The Thrill of Flight

Teacher's Guide

Welcome to the world of flight.

***The Thrill of Flight*, is a dynamic, interactive, multimedia resource that will engage your students and help them learn about aviation in a fun way.**

ALBERTA AVIATION COUNCIL

Learning Technologies Branch

Alberta LEARNING

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This electronic Teacher's Guide and the accompanying multimedia learning resource, *The Thrill of Flight*, may be reproduced in any format and distributed for educational use as needed for teachers and students.

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Appendix: Includes Additional Information and Master Copies of Student and Teacher Printouts

* Indicates printout is only in this guide for teacher discretion. All other printouts can be accessed from either the student resource or this guide.

Resource Overview

Technology has fundamentally changed the way people live and work. Now teachers need to apply technology's powerful tools to change the way students learn. Use of quality multimedia content challenges students at new levels–such as allowing students to explore 3-D models, to access current information from anywhere in the world, and to be able to take control and see the affects of one action on another. Technology allows teachers to connect students easily to the real world. Students can listen to pilots, see aircraft in action, and experience flying a plane. This resource's exploration of air and flight is anything but ordinary. It integrates technology into the curriculum engaging students and teaching skills necessary for the 21st century.

Resource Description

The Thrill of Flight includes three main components: a student resource, a teacher guide with suggestions for classroom use, and a parent guide for home use. The student resource is an electronic resource that contains information, activities, and assessment content in digital format. In addition, the student resource contains many opportunities for students to printout additional information and worksheets related to the content. **The Teacher's Guide includes all of the copies of the student printouts as well as many other suggested and optional teacher printouts.** All printouts are formatted as Acrobat PDF files for easy printing in colour or black and white.

The student resource includes five main topics briefly described below. At the end of the topic summaries, students are provided with links to topic-specific Glossaries and Frequently Asked Questions (FAQs). These Glossaries and FAQs are repeated in this guide for teacher reference.

Topic 1: Alberta's Aviation History (two lessons)
This introductory topic shows the connection of aviation to our province, Alberta. It introduces such questions as: Why is Aviation important? How has flight helped our province? What risks did these people take and why? It is intended that this topic will help students grow and broaden their appreciation of the benefits gained from the shared effort and cooperation of our ancestors.

Topic 2: The Air Out There (three lessons)
Students explore the characteristics of air and the interaction between moving air and solids. They are introduced to two basic principles of flight: Bernoulli's Principle and angle of attack. Animations allow students to see how air and aircraft are affected.

Topic 3: Airplanes (five lessons)
Students continue their study of aerodynamics by learning about the forces of flight. They have an opportunity to apply their knowledge of aerodynamics to airplanes. Students learn about the parts of an aircraft and how and why they move the way they do. In addition to many interactive segments, this topic includes two flight simulators (an easy version and a more challenging version.)

Topic 4: Helicopters (three lessons)
This topic helps students compare helicopters to airplanes. It also discusses how helicopters contribute to society's needs.

Topic 5: Gliders (four lessons)
Students have the opportunity to apply their aerodynamic knowledge to design, build, and test a variety of flying devices. The topic culminates with a class air show.

Resource Objectives

The Thrill of Flight is an authorized support resource.

Student Support Learning Resources are those resources authorized by Alberta Learning to assist in addressing some of the learner expectations of course(s); or assist in meeting the learner expectations across two or more grade levels, subject areas, or programs as outlined in the provincial Programs of Study. [1]

This resource has met Alberta Learning criteria for acceptability and is authorized to assist in addressing some of the learner expectations of the provincial Program of Studies for Elementary Science—grade 6 science (http://www.learning.gov.ab.ca/k_12/curriculum/bySubject/science/elemsci.pdf). As such *The Thrill of Flight* has the Alberta Learning designation of Student Support Learning Resource.

This resource can assist in addressing these grade 6 science topics and their associated general learner expectations:

Topic A: Air and Aerodynamics
General Learner Expectation 6–5: Describe properties of air and the interactions of air with objects in flight.

Topic B: Flight
General Learner Expectation 6–6: Construct devices that move through air and identify adaptations for controlling flight.

This resource can assist in addressing the following Grade 6 Science Skills and Attitudes:

Science Inquiry
General Learner Expectation 6-1: Design and carry out an investigation in which variables are identified and controlled, and that provides a fair test of the question being investigated.

General Learner Expectation 6-2: Recognize the importance of accuracy in observation and measurement; and apply suitable methods to record, compile, interpret and evaluate observations and measurements.

Problem Solving through Technology
General Learner Expectation 6-3: Design and carry out an investigation of a practical problem, and develop a possible solution.

Attitudes
General Learner Expectation 6-4: Demonstrate positive attitudes for the study of science and for the application of science in responsible ways.

[1] See *Guide to Education: ECS to Grade 12* pp 125–127 (http://www.learning.gov.ab.ca/educationguide/)

The Thrill of Flight Lesson Correlation to the Alberta Program of Studies for Elementary Science, Specific Learner Expectations (SLEs)

Topic 1: Alberta's Aviation History

This topic is considered an introductory topic and does not focus on specific SLEs. The intent is to establish an appropriate setting for students, to stimulate their curiosity and their quest to find out more. This topic is intended to promote discussion and questions about how and why.

SLE Number	SLE Description	Topic 2 "Air Out There" Lessons	Topic 3 "Airplanes" Lessons	Topic 4 "Helicopters" Lessons	Topic 5 "Gliders" Lessons
6.5.1	Provide evidence that air takes up space and exerts pressure, and identify examples of these properties in everyday applications.	**1**			
6.5.2	Provide evidence that air is a fluid and is capable of being compressed, and identify examples of these properties in everyday applications.	**1**			
6.5.3	Describe and demonstrate instances in which air movement across a surface results in lift—Bernoulli's principle.	**2**	**1**		
6.5.4	Recognize that in order for devices or living things to fly, they must have sufficient lift to overcome the downward force of gravity.	**2, 3**	**1, 2, 3**		
6.5.5	Identify adaptations that enable birds and insects to fly.	**3**	**1, 2, 3, 5**		
6.5.6	Describe the means of propulsion for flying animals and for aircraft.		**1, 4**		
6.5.7	Recognize that streamlining reduces drag, and predict the effects of specific design changes on the drag of a model aircraft or aircraft components.		**5**		
6.5.8	Recognize that air is composed of different gases, and identify evidence for different gases. Example evidence might include: effects on flames, the "using up" of a particular gas by burning or rusting, animal needs for air exchange.	**1**			
6.6.1	Conduct tests of model parachute design, and identify design changes to improve the effectiveness of the design.		**1**		
6.6.2	Describe the design of a hot-air balloon and the principles by which its rising and falling are controlled.	**1**			
6.6.3	Conduct tests of glider designs; and modify a design so that a glider will go further, stay up longer, or fly in a desired way; e.g., fly in a loop, turn to the right.				**2, 3, 4**

SLE Number	SLE Description	Topic 2 "Air Out There" Lessons	Topic 3 "Airplanes" Lessons	Topic 4 "Helicopters" Lessons	Topic 5 "Gliders" Lessons
6.6.4	Recognize the importance of stability and control to aircraft flight; and design, construct, and test control surfaces.		**1**	**1**	**3**
6.6.5	Apply appropriate vocabulary in referring to control surfaces and major components of an aircraft. This vocabulary should include: wing, fuselage, vertical and horizontal stabilizers, elevators, ailerons, rudder.		**1**	**1**	
6.6.6	Construct and test propellers and other devices for propelling a model aircraft.			**2**	**1**
6.6.7	Describe differences in design between aircraft and spacecraft, and identify reasons for the design differences.		**1**	**3**	

The Thrill of Flight Technical Specifications

Macintosh®

> Power Macintosh® running System 8.6 or later (200 MHz)
> For the optional F/A-18 flight simulator, a G3 Processor is recommended.
> 32 Mb RAM minimum (64 Mb recommended)
> 8x CD-ROM drive
> monitor capable of 800 x 600 screen resolution and thousands of colours
> a printer

PC Compatible

> Pentium® Processor 266 MHz running Windows 95/98/2000/NT/ME/XP®
> For the optional F/A-18 flight simulator, 400 MHz is recommended.
> 32 Mb RAM minimum (64 Mb recommended)
> 8x CD-ROM drive
> monitor capable of 800 x 600 screen resolution and thousands of colours
> a printer
> sound card and speakers

Browser and Plug-in Requirements

> Internet Explorer™ 5.0 or later (recommended)
> Netscape Communicator™ 4.77 or later
> QuickTime® 5.0 or greater (download from http://www.apple.com/quicktime/)
> Shockwave™/Flash™ Player 6 (download from http://www.macromedia.com/)
> Acrobat Reader™ 5.0 or later (download from http://www.adobe.com/)

How *The Thrill of Flight* Resource Can Be Used

1. In the Classroom, as the Main Resource
    a. You may choose to launch the resource and complete the first topic about Alberta's Aviation History as a large group. Then, you could direct students to complete Topics 2, 3 and 4 in small groups or individually using a computer or a computer centre in the classroom. You may want to set up an activities center where students can do their demonstrations. Topic 5 should be done as a group.

    b. While most of the work is designed for students to check themselves, there are a few activities within the topics that require teacher attention and assessment. You may direct students to print their work and leave it on your desk, or you may decide students should e-mail you their work when completed. Both options are possible.
    c. The air show portion of Topic 5 requires teacher/parent organization, direction, and monitoring.
    d. You may decide to use a projector (or a computer hooked to a classroom television) to proceed through all five of the resource topics as a large group.
2. In the Classroom, as an Extension or Enrichment Resource
    a. If you already have successful lesson plans for these topics, you may want to enhance your lessons by directing students individually, or in teams, to portions of this resource. For example, after your study of airplane movements, you may want the students to try the flight simulator.
    b. A computer center may be set up and students may be provided the opportunity, at various points in their day, to use the resource at their own pace.
    c. Students who are particularly interested in certain topics, such as helicopters, may be encouraged to delve further into the topic by using this resource.

3. In the Library or Home
    a. Students who are involved with home schooling or virtual schooling will benefit from this interactive resource that complies with the Alberta program of studies for Grade 6 Science, Topics A and B.
    b. Students, who are particularly interested in this topic and want to explore it beyond the classroom, can easily take home a CD-ROM and use the resource as desired.

Assessment

There are three types of assessment included in this resource. Throughout the resource there are opportunities for students to confirm their basic understanding and check their work themselves. At other points in the resource, students are directed to submit their work to their teacher for review. These activity sheets can be simply marked as approved or a grade could be assigned. The final assessment is the performance at the air show. A team of classroom students or adult volunteers will be assessing each entry and these scores could be used if a grade score on the work is required. **There is no final test included.** You may want to include marks for teamwork and participation.

Guest Speakers and Field Trips


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Appropriate guest speakers might be contacted for the following topics: Topic 1: veteran world war pilots, bush pilots, or historians; Topic 3: local pilots, commercial airlines steward or pilot; Topic 4: helicopter pilots; Topic 5: air traffic control personnel; aircraft design personnel.

Appropriate field trips might be planned before, during, or at the end of this study of air and flight. Following are some examples and suggestions of possible museums and airports.

You may want to plan a trip to an aviation museum. Here are some suggestions. Following these notes are more specific details about various Alberta sites to visit.

> Reynolds Alberta Museum in Wetaskiwin has received the highest ratings from visitors. One visitor, a Museum Consultant stated that the museum has one of the largest and most diversified collections of airplanes in Canada, including some of the most historically significant ones, most of which have been lovingly repaired.

> Nanton Lancaster Air Museum collection contains photographs and donated memorabilia that are attractively displayed. Included in the display are a Lancaster Bomber and a Fleet B7.

> The staff members of HMCS Tecumseh Naval Museum of Alberta are very knowledgeable and enthusiastic in their presentations of information about each exhibit on display. The museum is conveniently located in Calgary.

> The Calgary Aerospace Museum's airplanes are mainly Canadian Military aircraft, the highlights being the Avro Lancaster and Sopwith Tri-plane. One visitor, a teacher, stated that the tours for school and community groups were of a high calibre.

> The Alberta Aviation Museum located in Edmonton has over twenty-seven historical aircraft on display. There are forty display cabinets and exhibits. Students can actually see an active Aircraft Restoration Area. There is also a collection of personal artifacts from such famous bush pilots as "Wop" May, Stan McMillan, and many others.

Museums

Name of Museum	Alberta Aviation Museum
Are Guided Tours Conducted?	Yes, regular tours &/or Grade 6 Science Program (Air & Aerodynamics and Theory of Flight).
How Many Students Can be Accommodated?	Depends on which tour. Regular tours can accommodate up to 100 persons. Grade 6 Science class can accommodate up to 45 students plus teachers/supervisors
How Much Advance Notice is Needed?	At least one week notice; service well used; the earlier the better for preferred dates.
What is the Cost of Admission?	$4.00 per student.
Website Address?	www.albertaaviationmuseum.com
Other Requirements	Grade 6 program runs October through June. Regular tours are all year round. Like to have one parent/supervisor for every five students in attendance. (No charge for supervisors)
Contact Information	11410 Kingsway Avenue Edmonton AB T5G OX4 Phone 1 780 453 1078 FAX 1 780 451 1607 Emailto: lorrine@albertaaviationmuseum.com or info@albertaaviationmuseum.com

Name of Museum	Calgary Aerospace Museum
Are Guided Tours Conducted?	Yes
How Many Students Can be Accommodated?	70 at one time
How Much Advance Notice is Needed?	2 weeks
What is the Cost of Admission?	$3.00 per person.
Website Address?	www.asmac.ab.ca
Other Requirements	Ask that there be at least 1 chaperone for 10-15 kids.
Contact Information	Jennifer Herrick 4629 McCall Way NE Calgary, AB T2E 8A5 Phone 1 403 250 3752 FAX 1 403 250 8399 E-mail to: Jennifer@asmac.ab.ca

Name of Museum	Nanton Lancaster Society and Air Museum
Are Guided Tours Conducted?	Yes
How Many Students Can be Accommodated?	25-30 at one time
How Much Advance Notice is Needed?	2 weeks
What is the Cost of Admission?	donations suggested of $4.00 per adult and $1.00 per child
Website Address?	www.lancastermuseum.ca
Other Requirements	1 adult for every 6-8 students
Contact Information	Lea Norman, Museum Manager, Box 1051 Nanton, AB TOL 1RO Phone 1 403 646 2270 FAX 1 403 646 2214

Name of Museum	Reynolds Alberta Museum (also includes Canada's Aviation Hall of Fame)
Are Guided Tours Conducted?	Yes
How Many Students Can be Accommodated?	30 at one time
How Much Advance Notice is Needed?	4-6 weeks
What is the Cost of Admission?	$1 -$3.00 per student for the Main Gallery and Aviation Hangar tour. The Warehouse tour is $50 per tour.
Website Address?	www.reynoldsalbertamuseum.com
Other Requirements	Cafeteria specials for students at $3.75 and up
Contact Information	Leanne Wright Group Marketing Coordinator PO Box 6360, Wetaskiwin, AB T9A 2G1 Phone 780 361 1371 Toll Free: (R.I.T.E.) 310 0000 FAX 780 361 1239 E-mail to: leanne.wright@gov.ab.ca

Airports

Name of Airport	Calgary International Airport
Are Guided Tours Conducted?	Yes, however, since 9/11, many areas are restricted where we previously had access. There are also major renovations going on in our airport, so safety is a concern.
How Many Students Can be Accommodated?	30 students is our maximum.
How Much Advance Notice is Needed?	The bookings are made on a first-come, first-serve basis. Monday to Friday at 9:20 AM only.
What is the Cost of Admission?	No cost for admission.
Website Address?	http://www.calgaryairport.com
Other Requirements	
Contact Information	Elizabeth Wesley, Calgary Airport Authority, 200 Airport Rd. N. E. Calgary, AB T2E 6W5, Phone (403) 735-1200; Fax: (403) 735-1281 E-mail to: elizw@yyc.com

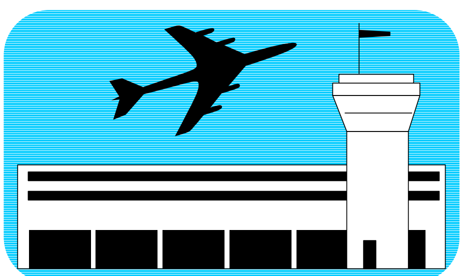
Name of Airport	Calgary SpacePort Program (Calgary International Airport)
Are Guided Tours Conducted?	The primary attractions at SpacePort are the Educational Stage shows and workshops. These programs involve elements of the school curriculum for elementary and junior high students that pertain to space exploration, rocketry, life in space, aviation, and problem solving in a fun and exciting multimedia environment. Workshops give students an opportunity for hands-on experimentation and creativity.
How Many Students Can be Accommodated?	We can accommodate classes of any size, large or small. Normally we try to limit classes to 60 students at a time, although we have accommodated larger groups when necessary
How Much Advance Notice is Needed?	Programs are on a first-come, first-serve basis—because we fill up quickly, the earlier the scheduling is made the better chance of getting your desired time slot.
What is the Cost of Admission?	Admission to SpacePort is free. The cost of a stage show presentation is $5 per student (includes one simulator ride per student). For an additional $1 per student one of our workshops may be added to the visit. For another $1 per student, they are treated to a Dairy Queen ice cream cone at the end of the program.
Website Address?	www.calgaryspaceport.com
Other Requirements	All those participating in a field trip to SpacePort are required to have fun and plenty of it!
Contact Information	Allan Gallant SpacePort Educational Program Director SpacePort Box 59, 2000 Airport Road N.E. Calgary, AB T2E 6W5 Phone: 1 (403) 717-7678 E-mail: sport1@yyc.com

