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Teacher's Guide

Plankton and Tube's

AMAZING SCIENCE ADVENTURES

PART 5: THE SCIENCE OF FLIGHT

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Produced by:
Mythic Productions

Video Synopsis:

Our two hosts, Professor Peter Plankton and Professor Tess Tube take students on a science field trip to learn all about flight. They begin to look at how air makes flight possible. For thousands of years, humans dreamed of flying, but it isn't as easy as birds make it look. Students learn about lift, gravity, thrust and drag, the four forces that make it possible for an airplane to fly. Our two hosts also examine Bernoulli's Principle, Newton's Third Law of Motion, the Angle of Attack, natural and man-made objects that use airfoils and how a pilot controls his airplane. A Teacher's Guide is included.

Curriculum Connection:

Recommended for the elementary Science curriculum.

Program Objectives:

Students will be able to:

- Identify the four forces of flight:
  - lift
  - weight
  - thrust
  - drag

- Describe the relationships between the forces of lift, weight, thrust and drag that are required for flight;
- Understand Bernoulli's principle;
- Understand Newton's Third Law of Motion;
- Understand angle of attack;
- Identify adaptations that enable birds and insects to fly;
- Recognize that streamlining reduces drag;
- Identify traditional stories of flight told by Canada's First Nations
- Identify various tools used by various cultural groups that incorporate the airfoil design;
- Examine how flight has changed the way people live, work and interact with one another;
- Examine the environmental impact of flight;
- Identify some famous people associated with flight.

Safety Notes

Emphasize the safety precautions you are taking before performing any of the experiments or demonstrations found in this teacher's guide or accompanying video and insist that students only attempt this demonstration under the strict supervision of an adult.

Before beginning any activity;

- Know what is expected
- Prepare a clear work environment
- Wait for permission to start

Safety Tips for you and your students:

1. Read the instructions twice before beginning the activity.

2. Explain the directions in your own words to your partner or team.

3. Get only the materials that are listed.

4. Wear safety goggles (protect eyes, face, hands and body)

5. Follow the instructions one step at a time.

6. If you make a mistake stop and ask for help.

7. Clean your area thoroughly.

8. Tie back all loose and long hair.

9. Don't wear jewelery while conducting eperiments.

10. Keep equipment safe and clean.

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Curriculum Correlations:

NORTHWEST TERRITORIES - Grade 6: Flight

NUNAVUT - Grade 6: Flight

ALBERTA - Grade 6: Flight

SASKATCHEWAN - Grade 6: Principles of Flight

MANITOBA - Grade 6: Cluster 2: Flight

ONTARIO - Grade 6: Flight

QUEBEC - Cycle 3 (Grades 5 & 6): Material World: Forces & Motion

PRINCE EDWARD ISLAND - Grade 6: Physical Science: Flight

NOVA SCOTIA - Grade 6: Physical Science: Flight

NEW BRUSWICK - Grade 6: Physical Science: Flight

NEWFOUNDLAND - Grade 6: Physical Science: Flight

Using the DVD *Flight*

Preview the video *Flight*, and select follow-up activities from this guide to help students understand the scientific concepts presented in this program. Assemble the materials you will need for the experiments you select.

Prior to using this program, consider using McIntyre's related video Properties of Air, which presents related concepts that will help students understand how air is important to flight.

Note that this video is divided into chapters, providing easy access to specific segments of the program as well as allowing you to use short clips to reinforce specific concepts.

Introduction and Concept Development Discussion:

- Discuss the following with your students:
- What is Flight?
- What are some things that can fly (natural and man-made)?
- What were the first things humans made that could fly (from kites to space vehicles)?
- What are the properties of air that make flight possible (things they learned while viewing Properties of Air)?

Vocabulary Development:

Present the words on page 7 to the class, and ask students to volunteer to define any words for which they think they know the meaning. Write keywords from their definitions beside the words. Highlight any words that no one can define with confidence.

Preparing to view the video program;

Explain that you will be viewing a video called "Flight".
Ask students to watch for words from the vocabulary list, especially words that they were unable to define.

During Viewing:

Pause the video after segments that contain explanations for the words that students were unable to define during the vocabulary development exercise. Discuss what they have learned, and replay the segment if it seems to be needed.

Postviewing Discussion:

Review with students what was learned about flight while viewing the video.
Did the program add to their understanding of some of the words they defined before seeing the program?
Add additional keywords to the vocabulary list that was worked on during the introduction.
Ask students to describe the most interesting thing they learned while viewing the video.

Extended Learning Activities:

Assign follow-up activities from this guide to expand the comprehension of the concepts presented in the video.

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Vocabulary List

AERONAUTICS - the science of flight.

AILERONS - they are hinged on the wings and move downward to push the air down and make the wing tilt up.

AIR PRESSURE - the amount of force air exerts on an object.

AIRFOIL - any object (such as the wing of an airplane) whose curved shape is desinged to provide maximum lift.

ANGLE OF ATTACK - the angle of a wing (or kite) to the oncoming airflow. A pilot can control the angle of attack by moving the elevators,

BERNOULLI'S PRINCIPLE - the law stating that the faster air oves, the less pressure it exerts.

COMPRESSED - pushed or squeezed into a smaller space.

DRAG - the force that resists movment.

ELEVATORS - are found at the rear of the plane. They can be raised or lowered to change the direction of the plane's nose. The plane will go up or down depending on the direction of that the elevators are moved.

FLIGHT - the ability to fly.

FORCE - a push or pull that makes an object move or change direction when in motion.

FLUID - matter (liquids and gases) that flows.

GRAVITY - the force which pulls objects towards Earth's surface.

LIFT - the upward force that enables objects to fly.

MASS - a measurement of matter.

NEWTON'S THIRD LAW - the law stating that for every action, there is an equal and opposite reaction.

PITCH - Pitch is to make a plane descend or climb. The pilot adjusts the elevators on the tail to make a plane descend or climb. Lowering the elevators caused the airplane's nose to drop, sending the plane into a down. Raising the elevators causes the airplane to climb.

PRINCIPLE - a basic law about the way things work.

ROLL - To roll the plane to the right or left, the ailerons are raised on one wing and lowered on the other. The wing with the lowered aileron rises while the wing with the raised aileron drops.

RUDDER - The rudder is found on the tail of the plane. Moving it right and left controls the left and right movements of the plane.

THRUST - the force that moves a plane forward through the air. In airplanes, thrust is created by a propeller or a jet engine.

YAW - Yaw is the turning of a plane. When the rudder is turned to one side, the airplane moves left or right. The airplane's nose is pointed in the same direction as the direction of the rudder. The rudder and the ailerons are used together to make a turn.

Key concepts of air and flight

The activities in this guide are designed to explore the following key concepts:

Easy concepts:

- Air is all around us.
- Wind is moving air.
- Air fills up spaces if allowed.
- Air can push or cause pressure on things.
- Air slows down falling objects such as paper, balls and parachutes.
- The shape and size of an object affects the nature of airflow around it, hence the air resistance.
- Planes and other flying things are held up by the force of air on their wings.

