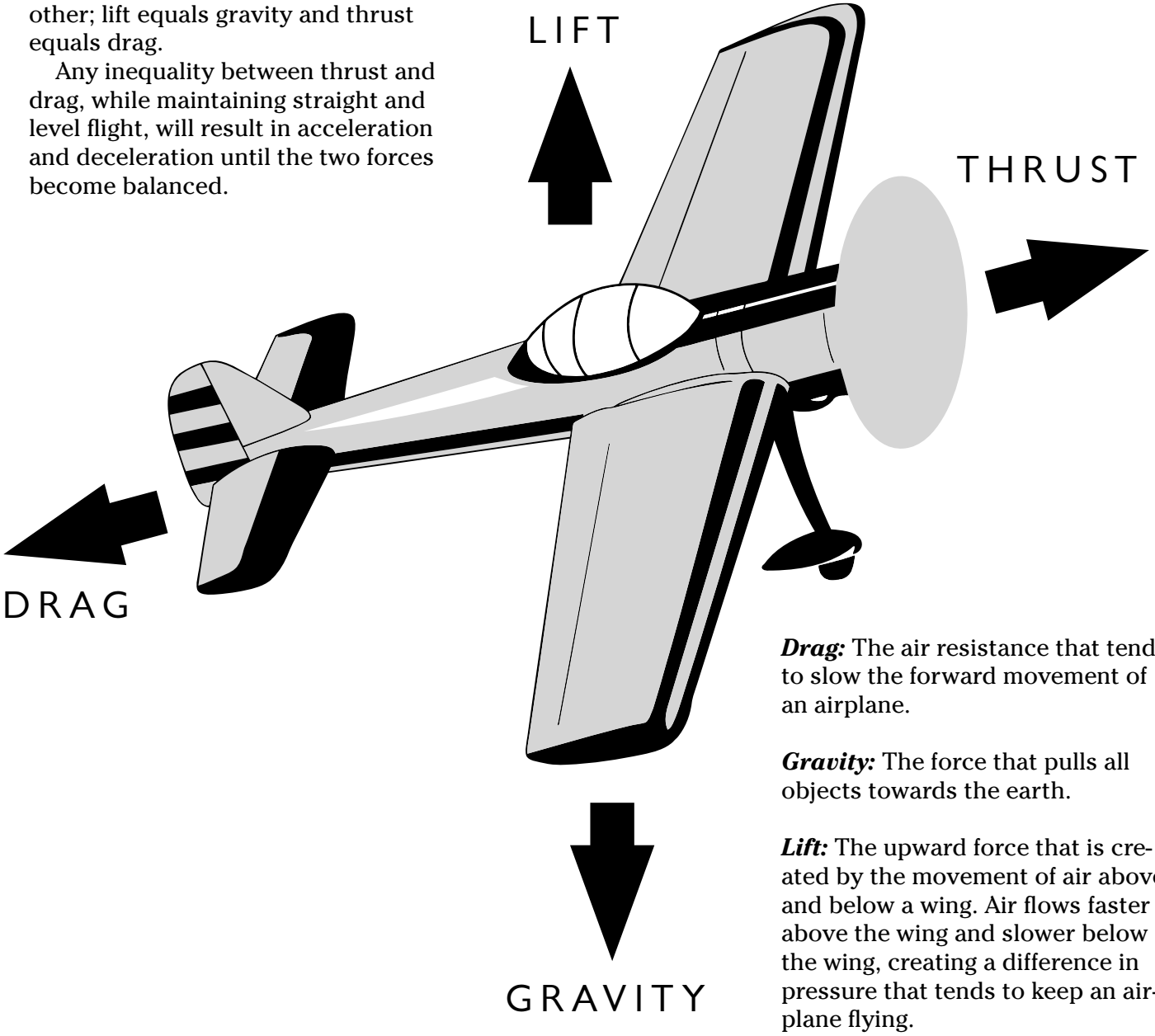
THE FOUR FORCES OF FLIGHT–THRUST

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 and deceleration until the two forces become balanced.



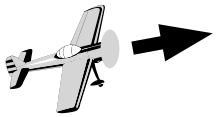
Drag: The air resistance that tends to slow the forward movement of an airplane.

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.

THRUST



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.