Name of Airport	Camrose Air Terminal
Are Guided Tours Conducted?	Yes, tours are organized on request.
How Many Students Can be Accommodated?	Maximum 15
How Much Advance Notice is Needed?	One week notice
What is the Cost of Admission?	No cost for admission
Website Address?	http://camrose.com/serv/air.htm
Other Requirements	Please note this is a local airport with no commercial traffic, and no tower. They can talk about airport operation, and may be able to talk a local pilot into allowing students to look at his airplane, but they don't have all the fancy gear that is at Edmonton or Calgary .
Contact Information	Ted Gillespie, City Engineer, City Hall 5204 50 Avenue Camrose, AB T4V OS8 Phone 1 (780) 672-4428 FAX 1 (780) 672-6316 E-mail: tgillespie@camrose.com E-mail to: leanne.wright@gov.ab.ca

Name of Airport	Lethbridge County Airport
Are Guided Tours Conducted?	Yes, from Hangar Operators and Flight Schools. Please make contact directly to make arrangements.
How Many Students Can be Accommodated?	
How Much Advance Notice is Needed?	
What is the Cost of Admission?	
Website Address?	http://www.lethbridgecountyairport.com
Other Requirements	
Contact Information	

Name of Airport	Medicine Hat Airport
Are Guided Tours Conducted?	Yes.
How Many Students Can be Accommodated?	Maximum 20 students
How Much Advance Notice is Needed?	Two weeks advance notice required
What is the Cost of Admission?	No cost for admission
Website Address?	www.city.medicine-hat.ab.ca/cityservices/airport
Other Requirements	Minimum 1 adult chaperone for each 10 students.
Contact Information	Cuyler J. Green Airport Superintendent Phone: 1 (403) 526-4664 FAX 1 (403) 528-4629

Name of Airport	Red Deer
Are Guided Tours Conducted?	Yes. Hour and a half to full-day tours. All Alberta students welcome.
How Many Students Can be Accommodated?	Maximum 120 students
How Much Advance Notice is Needed?	One month advance notice required
What is the Cost of Admission?	No cost unless a flight is to be included
Website Address?	www.info@skywings.com
Other Requirements	Adult supervision required
Contact Information	Sherry Cooper, Director of Student Services Phone: 1 (403) 886-5191



Other Alberta Airports Contacted				
Athabasca	no		Hinton	no answer
Bonnyville	no		Jasper	no answer
Drayton Valley	no		Lac La Biche	no answer
Edmonton	no answer		Manning	no
Edmonton International Airport	no answer		Peace River	no answer
Edmonton City Centre Airport	no answer		Rocky Mountain House	no
Cooking Lake Airport	no answer		Sherwood Partk	no
Villeneuve Airport	no answer		St. Albert	no
Edson	no		Valleyview	no
Gibbons	no		Vegreville	no answer
Grande Prairie	no		Wainwright	no
High Level	no		Whitecourt	no answer
High Prairie	no			

How to Navigate the Multimedia Resource

Navigating this resource has been made simple for both you and the students. Just after the introductory page (otherwise known as the “title page” or “splash page”), you will see a welcome page, which contains a picture of a simple airport terminal. There are five topics in the resource and each terminal building is coloured and numbered consistently with the resource to represent one topic. When the student clicks on each building, a special menu appears for each topic for immediate reference. **Be sure to point out to students that they can access a complete, interactive resource table of contents by clicking on the little sign at the airport terminal after they have gotten into the resource.** When they click on the sign, and the resource site map appears, students can use this interactive table of contents as another reference or as a tool to take them quickly and directly to a particular spot. Also, be sure to point out, on every main page in the resource, there is a small windsock icon in the lower left corner that can be clicked to return to this welcome page and site map.

The **terminal office** building contains special pre-flight instructions for the students. It explains about the windsock icon, the site map, and contains an introductory message from a pilot, Richie Clements (WestJet), setting the tone for the adventure.

The resource is set up so the student can progress clearly from one page (screen) to the next by following the cues at the bottom of every page. In most cases, the cue will advise students to click on the forward icon.

On many pages, extra information has been linked to content. Underlining, colour, start-up (forward) icons, or a change in the pointer design has been used to indicate links to definitions, worksheets that should be printed, more information, demonstrations, experiments, special charts, and small movies. Copies of all the students’ worksheets are also included in the Appendix of this Teacher's Guide. Note that there are a few worksheets or handouts that are only available in the Teacher’s Guide to be distributed at teacher discretion.

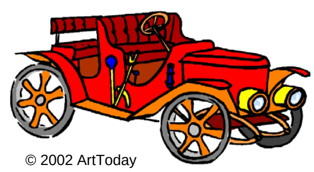
Be sure to explain to all students using this resource how it is structured before they begin. You may want to appoint one or two students with additional computer expertise as coaches, particularly if students will be expected to work individually or in small groups at certain points in their work.

Launching *The Thrill of Flight*

In preparation for teaching the Alberta Program of Studies, Topics A and B, consider some of these classroom ideas:

1. Designate a corner of the classroom as "The Hangar." Here students will be able to draw their own designs. Include drawing paper, paper clips, straws, pencils, paints, and markers. In The Hangar, include a flight library. Leave a shelf empty and as you progress through Topic A and B, encourage students to bring model planes or display their own paper gliders.
2. Build a wall display with the students of flying things. Include birds, insects, mammals, machines, and fantasy items like fairies.
3. Build a table model of an airport. Have the students bring miniature aircraft. You might want to start this activity with a field trip to your nearest airport. Check out this NASA Internet site for tips on constructing a table top airport: http://ltp.larc.nasa.gov/flyingstart/plane/mod1parts.html

Begin your introduction of *The Thrill of Flight* by discussing taking risks. Relate the concept to the students. *What is a risk? Why would you take one? Is speeding in a car a risk? What could happen? What would be a good reason for taking such a risk? (an emergency, catching a criminal, a fire) What are some of the not-so-good reasons for taking such a risk? (adventure, thrill, danger) Do you think it is a risk to drive a car? When cars were first invented, do you think it was a risk then? What about airplanes? Do you think they were as safe when they were first invented then as they are now? When were airplanes invented? Why would people take the risk of flying in a new invention that wasn't proven?*



You are going to begin an adventure today into the world of flight. Find out why Captain Richie Clements likes to fly… .

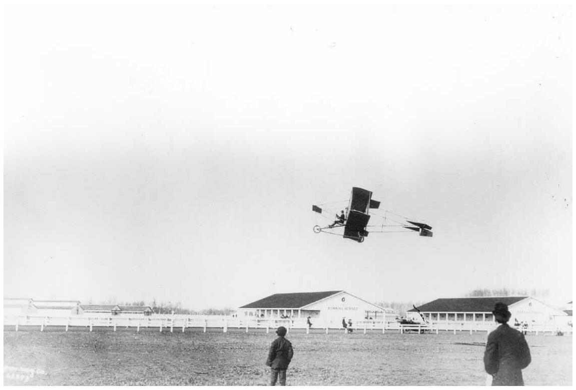
Either use a projector or have students gather around a computer to watch the introduction of *The Thrill of Flight*, which includes a short movie segment of a WestJet pilot, Captain Richie Clements.

Topic 1: Alberta's Aviation History

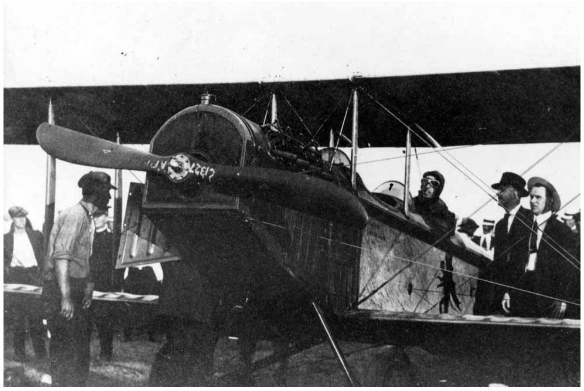
As you move into Topic 1, continue your discussion of risks, needs, and adventure. Talk about heroes like firefighters who save people. Lead the discussion to early pilots and how many Albertans became heroes by flying planes to help others.

Tell them they are going to watch a **very short** movie about a lady pilot talking about our Alberta aviation heroes and why they did what they did. She will also share some old photographs that show what these risk-takers accomplished long ago.

Here is some additional information about each of the five photographs used in the slide show.



Slide One
Hugh Robinson's pusher-type Curtiss Airplane
© Glenbow Archives NA-1258-15



Slide Two
Ernest Hoy – First pilot to successfully cross the Rockies
© City of Lethbridge Archives

Slide Three
Vic Horner and Wop May—Mercy Mission in 75-horsepower Avian
© City of Edmonton Archives

Slide Four
Captain Don R. MacLaren with Sopwith Snipe Plane
© Glenbow Archives NA-3206-18

Slide Five
George (Grant) McConachie with Fokker Universal airplane
© Glenbow Archives NA-2097-38

Slide Six
Max Ward in his Fox Moth, which belonged to his company, Polaris Charter Co. Ltd. of Yellowknife, N.W.T., which he established in 1946. Max Ward hauled prospectors and supplies into the mining exploration camps.
© Max Ward

Slide Seven
Mr. Wilkin hands a package to Punch Dickins for air delivery.
© Provincial Archives of Alberta B1.156

Have the students watch the introduction to Topic 1. The speaker, Joy Carscadden, is an experienced pilot who has flown many kinds of planes. Joy Carscadden is a member of the executive of the Alberta Aviation Council.

Lesson 1: Famous Aviators

The first lesson introduces the students to some of the specific contributions of our famous aviators. You might want to organize the class into teams and have each team collect more information about these aviators or other famous aviators. If time is limited, you may want to read the following information ahead of the lesson and discuss these people and others and what they have accomplished.

Additional Background Information About Alberta's Famous Aviators

The heroism of our Alberta Bush Pilots became evident soon after the invention of the first airplane. These adventurous pilots transported valuable goods and provided essential services for the entire province.

Their services included:

> The delivery of airmail.
> The provision for polio vaccines and diphtheria anti-toxins.
> The establishment of search-and-rescue missions.
> The use of the plane for surveying and mapping.
> The seeding of clouds to make rain to extinguish forest fires.
> The use of planes for crop-dusting.
> The ferrying of prospectors and supplies to remote areas.
> The training of British and Canadian pilots for World War I and World War II.
> The transportation of furs from the North Country to Winnipeg.

During the early years, bush pilots flew into unmapped territory without the use of a compass because of magnetic interference. These were the brave pioneers of the North Country who established maps and routes for later travelers. Alberta is proud to remember Moss Burbidge, “Wop” May, “Punch” Dickins, George McConachie, and Max Ward among our many Alberta aviation heroes.

One of the famous bush pilots was **Wop May.**

> In –30 degrees Fahrenheit he delivered an anti-toxin to curb a diphtheria epidemic at Little Red River.
> He established an airport at Blatchford Field, which later became the Edmonton Industrial Airport, and is now known as Edmonton City Centre Airport.
> He founded Commercial Airways, and with five others, flew the first airmail flight into the Arctic.
> From Fort McMurray, in January 1932, he assisted in locating the “Mad Trapper” (Albert Johnson).
> In 1946 he established aerial rescue crews to assist in locating and rescuing pilots who went down during flights to Siberia via the Yukon. He also recruited and trained paramedics who parachuted into crash sites to help the stranded people.

Moss Burbidge's major contribution to aviation history was as a teacher.

> He spent some of his career as a Flight Instructor in Britain during the WW1 and in Canada, after 1928, trained such later heroes as George (Grant) McConachie and Alf Caywood.
> He trained over 700 students, captained 32 types of aircraft, and logged over 15,000 hours.

"Punch" Dickins, another brave Alberta bush pilot, made many important contributions to aviation in Alberta.

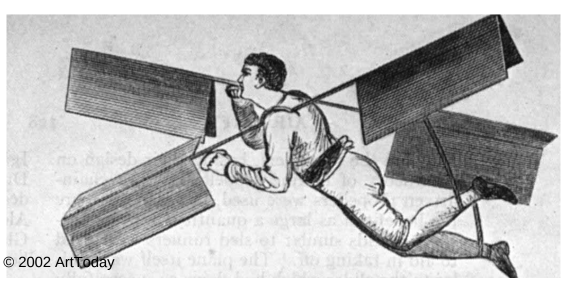
> He proved that cold weather flying was possible by conducting cold- weather, high-altitude experiments in 1924.
> "Punch" flew forest patrol and conducted aerial photographic survey flights for the Royal Canadian Air Force until 1927.
> He also flew the first airmail flight on a circuit of Winnipeg, Regina, Calgary, Edmonton, and Saskatoon using a Fokker Super Universal plane.
> In 1928 he flew as a bush pilot, covering over 4,000 miles. A few difficulties he encountered were:
  - No maps.
  - No radio communication past Fort Churchill.
  - Flying with the sun as his only reference because magnetic interference prevented him from relying on the compass.
> He flew the first fur shipment from Fort Good Hope to Winnipeg.
> In 1929 he was the first pilot to fly the whole 2,000-mile length of the Mackenzie River.
> He was also the first pilot to cross the Arctic Circle.
> In 1942 he managed six of the many air-training schools that produced aircrew for the Allied Air Offensive of World War II.

George (Grant) McConachie, another bush pilot, also made many important contributions to Alberta aviation.

> In his early years he carried fish from remote northern lakes in the winter
> In 1939 he pioneered the first scheduled airmail and passenger service between Edmonton, Whitehorse and the Yukon.
> He also completed many rescue missions in bad weather, on bad terrain, and he encountered and solved many mechanical difficulties with his aircraft.
  > In 1949, as a Canadian Pacific Airline President, he set up scheduled air passenger service from Vancouver to Australia, Japan and China.
  > By 1957 he had set up seven more routes that included South America, Holland, Portugal, and Spain.
  > He helped establish an air pact with the United States.

Max Ward is another well-known name in aviation circles in Alberta.

  > He was a Flight Instructor from 1940-45.
  > As a bush pilot, in 1945, he carried prospectors and supplies from Yellowknife to remote mining camps.
  > He was the first to land a wheeled plane at the North Pole.
  > With the establishment of Ward Air in 1953 he pioneered the air transport of heavy equipment into the Arctic.
  > His company became Canada's largest international air charter carrier.



The next lesson deals more with timelines. This Lesson 1 focuses on people. You may want to work with the students to develop a chart like the following as an introduction, or link, to Lesson 2:

Person or People	Home Country	Date	Flying Apparatus	Contribution
Orville and Wilbur Wright	USA	1903	Wright Flyer I	Made the first controlled powered flight, powered by a small petrol engine
Richard Rutan and Jeana Yeager	USA	1986	The Voyager	First non-stop flight around the world
Montgolfier brothers	France	1783	Hot air balloon	Launched the first hot air balloon

Lesson 2: Aviation Events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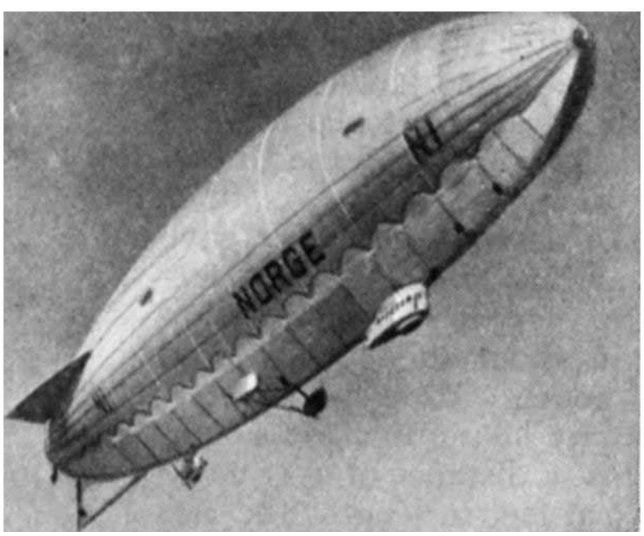
Use this lesson as an introductory activity to learn about important aviation events spanning over a hundred years. Use a projector to show this activity so the events can be put in the correct order as one large group, or have the students work in teams around a computer. Through discussion, the class should try to position the different aviation events into a logical order.

If time permits, divide the class into teams to investigate each category. Use the printout of the **Alberta Aviation Time Line** as a chart for ongoing reference.

There are many sources of information for students to use when collecting information about the history of aviation. In addition to books and the Internet, you may want to invite some guest speakers, perhaps air force war veterans or simply old-timers who could discuss the marvel of flight and the benefits to our country.