More advanced concepts:

- Air in the atmosphere exerts a pressure in all directions.
- The atmosphere can exert a surprisingly strong force on objects.
- 'Sucking' reduces pressure, causing a force imbalance towards the low-pressure region.
- The pressure of air is used in many applications (tires, hoists, etc.).
- Air pressure differences tend to equalise.
- A moving stream of air has reduced pressure.
- Air has weight.
- Air expands on heating, causing a pressure increase if it is contained.
- Hot air is less dense (or more spread out) than cold air, and rises.
- Air consists of a mixture of gases, one of which (O2, dioxide) is necessaryfor burning.
- Objects can be shaped to either minimise or maximise the force of air on them.
- A flat object such as a plane wing, a boomerang or a paper tube can be supported by forces that arise due to differences in airflow across the top and bottom surfaces.
- To every action there is an equal and opposite reaction: a stream of air (or water) forced from a balloon or rocket will cause a force back on the balloon or rocket to propel it.
- The force from air on a moving object depends on the surface area, and the shape of the object.
- Wind is moving air.

Properties of Air:

- Air has weight.
- Air takes up space.
- Air presses on things.
- Air can be compressed.
- Air resists things moving through it.
- Air expands when heated.
- Air has insulating quality.

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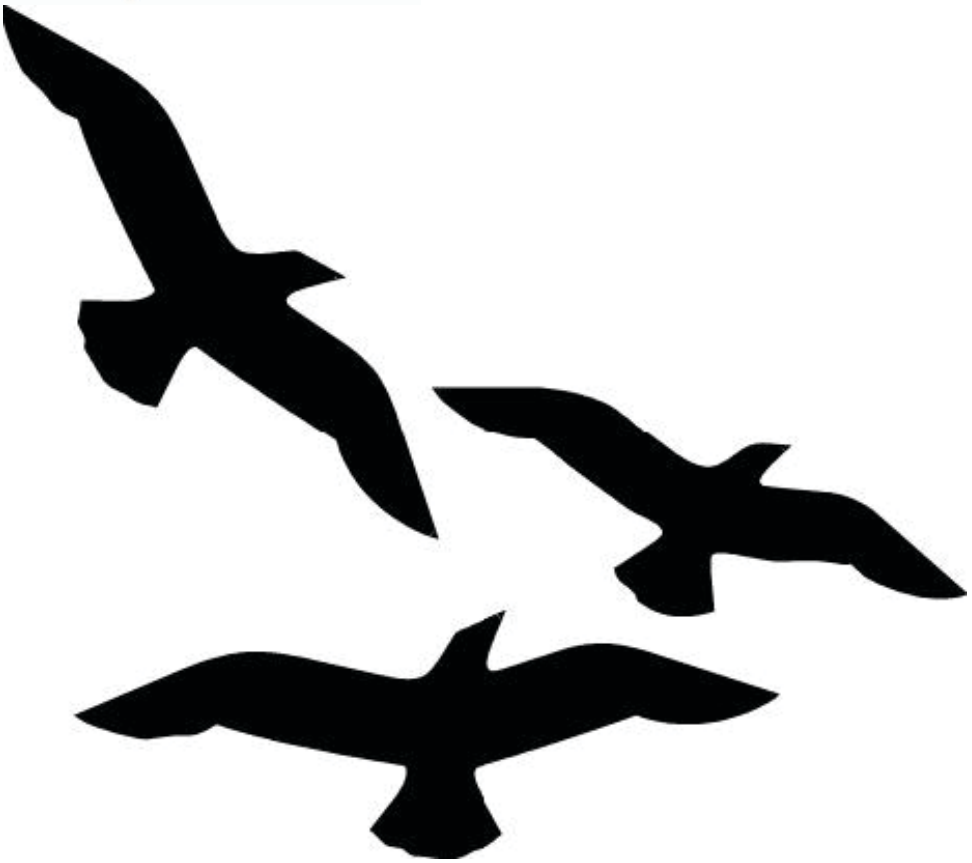
Flight



Activity #1 - What makes a plane go up?

Teacher Text:

What makes a plane go up? Air. A plane flies through the air by continually pushing and pulling the surrounding air downward. In response to the force of moving the air down, the air pushes the airplane upward. Newton's 3rd law of motion states that for every action there is an equal and opposite re-action. An airplane wing is shaped so that the air is deflected downward as the wing passes. Because air is a fluid (a gas), both the top and the bottom surface of the wing deflect the air. The faster an airplane travels the more lift is generated. Inclining the wing to the wind also produces more deflection and more lift. The wings of an airplane have adjustable flaps that can be extended or retracted. When extended, the flaps increase the deflection of the air and provide greater lift for takeoff and landing.

As it flies, a plane is in the center of four forces. **Lift** (upward force) and **thrust** (forward push, provided by a propeller) get a plane into the air. **Gravity** and **drag** (air resistance, which is friction caused by air rubbing against the plane) try to pull the plane down and slow its speed. A plane must be built so that lift and thrust are stronger than the pull of gravity and drag by just the right amount. Lift from the wings is used to overcome the force of gravity. Shape is important in overcoming drag. For example, the nose of a plane is rounded so it can push through the air more easily. The front edge of each wing is rounded too. An airplane built like a railroad boxcar just wouldn't fly very well.

Beginning Activity: Have students watch the video, "Flight".

1. Students will work with a partner to list what they know about the force of air helping an airplane fly. Use Activity #1 Worksheet - The Four Forces of Flight on page 11 and 12.

2. Students will share with the whole class and teacher will compile information on class chart.

3. Teacher will elicit responses about what we know about how the force of air helps an airplane fly, and record.

4. Teacher will give vocabulary words to students and they will look them up in an appropriate source. Definitions will be written in student science log or journal.

5. Teacher will use "What makes a plane go up?" - above article - and discuss the elements of force (drag, lift, thrust, gravity).

Evaluation: The students will be able to accurately use vocabulary terms in context. (drag, lift, thrust, gravity, aerodynamics.)

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Activity #1 Worksheet - The Four Forces of Flight

Name _____ Date _____

What do I know about FLIGHT?

_____

_____

_____

_____

_____

_____

How does a heavy airplane stay up in the air?

