane stay aloft.

MANAGEMENT:

1. 45–60 minutes
2. Work individually or in pairs.
3. A large open space is required for this activity.
4. Instruct students to launch the planes away from others.

WORD BANK: *lift, thrust, gravity, drag, loop, tube, Venn Diagram, compare, similar, different, flight*

PROCEDURE:

1. Give each pair of students the materials and have them construct the loop and tube planes.
2. Experiment with the two planes. Have students observe the similarities and differences in both flight and design.

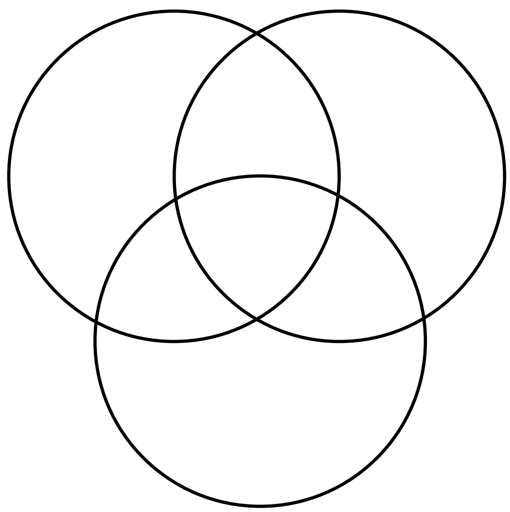
3. Working in pairs, students will complete the Venn Diagram and record their observations.

DISCUSSION QUESTIONS:

1. How are the two planes similar? How are they different?
2. How do lift, thrust, drag, and gravity affect these two planes?
3. Have you ever seen an airplane that is similar in design to the loop and tube planes?

EXTENSIONS:

1. Add a third design for an airplane and a third ring to the Venn Diagram to write comparisons.



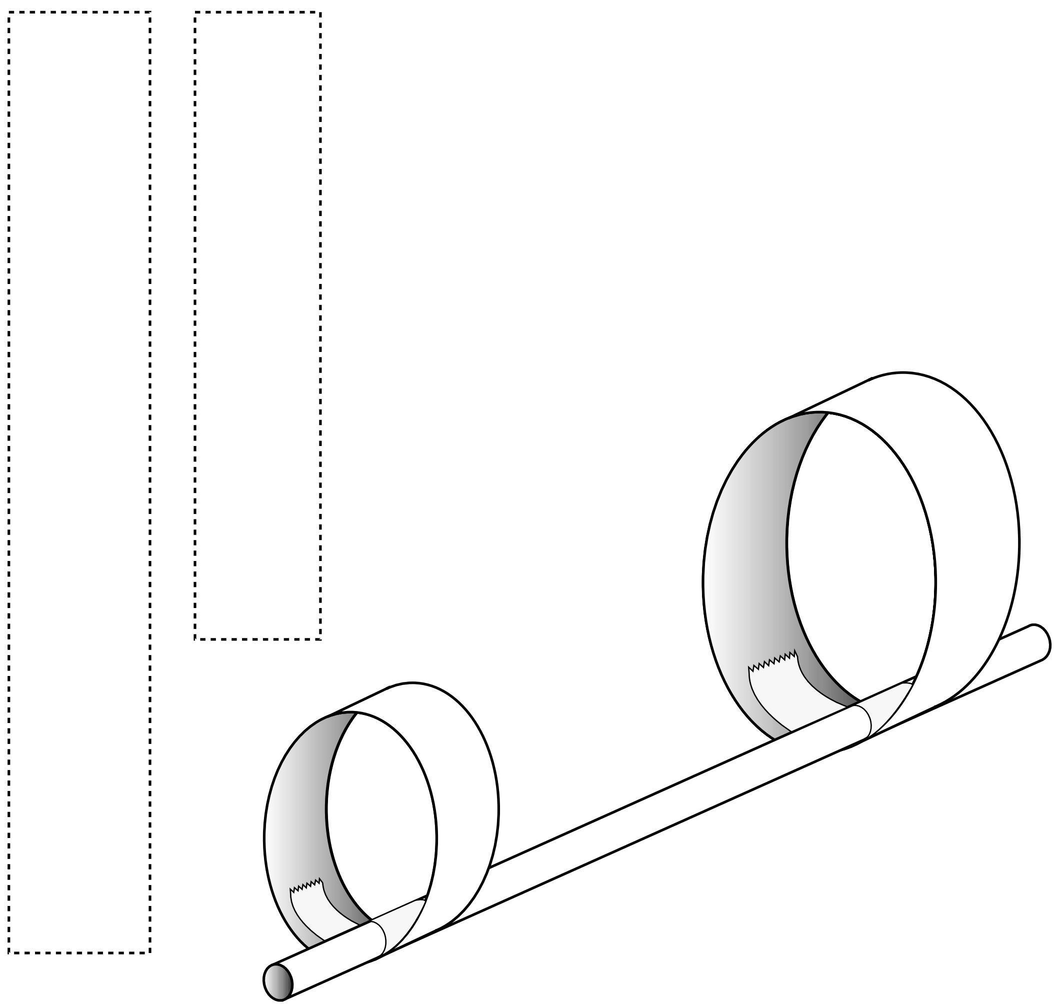
2. What happens if you use different sized tubes instead of a straw, as the loop plane's fuselage?
3. Use different sized sheets of paper to make the tube plane.

CULMINATING ACTIVITY:

Challenge the students to design a plane that uses multiple loops to create lift.

Loop Plane

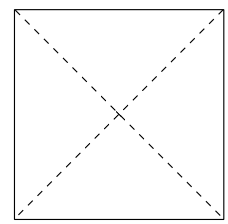
1. Cover both ends of the straw with pieces of tape.
2. Cut out the two loop patterns below.
3. Loop the strips of paper and secure with tape.
4. Tape the small loop to one end of the straw and the large loop to the other end.