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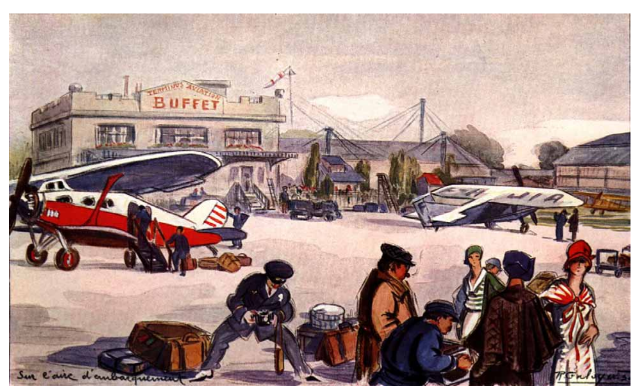

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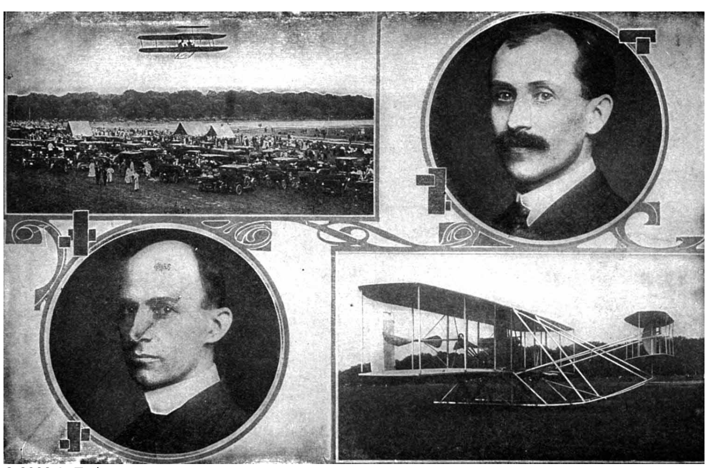
More Information

Aviation History in Alberta

Alberta played a very important role in the aviation history of Canada. The following timeline indicates only some of Alberta's contributions to aviation history.

Date Range	Year	Event
1907 – 1913	**1911**	On April 28, Hugh A. Robinson flew the first airplane in Alberta using a Curtiss Pusher Biplane.
1914 – 1919	**1914**	Alberta provided much of the training for Canadian and Allied aircrew during WW I.
1920 – 1936	**1920**	On July 1, Keith Taylor completed the first passenger flights between Edmonton and Calgary, flying an Avro 504K.
	1928	Pilot 'Punch' Dickins made the first flight across the unmapped Arctic Barrens and shortly after flew the first airmail into the Arctic, returning with a load of furs.
	1931	In January 1931 the RCMP asked Canadian Airways for help in tracking the 'Mad Trapper' who was wanted for murder. 'Punch' Dickins sent 'Wop' May to carry out this mission, the first time a wanted criminal was tracked by air.
1937 – 1939	**1937**	In early July 1937 MacKenzie Air Service began flying a passenger service between Edmonton and Great Falls, Montana with stops at Calgary and Lethbridge – quite an expansion from the bush flying of 1932!
1939 – 1949	**1939**	The British Commonwealth Air Training Plan (BCATP) was formed to train Canadian and other Allied aircrew – much of the training took place at eleven training centres in Alberta.
	1944	Edmonton Municipal Airport, because of its strategic location, provided training to air crew, and a centre for aircraft industries and repair.
1950 – Present	**1955**	The present site of Edmonton's International Airport was chosen in 1955 and began to accept jets in 1960.
	1973	Canada's Aviation Hall of Fame was established in Edmonton and was moved to the Reynolds-Alberta Museum in Wetaskiwin in 1992.



Timeline of Alberta, Canada, and World Aviation Events

Turn to the printout **Alberta, Canada, and World Aviation Events Chart in** the Appendix for a more detailed timeline**.**

Milestones of Flight

Year	Item	Milestone
1903	Wright 1903 Flyer	First successful airplane
1926	Goddard Rockets	First Successful Liquid-Propellant Rocket
1927	Ryan NYP "Spirit of St. Louis"	First solo transatlantic flight
1942	Bell XP-59A Airacomet	First American Turbojet
1947	Bell X-1 "Glamorous Glennis"	First aircraft to travel the speed of sound
1957	Sputnik 1	First artificial satellite
1958	Explorer 1	First successful United States satellite
1962	Mariner 2	First interplanetary probe
1962	Mercury "Friendship 7"	First American in Earth orbit
1965	Gemini IV	First American spacewalk
1967	North American X-15	First hypersonic, high altitude aircraft
1969	Apollo 11 Command Module "Columbia"	First manned Lunar landing
1972	Lunar "Touchrock"	Apollo 17 Lunar basalt
1976	Viking Lander	First spacecraft to operate on Mars
1983	Pioneer 10	First spacecraft to leave our Solar System
1987	Pershing-II & SS-20 Missiles	First international effort to control nuclear arms
1999	Breitling Orbiter 3 Gondola	First Nonstop Flight Around The World by Balloon

Refer to The Smithsonian National Air and Space Museum at http://www.nasm.si.edu for pictures and more information about these flight milestones.

SPECIAL NOTE TO TEACHERS:

WEBSITES CHANGE. Teachers need to check all websites before sharing them with students. It is for this reason that the website addresses have not been included in the Student Resource.

Annotated Websites

> http://www.edmontonairports.com/cca/history.htm	Edmonton Airports—historical facts of flight history in Edmonton area
> http://www.geocities.com/CapeCanaveral/9581/index.html	A history of the Avro Arrow put together by Calgary high school students. A lot of information and a list of references.
> http://www.canadianflight.org/history/index.htm	Canadian Aviation History—Historical information and photographs
> http://www.maverick2.com/ArrowMain.htm and http://exn.ca/FlightDeck/Arrow	Avro-Arrow history includes photographs
> http://www.gpfn.sk.ca/culture/history/cah.html	Historical facts of Saskatchewan aviation
> http://www.aerofiles.com/chrono.html	American "firsts" in aviation interspersed into World firsts. Viewer feedback has been added and is colour coded.
> http://www.aviation.nmstc.ca/Eng/Collection/coll_alphabet.html	Canadian Aviation Museum photographs
> http://collections.ic.gc.ca/highlights/guide/maine.htm	History and photos of Canadian aircraft – site produced under contract by Industry Canada
> http://www.generation.net/~gjones/space.htm	List of Websites on aviation—includes historical Canadian site
> http://www.airforce.dnd.ca/hist/hist_e.htm and > http://www.airforce.forces.ca/equip/hist_e.htm	History of Canadian Air Force—by the Department of National Defense and Canadian Air Force information on historical aircraft

Annotated Book List

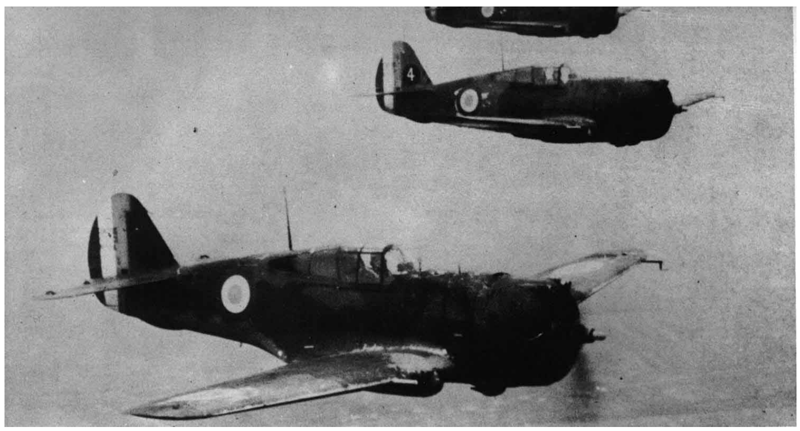
Author	Title	Publisher	Location	Description
Canadian Aviation Historical Society	CAHS Journal	Published quarterly	Willowdale, Ontario	
Corley-Smith, Peter	Barnstorming to Bush Flying 1910–1930	Sono Nis Press, 1989	Victoria, BC	This book deals mainly with British Columbia's aviation pioneers, the stories of those legendary people who helped shape the future of aviation in Canada. Makes excellent reading. Many photos.
Ellis, Frank	Canada's Flying Heritage	University of Toronto Press, 1954	Toronto	
Ellis, Frank	In Canadian Skies: 50 Years of Adventure and Progress	Ryerson Press, 1959	Toronto	
Foster, J. A.	The Bush Pilots	McClelland & Stewart, Inc., 1990		
Fuller, G. A., Griffin, J. A., Molson, K. M	125 Years of Canadian Aeronautics: A Chronology 1840–1965	Canadian Aviation Historical Society, 1983	Willowdale, Ontario	This is the first complete chronology of Canadian aeronautics to be published. Canadian Aeronautics is considered to begin with the first manned balloon flight, and this book also includes references to some earlier unmanned experiments. Each aeronautical event is presented briefly, noting who did what, when, where, and in what type of aircraft. Well illustrated.
Gilbert, Walter and Shakleton, Kathleen	Arctic Pilot	Nelson Publishers, 1940	Toronto	Tells about Gilbert's flying experiences in Canada's far north, exploring, surveying in the region of the North Magnetic Pole, and ferrying supplies to isolated mining camps in the Great Bear Lake region. During his flying career, Gilbert penetrated further into the Canadian Arctic than any airman before him.

Author	**Title**	**Publisher**	**Location**	**Description**
Gowans, Bruce W	Wings Over Calgary, 1906–1940	Historical Society of Alberta, 1990	Calgary, Alberta	Wings Over Calgary records the history of civil aviation in the Calgary area from 1906, when the first aeronautical event occurred, until 1940 when World War II curtailed civil aviation. This book details Calgary's extensive aviation past, from its first Aviation Exhibition in 1911 to the arrival of its first corporate aircraft in 1928 to its important role as a training base for the RCAF. Photos.
Grant, Robert S.	Great Northern Bushplanes	Hancock House Publishers, 1997	Surrey, B.C.	Commemorates and honours the bushplanes and their pilots who helped to open Canada's northland through wilderness transportation. Each chapter takes readers into a different airplane's history. Real-life experiences are interwoven with technical details and ensure an enjoyable read for anyone with an interest in aircraft or the North. Contents: The First Bushplanes; Noorduyn Norseman; Stinson Gull Wings; Beech 18; Fairchild Husky; De Havilland Beaver and Otter; Found FBA-2C; and Cessnas. Photo sections.
Hartley, Michael	The Challenge of the Skies	Puckrin's Publishing House Ltd., 1981	Edmonton	Brings the history of flying activities in Alberta and the North, from the beginning, when the Underwood brothers exhibited their non-powered flying machine at the Stettler Exhibition in 1907. It takes us through the days of the daring barnstormers, World War I, daring search and rescues in Canada's unmapped Northern regions, northern explorations and mapping, to the entrepreneurs who took the risks involved in setting up commercial aviation ventures, including George (Grant) McConachie and Max Ward. Many excellent photos throughout, but no index.
Henry, Walter, editor, and the Canadian Bush Pilot Book Project	Uncharted Skies: Canadian Bush Pilot Stories	Reidmore Books, 1983	Edmonton	Tells the stories of a few adventurous bush pilots who established Canada as one of the world's premier aviation nations. The book describes how they opened up vast northern areas for exploration and development. Includes stories by Stan McMillan, Punch Dickins, Herbert Hollick-Kenyon, Mike Finland, Page McPhee, Wop May, Matt Berry, and others. Photos, no index.

Author	Title	Publisher	Location	Description
Matheson, Shirlee Smith	Flying the Frontiers, A Half-million Hours of Aviation Adventure	Fifth House Ltd., 1994	Saskatoon, Saskatchewan	Brings to life tales from the log books and journals of people for whom aviation is a way of life. These intrepid and independent pilots, engineers, aircraft salvagers, and smoke jumpers tell of their adventures over the endless bush and forbidding barrens of Canada's North, allowing readers a rare glimpse of a unique way of life. This book tells of an era that has all but disappeared, and of people whose careers spanned the pioneer age in aviation. Many continue to fly today. Included are stories told by Weldy Phipps, Olden Bawld, Lorna deBlicquy, Catherine Fletcher, Phil Lucas, Chris Templeton, and others. Photos.
Matheson, Shirlee Smith	Flying the Frontiers, Volume II, More Hours of Aviation Adventure	Detselig Enterprises, 1996	Calgary, Alberta	Vol. II continues the stories of a disappearing era as aviation pushed back the frontiers. It shows the impact of these explorations on both the environment and the people who met the challenges. Among the stories are those told by Colin Campbell, Eleanor Bailey, Father Bill Leising, OMI, the Underwood Family, Roy Staniland, Harold Rainforth, Bill Watts, Mildred Beamish, Floyd Glass. Photos.
Matheson, Shirlee Smith	Aviation Adventures Around the World	Detselig Enterprises, 1999	Calgary, Alberta	Vol. III continues Matheson's stories from all sides of the flying field - old stories and new, heroic and imprudent, in peace and in war. The reader will meet aviators and engineers who have taken to the air in fixed- and rotary-wing aircraft, and even in a space shuttle. Among them are Cedric Mah, the Neil Armstrong family, Wally Wolfe, Gordon Cannam and Chuck MacLaren, Brian Ewenson and Chris Hadfield. Photos.
McGrath, T. M.	History of Canadian Airports	Lugus Publications, in co-operation with Transport Canada and the Canadian Government Publishing Centre, Supply and Services Canada. 1992	Ottawa	A comprehensive history of the opening up of Canada to all its peoples and to the world in the twentieth century through the phenomenon of aviation. The book, which is very well researched, details development of the technology of aviation, in the air and on the ground, from the bush pilots, to the growth of dependable air mail delivery, to the Transatlantic crossings. Photos.

Author	Title	Publisher	Location	Description
Meyers, Patricia A.	Sky Riders: An Illustrated History of Aviation in Alberta, 1906-1945	Fifth House Ltd., 1995	Saskatoon, Saskatchewan	Is a history of aviation events in Alberta, and details the lives of the pilots and those who supported them and their visions of a life in the air. Contains many photographs.
Myles, Eugenie Louise	Airborne from Edmonton	The Ryerson Press, 1959	Toronto	Is the story of the pioneers who were the first to be airborne from Edmonton or who were among the first to be airborne in northwestern Canada. It is the story of "bush" flying, of the daring young aviators and air engineers whose exploits continue to amaze today's aviation enthusiasts.
Oswald, Mary	They Led the Way. Members of Canada's Aviation Hall of Fame	Canada's Aviation Hall of Fame, 1999	Wetaskiwin	Provides brief biographies of Members of Canada's Aviation Hall of Fame, elected for their lasting contributions to aviation in Canada, from the first experiments with powered flight in 1909, the daring barnstormers, the northern explorers and surveyors, bushpilots, the airmen who used aircraft in new ways to fight in the wars, the inventors, the entrepreneurs. This is the history of the Hall of Fame's first twenty-five years, 1973–1998. Annual updates, available from the Hall at the Reynolds-Alberta Museum in Wetaskiwin, Alberta, feature the stories of those who have been inducted since 1999. Contains many excellent photographs and is fully indexed.
Reid, Sheila	Wings of a Hero, Ace Wop May	Vanwell Publishing, 1977	St. Catharines, Ontario	This is a well-researched and complete story of the life of Wilfrid 'Wop' May, who is credited with achieving many firsts in aviation, in Alberta and northern regions.
Sutherland, Alice Gibson	Canada's Aviation Pioneers: 50 Years of McKee Trophy Winners	Hill Ryerson, 1978	Toronto: McGraw	Canada's Aviation Pioneers tells the exciting story of the adventurous and often visionary men who pioneered aviation in Canada. From Canada's first pilot to modern airline pioneers and inventors, here are the winners of the Trans-Canada (McKee) Trophy, awarded annually for outstanding contributions to the development of aviation in Canada. This book tells in words and photos the story of every McKee Trophy winner from 1927 to 1977. Photos.

Author	Title	Publisher	Location	Description
Ward, Maxwell	The Max Ward Story	McClelland & Stewart, 1991	Toronto	Max Ward's own story, told in his own words. This very readable book details his involvement in aviation from his first ventures with a de Havilland Fox Moth at Yellowknife to the formation of his charter company, Wardair. He describes the expansion of his operations to become Canada's largest international air charter carrier renowned for its top-rated service, and concludes with his decision to sell his company to Pacific Western Airlines, which later became Canadian International Airlines. Photos included.



Topic 1: Glossary

aerodynamics — the study of the forces of flight acting on bodies in motion through the air

aeronautics — the science of flight

aircraft — a machine used for flying. Airplanes, helicopters, blimps and jets are all aircraft.

airplane — an aircraft that uses the force of air on its wings (called lift) to fly

aviation — the operation of aircraft. There are three types of aviation: general, commercial, and military

biplane — an airplane with two sets of wings. The first airplane ever built had two sets of wings, one on top of the other.

monoplane — an airplane with one set of wings. Most aircraft today have only one set of wings and are classified as monoplanes.

pilot — a person who flies an aircraft

reconnaissance — in aviation, to fly over and look closely at an area below to gather information about it.

Topic 1: FAQs

1. When was the first flight made in Alberta? 1911 Hugh A. Robinson in a Curtiss Pusher Biplane.

2. Who flew the first flight in Canada? John A.D. McCurdy in the A.E.A. Silver Dart, a plane he had designed on February 23,1909, with Alexander Graham Bell looking on.

3. What were some of the things Alberta civilians did to help during the first and second world wars?
   a. Trained pilots mechanics and nurses
   b. Repaired airplanes
   c. Sewed uniforms
   d. Prepared food packages and bandages
4. Who was the famous Alberta bush pilot who was the first to fly across the Arctic? “Punch” Dickins September 1928

5. Which famous Albertan assisted the police by using his airplane to help search for a criminal? “Wop” May 1931

6. When did the first official passenger service begin in Alberta? July 1, 1920, Keith Taylor, who flew an Avro 504K

7. Name one airport that was used to train pilots for World War 1 and World War II. Edmonton Municipal Airport

8. When did jets start to land at Edmonton International Airport? 1960

9. Where is Canada’s Aviation Hall of Fame located? Wetaskiwin, Alberta

10. Who was the first Alberta woman to get her pilot’s licence? Gertrude De La Vergne on December 4, 1928.

11. What is the name of the first Canadian astronaut? Marc Garneau

12. What is the name of the first woman astronaut? Roberta Bondar

13. What contributions has Chris Hadfield made towards the advancement of Canadian aviation? First Canadian to operate the Canada-arm in space, first Canadian Mission Specialist, and the only Canadian to visit MIR.