_____

_____

_____

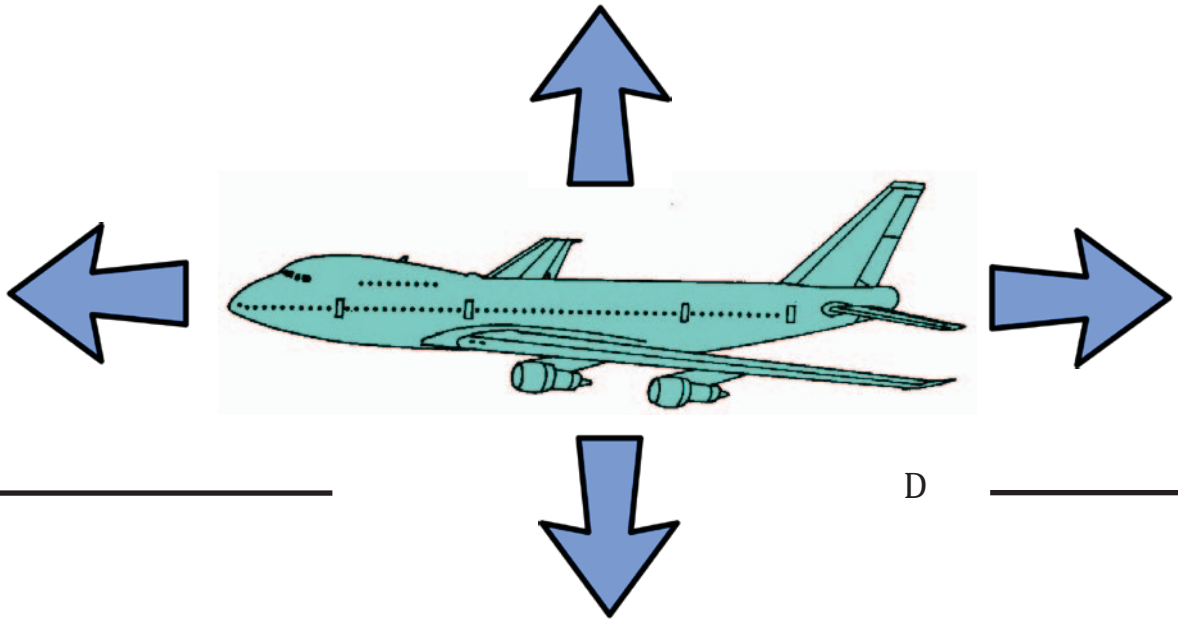
_____

_____

_____

Activity #1 - Worksheet #2: The Four Forces that act on a Plane

A _____



B _____

D _____

C _____

Discuss the following terms.

Drag - Lift - Thrust - Weight

Fill in the blank with the appropriate term. Label the airplane.

A _____ is the force caused by the rush of air around the wings, supporting the airplane in flight.

B _____ is the force of the engine that drives an airplane forward.

C _____ is the force that pulls an aircraft towards the centre of the earth.

D _____ is the force that slows down an airplane as it flies through the air.

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Activity #2: Demonstrate Flight with Paper Airplanes

Objective: Students will measure the distance and duration of fight .

Approximate time: 45 minutes.

Key ideas: Air moving across wings can cause an uplift force. The shape of wings and balance of weight can be manipulated to control the flight. The shape of a flying object affects the air resistance on it.

Materials: Sheets of 8 1/2 x 11 paper; paperclips; stop watch that measures seconds; measuring tape.

Using the instructions on page 14, make a paper plane that:

- stays as long as possible in the air
- does spectacular tricks.

You may want to investigate the effect of paperclip weights, wing size, flaps, etc.

Try some different designs.

1. Predict what will happen when you launch The Dart. Use Science Lab Observation Form (on page 15)

Go into the hallway outisde your classroom.

2. Launch the Dart by holding it at the back of the keel and throwing. How long does the Dart stay in the air? How far can you throw it?

3. Observe and record observations on the Science Lab Observation Form.

4. Discuss ways in which your planes could be altered. What effect will each variable have on the flight of the plane? (Add paper clip to nose, fold elevators down)

5. Try flying your plane with these new design adaptions and record your observations. Put data in a table.

6. Closure: Discuss what changes were made and what effect they had on the flight time and distance.

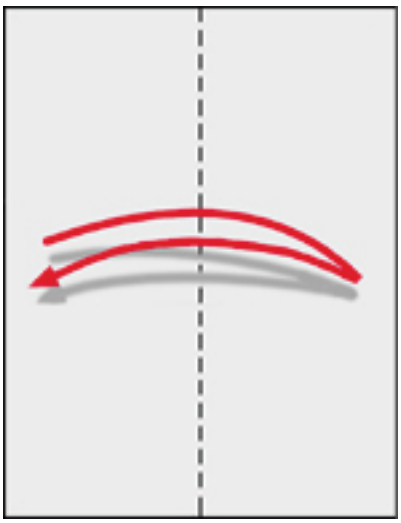
Extension Activity: Graph results using a computer program or =spreadsheet.

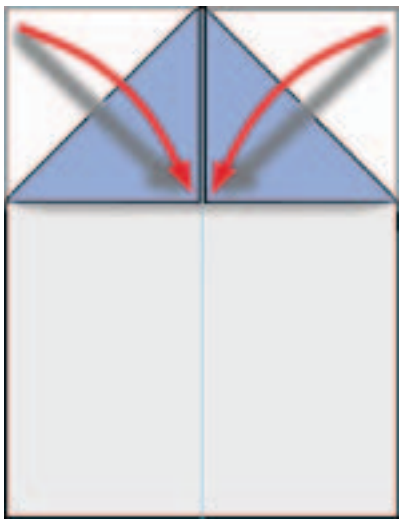
Sample Chart

Name of Plane

Launch	Time aloft (sec)	Distance cms	Changes made to plane
1	1.5	115	none
2	2.0	75	added a paper clip to nose
3	.25	38	elevators down
4	2.5	102	added paper clip to nose & elevators down

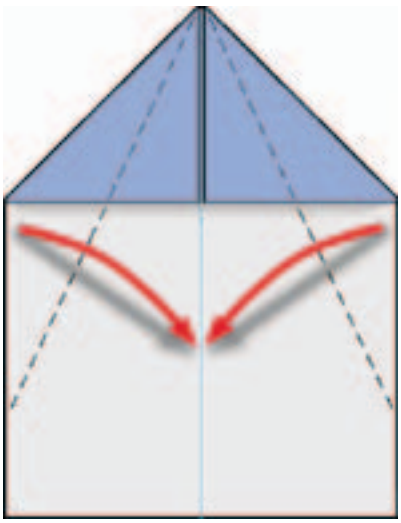
Activity #2 Worksheet - Basic Dart Plane Folding Instructions

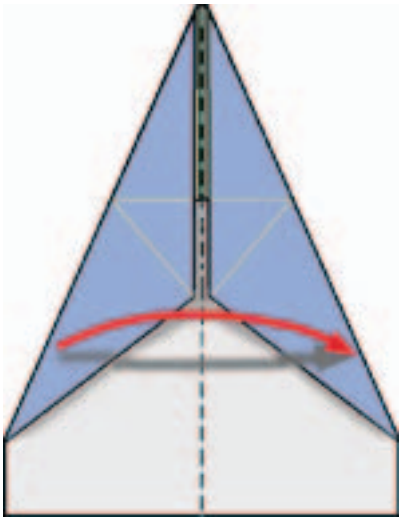




Step 1.
Use a sheet of 81/2-by-11 inch paper. Fold the paper in half lengthwise and run thumbnail along the fold to crease it sharply. Now, unfold the paper.