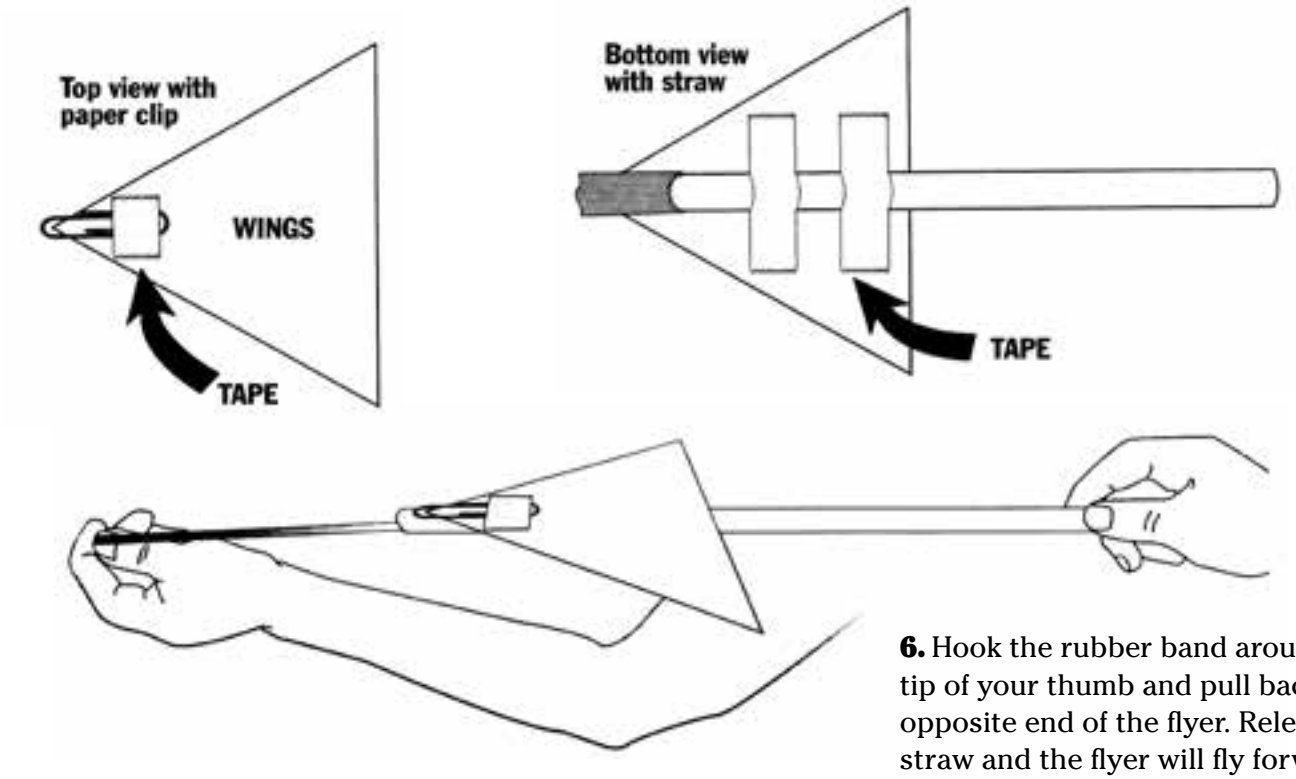
MANAGEMENT:
1. 45-60 minutes
2. Students will build their own flyer.
3. When launching the flyers, form groups of 3 or 4 so that all students are not launching at the same time.
4. This is an outdoor activity.
5. Foamie Flyers must be launched away from other children.
6. Save the unused parts of the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

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

Foamie Flyer

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 lip.



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 the flyer's flight and distance. These observations can be recorded on the Student Data Sheet, Blackline 1.

Foamie Flyer

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 the wings flaps and ailerons into the back of the foam wings and can 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.

Foamie Flyer

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STUDENT DATA SHEET

Foamie Flyer Captain: _____

1. Did the amount of thrust affect the 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?

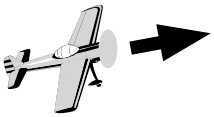
_____

_____

_____

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

THRUST



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 the jets away from each other.

5. Set up a runway using tape measures for the students to launch their jets.

WORD BANK:

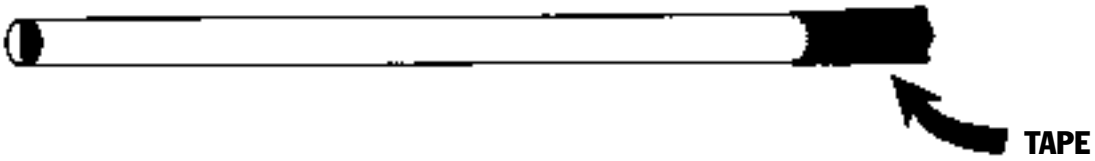
thrust, fuselage, wings, nose, stabilize

Jammin' Jets

PROCEDURE:

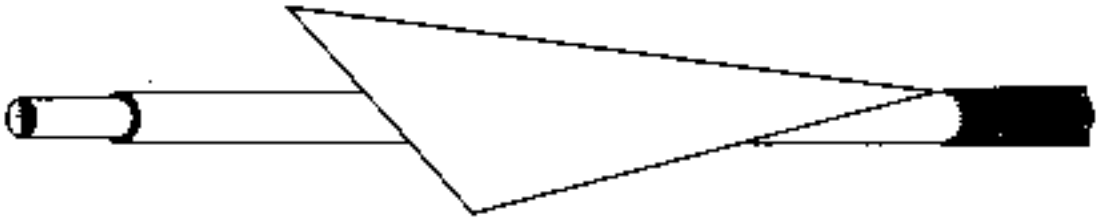
1. Hand out materials to each student.

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.

Jammin' Jets

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.

Jammin' Jets

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 not successful?

_____

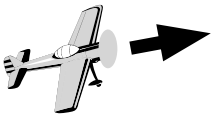
_____

Why do you think these changes were successful?

_____

_____

THRUST



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 always have a designated "balloon blower" so that the same student always inflates the balloon.

WORD BANK:

thrust, average (mean), launch

Balloon Jet

PROCEDURE:

1. Thread the 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 the 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 end 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.

Balloon Jet

DISCUSSION:

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

Balloon Jet

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GROUP DATA SHEET

Pilots: _____

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

The name of our balloon jet is _____.

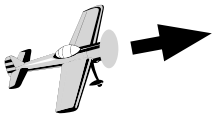
Diagram and label your balloon jet.

	DISTANCE TRAVELED			
BALLOON LENGTH	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE DISTANCE

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

_____

_____

THRUST 

Balloon Jet

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CLASS GRAPH

Pilot: _____

Title: _____

DISTANCE

GROUP _____	GROUP _____	GROUP _____	GROUP _____	GROUP _____	GROUP _____	GROUP _____