14. What is the sound barrier and who was the first pilot to break it? The sound barrier refers to the speed at which sound waves travel. If you stand a distance away from a friend and say something to your friend, the sound waves of your voice will travel very quickly to the ear of your friend. The speed of sound is the speed at which those sound waves travelled. A speed (velocity) greater than sound is referred to as supersonic. The speed threshold for airplanes is 1223 kilometres per hour (761 mph) at sea level.

    Retired Air Force Brigadier General Charles E. "Chuck" Yeager gained fame as the first man to fly faster than the speed of sound. This historic flight in the Bell X-1 aircraft took place on October 14, 1947 at Muroc Dry Air Field (now Edwards Air Force Base) California, USA. Yeager was chosen from several volunteers to test-fly the secret, experimental X-1 aircraft, built by the Bell Aircraft Company. The Bell X-1 was designed to test human pilots and fixed wing aircraft against the severe stresses of flight close to the speed of sound, and to see if a straight wing plane could fly faster than the speed of sound (approximately 1223 kilometres per hour (761 mph), in air at sea level). No one knew if a pilot could safely control a plane under the effects of the shock waves produced as the plane's speed neared Mach 1.

    On October 14, 1947, over dry Rogers Lake in California, Yeager rode the X-1, attached to the belly of a B-29 bomber, to an altitude of 25 000 feet. After releasing from the B-29, he rocketed to an altitude of 8 200 metres (25 000 feet). After releasing from the B-29, he rocketed to an altitude of 13 200 metres (40 000 feet). He became the first person to break the sound barrier, safely taking the X-1 to a speed of 1061 km/h (662 mph), faster than the speed of sound at this altitude.

15. What contribution has Major Deana Brasseur made to Canadian Aviation? She became one of two first women to fly the CF-18 Hornet jet fighter airplane.

16. When was the first hot-air balloon launched? In 1783 by the Montgolfier brothers, Paris, France. The first passengers were a duck, a sheep, and a rooster.

17. In 1849, who built a glider and made the first 'heavier-than-air" flight? Sir George Cayley from England. Cayley is referred to as the "father of aerial navigation."

18. Who built the first practical glider for long flights? In 1891, Otto Lilienthal built the first practical glider.

19. When was the first passenger airplane flown? In 1933, a Boeing 247 (USA) became the first passenger airplane.

20. Who flew the first jet airplane and when? In 1939, Pabst von Ohain of Germany and Frank Whittle of England flew the first jet airplane.

21. What is an ornithopter? An ornithopter is a wing-flapping aircraft. In 1490, Leonard da Vinci designed an ornithopter.

22. Who was the first person to fly across the Atlantic Ocean, nonstop? In 1927, Charles Lindbergh flew across the Atlantic Ocean, nonstop.

23. Who was the first person to fly solo across the Pacific Ocean from Hawaii to California? In 1935, Amelia Earhart flew solo across the Pacific Ocean from Hawaii to California.

Topic 2: The Air Out There

Topic 2 begins with a quest to find out more about air – this invisible fluid that can allow flight if directed in certain ways. There are many activities in this topic, so the students can learn by being actively involved. The students begin their examination of lift – a force of flight. They learn about Bernoulli's Principle and the importance of the angle of attack. They have the opportunity to experiment with kites and manipulate a virtual wind tunnel to apply these principles of flight.

Start this topic off with a bang! Show the students a clear plastic bag (flattened) and ask them what's in the bag? Now open the bag and wave it around and then quickly close the expanded bag. Ask, again, what is in the bag? Slam the bag between your hands. Explain in your discussion that the explosion is caused by the sudden expansion of the air rushing out of the torn bag. Now that you have their attention, continue the introduction of the topic.

The teacher in the little introductory movie discusses the forces of this mysterious, invisible gas. This topic is designed to provide many opportunities for student participation. You may want to set up a station or small groups to do the various demonstrations. The following supplies will be needed. **It is recommended that you read through all of the Topic 2 lessons in advance, so you can plan how the activities will be set up.**

Materials Needed to Do the Activities in Topic 2		
Hair dryer (blower style)	Large glass jar	A pencil, full length or a small piece of wooden dowel, approximately 15-20 cm long
Ping-pong ball	Floating tea candle	Aluminum pie pans
Empty plastic pop bottle (2 litre)	Matches	Scissors
Balloons (try to get the same kind and size)	Saturated limewater (calcium hydroxide in water)	A candle or a lamp as a heat source
Banana	A glass	A marker
Peach and/or apple	A box of plastic straws	A Frisbee
Lemon juice	A piece of wood dowel, approximately one metre in length	Several large pieces of cardboard (40 cm by 40 cm)
Clear plastic tray (at least 15 cm wide and long) with adequate sides to hold 10-15 cm of water	Two cans, the same size	Baking Soda
Vinegar		

Lesson 1: What Is Air?

Students learn that air takes up space in the Huff 'N Puff activity. Make sure the students have been successful printing their worksheet before they start the activity, or, if you prefer, use your master copy of the same handout (in the Appendix) and make copies for each student. Guide students through the worksheet to be sure they understand what is expected and provide instructions for submission.

Activity on Printout: Huff 'N Puff [1]

Observations:
As you inflate the balloon, it takes up more space in the bottle. But the bottle is already full–of air. Even though you can't see it, air takes up space. When you try to inflate the balloon, the air trapped inside the bottle prevents you from doing it.

Inference/Conclusions:
Air takes up space. The pop bottle is full of air. When you blow, the balloon will inflate a little as the air trapped inside the bottle is compressed (squeezed into a smaller space). When the compressed air begins to push back as hard as you are blowing in (air pressure equals the pressure you are applying), the balloon cannot get any bigger.

Activity on Printout: Air Force [2]

Observations:
The ping-pong ball is held in the middle of the moving stream of air. When the hair dryer is placed on a lower fan setting, the ball is suspended (still in the center of the stream) at a lower height.

Inference/Conclusions:
Air is able to support objects in sustained flight. On high speed, millions of air particles/second push up on the ball. On lower speed, fewer particles/second push up–with few particles pushing the ball can't be pushed up as high as it is on the high setting. The ball stays in the center of the stream because that is where the air is moving fastest, producing the lowest pressure. If the ball moves to one side, it is quickly pushed back into the center by the slower moving, higher-pressure air at the edges of the air stream.

1 © 1997 Edmonton Public Schools/Resource Development Services
2 © Jane Skinner, Edmonton Public Schools, seconded to Alberta Learning, 2002

Activity on Printout: Fruity Oxidation [1]

Observations:

> The fruit turns brown in spots. The brown is rust. Rusting uses up oxygen. Rusting is oxidation. The fruit oxidized because the oxygen in the air reacted with chemicals on the surface of the fruit

> As part of the observation step, a discussion needs to occur before an acceptable conclusion can be drawn

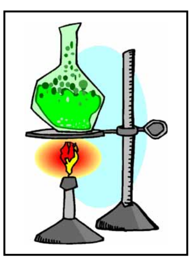
Inference/Conclusions:
The student's conclusion should be similar to this: There is oxygen in the air. When the fruit surface was in contact with air, oxygen was available to cause the fruit to turn brown.

Discuss how fruit can be protected from oxidation. (Leave the peel on. Refrigerate the fruit to slow down the process. Use ascorbic acid, like lemon juice, to slow down the process. Cover fruit with plastic to limit air exposure.)

You might want to take this opportunity to discuss rusting of iron. Discuss the fact that rust causes millions of dollars of damage each year. Painting iron protects it, so does applying thin layers of grease or oil. Sometimes iron is coated with a thin layer of zinc metal, called galvanizing, which is also effective at reducing rust.

Magic?

You may also want to perform a classroom demonstration to demonstrate there is oxygen in air. To get their attention, don't explain ahead what and why you are doing this. Ask the students to watch closely to see what happens and think why it happens.



Take a glass jar (like a pickle jar) and mix together about ½ cup of vinegar and ¼ cup of baking soda to make CO_2. Let it rest for a short time, covered. In another empty pickle jar, insert a tall candle that is about 2/3 the height of the pickle-jar. Set it in the jar off centre so you have room to work on one side. Light the candle and then lift the corner of the cover off the CO_2 jar and slowly pour in the CO_2. The candle will eventually go out. Try to relight the candle. Elicit from the students that the CO_2 (which is heavier (denser) than air displaces the air. The flame goes out because it needs the oxygen in the air to burn

Activity on Printout: A Slow Burn [2]

Safety is an issue with this activity because of the fire required. Be sure students are supervised.

Observation:
Burning (combustion), like rusting, uses up oxygen. The burning candle uses the oxygen in the jar. Once the oxygen is used up, burning stops. The water level indicates the approximate amount of oxygen that was in the jar at the time. Oxygen makes up about 1/5 of the air.

[1] © 1997 Edmonton Public Schools/Resource Development Services
[2] © 1997 Edmonton Public Schools/Resource Development Services

Inference/Conclusions:
As the oxygen level decreases, the intensity of the flame diminishes; burning slows down as less heat is produced. This causes burning to slow down even further until the candle is to cool to burn.

Activity on Printout: All Mixed Up[1]

Observations:
When you blow air through limewater, the limewater turns cloudy.

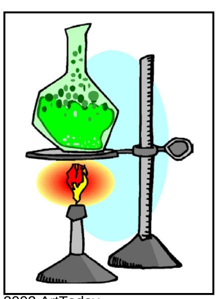
Inference/Conclusions:
There is something in the air that causes the limewater to change from a clear solution to a cloudy solution. That something is carbon dioxide (CO_2), which reacts with the calcium hydroxide to form calcium carbonate. Calcium carbonate is the chemical that is insoluble in water, so when it forms, it appears as a white precipitate. Atmospheric air is only 0.03% CO_2. The air from our lungs contains a much higher percentage. You could do this same test by pumping atmospheric air through the limewater. You would get the same results, but it would take much longer. All animals, and burning and rotting materials, release CO_2 in the air. Plants use CO_2 from the air to make food using a process called photosynthesis.

Activity on Printout: A Balancing Act

Observations:
The balance tips because the larger, inflated balloon is heavier than the smaller, inflated balloon.

Inference/Conclusions:
Air is quite heavy. The only difference between the two balloons is that one has more air in it. This proves that air has (mass and thus) weight.

Activity on Printout: Heating Air[2]



Safety is an issue with this activity if a flame is used. Be sure students are supervised.

Observations: The spiral begins to turn when placed above the heat source.

Inference/Conclusions:
Air rises when it is heated. As heat energy is added to air, its particles begin to move faster and push against each other harder. The air particles move farther apart and the air becomes less dense (lighter due to less matter in the same volume) than the air around it. The lighter (less dense) air gets pushed up by the heavier (denser) air around it. This upward movement of warmer air is called convection.

[1] © Jane Skinner, Edmonton Public Schools, seconded to Alberta Learning, 2002
[2] © Jane Skinner, Edmonton Public Schools, seconded to Alberta Learning, 2002

Hot Air Balloons

Hot Air balloons are introduced in a simple way within the resource. To provide more information see, the **Hot Air Balloon Design** printout, located in the Appendix**.** It is not located in the student resource. You can photocopy or print as many copies as you need for distribution. You may want to have students do research on one of the following: hot air balloons, helium balloons (like the ones at special parties), or blimps. Here is some background information.

More About Hot Air Balloons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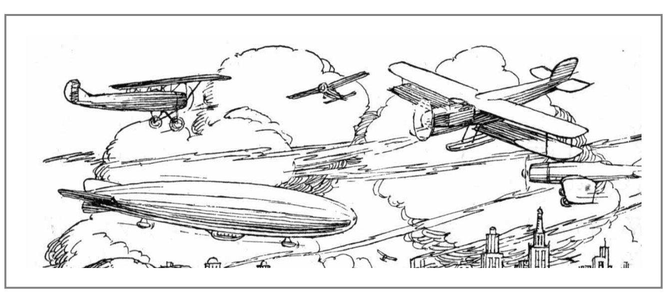
- Based on the principle that warm air rises in cooler air
- Hot air is lighter than cooler air because it has less mass per unit of volume.
- A litre of air weighs roughly 1.2 grams. If you heat that air by 60° C, it weighs about 1.0 gram. Each litre of air in a hot air balloon can lift about 0.2 gram. To lift 500 kilograms, you need about 2 500 000 litres of hot air.
- To keep the balloon rising, you need a way to reheat the air. Hot air balloons do this with a burner (typically, propane). Point out the propane tanks on the Hot Air Balloon Design printout.
- The skirt on the balloon is coated with special fire resistant materials to keep the flame from igniting the balloon. (Point out the skirt on the printout.)
- Most modern hot air balloons, use nylon for the envelope, which is made up of panels and gores. (Point this out in the diagram on the printout.)
- The hot air doesn't escape from the hole in the bottom of the balloon because buoyancy keeps it moving up.
- The buoyant force is equal to the weight of air displaced by the balloon, so a larger balloon envelope will generally have a higher upper altitude limit than a smaller balloon. This could be turned into a question for students: Which size of hot air balloon can go higher?
- The basket holds the passengers, navigation equipment, and propane tanks.
- The controls are very simple. To go up, the pilot moves a control that opens up the propane valve. As the flow of propane increases, the flame grows in size.
- Hot air balloons also have a cord to open the parachute valve at the top of the envelope. When the cord is pulled, some hot air can escape. This causes the balloon to slow its ascent. If the pilot keeps the vent open for too long, the balloon will sink.
- The pilot can control moving up and down. To move horizontally, the pilot has to change altitudes because the wind blows in different directions at different altitudes.

About Helium Balloons

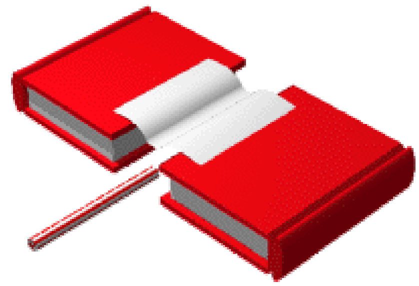
> If you let go of the string of a helium balloon, it will fly away until you can't see it anymore.
> Helium balloons work on the principle of buoyancy. Compare the balloon to a sealed, empty pop bottle (full of air) that floats in water. The reason the pop bottle wants to rise in the water is because water is a fluid and the one litre bottle is displacing one litre of that fluid. The bottle and the air in it weigh perhaps an ounce at most. (The litre of air weighs a gram and the bottle is very light.) The litre of water it displaces, however, weighs about 1,000 grams (approximately 2.2 pounds or so). Because the weight of the bottle and its air is less than the weight of the water it displaces, the bottle floats. This is the law of buoyancy.
> The helium balloon is floating in an ocean of air. The helium balloon displaces an amount of air. As long as the helium plus the balloon is lighter than the air it displaces, the balloon will float in the air.
> Helium is a lot lighter than air. (A litre of water weighs about 1,000 grams; a litre of air weighs about one gram; helium weighs about 0.1785 grams per litre.)

About Blimps

> Unlike a hot air balloon, a blimp has a shape and structure that enables it to fly and maneuver.
> Blimps are often called Airships or LTA (lighter than air) craft because they use gases lighter than air to create lift.
> Helium gas is commonly used today. Helium is not flammable.
> Hydrogen was used in the early days because it was even lighter than helium, however, the Hindenburg disaster ended the use of hydrogen in airships because hydrogen burns so easily.
> The cone shape of the blimp helps generate lift.
> A blimp controls its buoyancy like a submarine. It has ballonets that act like ballasts tanks, holding heavy air. Adding air makes the blimp heavier to maintain a steady cruising speed.
> Blimps can cruise at altitudes of 305–2135 m.
> The engines provide forward and reverse thrust.
> Airships can stay aloft anywhere from hours to days.
> Blimps are used to cover sporting events, for advertising, and for doing research such as scouting for whales.



Lesson 2: Lift and Bernoulli



Bernoulli is introduced at the end of Lesson 1 in the discussion of how the fluid, water, behaves when flowing through pipes. Those learnings provide a link to Bernoulli's principles about aerodynamics. The lesson starts out with a small movie of a science teacher talking about Daniel Bernoulli. The movie includes a simple demonstration that the students are encouraged to try as well. Be sure the two books are of a similar height and placed seven centimetres apart. As shown, place a sheet of paper over the books. Have on hand a box of straws so each student can use two to move more air.

Activity on Printout: Magnetic Paper [1]

Observations:
When you blow between the two pieces of paper, they will move toward each other. The harder you blow, the closer they get. They will maintain their position as long as you continue to blow at that speed (strength). [2]

Inference/Conclusions:
Fluid (gas and liquid) pressure drops as the fluid's speed increases (Bernoulli's Principle). When you blow air out, it pushes on the air in front of you forcing that air to move faster. Air particles move from between the papers. Because there are less particles pushing outward on the papers, the air pressure between the papers decreases. Since there are a greater number of particles pushing on the outside of the papers, the higher air pressure pushes the papers together.

The next page (Screen 1 within the student resource) continues with Bernoulli. The teacher in the movie ties his principles to lift.