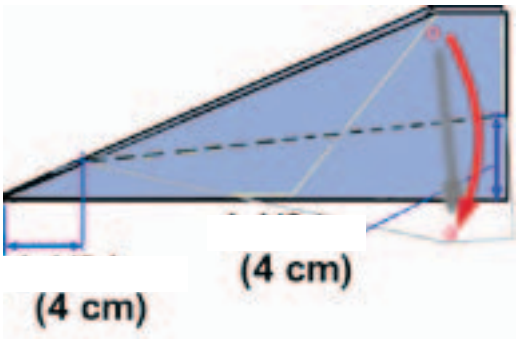
Step 2
Fold down the top corners as indicated by the arrows.

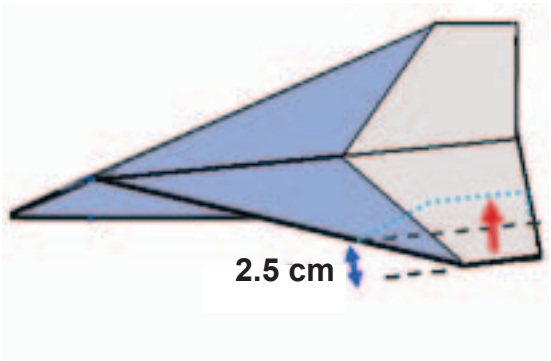




Step 3
Fold the two edges toward the center line, as indicated.

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.

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Activity #2: Science Lab Observation Form

Scientist _____ Date _____

Procedure - This is what I will do.

_____

_____

_____

Prediction - This is what I think will happen.

_____

_____

_____

Observation - This is what I saw happen.

_____

_____

_____

Evaluation - This is why I think it happened, and this is what I learned.

_____

_____

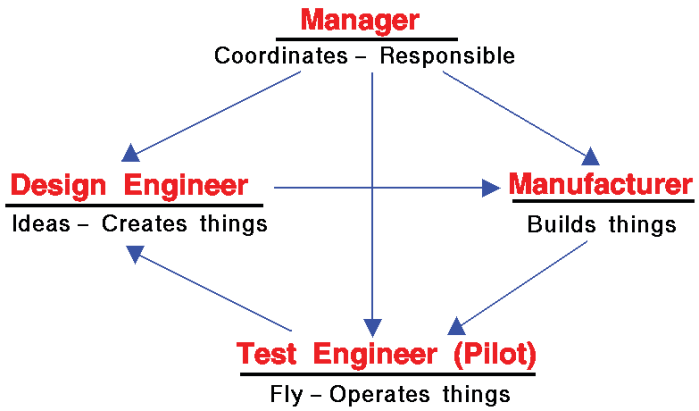
_____

Activity #3: Group Activity - Aerospace Teamwork

The Canadian Space Agency requires a new paper glider aircraft for its Visitor Centre student projects area. Using the four forces of flight that you have learned about, design and build something that flies. The aircraft are to be hand launched with no other external or internal source of power. The aircraft is to be optimized for time aoft, not speed or distance travelled. The aircraft is to be contstructed from a single, 8 1/2 x 11 sheet of paper.

To make things interesting, the students are organized into groups (companies) which must produce one airplane per group in a short time (30 minutes). The groups "fly-off" against each other in a competition to see who can keep their plane in the air the longest. After the fly-off, the fun begins with a discussion with all the companies. This discussion is guided by the teacher and runs for the duration of the exercise.

The emphasis of the activity is not on the aerodynamics of their gliders or who wins the contest, but on the process that produced the plane. There are several variations on the basic game which are used to make things more interesting. Divide the class into groups of four and give them enough resources that everybody can make their own plane, but ask for only one plane from each group. The discussion then becomes one of evaluating how they chose the one design and the team dynamics. Appoint manager, design team, manufacturer, and test (pilot) positions, to clearly define the roles of each, and to enforce boundaries (managers can't fold paper .. manufacturers can't fly). This emphasizes the process of communication within a team.



In the discussions it is important to point out that the problems they encounter (time scheduling, bias, authority, communications, personalities .. etc) are all things that engineers face on the job every day. Solving these problems are every bit as important as solving differential equations, and the problem solving skills are learned in school, at home, and at their jobs. There's much more to aerospace than airplanes and rockets.

Rules:

- Form your design team.
- In 30 minutes, produce a single paper airplane.
- Team whose aircraft stays aloft for the longest time wins the competition. Average time of 2 demonstration flights.
- Select a pilot to demonstate your aircraft.

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Manager Tasks:
- Keep team focused and on-schedule
- Resolve any conflicts
- Communicate with team members
- You are repsonsible for everything in your company.
- Do NOT fly, design or build.

Design Engineer Tasks
- Follow the directions of the manager
- Design aircraft and communicate design to the manufacturer.
- Refine your design based on input from pilot or test engineer.
- Do NOT build. Do NOT fly.

Manufacturer Tasks
- Follow the directions of the manager
- Construct the aircraft based on input from the design engineer and provide aircraft to the test engineer or pilot
- Modify the aircraft based on input from the test engineer/pilot and design engineer,
- Produce the final aircraft isng a single sheet of paper
- Do NOT design. Do NOT fly.

Test Enginner/Pilot Tasks
- Follow the directions of the manager
- Test fly the aircraft produced by the maufacturer
- Communicate your findings to the design engineer.
- Do NOT modify the aircraft.
- Fly the final competition.

Questions:

How did your team arrive at a design? Did you consider more than one design?

Did your team have a leader? How was that person selected?

Did everyone participate in the design process? How did you feel about the process?

Did you feel constrained or pressured by the time limit? By the paper limit?

Did you worry about what other teams were designing?

How did your team arrive at a design?

Did you work together on a design?, or, did you work individually?

Did you share information with your fellow team members?

Activity #4: Drag and Lift Experiment

Aerodynamics is the study of the forces acting on an object due to air, or some other fluid, moving past it. Aerodynamic forces act upon airplanes, sailboats, and other objects moving through the air, thereby affecting the motion of those objects.

Objective: The student will experience the force of drag, the reduction of drag, and the force of lift in this experiment. In this activity, the student will hold up a large cardboard when the wind or a fan blows. When the student holds up the cardboard they will feel the large force of drag. Then the student will turn the cardboard sideways and the drag will be reduced. And when the student tilts the board they will feel the lift.

Materials: Pieces of cardboard 50 cm x 75 cm (20 x 30 inches); Other size cardboard pieces; fan (optional)

Teacher Text:

Engineers must use aerodynamic principles when designing all airplanes. It is also necessary for architects of sky scrapers and bridges to understand aerodynamic forces because air flowing past stationary structures also exerts pressure upon them. Aerodynamic forces are also important to designers of cars, submarines, pumps, automobile carburetors, and gas and water turbines because moving fluids affects each in their own way.