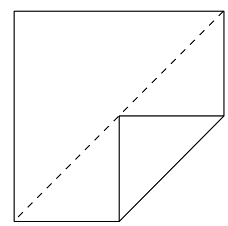
Tube Plane

MATERIALS: 8-1/2 x 8-1/2” paper and scotch tape

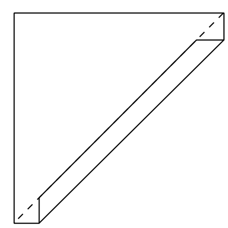
1. Fold the paper diagonally to find the center point.



2. Open the paper and fold one corner to the center point.

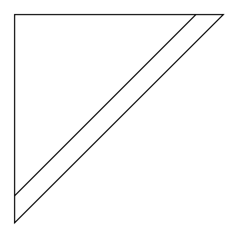


3. Continue folding to the center (1-centimeter folds).

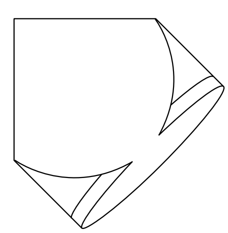


4. Fold once more past the centerline.

5. With the fold up, run the paper over the edge of the table several times to establish a curve. Then tape the overlapped ends.

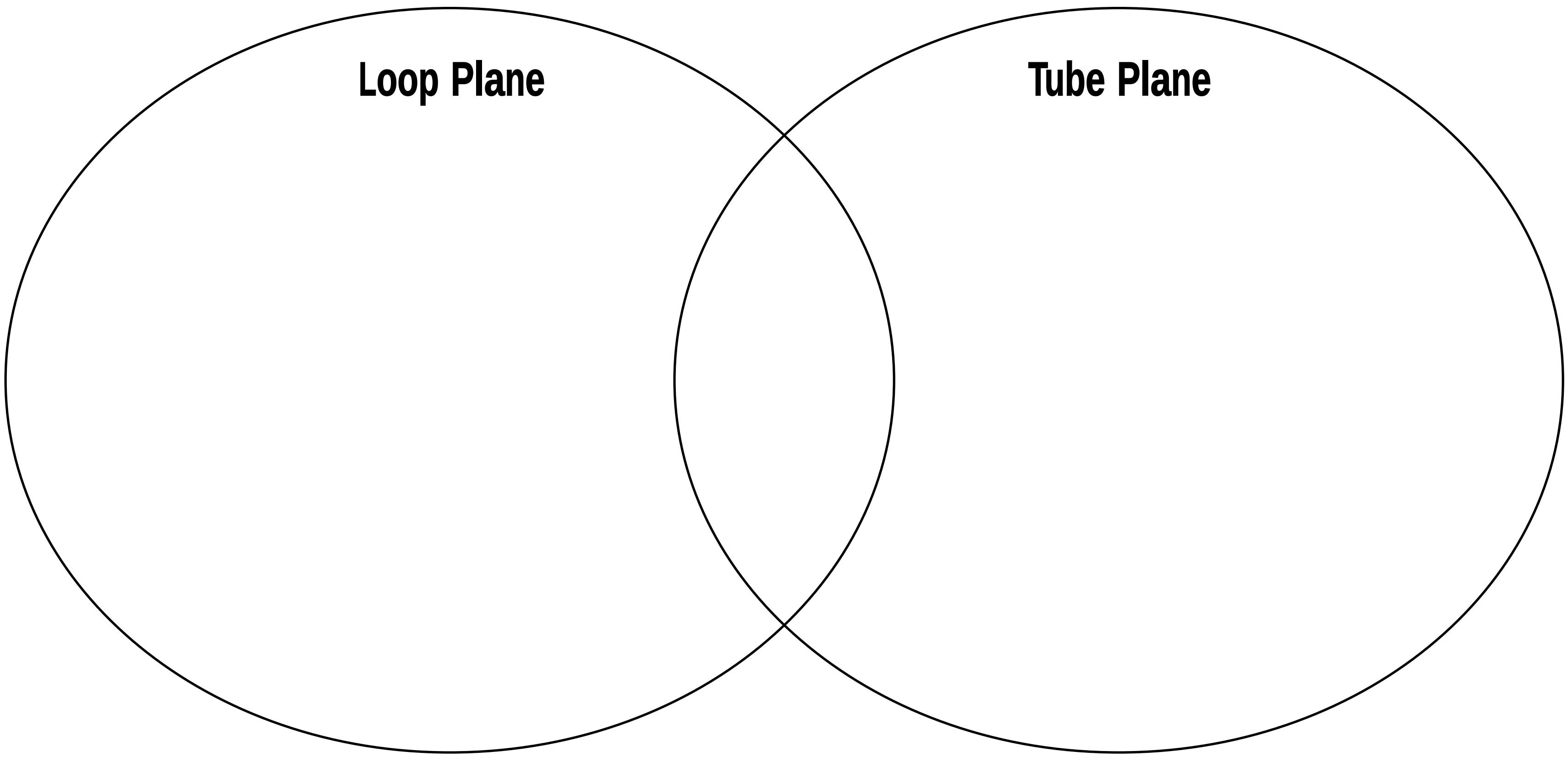


6. Pinch at the folded end and gently toss.

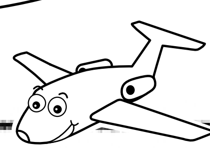


Loop-to-Loop AdVENNtures

Pilots: ______________________



Did You Know?



Did you know: The first flight across the United States was in 1911 by pilot Calbraith Rodgers. The actual flying time was three days and ten hours, although it took him 84 days, landing or crashing his plane 70 times.