Activity on Printout: Lift and Bernoulli

Paper Strip Activity

What happened? The strip of paper lifts when the students blow.
Why did this happen? Standing air exerts pressure in all directions. When the air begins to move across the top of the paper, there are less air particles pushing down at any one moment, so the air pressure above the surface decreases. The higher pressure under the paper pushes it up. The faster the air moves, the lower the pressure it exerts (Bernoulli's Principle).[3] In other words, the paper rises because the moving air creates a partial vacuum. The paper is pushed up to fill this vacuum. The high pressure below the paper pushes up toward the relatively low pressure above the paper.

1 1998 Infouse/NASA
2 © Jane Skinner, Edmonton Public Schools, seconded to Alberta Learning, 2002
3 © Jane Skinner, Edmonton Public Schools, seconded to Alberta Learning, 2002

Paper Bridges Activity

What happened when you blew beneath it? The bridge sank down.
Why do you think this happened? Blowing through the bridge creates a low-pressure area inside the bridge. The higher pressure of the air above the bridge pushes it towards the table. The students' diagrams should show the bridge deck sloped in.

The Test Your Understanding link shows students two airplane shapes (one with aerodynamically shaped wings and the other with box-shaped wings). They have to predict which plane will go higher? The wings with the curved surface on the top and the flat bottom have the shape that actually creates lift.[1] Use the diagram and animation on this page in the student resource to reinforce the importance of the wing shape.

The final activity related to lift and Bernoulli (linked to "Try This Out") is an innovative, interactive animation that allows students to try various-shaped airfoils in a virtual wind tunnel. The students can also vary the air speed. Manipulating these two variables, they can note the differences in left and drag. Students can create a data chart for this activity. They can fill in values for speed, lift, and drag as they explore the characteristics of the symmetrical and asymmetrical airfoils with the wind tunnel.

Air divides smoothly around a wing's rounded leading edge, and flows neatly off its tapered edge. . . . This is called streamlining. Be sure to emphasize this concept/term in your discussions.

A way to link Bernoulli's Principle to the other important factor for lift is to pose this question: If air going over the top of specially shaped wings makes a plane fly, what happens when the plane flies upside down?

(As long as the front edge of the wing is tilted far enough above the rear edge, the wind will produce lift. It doesn't matter which surface of the wing–top or bottom–is facing up. So the trick to flying upside down is to maintain a high enough tilt. This tilt, or slope (known as angle of attack), deflects air downward and the downward force pushes the plane into the air and that is what is emphasized in this next lesson.

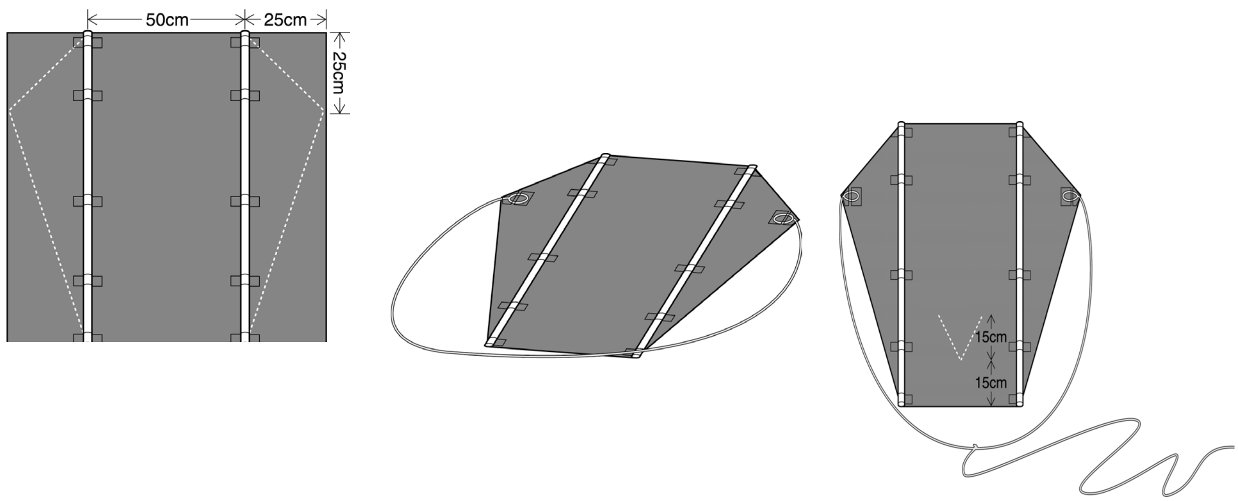
Lesson 3: Another Factor That Affects Lift

The importance of angle of attack is taught in this lesson. Kites are an excellent way to demonstrate this. A kite flies in a state of equilibrium when the forces of flight (lift, weight (or gravity), drag and thrust) are in balance and the angle of attack is correct. The students will be learning more about the forces of flight in the next topic. This lesson focuses on how important the angle of attack is to lift.

More About Kites

To make kites, you can use plastic garbage bags, garden canes or thin pieces of dowel, tape, scissors, and string. Use the following diagrams and dimensions for guidance:

[1] 1998 Infouse/NASA



Students may need to work in pairs when flying kites so one can hold the kite in the air to get it going while the other holds the end of the string. (If there is not much wind, the students may need to run with their kites to make them fly.)

Warning: Never fly a kite where there are electric cables or near a road or railway line.

Students should be encouraged to draw conclusions about the effect on flight of the changing weight of the kite, the speed of the wind, the length of the tail, and the placement of the string. You may want to set up different teams, each with different designs so data can be collected. (e.g., have one team develop and test a kite without a tail.)

The three-page printout on the next page of the student resource linked to the words, **Flat Cardboard Wing Activity**, is repeated in the Appendix. Use this activity and summary to reinforce the angle of attack. You might begin introducing lift's opposing force: drag. Drag will be discussed in more detail in the next topic.

Annotated Kite Sites

Anthony's Kite Workshop	http://www.sct.gu.edu.au/~anthony/kites/
Kite Fliers Site	http://www.kfs.org/kites/ or http://www.kitez.com/
20 Kids 20 Kites 20 Minutes	http://www.aloha.net/~bigwind/20kidskites.html
Dancing Frog Production Kite Page	http://bhc.com/Dancingfrog/#
Kites and Kite Flying	http://www.geocities.com/Colosseum/4569/main.html
Kitelife Links Page	http://www.kitelife.com/other.htm
Kite Sites to Visit	http://www.bhc.com/California_kite_art/sites_to_visit.html
Anthony's Kite Link Farm	http://enterprise.sct.gu.edu.au/~anthony/kites/linkfarm.html

These sites have links to many different kinds and shapes of kites. There are two different urls to Anthony's Kites out of Australia.

Frisbees

To be sure the students understand both the shape of the object and slope (angle of attack) are important to lift, talk more about Frisbees. Angle is important, but what would happen if your Frisbee was flat? Try tossing a flat-shaped Frisbee. (Students should know that the airspeed would be the same on both the top and the bottom of the Frisbee so no lift would be created.) You may want to bring a Frisbee into the room for those students who have not had the opportunity to see how one moves.

Things That Fly

The summary of Topic 2 involves having the students fill in the **Things that Fly** chart printout. You may have to prompt them about beetles, bats, flying fish, flying squirrels, fairies, Superman, Mary Poppins, Peter Pan, witches on brooms, dragons, etc.

Adaptation of species, like birds, is discussed more fully later in the resource; at this point the emphasis is on discussion of the bird's wing shape. You may be able to get a taxidermic (stuffed) bird for demonstration. Point out to the students that the wings are curved outward (convex) on top and are flat or slightly curved inwards (concave) on the bottom. This shape gives lift as the bird flies through the air just like an airplane wing.

The final task of Topic 2 is for students to explain how airplanes fly.

Suggested Answers

The shape of the object affects whether it can fly. If it is streamlined (air-foil shaped) it will fly (like the Frisbee). Also, if it has the right angle (like a kite) that also provides lift. The forces of flight combine with the angle of attack to keep the airplane in the air.

The principles of flight relate to an airfoil. As an airfoil moves through the air, the air over the rounded surface must travel faster than the air along the flat surface because the rounded distance is greater. This quicker movement of air over the top of an airfoil creates a low-pressure area above the airfoil and a high-pressure area below the airfoil. The difference in pressure causes the wing to lift.

It is the air that is pushing the airplane's wings and the rest of the aircraft up. The air under the wings pushes up more than the air on the top of the wings pushes down. The pushing by the air is called the air pressure. The special shape of the airplane's wings makes the air moving around it behave in a certain way. An airfoil is curved, causing some of the air to go over the top and the rest of the air to go along the bottom.

More Information

Annotated Hot Air Balloon Websites

http://www.balloonzone.com	Balloon Zone – This site includes a brief history, links, balloon parts, pictures, and other interesting stuff.
http://howstuffworks.lycoszone.com/hot-air-balloon.htm	Marshall Brain's How Stuff Works – This site includes designs, piloting, landing and launching, and lots more interesting information.
http://www.overflight.com/rosebud.html	This site includes instructions on how to build a homemade hot air balloon using birthday candles and various other materials – may be too advanced for young readers.
http://www.defence.gov.au/raafballoon/	This site, for the Royal Australian Air Force, describes the advantages of using hot air balloons in the Air Force along with other information about the RAAF's balloon fleet.
http://www.cln.org/themes/hot_balloons.html	Model Hot Air Balloons Theme Page – This includes curricular resources for students and teachers, plus links to other sites.
http://www.nasm.si.edu/galleries/gal109/LESSONS/TEXT/HOTAIR.HTM	How Things Fly – Full of Hot Air – This site includes an educational activity to assist in learning/teaching about how hot air balloons fly.
http://library.thinkquest.org/28629/index.html	"Happy Landings" – This is an educational site with information on balloon history, how to pilot a balloon, plus more information.

Annotated Blimp Websites

http://spot.colorado.edu/~dziadeck/zf/introduction.htm	This is a site about the Zeppelin – a versatile airship/blimp.
http://www.afn.org/~afn42211/genealog/sterner/hindenburg/	This is a site on the Hindenburg – a historical warship/blimp.
http://www.worldwar1.com/arm010.htm	This site provides more information on Zeppelins.
http://www.worldwar1.com/sfzepp.htm	Dirigibles, Airships, Zeppelins, and Blimps. Information on the difference between airships and balloons, other historical facts.
http://www.goodyearblimp.com/	This site includes the Goodyear Blimp, information on the Goodyear fleet, plus "Building a Blimp," "History and Blimp Basics," FAQs, and more.

http://www.looklearnanddo.com/documents/history_blimp1.html	This educational site has information on how the history of blimps and airships. It also contains information on how blimps work.
http://www.geocities.com/CapeCanaveral/1022/	Larry's U.S. Navy Airship Picture Book – This is a site by a navy airship pilot who flew Navy blimps from 1954 to 1956. Includes pictures, plus lots of interesting information.

Topic 2: Glossary

air pressure	the application of force by air, or the downward force of air in the atmosphere; the amount of force air exerts on an object
air pressure	the application of force by air, or the downward force of air in the atmosphere; the amount of force air exerts on an object
airfoil	any object (such as the wing of an airplane) whose curved shape is designed to provide maximum lift when in motion through the air
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 moves, the less pressure it exerts
bridle	the line that connects a kite to its control line
camber	the curve of an airfoil
compressed	pushed or squeezed into a smaller space
expand	increase in size
fluid	matter that flows: liquids and gases
fluid dynamics	the study of how fluids move. Fluids include water and gases (such as air).
gas	a form of matter that has no definite shape of its own but tends to expand indefinitely
gravity	the attraction between large objects in space; the force which pulls objects towards Earth's surface
hypothesis	a prediction that needs to be tested to tell if it is correct
leading edge	the front edge of an airfoil; the leading edge is normally rounded and thicker than the trailing edge
lift	the upward force that enables objects to fly
LTA	Lighter Than Air; a blimp is an example of a LTA craft
molecule	the absolute tiniest part of something that can still be called by that name. For example, two hydrogen atoms and one oxygen atom make up one molecule of water.

Newton's Third Law	a principle formulated by Isaac Newton, stating that for every action, there is an equal and opposite reaction
oxygen	a gas found in air; essential for plant and animal respiration, and for burning`
principle	a basic law or assumption about the way things work
scientific method	a systematic way of solving a problem or answering a question using observation and measurement. The six steps of the scientific method are state the problem, create a hypothesis, design an experiment, perform the experiment, organize and analyze the data, and draw conclusions.
streamlining	making a shape or design that will offer the least possible resistance to air (create less drag and move smoothly and easily); airfoils are streamlined
wind tunnel	a long tube or tunnel in which a controlled stream of air is used for aerodynamics testing of models
vacuum	an area where there is no air pressure; outer space is a vacuum
velocity	the speed of an object in a certain direction

Topic 2: FAQs

1. Is a wind tunnel really a tunnel? Not really. A wind tunnel is a device where a powerful fan pulls a stream of air past an object positioned inside. The air moving past the object produces the same effects you would observe if the object were moving through the air. It's a safe way to test new shapes for aircraft, boats, cars, and even athletes. Models are used. It is a lot cheaper, easier, and safer to build and test a model than to build and fly a real airplane.

2. When you buy special balloons filled with helium, and let them go, they float way up. Why? Helium balloons work on the law of buoyancy. The helium balloon is floating in a "pool" of air. The helium balloon displaces an amount of air. As long as the helium plus the balloon is lighter than the air it displaces, the balloon will float in the air. Helium weighs 0.1785 grams per litre. Nitrogen weighs 1.2506 grams per litre, and since nitrogen makes up 80% of the air you breathe, 1.25 is a good estimate to use for the weight of a litre of air. A 25-cm diameter helium balloon has a lifting capacity of 14 grams.

3. What makes some things rust faster? There are many factors that control the rate at which rust forms on an object. One of the main factors is temperature. Warmth allows the particles and electrons involved in the rusting process to move faster, and therefore, the metal that is being oxidized also rusts faster. If it is cold, the opposite is true – the particles and electrons are not capable of moving very fast, so rusting occurs very slowly. Another very important factor in rust formation is the amount of oxygen or air that is present around the rusting metal. The more oxygen present, the longer the metal will continue to be oxidized, and therefore, more rust will form because it takes longer to "use up" all the oxygen around the metal. Some other factors that affect how fast rust forms are the amount of moisture present around the metal, the type of solutes present around the metal (for example, if a metal is surrounded with salt water, it will rust faster than if it is surrounded by air), and the type of metal that is being oxidized.

4. When do you think the first kite was invented? Exactly how old kites are is not known. However, the earliest recorded instance of kite flying was around 200 B.C. describing a Chinese General who flew a kite above a town to determine how far his army would have to tunnel. Since they knew the distance, the soldiers under his command surprised their enemies and won the battle.

5. Some kite-fliers enjoy “buggying.” What do you think kite buggying is? Kite buggying is when a stack of dual line kites are used to pull a small go-cart along a beach, field, or some other area suitable for kites. This type of kite flying requires fairly strong wind, as quite a lot of force is needed to allow the “buggy” to reach maximum speed.

Topic 3: Airplanes

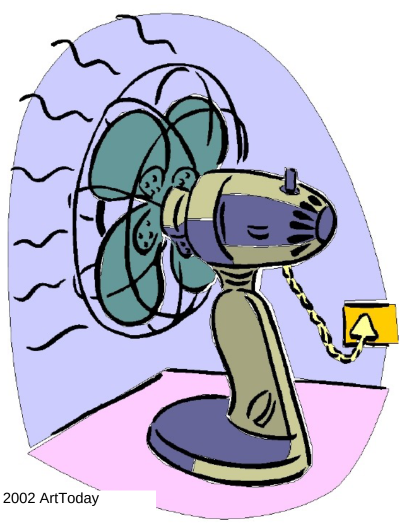
This topic focuses on the forces that act on airplanes (aerodynamics); the parts of airplanes; how an airplane moves; what propels an airplane; and kinds of airplanes.

Although types of airplanes is not taught until Lesson 5, you may want to encourage students to bring in airplane models and pictures for a special display if it wasn't done at the beginning of this work. You may want to start your own collection of unusual airplanes to begin discussion of why, how, etc.

It is recommended that you read through all of the Topic 3 lessons in advance, so you are familiar with the content and can plan appropriately.

Materials Required for Topic Three		
Balloon	Straws	Pinwheel (optional)
Strings	Chairs	Household fan (optional)
Balloon	Straws	

Lesson 1: Forces Acting on an Airplane



This lesson focuses on the basic elements (forces) of flight – lift and weight (gravity) and thrust and drag. These are examples of sets of opposing forces acting upon one another. It doesn't matter whether you're talking about birds flying or airplanes flying, it's these same forces that are at work. A bird flies as the downward pull of the bird's weight (gravity) opposes the upward lift created by its wings. At the same time, the force of drag opposes the thrust created by its forward motion. By making the most use of this technology, the movement of air and the effects of the force can be easily shown. Once again, students have an opportunity to use a virtual wind tunnel – this time to manipulate different kinds of objects to test the effects of streamlining.

Air Tunnel Interaction

There are five objects available in the student's interactive air tunnel for them to test. All objects are tested at the same wind speed (200 kph). Their varying shapes affect the lift and drag and in the case of the door, angle.

Here is a summary of the air tunnel data:

Object	Wind Speed (kph)	Weight (kg)	Lift (kg)	Drag (kg)
Van	200	1250	0	1193
Basket Ball	200	1	0	3
Plane with Propeller	200	1900	5362	487
Jet Plane	200	25 500	3786	416
Door (Slightly Inclined)	200	25	253	22

Elicit from students that objects require a certain shape or angle to produce lift. Do not dwell on the weight factor. Students need to understand that shape and angle affect drag.