There are two basic aerodynamic forces: lift and drag. But these alone cannot produce flight. Movement is necessary; but it doesn't matter what moves. Lift enables an airplane, or other object, to climb into the air and remain aloft during flight. For example, an object held flat against a stream of air, is pushed backward. However, if the object is rotated forward toward the ground, the air can now push it up as well as back.

Lift is produced by the motion of an airfoil, or wing, moving through the air. The special shape, or camber (the curved upper surface and a straight or less curved under surface), of the airfoil is what produces a change in air pressure above the wing by deflecting or turning the air. As the airfoil moves through the air, air goes above and below.

Another way of understanding the deflection of air by an airfoil, is by applying Newton's Third Law of Motion. The airfoil deflects the air going over the upper surface downward as it leaves the trailing edge of the wing. When the wing is at an angle, this deflection is even greater. According to Newton's Law, for every action there is an equal, but opposite reaction. Therefore, if the airfoil deflects the air down, the resulting opposite reaction is an upward push. Deflection is an important source of lift. There are some planes that do not have cambered wings. Their wings are flat and are designed to fly at very high speeds. These planes get lift only by deflection. Planes flying upside down, even with cambered wings, can deflect enough air to get lift.

Drag is the second aerodynamic force. It resists the forward motion of any object: airplane, car truck, boat, fish, or bird. The shape of the object determines the amount of drag which is produced. Objects that are streamlined produce the least amount of drag. Streamlining has additional advantages of reduced engine power necessary for movement, less fuel required, and overall increased performance and maneuverability of objects in motion. However, not all drag is detrimental.

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Procedure:

Discuss with the students the aerodynamic basics of lift and drag.

On a windy day, or using a large fan have each student hold a piece of cardboard so that the wind blows against the flat side. You can feel the large force of drag.

Next have the students hold the cardboard with the edge facing the wind. In which case is the drag greatest? In step 2 or 3? Do you see any connection between area and drag?

Now tilt the cardboard and feel the lift.

Then experiment with different sizes of cardboard.

The students can also fold a piece of cardboard into different shapes and experiment until they find a shape that resembles an airplane (a shape that seems to offer the least resistance to the wind).

Questions:

Wrap up the experiment with a discussion with the students and what they have experienced about drag and lift.

Explanation:

Look at an airplane wing from the edge. You see a shape in which the top of the wing is quite curved. When in flight the position of the wing is set at an angle so that air hits the bottom of the wing. The moving air then creates a high pressure under the wing. A pressure difference with a lower pressure on top and a greater pressure below creates the net upward force of lift on the wing. The lift of a wing can be increased by tilting it upward at an angle to the air flow. This gives the wing a greater angle of attack. There is an angle of attack (usually about 18 degrees) at which lift is greatest. If the angle of attack is made too large, the air will no longer flow smoothly over the wing and lift will become less. The other force acting on a wing from the flow of air is drag. The drag acts to slow the speed of the wing through the air. If there were no drag, an aircraft could just keep going faster and faster. A flat wing, like one you would make for a paper airplane, can create lift if given some angle of attack. It will have greater drag for the same amount of lift than a properly curved wing.

Activity #5: Thrust

Teacher Text:

Thrust is the force that pushes an airplane forward and allows enough air to run above and below the wing in order to create lift. Developing thrust was the final hurdle for the early pioneers of flight in getting aircraft off the ground. Thrust is the force that opposes drag and can be achieved be either pulling or pushing the airplane in a forward direction.

Without an engine, airplanes are unable to produce their own thrust. Planes without engines are called gliders, sailplanes, or hang gliders. These engine-less planes are able to glide if there are special upward winds called thermals or if the plane gets a tow to a higher altitude by an engine-powered airplane. Thrust can be produced in a number of ways. Birds, bats, and insects flap their wings and sharks swing their tails to create thrust. The four main ways modern airplanes produce thrust are propellers, rockets, jet turbine engines, and ramjet engines.

Propeller: A propeller is made of rotating blades, each one shaped like an airfoil. The rotating blades convert the engine's power into forward thrust. Propellers can push or pull the aircraft along, depending on how the blades are angled and which direction the propeller is turning.

Rocket: A rocket engine is the only engine type that does not require outside air to operate. Rocket engines burn a fuel to create thrust, pushing hot exhaust out a nozzle at the back of the engine. Rockets can even operate in space, where there is no air at all!

Jet Turbine: Jet turbine engines push air through the blades of a spinning turbine, which compresses the air. Fuel is then combined with the air and ignited. When the fuel burns, it rapidly expands from liquid to a gas and is forced out the rear of the engine. As the gas is forced out the back of the engine, the airplane is pushed forward.

Ramjet: A ramjet engine is similar to a jet turbine, except it has no moving parts. Ramjets only work after the aircraft is already moving quickly, so the aircraft initially needs another source of thrust. Once the aircraft is moving quickly, air is forced into the front opening of the engine at a high speed, which compresses the air. Inside the engine, fuel is injected, mixed with the compressed air, and ignited. As the fuel burns, the exhaust explodes out the nozzle at the rear of the engine, which creates thrust. Ramjet engines are usually lighter than jet turbine engines, which makes them ideal for supersonic fl ight. Ramjet engines are also used for missiles and some types of space craft.

Have students complete the experiment - Balloon Thruster Challenge - found on page 21.

http://www.legendsofflightfilm.com/resources/downloads/Teacher_Guide_4-8_Web.pdf

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Activity #5: Balloon Thruster Challenge

Students are challenged to design a balloon thruster that can travel a certain distance in the shortest amount of time. Divide students into groups of 3 to 5.

Materials: (per team of students)

- 10 Drinking straws
- 1 Pair of scissors
- 1 or more 4 meter lengths of string, floss, ribbon, and/or fishing line
- 5 Balloons (different sizes and shapes)
- 2 Chairs the same size
- 1 Roll of cellophane tape
- 1 Sheet of poster paper
- Markers
- 1 Stop watch or clock with second hand
- 1 Tape measure

Time: 30 to 40 minutes

Procedure:

The Challenge

Find the combination of balloon shape, string type, and straw length that moves the balloon thruster from one chair to the other in the shortest amount of time.

Plan and Predict

1. In a team of three to five, fold the poster paper into three columns and label the columns: Plan, Predictions and Results.

2. Review the Design Set-Up section for the background you need to plan your design and make your predictions.

3. Develop a plan to meet the challenge and predict your results. Record your plan and predictions in the columns on the poster and provide explanations for your reasoning.

Test

4. Once planning is complete, test your design.

- Inflate the balloon and hold the neck of the balloon closed.
- Slide the Balloon Thruster so that it is pushed against the "start" chair.
- Release the neck of the balloon and time how long it takes for it to reach the other chair.

5. Make adjustments or improvements to your design, as needed, using the extra materials. Record all of your adjustments on your poster paper.

6. Test your improved design and make improvements until you are satisfied.

7. Share your poster with the entire class before running the final trials.

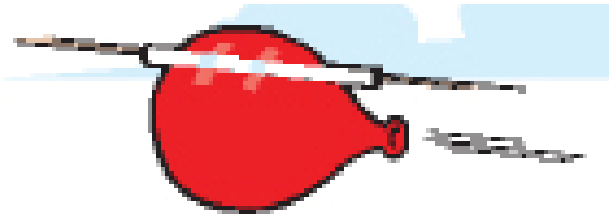
Final Trials

8. Run the final trials as either a race between all teams at the same time using multiple tracks, or as time trials where everyone watches while each team runs their best-tested design.

Design Parameters

These are the guidelines for designing your investigation:

- Set two chairs 3 metres apart with the backs facing each other.
- Thread the straw onto whatever stringing material you chose for your track (string, floss, ribbon, or fishing line).
- Tie or tape your track to the back of the chairs in order to create a level track for the balloon thruster.



- Tape the balloon to the straw.

Results:

The results will depend on the teams' unique designs. Why? Newton's Third Law of Motion states that for every action, there must be an equal and opposite reaction. In this scenario, the action is when the opened balloon pushes the air out the back of the balloon. The reaction is when the air pushes the balloon forward, which creates thrust and moves the balloon along the track.

Assessment:

Are students able to provide an explanation for why one design was faster than the others? Encourage students to use data evidence to support their reasoning.

Activity #6: The Bernoulli Principle

Teacher Text:

In this lesson your students will conduct a series of hands-on experiments (see pages 25 & 26) that will help them to understand the role of lift in flight. Students will observe the flow of air and water around several surfaces and then consider the dynamics of airflow around an aircraft wing.

You may wish to begin the activity by telling your students that, although air is invisible to the human eye, it is made up of physical matter--real "stuff." This means that air exerts a force that helps to keep an airplane up in the air.

A force is a push or a pull. It affects the way things move. Forces can make objects speed up, slow down, stop or change direction. Forces can occur naturally, such as gravity, or they can be produced by people or machines.

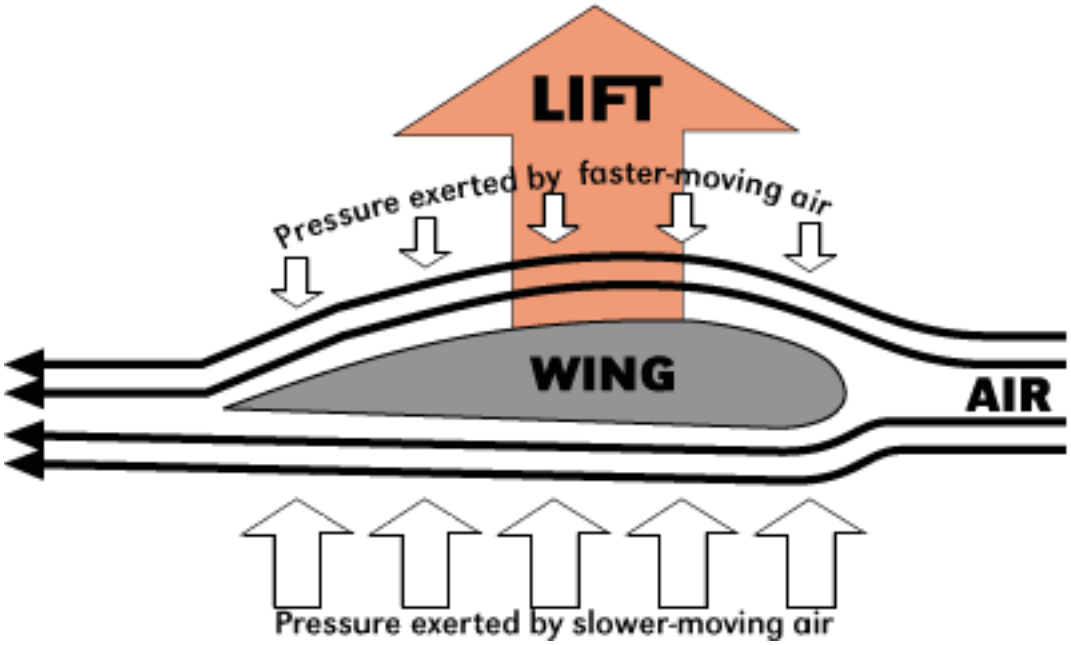
Forces act in particular directions, and they always act in pairs. Whenever an object pushes another, the object also pushes back. If these forces are balanced, as in a floating object, then the object at rest will stay still. If the forces are unbalanced, the object can speed up, slow down or change direction.

To achieve flight, there must be four forces in play.

Drag is the force that slows the flying device, gravity is the force that pulls it towards earth, thrust is the force that propels, and lift is the force that keeps it up in the air.

If a plane is moving forward, it means that thrust is overcoming drag. If a plane is climbing, the force of lift is greater than the force of weight. If a plane is descending, weight is greater than lift.

Tell your students that the experiments in this lesson will demonstrate what Swiss mathematician Daniel Bernoulli discovered in the early 1700s: When flowing air or water changes speed, its pressure also changes.



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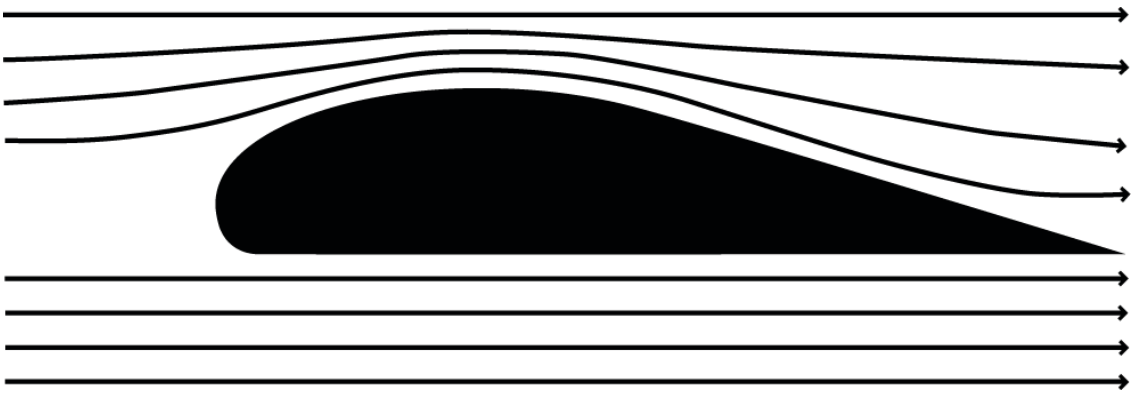
What's a Bernoulli? (pronounced Ber-noo-lee)

Eighteenth-century Swiss mathematician Daniel Bernoulli discovered an important principle. Bernoulli found that when a fluid (such as moving air) changes speed, its pressure also changes. Airplane wings are specially designed to take advantage of this.