Within the study of lift and drag, there is a **Parachute** printout activity in the Appendix for **students involving the design of parachutes.**

Annotated Parachute Web Sites

http://www.aero.com/publications/parachutes/ — This site contains lots of interesting info about the origin of parachutes, articles and stories about parachutes, and more.

http://www.spartacus.schoolnet.co.uk/FWWparachutes.htm — More information is available here on parachute history and origins.

http://parachuting.tripod.com/ — This site contains a gallery of parachuting pictures.

Lesson 2: Parts of an Airplane

Lesson 2 focuses on parts of an airplane that are organized into four categories:

Fuselage	Engine	Wings	Tail
Cockpit	Propeller	Wing span	Vertical stabilizers
Landing gear		Ailerons	Rudder
		Flaps	Horizontal stabilizers
			Elevator

As the students study about the cockpit in the fuselage category, the student resource includes two virtual reality opportunities. Remind students virtual reality is a computer representation of something that is real. "VRs" allow students to explore three-dimensional "worlds." Students can manipulate the cockpits in any direction to get a better sense of how they are designed. Remind students to use their mouse or arrow keys to explore in all directions.

After that experience, students will have the opportunity to learn about Jimmy Doolittle. Lt. James Harold Doolittle was an early aviator who set speed records, performed the first outside loop, and was the first pilot to fly with instruments only.

The students are able to link to an **Altimeter Activity** and are provided the opportunity to virtually control an airplane using only their instruments to guide them. There are two versions of this activity in the student resource: a simpler Explore Mode and the Challenge Mode. [1] Remind the students that on an altimeter, the little hand stands for 10 000s; the medium hand stands for 1000s; and, the big hand stands for 100s. The student's assignment is to take aerial pictures of various scenic locations. Like Jimmy Doolittle, they will fly using only their instruments to guide them. In Explore Mode, they are given the altitudes of each location and shown numbers for each altimeter setting. In the Challenge Mode, they have to figure out the altitude by estimating using lines on the screen and setting the altimeter by looking at the dial.

Game Hints for Altimeter Activity

To use the keyboard instead of the mouse, the spacebar will move the indicator to another button; the up or down arrow keys change arrows for the heading or wind. The return or enter key selects a button.

Note: The "Back to Cabin" button and the “Directions” button have been disabled.

Within this lesson, only propellers are discussed in the engine section. Lesson 4 deals specifically with propulsion.

In the lesson review, the students are linked to an interactive matching game that helps reinforce their understanding of the airplane parts. As well, the students are instructed to printout the two-page **Parts of an Airplane**.

Note, the Appendix also contains printouts of **Parts of an Airplane** (a word search) and **Parts of an Airplane** (a crossword puzzle) that you may want to distribute. The answers are below for the crossword puzzle. They are not included in the student resource.

Note: 6 Down cannot be AIRCRAFT as aircraft includes blimps and balloons, which are not heavier than air; blimps and balloons are classified as aircraft lighter than air (LTA).

ACROSS	
1. LANDING GEAR	4. AILERONS
2. ELEVATOR	
3. FLAPS	

DOWN	
1. FUSELAGE	4. PROPELLER
2. RUDDER	5. COCKPIT
3. WINGS	6. AIRPLANE

[1] © 1998 Infouse/NASA

Lesson 3: Movements of an Airplane

An airplane in flight changes direction by movement around one or more of its three axes of rotation: lateral axis, vertical axis, and longitudinal axis. The airplane's rotation is called pitch, roll, and yaw. The pilot guides the airplane by controlling pitch, roll, and yaw and by appropriately manipulating the control surfaces (elevators, ailerons, and rudder). The pilot requires skill and concentration to maintain stability—the ability of an airplane to control movement (pitch, roll, and yaw) in order to maintain altitude despite air turbulence and to control the plane directionally with the control surfaces.

Again, the ability to move objects in all directions helps teach this concept. After the students try the animated examples, have them practise the movements using their hands. When you say **pitch**, their fingers (as the nose of the airplane) should move up and down. When you say **roll**, the students' hands should roll from side-to-side in a swinging motion. When you say **yaw**, their fingers should move flatly to either the right or left. (Their wrists will automatically turn in the other direction.)

Use two darts (or arrows) to make your point. Have one dart stripped of its feathers. Begin by throwing that dart (or designating a student) at a particular target. Does the dart fly in a controlled manner? Discuss the design and parts of the second, complete, dart. What is the purpose of the tail section? Have the student now throw that dart at the same target. **Be sure this demonstration is closely supervised.**

An additional printout is included only in the Appendix of this guide as an optional reinforcement of Control Surfaces, called **Summary: How to Move an Airplane**. You may want to do this activity as one large group, in small groups, or have students try it by themselves. Here are the answers:

Maneuver	Right Aileron	Left Aileron	Rudder	Elevator
Rising Left	*Down*	*Up*	*Left*	*Up*
Rising Right	*Up*	*Down*	*Right*	*Up*
Diving Left	*Down*	*Up*	*Left*	*Down*
Diving Right	*Up*	*Down*	*Right*	*Down*
360º Roll	*Up*	*Down*	*Neutral*	*Neutral*

© NASA. Toodles, W

Lesson 3 ends with information and a recording about Amelia Earhart, the first woman to fly across the Atlantic Ocean. Amelia established many distance records. Amelia's last flight was in the South Pacific during her attempt to fly around the world. Unfortunately, in June 1937, she flew off-course while attempting to fly to Howland Island and was never heard from again. In the audio track, Amelia explains how to navigate by calculating a true heading, true course, and drift angle. After the recording, students have the opportunity to learn more about flight paths by helping Amelia get to Howland in the South Pacific by doing the **Drift Angle Activity**.[1] They have to calculate the true heading from the true course and the drift angle. In Explore Mode, the students can change the wind speed, wind direction, and the true course as well as the true heading during Pre-Flight planning. This lets them see what might happen in different situations. In Challenge Mode, the students can only set the true heading in Pre-Flight planning. If their calculations are wrong, they can adjust the true heading using In-Flight Correction.

Game Hints for Drift Angle Activity

To use the keyboard instead of the mouse, the spacebar will move the indicator to another button; the up or down arrow keys change arrows for the altimeter. The return or enter key selects a button.

Note: The "Back to Cabin" button and the "Directions" button have been disabled.

Lesson 4: Propulsion

Getting up in the air takes more than lift–it also takes thrust. Thrust gives you the forward motion to sustain lift and counteract drag. It's also used to accelerate, gain altitude, and maneuver. Airplanes get their thrust from engines. Smaller planes use piston engines like car engines. Most commercial and military planes use some type of jet engine. Because most jet engines contain a fan-like part called a turbine, such engines are called turbine engines or turbojets.

This lesson starts with a discussion of piston engines and propellers. Household fans are used as an example. Newton's Third Law again comes into play. This law was first introduced in Lesson 2 when it was mentioned that the wing deflects air downward, an opposite, upward force is placed on the wing, causing lift.

Then turbine engines are described. A comparison is made to a pinwheel. (If you have one in your supplies, you may want to bring it forward at this time.) Students also learn that in addition to turbojets, there are two other kinds of turbo engines: turbofan and turboprop. The students can compare the similarities and differences, and the advantages and disadvantages of the engines in a chart.

A good example of a Canadian aircraft that uses a high-powered turbofan engine is the CT-155 Hawk. The Hawk is powered by the Rolls-Royce Mk.871 Adour turbofan engine, which provides almost 6 000 pounds of thrust; it can fly at Mach1.2.

[1] 1998 Infouse/NASA

Lesson 5: Types of Airplanes

You may want to start this culminating lesson on airplanes with a general discussion about how many types of airplanes they can name. Have students tell of experiences and bring pictures.

Airplane types can be categorized in many ways. Here's a suggestion with accompanying notes:

Cargo/Transport	Experimental/Concept	Fighter/Military	Passenger
> Are very large	> Engineers may build one or two prototypes to test a new model.	> There are many kinds; some are used for transport to carry armies and equipment.	> For business and pleasure
> Can carry construction equipment, other aircraft, trucks, etc.	> Requires specially trained pilots.	> Others are used for reconnaissance or spy for secret missions; examples are the CP-140A Arcturus, which is used for marine surface surveillance; the CP-140 Aurora, a long range patrol aircraft, which can fly over 9 000 km without refueling; and the CC-115 Buffalowhich is especially suited for flying Rocky and Coastal Mountain ranges.	> Most jetliners travel at about 965 kilometres per hour.
> Have large, powerful engines	> Often unique looking, like the X-36 and X-29.	> Some aircraft such as the CT--114 Tutor can perform high above clouds; an example are the Canadair CT-114 Tutors used by the Snowbirds, Canada's world famous aerial acrobatic team. Another highly maneuverable versatile aircraft is the CC--138 Twin Otter, which provides short take-off and landing (STOL) capabilities on floats, skis, or wheels.	> Some can go over 12,874 kilometres nonstop.
> Have unusual shapes; examples are Hercules (Canadian) and Guppy, Beluga	>	> Fighter airplanes are used for aerial combat. Some fly faster than the speed of sound (supersonic); an example is the CF-18 Hornet; which is a twin-engine, supersonic tactical fighter jet.	> The Concorde is the only supersonic passenger jet that travels at twice the speed of sound (2,250 kilometres per hour).
>	>	> Some use stealth technology to make themselves nearly invisible to enemy radar.	>
>	>	> The first letter in the name of a military airplane tells what kind of mission it flies (e.g., F-16 are fighters; B-2 are bombers; A-10 is an attack airplane; and a C-7 is a cargo/transport airplane.	>

More details about Canadian aircraft can be found at: http://www.airforce.forces.ca then 'aircraft' (Canada National Defense, Air Force).

Direct students to the lesson introduction in the resource to hear what Janet, the flight instructor, has to say. After a brief introduction, students are instructed to printout a one-page **Types of an Airplane** worksheet. (A copy is provided in the Appendix.) Answers:

Picture 1	Picture 2	Picture 3	Picture 4	Picture 5
Single engine	Tri-plane	Fighter jets	Jet airliner	Water bomber

You may decide to do this activity as a large group in a discussion, or have students work alone and then discuss it.

Using the **Commercial Airplane** and **Private Airplane** printout activities integrates some creative thinking. Students are instructed to print two different pictures of airplanes. One is a commercial airliner and the other a smaller, personal-type plane. Students are encouraged to pretend they own their own airline so they can create their own company airplane name and design. For the second poster-picture, students are encouraged to design their own personal airplane design. The printouts have been designed full size so they can be displayed.

Topic 3: Summary

Students review what they have learned about the forces of flight, the parts of an airplane, and the movements an airplane can do and why. Propulsion and engine-types are also reviewed.

Rocket Engines and Space Shuttles

As an extension, a link is provided for students to compare their understanding of aircraft design to spacecraft design. This two-page printout **(Rocket Engines, Space Shuttle Launch Configuration and Space Shuttle Stages)** is intended for use in a large group as part of a general discussion.

The first part of the printout discusses rocket engines and provides students with a simple balloon activity to support the concept. The bottom part of the first page of the printout includes a diagram of a space shuttle launch configuration labeling the orbiter; solid rocket boosters, and the external fuel tank. Here is some additional information for your discussion:

Orbiter: The orbiter has three main engines located in the back of the fuselage. These main engines provide less than a third of the thrust required to lift the shuttle off the pad and into orbit. Once in space, the shuttle orbiter is the astronaut’s home. The orbiter contains a crew compartment that provides support. The orbiter must also be able to change positions, change orbits, have the ability to talk to ground-base, navigate, handle information (computers), and generate electrical power.

Fuel tank (external or ET): The ET holds fuel for main engines. The ET is 48 m long with a diameter of 8.4 m.

Solid Rocket Boosters: These SRBs provide most of the main thrust. There are two used. Each has a height of approximately 46 m and a diameter of 3.7 m. When full, each weighs about 589 670 kg.

The second page of the printout shows the path and stages of a space shuttle with some space shuttle images.

What kinds of spacecraft do the students know about (space shuttles and possibly, lunar modules)? Show the students a picture of a space shuttle and one of a lunar module or have them search on the Internet for relevant information. Discuss the great differences in aerodynamics. (Lunar modules are carried up to space attached to a space shuttle. They fly on their own power only when in space and do not fly back to Earth.)

Following are some points to help guide your discussion.

Features	Similarities Between Aircraft and Space Shuttles	Differences Between Aircraft and Space Shuttles
Lift-off	Have wings and the ability to maintain an efficient angle of attack to sustain lift after initial thrust from engines. Altitude is reached in a short time.	Need to harness enough energy to get the spacecraft off the ground. Need rocket boosters to escape gravity; rockets must provide more force up than the force of gravity pulling the spacecraft down.
Shape	Both aerodynamic to reduce drag	
Landing	Aircraft use control surfaces and changes in propulsion to control and direct landings.	When spacecraft come back to Earth from space, they move through the atmosphere very fast; too fast for a safe landing so a parachute is used to slow the shuttle.
Engines	Gasoline or turbine	Reaction engines (Based on Newton’s Third Law, a rocket engine is throwing mass in one direction and benefiting from the reaction that occurs in the other direction as a result.)
Control		Once launched, the rockets cannot be stopped or restarted.

The amount of time spent on spacecraft is largely dependent on the teacher’s schedule. Students are usually very interested in this fascinating topic.

What Adaptations Enable a Bird to Fly?

The Topic 3 summary continues with a printout **What Adaptations Enable a Bird to Fly** that applies students’ knowledge of aircraft to how birds fly. You may want to assign this as an individual assignment or have students work in groups.

Suggested Answers

Propulsion	In birds, the flapping of wings provides propulsion. As the wings are pulled down, they push on the air, providing lift as well as thrust. The thrust is generated on the down stroke as the wing is twisted forward, forcing the air underneath the wing to slip along the wing from front to the back. Some birds run along the ground or water to gain momentum and lift before lift-off is possible, just like a plane taking off down a runway.	
Wings	The wings are curved outward on top in an airfoil shape, which provides lift just like an airplane wing.	
Body Shape	The feathers on birds are very contoured, making the bird streamlined and sleek (reducing drag).	
Skeleton	Bones are hollow or partially hollow, making them light but strong.	
Other (Example)	Muscles	Birds have large pectoral muscles that generate power to flap the wings. Their muscles do not tire easily

Why can't penguins fly? Have a large picture of a penguin on hand and encourage a discussion of the features that contribute to flying and whether a penguin has these features.

Topic 3 ends with an opportunity for students to experience flying an airplane. Two flight simulators have been added to this resource. The first is an easier level and the second, *F/A-18 Korea Gold* [1], is more challenging. You might want to have one or more of your students with the most computer expertise experiment with the flight simulators before hand so they can help coach other students.

Flight Simulator (Easy Version) Instructions

The goal of this simulation is for the pilot to manipulate the airplane so it hits each target. The students will need to use the arrow keys to control the airplane's movements. Be sure to point out to students which parts of the airplane move to make the different movements.

Flight Simulator (Challenging Version) *F/A-18 Korea Gold Demo*

F/A-18 Korea puts students in the cockpit. Included in this package is a demo version **only**; however, a complete version can be purchased from the website of Graphic Simulations Corporation (www.graphsim.com).

In order to use this simulator, you will need to begin by printing and studying the manual that is included in the installer. All of the instructions are in this manual. Use the link provided in the student resource.

In addition to applying their knowledge about flight, you should be aware that this simulation involves destroying enemy air defense, maintaining air superiority and destroying hostile aircraft. Some teachers and students may be uncomfortable with this aggressive environment; in such instances, restrict use to the Easy Version.

To help students, a **Quickstart Tips** printout has been included. This guide is not intended to replace the detailed manual. It is intended as a quick reminder for students and teachers after they have read the manual.