Wings are designed so the air moving over the top of the wing is forced to speed up more than the air moving below the wing.Why does the air speed up? An airplane's wing is an obstacle to the oncoming air. As the air meets the wing, its path narrows. But the amount of air moving past remains the same. Think of water moving past rocks in a creek. The rocks are an obstacle that narrows the path of the flowing water. But the amount of water that must pass by remains the same. The flowing water speeds up as its path narrows around the rocks.

Bernoulli's principle: fast moving air exerts less pressure than slow moving air.

Wings have an airfoil shape. What is an airfoil?



Airfoil is the name for the special shape of airplane wings. Wings come in different shapes and sizes, but a wing's airfoil shape—like a teardrop on its side—is always designed to create lift. An airplane wing is designed so air flows faster over the wing than it does beneath the wing.

With each activity, ask your students to consider what is going on.

- Is air slowing down or speeding up?
- How might air pressure be changing?
- How might the flow of air (and its changing pressure) help to keep an aircraft up in the air?

Direct your students to the "Use Your Lips to Levitate" and "Balloons That Boggle" activities on page 25. What happens when air is blown over the paper or between the balloons? Ask students what they think causes the paper and balloons to move.

After your students have finished the activities, direct them to the "What's Going On? The Simple Explanation" section. You may wish to have several students alternately read this section aloud.) Use the questions in the text as the basis for a class discussion. Be sure that students understand that air loses pressure when it speeds up.

Conclude the activity by reinforcing these important concepts:

1. Air speeds up as it moves around an object.
2. When air moves faster, its pressure drops and it pushes less.
3. When an airplane flies, air speeds up more above the wing than below it. As a result, the air above an airplane wing pushes less than the air below the wing. The higher pressure below the wing pushes the wing (and the airplane) up.

Air behaves the same way as it rushes over and under an airplane wing. The curved upper surface onstricts the flow of air more than the flatter lower surface, causing the air above the wing to speed up more than the air below. And as Bernoulli discovered, when air speeds up, its pressure lowers. The faster the air speeds up, the lower its pressure becomes. So the faster moving air above has less pressure than the slower moving air below. The higher air pressure below pushes the wing up.

Many factors affect lift.

The size and shape of an airplane's wings,
The angle at which the wings meet the oncoming air,
The speed at which an airplane moves through the air, and
even the density of the air all affect the amount of lift a wing creates.

How can an airplane fly upside down? Wing tilt is the trick. Tilting the upside-down wing upward forces the air traveling over the wing to speed up more than the air passing beneath the wing. The difference in air pressure results in lift.

What's not going on?

A common explanation of lift states that air moves faster over a wing's curved upper surface because it has farther to travel than air moving under the flatter lower surface. This explanation is wrong! It assumes that a volume of air separated by the wing's forward edge must meet again at the rear edge, but that doesn't necessarily occur.

Did You Know?

Canada Geese have the right idea when it comes to flying. They fly in a V-shaped formation that allows them to get lift from air currents coming off the wing tips of the bird flying ahead. In the V formation, the geese can fly up to 71 percent farther than if they flew alone!

Early aircraft had airfoils that were inspired by the wings of birds and fins of sharks. The profile of the albatross' wing shows the familiar shape of an airfoil. The bird can use its muscles to adjust the angle of its wings, either increasing or decreasing the amount of lift that it wants. Even the most modern airplanes are not able to do that…yet.

The powerful swing of a shark's rear caudal fin propels the shark forward through the water. To keep its head from dropping, the shark's wing-like pectoral fi n generates lift and keeps the shark's body on a horizontal plane.

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Bernoulli Brain Teasers

To pilots, lift means the way that air holds up airplanes and other flying objects. These activities will show you how this force works--and they don't require a pilot's license.

Experiment #1: Use Your Lips to Levitate

Materials: Piece of paper (approx 5 cm x 20 cm)

Hold a piece of paper between your thumb and forefinger, as shown in the picture. Now blow over the paper. What happens?

Experiment #2: Balloons That Boggle

Materials: Same-size balloons; string

Blow up two balloons and tie each one to a string. Hold the balloons 10 centimetres apart and blow between them. Can you do it? What happens?

What's Going on? The Simple Explanation:

Air is pretty pushy stuff. It never pulls or sucks; it pushes. Air is pushing on you right now from every direction. We're so used to air being around us that we often don't notice it. This constant push of air is called air pressure. It allows us to breathe - not a bad thing! Now think about what was happening in the activities you just finished.

Why did the balloons come together when you blew between them? Why did the paper lift up when you blew over it? Air must be pushing these things, but how?

Even before you blew at the balloons, they were surrounded by air pressure. If you tried blowing between them, you disturbed this push in a very special way. How?

Think about this: Either the air between has stopped pushing as hard or the air on the outer sides is pushing harder. Which do you think happened? Which air did you disturb, the air between the balloons or on the outer sides of the balloons? Can you figure out what happened with the paper?

Now you know that the paper was surrounded by air pressure. How did you change the air when you blew over the paper? Remember, air can't suck up anything, but it can push. Did you change the push of air on the top or the bottom of the paper?

Okay, enough questions! Here's what was going on: In both the balloon and paper activities, air lost pressure and stopped pushing as hard. This happened because you blew the air, and it had to "squeeze" between or around the objects. As it "squeezed" through, it sped up, lost pressure, and stopped pushing as hard.

Bernoulli's Brain Teasers (continued...)

Experiment #3: Squeeze the Stream

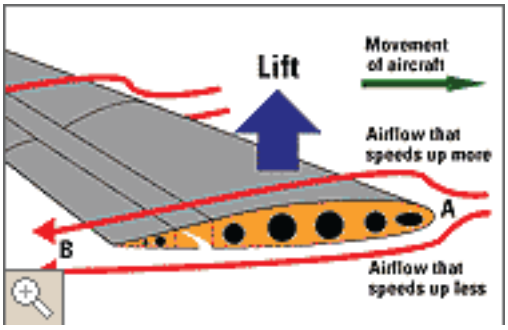
Materials: cookie sheet, unsharpened pencils or wooden dowels, tape, plastic wrap, sink or tub, water, small scraps of paper or styrofoam bits (optional)

Fluids, such as air and water, change speed as they flow between and around objects. To see how this happens, build a tiny stream channel. Tape pencils to a cookie sheet so that they make a channel that starts out wide and then narrows. Drape the pencils and cookie sheet with plastic wrap; this creates a waterproof channel. Now barely tilt the cookie sheet against the sink and slowly pour soapy water into the channel.

Does the speed of the water change? How? When?
(Hint: You may want to add small scraps of paper or Styrofoam to the water to help you observe the current's flow.)

What's Going on? The Advanced Explanation...

Now that you know about push and lift, can you see how these forces might relate to airplanes? If we can make air speed up over a wing, the pressure of the air over the wing will drop. The higher pressure air below the wing then pushes the airplane up. How would you shape a wing so that the air moves more quickly over the top than under the bottom?