[1] Grapic Simulations Corporation—www.graphsim.com

More Information

Annotated Airplane-Related Web Sites

http://www.howstuffworks.com/airplane.htm	Very good site – lots of information on the basics of how airplanes work, explained well.
http://www.ueet.nasa.gov/StudentSite/	NASA site for Kids – Ultra-Efficient Engine Technology. Includes info on "What is Aeronautics", "History of Flight", "Dynamics of Flight", "Airplanes, Engines", and more. Also includes quite a few educational links.
http://www.grc.nasa.gov/WWW/K-12/airplane/bga.html	Beginners Guide to Aerodynamics. Provides a better understanding of how airplanes work.
http://www.allstar.fiu.edu/aero/princ1.htm	This site contains a lot of resources for instructors. It includes experiments on the principles of flight, as well as lessons on the history of flight. All material is copyrighted and permission must be obtained before downloading.
http://www.ameliaearhart.com	Includes biographical quotes, achievements, and a photo gallery
	The Epic of Flight: Women Aloft, by Valeria Moolman, Time/Life Books, ISBN 0-8094-3289-7
	Biography: Amelia Earhart, by Blythe Randolph, 1987, Franklin Watts Publisher, ISBN 0-531-10331-5
http://www.aero.hq.nasa.gov/edu	Explains at an appropriate student level how things fly
http://ltp.larc.nasa.gov/flyingstart/	Appropriate level, Off to a Flying Start
http://quest.arc.nasa.gov/aero/background/	Talks about what is aeronautics
http://www.sky-flash.com/snow1.htm	This site includes interesting information about the Snowbirds as well as links to other related sites. Other Snowbird sites: http://www.rcaf.com/snowbirds and http://www.snowbirds.dnd.ca/forms_e.asp

Topic 3: Glossary

ailerons	control surfaces found on the trailing edge of the wings of the airplane. These work in opposition to each other (one goes up and the other goes down) to help create roll in the airplane.
airspeed	the speed of an aircraft relative to the air around it; velocity of a flying machine
altitude	the height of an object, like an airplane, above sea level or above the Earth's surface
basket	the container that hangs below a hot air balloon and transports people
buoyancy	the tendency of a body to float or rise when placed in a fluid; if an object is less dense than an equal volume of fluid surrounding it, that object will float
burner	the source of heat for increasing the temperature of the air in a hot air balloon
camber	the curved shape of a wing that creates lift
cockpit	the area of the airplane in which the pilot and other officers sit. The airplane is controlled from the cockpit.

control surfaces	the rudder, ailerons, and elevator that work together to provide directional control for the airplane by altering the airflow around the surfaces of the airplane
dihedral angle	the upward angle of the wings that is formed where the wings connect to the fuselage
dirigible	a lighter-than-air craft (LTA) constructed with a lightweight rigid frame
drag	a force that opposes the force of thrust, thus keeping the airplane from moving easily; the resistance air puts on a flying object
elevator	the control surface found on the horizontal stabilizer of the airplane. Movement of the hinged elevator causes the airplane to pitch up or down.
empennage	the parts of an airplane located at the tail end. The empennage includes the horizontal stabilizer, the vertical stabilizer, and elevators.
envelope	the balloon, which holds hot air in a hot air balloon
equilibrium	when all the forces of nature are in balance
expand	to enlarge
fin	the vertical surface of an airplane's tail
flaps	the inner sections found on the trailing edge of the wings. The flaps are lowered to help increase lift on takeoff and increase drag upon landing.
flight simulation	a tool of aeronautics in which a flight simulator on the ground is used to create an environment where a pilot sees, hears, and feels like he or she is in a real aircraft. Flight simulation is used to investigate how an aircraft responds to a pilot's movements of the controls.
fuselage	the main portion (body) of the airplane to which the wings are attached
ground speed	the speed an airplane travels in relationship to the Earth
horizontal stabilizer	this is the horizontal portion of the tail section of the airplane. On the horizontal stabilizer, you will find the elevators.
instruments	tools used to observe, measure, and control. For example, pilots use instruments to measure and observe the altitude, speed, and direction of an aircraft.
jet engine	an engine that works by creating a high velocity jet of air to propel the engine forward
landing gear	the portion of an airplane that supports the airplane while on the ground or other landing surfaces; the undercarriage. The landing gear may be wheels, pontoons, or skis.
lift	the force that counteracts gravity. Lift is needed in order to get an airplane off the ground.
model	a simpler, smaller, or less expensive version of a final design
pitch	movement around the lateral axis, moving the nose of the airplane up and down
propeller	this is the spinning structure that is attached to the front of a single-engine airplane. It is attached to the drive shaft of the engine. When it spins, it causes a movement of air that helps move the airplane. It is the main means of propulsion for an airplane.
propulsion	moving an object

prototype	an original model on which something is patterned; prototypes are tested in wind tunnels
regimes of flight	a way of placing aircraft into different categories based on their speeds: subsonic, transonic, supersonic, hypersonic
relative wind	the wind speed and direction relative to an airplane's speed and direction
rocket	any devise propelled by the ejection of matter
roll	movement around the longitudinal axis, moving the wings up and down; fuselage rotation
rudder	a hinged control surface on the vertical stabilizer affecting the yaw of the airplane
speed of sound	the speed at which sound travels; a speed threshold for airplanes; approximately 760 miles per hour (1,220 km/h) at sea level
stability	the ability of the airplane to control movement (pitch, roll, and yaw) in order to maintain altitude despite air turbulence.
stabilizer	the horizontal surface of the airplane's tail
stall	a breakdown of the airflow over a wing, which suddenly reduces lift. When an airplane stalls, it will usually drop suddenly. Pilots know how to recover from a stall and smooth out the airflow over the wings to produce more lift again.
streamline	the design of an object that reduces drag
takeoff	the process of using the thrust of the engines to accelerate an airplane down a runway until enough lift is generated so that the aircraft begins to fly
thrust	the force that opposes the force of drag. Thrust helps move the object forward or in the direction of the thrusting force.
turbine engines	jet engines that contain a fan-like part called a turbine. Turbine blades are turned by air flowing past them unlike propellers that have energy of their own.
turbulence	airflow that is not smooth and steady. When an airplane flies through turbulent air, it can unexpectedly rise, drop, roll, pitch, or yaw very abruptly
velocity	the speed at which a flying machine travels through the air; the speed of motion; airspeed
vertical stabilizer	the vertical portion of the tail of the airplane. The rudder is attached here.
weight	the force of gravity. It acts in a downward direction, towards the centre of Earth.
wings	the two or more sections that extend from both sides of the fuselage of the airplane. The ailerons and flaps are attached to the wings.
X-29	an experimental supersonic jet that has forward sweep-wings. It is capable of going over one and one-half times the speed of sound.
yaw	movement around the vertical axis, moving the nose of the airplane left or right; used to maintain or change direction

Topic 3 FAQs

1. Who are the Snowbirds and what can thy do? The Canadian Forces 431 Air Demonstration Squadron – better known as The Snowbirds – is a world-famous military aerobatic demonstration team. The Snowbirds team consists of nine CT–114 Tutor aircraft and a personnel staff of only 24.

   The Snowbirds are capable of many high-speed and often high-risk maneuvers and formations. Many of the Snowbirds “tricks” involve flying inverted, high- speed passes at close range, and formations that include nine aircraft.

   Throughout the course of a show, the speed at which The Snowbirds travel varies quite substantially; however, it is not uncommon for the jets to reach speeds of 600km/hr.

2. What produces thrust on satellites? Tiny rocket engines called attitude thrusters are used on satellites as they don’t need much thrust. One common satellite engine uses no “fuel” at all. These engines are called pressurized nitrogen thrusters, which simply blow nitrogen gas from a tank through a nozzle. Thrusters like these kept Skylab in orbit, and are also used on the shuttle’s manned maneuvering system.

3. When did the USA decide to develop a reusable space shuttle? In 1972, NASA announced their plans to use a reusable shuttle design consisting of an orbiter attached to solid rocket boosters and an external fuel tank.

4. 

   Meteors burn up when they hit the Earth’s atmosphere. Why doesn’t the space shuttle? The shuttle orbiter uses a special design. It is covered with many insulating ceramic tiles that absorb the heat of re-entry without harming the astronauts.

5. When was the first shuttle flown and who were the astronauts? The first shuttle was called Columbia. It was piloted first by John Young and Robert Crippen in 1980. Later shuttles were called Discovery, Atlantis, and Challenger.

6. Which shuttle was destroyed in flight? In 1986, the shuttle, Challenger, was destroyed in flight when a flame from a leaky joint on one of the solid rocket boosters ignited fuel in the external fuel tank. The Challenger exploded and the entire crew was lost. The Challenger was later replaced by the Endeavor.

7. How can a rocket fly without wings? A rocket can fly without wings because it has so much force applied to it that gravity can’t keep it down. A baseball flies without wings because of the force with which it is hit. It takes a while before the gravity pulls it to the ground.

8. If you are flying 150 km/h into a 50-km/h head wind, what is your ground speed? In order to determine how fast a plane is moving over the ground, wind speed must be considered. First, subtract the speed of the head wind from the air speed if the airplane is flying into a head wind. So if you were flying 150 km/h into a head wind of 50 km/h, your ground speed would be 100 km/h. If you are flying with a tail wind, you add the speed of the tail wind to your air speed.

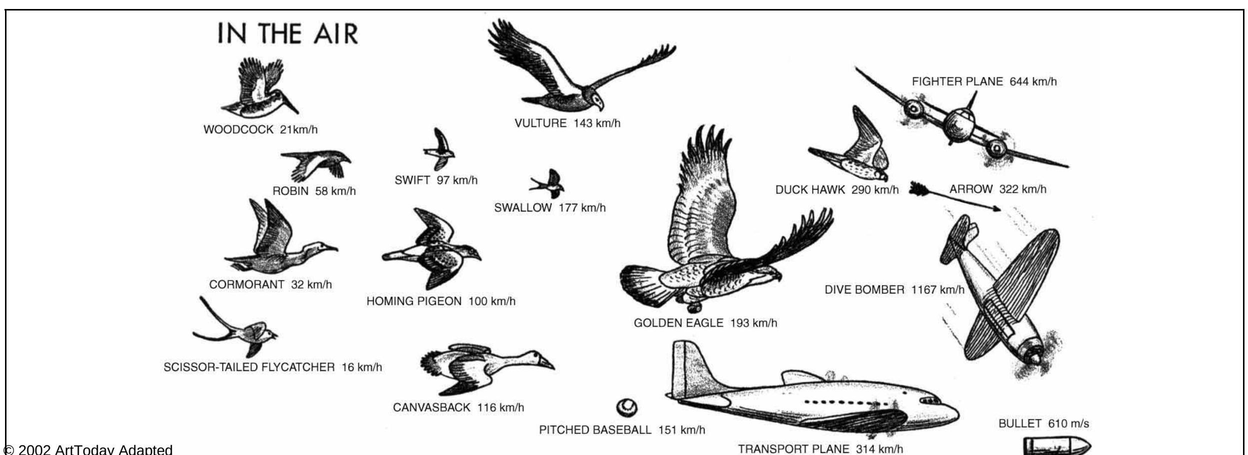
9. What does it take to lift a jumbo jet? An airliner, like a jumbo jet, may produce an average pressure difference of about 70 grams per square centimetre. That may not seem like much, but over the entire wing, it adds up. The wings of a Boeing 747 have enough surface area to lift 4,000,000 kilograms into the air.

10. What was the first craft powered by a human called and when did it fly? In 1977, the Gossamer Condor successfully demonstrated sustained, maneuverable, manpowered flight. The flight took off from California, USA, piloted by Bryan Allen. The Gossamer Condor flew nearly 2 km.

11. How does a pilot make a level turn? Maintaining a constant altitude through a turn requires extra lift. In level flight, the opposing forces of lift and weight are equal, but as an airplane banks into a turn, the balance shifts. Lift, which acts perpendicular to the wings, is no longer acting directly upward and, therefore, is not fully supporting the weight of the airplane. Unless the pilot compensates for this imbalance, the airplane will lose altitude and spiral downward, so the pilot increases the wing's angle of attack, which increases lift but also decreases drag. The pilot can compensate for the added drag by increasing thrust.

12. Do birds fly the same way airplanes do? Yes, basically, birds and airplanes fly for the same reasons. If you look at the shape of a bird's wing, you would see they are curved the same way airfoils are on an airplane wing. When a bird glides during level flight, it stays in the air just like airplanes do– its wings provide lift. However, birds flap their wings up and down to go higher in the sky while airplanes must use a combination of control surfaces and powerful engines. Birds have strong wing muscles that give them the power to fly

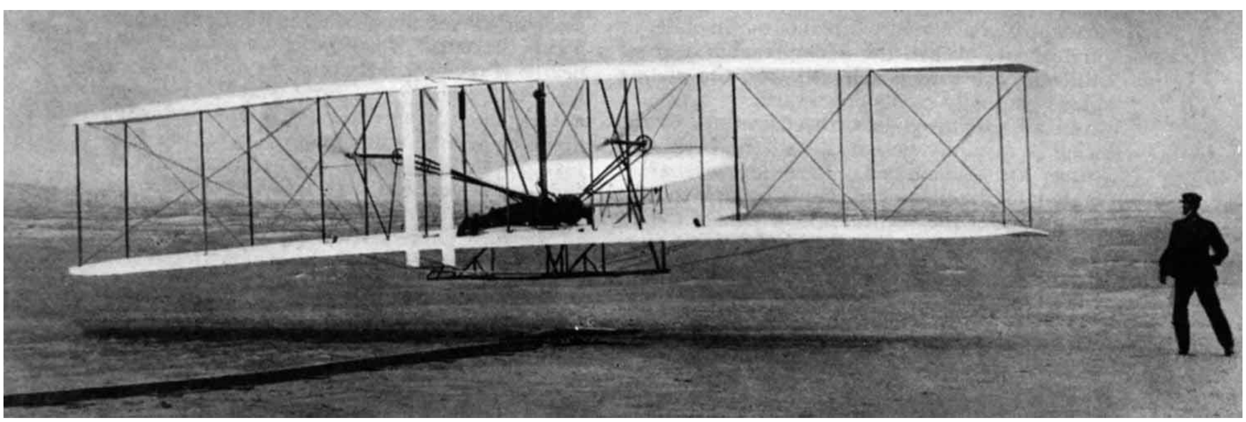
How Fast Do They Travel?



13. What does it feel like when you take off in an airplane? Right before takeoff, you can feel your back being pushed against your seat as the airplane builds up its speed before leaving the ground. As the airplane races down the runway, it's waiting until the wings create enough lift to lift the craft off the ground. During the flight, if you are sitting by a window near a wing, you will see the flaps at the back of each wing (ailerons) move up or down when the airplane banks or turns.

14. What does it feel like when you are going to land? When the airplane you are flying in gets ready for landing, you will be able to hear the sound of the landing gear being lowered below you. Just before touchdown, if you are by a window by a wing, you will notice the large wing flaps in their down position. The pilot lowers these flaps so he or she can more easily control the airplane at such a slow speed. After landing, look at how the spoilers (big rectangular sections in the middle of the wing) pop up to create more drag to slow down the airplane even more.

15. Why do airplane cabins have to be pressurized? The atmosphere is 80 km (50 miles) deep. At sea level it exerts 101 kPa (14.7 pounds per square inch). Our bodies think this is completely normal. An airplane flies at 10 000 metres (30 000 feet). Air pressure is significantly lower at that height. High-pressure air is used to "pump up" the cab in much the same way that a tire is pumped up. The high-pressure air on most planes comes from the compression stage of the jet engines.



Topic 4: Helicopters

You might want to begin this topic with a general discussion to draw out what students already know about helicopters. Some students may have ridden in one or know of someone who has. Certainly they have seen helicopters in action on TV in shows, movies, and the news. Talk about what kinds of helicopters there are and what kinds of jobs they do. Ask them if they think it is easier or harder to fly a helicopter than a jumbo jet?

The resource does not deal with the history of helicopters. An optional printout **Early Days of Helicopter** discusses some of the key milestones. (A copy is not included in the student resource.) The printout ends with a simple activity, asking students why many countries were so anxious to improve on the first helicopters during World War II (1939–1945). They are encouraged to hypothesize what the advantages might be of helicopters over airplanes.

Here is some background information for your discussion:

Advantages of Helicopters	Disadvantages of Helicopters
> Can hover (stay in one spot)	> Unable to carry many passengers
> Are very maneuverable	> Cannot fly as fast or as high
> Can drop supplies more easily in one spot	> Use more fuel as they have two rotors
> Could land more easily on ships	> Travelling range is shorter
> Helped to fight enemy submarines by tracking and finding them	>
> Doesn't need a runway to take off or land	>
> Can move in any direction	>
>	>
>	>
>	>

Topic 4 begins with a small movie with Pilot Richie Clements talking generally about helicopters. The movie also includes samples of types of helicopters.

Lesson 1: Parts of a Helicopter

As with the study of airplanes, parts of a helicopter are examined. At every opportunity within this topic, students should be encouraged to compare helicopters to other aircraft and spacecraft. After practicing and testing their understanding of the parts, the students are instructed to printout the **Parts of a Helicopter List.**

Suggested Answers

Main rotor	The main rotor contains the rotor blades. These rotor blades are shaped like long, thin wings. The main rotor head spins the main rotor. As the blades spin, they raise the helicopter into the air.
Tail rotor	The helicopter has another set of blades (propellers) attached at the end of its long tail. The tail rotor produces thrust just like an airplane's propeller does. By producing thrust in a sideways direction, it counteracts the engine's desire to spin the body. Instead of producing lift, the tail rotor stops the tail from swinging around. The pitch or angle of attack of the tail rotor can be changed to make the helicopter turn left or right, becoming a rudder.
Main rotor head	This is one of the most important parts of the helicopter. This is the piece of machinery located at the center of all the blades. It is designed to spin the rotor blades around, as well as to tilt or angle them. This produces the lift that raises the helicopter up.
Landing skids	Some helicopters have landing gear that looks like skids and others have wheels. Skids are mainly used because they weigh less than wheels. In larger helicopters, where speed is critical, retractable wheels allow for greater speed and increased fuel economy over long distances.
Engine	The two engines are located behind the cockpit. They are connected to the main shaft and power both the main rotor and the tail rotor. Earlier helicopters used gas engines. The turbo shaft engine replaced the gas engines. It is the turbine that powers the helicopter's drive shaft.
Drive shaft	A long drive shaft runs from the main rotor's transmission back through to the tail rotor's transmission. The turbine engine powers the drive shaft.
Cockpit	This is where the pilot can control the helicopter's movements. The many instruments tell the pilot how high the helicopter is, in what direction it is flying, and how fast it is going. The cockpit also contains all the communication equipment.

This lesson includes a virtual-reality (vr) experience for students to explore the inside of a helicopter cockpit. While many students will be able to manipulate the "vr" without guidance, following are some reminders for them:

> The virtual-reality screen contains several active buttons on the bottom bar. When clicked on, the back-arrow button returns students; the dash button allows students to zoom out (if they have already zoomed in); and, the plus-sign button allows students to zoom in.