The "Squeeze the Stream" activity shows what happens when a fluid is forced to flow from a wide space through a narrower channel. For the water to squeeze through a thinner space, something must either compress the water (think of pulling a sponge through a bottle neck) or speed it up. Freely flowing water does not compress easily. Instead, it speeds up as the channel narrows. Water also speeds up as it moves around an object, such as a rock in a river. Air is a fluid, too, and it behaves like water when it moves through a narrow channel or around an object: It speeds up. As you saw with the other activities, when air moves faster, its pressure drops and it pushes less.

When an airplane flies, it pushes air out of the way. That air must go somewhere so it "squeezes" between the wings and the surrounding air. The wings are shaped and tilted so that the air moving over the top has less room than the air moving below the wings. Because it has less room, the air moving over the top must speed up more than the air below the wing. As it moves faster, the air on top of the wing also loses pressure and push. The slower moving air below the wing maintains more of its pressure, which pushes the wing, and the plane, up.

An airplane wing affects moving air much like a rock in a stream affects moving water. Remember that the space around the wing is already jammed full of air, so there's no empty space for more air to move into. As oncoming air hits the wing and moves either over or under it, it speeds up and "squeezes" between the wing and the surrounding air.

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Imagining Flight

People have dreamed about being able to fly for thousands of years, many religions have included supernatural beings that fly, and inventors long before the Wright Brothers tried to design flight machines.

Flight Research

- Select one of the topics below, or find a similar topic of your own.
- Research this topic using at least five different sources from libraries and the internet.
- Make notes and record the source for each fact you write down.
- Use these notes to write a report about your topic.
- Illustrate you report with pictures you draw, or cut and paste from an internet source.
- Present your report to the class.

Possible topics for research:

- Alexander the Great, and his Griffins
- Angels in various religions
- Chinese flying chariots
- Etana, a Babylonian myth
- Fairies
- Flying carpets
- Hindu gods that fly
- Imaginary flight in science fiction
- King Kaj Kaoos of Persia
- Leonardo Da Vinci's designs for flying machines
- Otto Lilienthal and his gliders
- Pegasus, the winged horse
- Samuel Langley's Aerodrome
- Sir George Cayley, the father of aeronautics
- The Greek legend of Daedalus and Icarus
- The Legend of Thunderbird
- The Montgolfier Brothers' balloon flights

Activity #7: Culminating Project:

Have students pick one of the following topics and do a research-oriented project. Using as many resources as they can find, students will put together a presentation for the class. The presentation should be written and be 2 pages in length. In addition, a labelled diagram on bristol board, a Powerpoint Presentation or some other form of media will be used to supplement your presentation.

Activity #7 (a):

You've learned a lot about the properties of air and flight. With all of this new knowledge, you are going to do a short research project. Using the list below or coming up with your own idea, pick one thing and describe how it flies. Identify adaptations that these things to fly. Explain how the four forces of flight help in the process of flight.

Kite
Glider
Hot Air Balloon
Satellite
Bird
Bat
Insect
Flying Squirrel
Dandelion
Maple Key
Frisbee

Activity #7 (b)

Flight has brought humans huge advantages such as seeing the wonders of the whole world. How has flight negatively and positively impacted the world and its inhabitants? Knowing the positive and negative sides of mechanical flight, should humans continue the quest for flight outside of the earth (i.e. space exploration). Why or why not? Consider such areas as travel, defense, commerce, and information.

Activity #7 (c):

Create a written report and a timeline display that illustrates a variety of aircraft showing developments from past to present day. Be sure your work has Canadian content!

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Objects and Materials
Grade 1 2011 13 min
Have you ever seen a professional baseball player hit a homerun with a bat made of glass or a hockey player take a slapshot with a stick made of paper? In this fun, educational and entertaining video, students are invited into a science lab where they meet the zany Professor Peter Plankton and his adorable partner, Professor Tess Tube. Professor Plankton takes us on a whirlwind tour around the world as he ends up in the Brazilian rainforest dressed for winter, and in the snowy north dressed for the beach. Thankfully, Professor Tube is on hand to get him back to the lab where they demonstrate the "science of materials and objects". Students will join in the romp as they learn that objects are all around us, and that all objects are made of materials such as plastic, wood, glass, and steel. The two professors demonstrate the various properties of a material and an object. Students are introduced to vocabulary such as shiny, hard, smooth, and flexible. Short, fun experiments demonstrate key concepts.
#MCI046DV-NR2 $149: DVD, PDF
Teacher's Guide & Student Worksheets

Structures: Man-made and Found in Nature
Grade 3 2011 22 min
Structures are all around us. Take a look. Structures include bridges, buildings, chairs, shoes, spider webs, beehives, anthills, tables and even your own body. Structures are made by man and also found in nature. This program looks at various made-made and natural structures found all over the world. Through the use of fun experiments and short skits in their science lab, our two engaging hosts, Professor Peter Plankton and Professor Tess Tube help young students explore the science of structures. They learn that both humans and animals build specific structures with specific functions and that structures have many forms. Students are introduced to the complex, yet intriguing honeycomb structure that bees build. We look at modern day structures as well as those used by the First Nations people and other cultures around the world. In addition, students are introduced to the concept of reducing , reusing and recycling, and how structures impact the surrounding environment.
#MCI047DV-NR2 $149 DVD, PDF
Teacher's Guide & Student Worksheets

Forces Acting on Structure
Grades 5-8 2011 24 min
Structures are all around u
everywhere we look. They
and sizes. Some are made
others are natural. Structu
shelter and protection. Al
forces acting on them. In t
Peter Plankton and Profes
these forces. They specific
impact of earthquakes and
from the recent earthquak
Japan shows the devastati
natural forces. Students w
between internal forces ar
load vs. dead load; the var
including compression and
and their properties; and t
impact of these events.
#MCI048DV-NR2 $1
Teacher's Guide & Student

Properties of Air
Grades 5-8 2011 123min
Our two engaging hosts, Professor Peter Plankton and Professor Tess Tube take students on a fun science field trip to discover the properties of air. Through engaging onscreen experiments, students explore the various properties of air such as air has mass, air takes up space, air expands when heated, and air can be compressed.#MCI049DV-NR2 $149: DVD, PDF Teacher's Guide & Student Worksheets

The Science of Flight
Grades 5-8 2011 25 min
Building on the *Properties of Air* DVD, this program introduces students to the science of flight and aerodynamics. Once students understand the properties of air, they begin to look at how air makes flight possible. For thousands of years, humans dreamed of flying, but it isn't as easy as birds make it look. Students now learn about lift, gravity, thrust and drag -- the four forces that make it possible for an airplane to fly. Our two hosts also examine Bernoulli's Principle, Newton's Third Law of Motion, the Angle of Attack, natural and man-made objects that use airfoils and how a pilot controls the airplane. In addition, students learn about the history of flight in Canada. #MCI050DV-NR2 $149: DVD, PDF Teacher's Guide & Student Worksheets

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