Lesson 2: Movements of a Helicopter

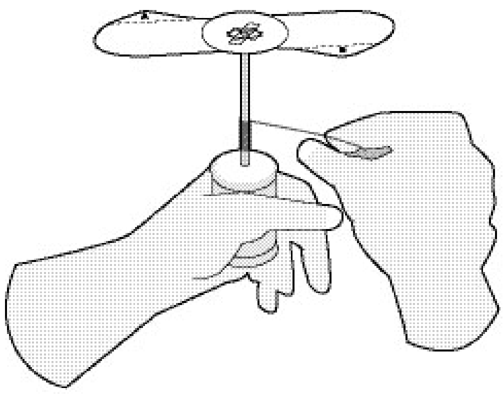
Lesson 2 begins with a comparison of the complexities of driving a car, a train, a plane, and a helicopter. You may want to discuss this as a large group, making a chart on the white board. The lesson uses interactive animation to demonstrate the many movements a helicopter can make.

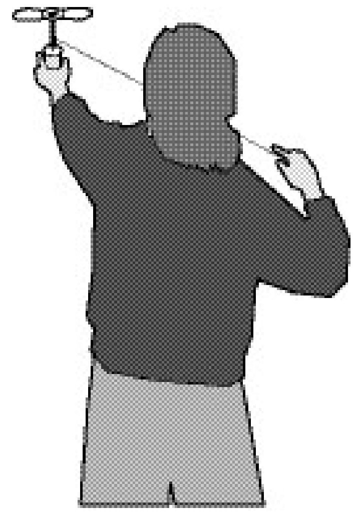
Helicopter Rotor Blades

The next part of this lesson deals with lift. The students are instructed to printout an activity that explains more about helicopter blades **(Helicopter Rotor Blades).** Before you begin work on the printout, show the students the "seedlings" from the Manitoba Maple. Have the students carefully examine the shape (design) of the "gray fruit." Make a connection between the fruit and the design of helicopter rotor. In Western Canada, the seedlings, or "gray fruit" from the Manitoba Maple should be collected before hand to show students. (In other places, the Sycamore tree can be used.)

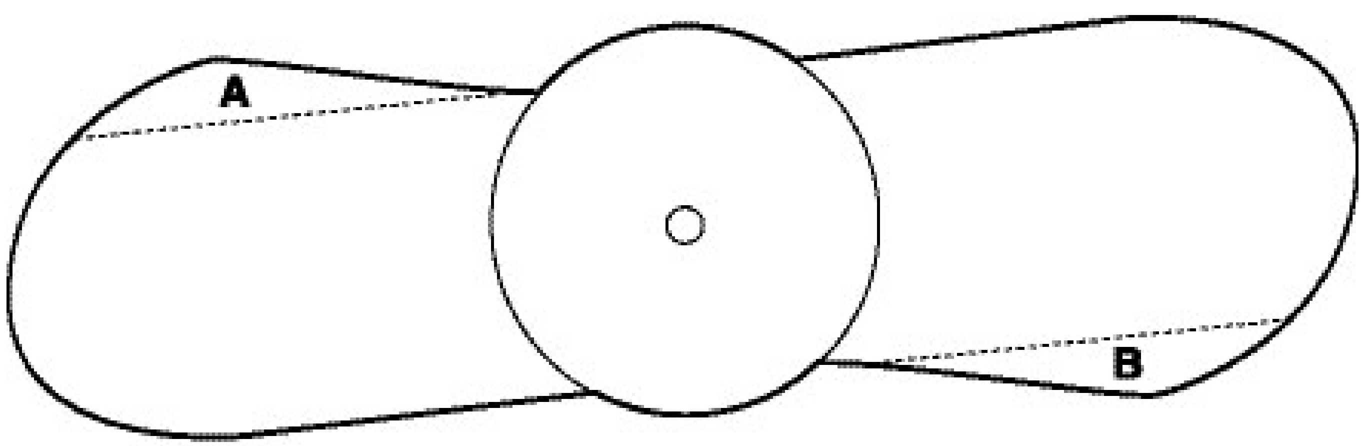
The second part of the printout **(Make Your Own Paper Helicopter)** provides students with an opportunity to design and develop a simple helicopter and then they are encouraged to design their own helicopters.

Here is another suggestion for a **simple homemade model propeller**.





Cut out the following pattern; fold one flap down and the other up. Use a paper hole punch to make a hole in the centre of the paper propeller. Use tape to attach the propeller to the end of a small gauge dowel rod. Insert the dowel rod into an empty spool and tape over the bottom hole so the dowel doesn't slip through the spool. Wrap string thirteen times around the spool. Hold the spool as shown in the picture. Pull the string down hard to your side. At the same time, punch the hand holding the spool forward and up.



Go to the Sikorsky web site for a free download of a pattern for a 3-D Sikorsky helicopter model. This full-colour model has spinning main and tail rotors: http://www.sikorskyarchives.com/body60.htm

The rest of Lesson 2 focuses on the basic controls (foot pedals, collective pitch control lever, and collective control stick.) You may want to begin this discussion with computer games and joysticks and what that control stick allows players to do.

The lesson ends with a description of autorotation. You might stir the students' curiosity by asking, *What happens when a helicopter's engine fails?*

Lesson 3: Types of Helicopters

Encourage students to bring pictures of different types of helicopters. If at all possible, invite a helicopter pilot to come to the class or visit an airport or heliport near you. The Canadian Air Force web site has some information on Canadian helicopters in their force at http://www.airforce.forces.ca/equip/equip1d_e.htm. For example, it includes pictures and information on the CH-113 Labrador, a twin-engine, work-horse for search and rescue missions; the CH-124 Sea King which has a fold-up rotor and tail to fit on small decks of navy vessels; the new CH-149 Cormorant used for search and rescue which has three engines, and the CH-146 Griffon, a utility transport tactical helicopter that is used for many important military jobs.

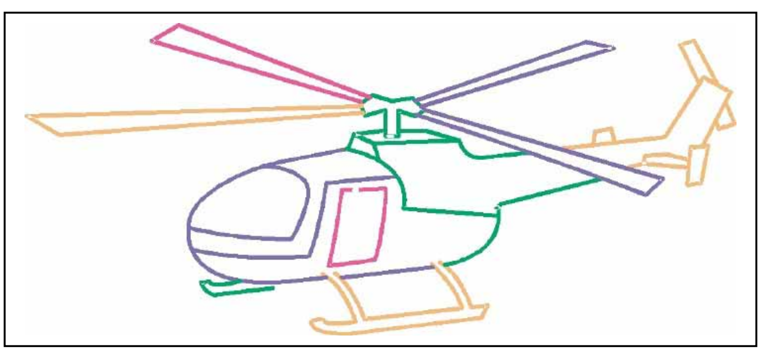
More Information

Interesting Helicopter Websites

http://www.helis.com/	This is a very interesting website. It includes lots of information on how helicopters fly, the history of helicopters, a gallery with pictures, movies, and sounds, and lots more.
http://www.soton.ac.uk/~thunder/education/helicopter/helicopter.htm	This website contains basic, intermediate, and advanced information on helicopters – parts, how they work, etc.
http://avia.russian.ee/index.html	This website contains some general information on how helicopters work and cockpit photos of various helicopters, among other things.
http://www.warmachines.50g.com/index.htm	Apocalyptic Warmachines – This site is dedicated to military aircraft. The site includes various categories helping make finding different types of helicopters easy. The site also includes links.
http://www.dynamicflight.com/	This is a fairly advanced site with lots of information on the physics of helicopter flight, maneuvers, etc. Note, the content is very "American."
http://homepage.eircom.net/~helicopters/	This site contains mostly pictures of different varieties of helicopters.

Topic 4 Glossary

cockpit	where the pilot can control the helicopter's movements. The many instruments tell the pilot how high the helicopter is, in what direction it is flying, and how fast it is going. The cockpit also contains all the communication equipment.
collective control stick	also known as the joystick; a lever used by the pilot to control the movements of the rotor blades; the stick is located between the pilot's knees; it makes the helicopter fly forward, backward, or sideways.
cyclic pitch control	this control, located at the pilot's left, tilts or pitches the main rotor to make the helicopter go up or down
drive shaft	runs from the main rotor's transmission back through to the tail rotor's transmission. The turbine engine powers this shaft.
helicopter engines	two engines are located behind the cockpit. They are connected to the main shaft and power both the main rotor and the tail rotor. Earlier helicopters used gas engines. The turbo shaft engine replaced the gas engine. It is the turbine that powers the helicopter's drive shaft.
hovers	stays still in the air
landing skids	some have landing gear that looks like skids and others have wheels. Skids are mainly used because they weigh less than wheels. In larger helicopters, where speed is critical, retractable wheels allow for greater speed and increased fuel economy over long distances.
main rotor	the main rotor contains the rotor blades. These rotor blades are shaped like long, thin wings. The main rotor head spins the main rotor. As the blades spin, they raise the helicopter into the air.
main rotor head	one of the most important parts of the helicopter. This is the piece of machinery located at the center of all the blades. It is designed to spin the rotor blades around, as well as tilt or angle them. This produces the lift that raises the helicopter up.
rudder pedals	control the tail rotor to keep the helicopter pointed in the exact direction
tail rotor	the helicopter has another set of blades (propellers) attached at the end of its long tail. The tail rotor produces thrust just like an airplane's propeller does. By producing thrust in a sideways direction, it counteracts the engine's desire to spin the body. Instead of producing lift, the tail rotor stops the tail from swinging around. The pitch or angle of attack of the tail rotor can be changed to make the helicopter turn left or right, becoming a rudder.
VTOL	vertical takeoff and landing aircraft such as the helicopter



Topic 4 FAQs

1. How is the helicopter like a hummingbird? Both the helicopter and the hummingbird can hover and move in any direction.

2. What other kinds of VTOL are there besides helicopters? A more airplane-like aircraft with VTOL capabilities is the Harrier "jump jet." The Harrier, developed in England, has fixed wings. It uses directional thrust (swiveling nozzles) to direct the jet stream from its engine downward for vertical flight and backward for horizontal flight.

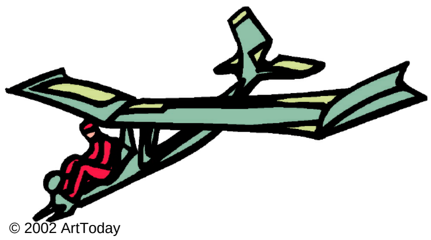
3. What is the largest helicopter? The world's largest helicopter is the Russian Mil MI-12, called "Homer." It has a span across its two rotors of 67 m (220 feet) and is over 37 m (121 feet) long.

4. How fast can a helicopter go? The fastest a helicopter has ever flown is 402 km/h (249 miles per hour). This record was achieved in a specially adapted Westland Lynx in 1986.

5. What does compressed air have to do with a helicopter lifting off? Compressed air helps a helicopter lift from the ground. When a helicopter's rotor blades spin, they push air down. The air is squeezed between the rotor blades and the ground. This compressed air pushes up against the rotor blades and helps the helicopter rise.

6. Why are skids used more than wheels for landing gear? Skids are used mainly because they weigh less than wheels. On larger, more powerful helicopters, wheels are used because of their convenience. It is hard to move a helicopter with skids when it is on the ground.

Topic 5: Gliders



Topic 5 focuses on gliders–airplanes designed specifically to fly without engines.

Explain to the students that this topic begins with information about gliders and the different types of gliders. Following that, students start by making various kinds of gliders from tested patterns. Students then learn how to test their gliders and collect appropriate data to analyze. Students are encouraged to try different modifications to the designs to find solutions to problems. After testing their modified gliders, students are encouraged to design their own glider.

The topic culminates with a class air show. You may want to invite parents or other classes to see the airplane models or to watch the air show.

Materials Needed to do the Activities for Topic 5	
Photocopies of all glider templates	Tape
Glue	Paperclips
Straws	Aluminum foil
Stryofoam sheets (or egg cartons—2 tops per plane)	Scissors
Light cardboard	Measuring tapes, at least three, that can measure a minimum of ten metres
Rulers	
Pencils	

Lesson 1: Types of Gliders

Start this lesson by asking students why they think gliders can fly without engines and airplanes cannot. (They have long wings to create more lift and very smooth surfaces to reduce drag, and they are made of very light materials. Just like birds, gliders use their long wings and make use of rising hot air currents.)

Ask students if they have ever ridden in a glider or know anyone who has. You may be able to arrange for an experienced glider pilot to come visit the class.

If you have the opportunity, you might want to purchase a balsa airplane kit with the rubber band “motor” for demonstration purposes. Balsa planes fly farther and with greater predictability. Later, when the students have tested their own paper or Styrofoam models, bring out the balsa model again and discuss why it is superior.

Lesson 2: Constructing Gliders

This lesson includes six tested glider (paper airplanes are gliders) patterns as a printout, which can be reproduced easily (**Basic Square Paper Airplane, Egret Paper Airplane, Flex Paper Airplane, Condor Paper Airplane, Straw Glider, and Basic Styrofoam Glider.)** Hand out three small pieces of paper to each student. Start by discussing the three basic folds: valley fold (V); mountain fold (upside down V), and the sink fold (upside down W). Have the students practise making these folds and have them label each fold for future reference. Discuss the following terms: parallel, crease, triangles, diagonal lines, vertical, and horizontal. (The terms are in the Topic 5 Glossary).

Have the students look at the pictures in their resource of all the models. You may want the students to pick two or three of the four paper models and the Styrofoam model for their tests. (The Condor is the most difficult model, so students with difficulties should be encouraged to work with the others.)

Two different station models can be used: in the one version, each station is set up for a certain type of model (e.g., The Condor Station) so that students can move to a new station to make a new glider. A student could be appointed as coach for each table. Another station model might be to have six students per table and have each student be the coach of one model, so students would not have to move.

Do not encourage individual designs at this point. The goal here is to follow standard instructions and test standard models and collect data. Experimentation is encouraged as a next step.

Lesson 3: Glider Testing

Testing the gliders is an important second step in the aircraft design process. In this case, the initial design stage for their models was already completed for them. Students need to understand that testing is a critical step in the design of all aircraft. Remind the students about wind tunnels. In order to test effectively, a plan has to be put in place so that information (data) can be collected to carefully evaluate which gliders are the best and what are some of the problems. Students need to understand that after analyzing the data and completing the evaluation stage, they will be encouraged to go back and modify their designs and re-test their models to see the effect of their modifications.

Aircraft Design Stages
Design
Test
Evaluate

Discuss with students what factors might be important in testing the efficiency of the gliders (*distance and ability to maneuver*).

Also introduce the terms *trials* and *sample size*. Explain that each time you test a prototype of an airplane it is called a trial or sample size. *Is it better to have a sample of 2 or 9? Which is faster? Which is more accurate?* The more times you fly each airplane, the better you will know how the design performs.

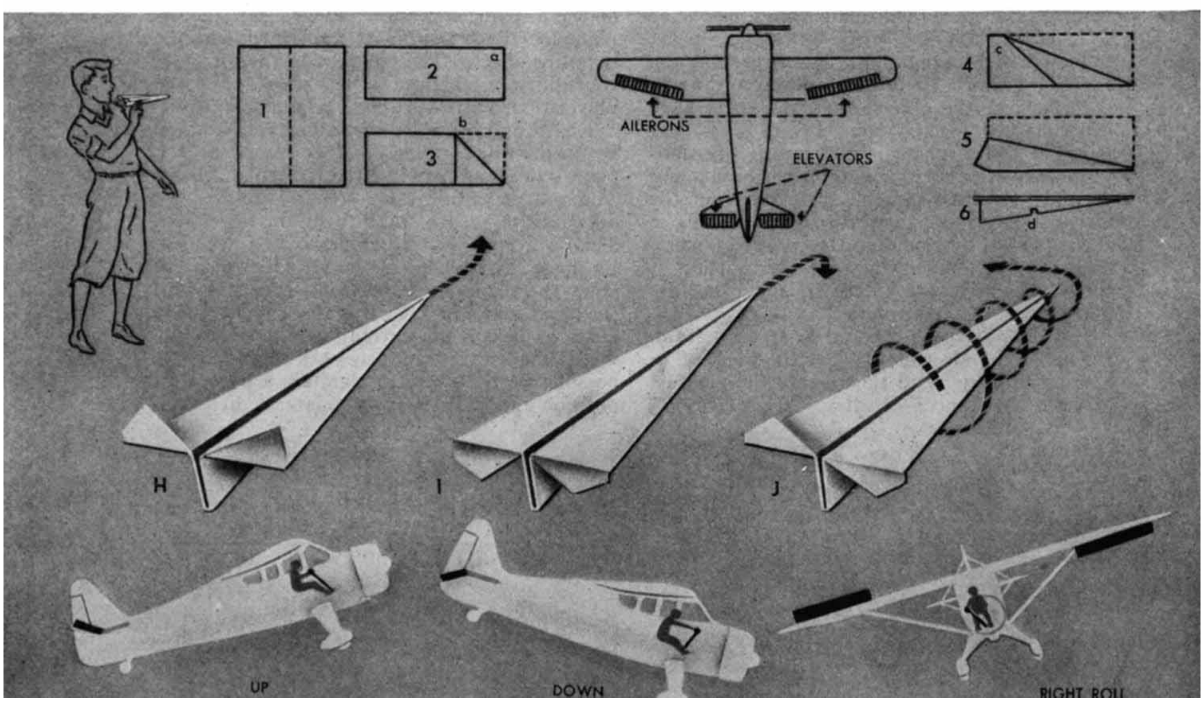
Start by having the students study their **Glider Testing printout**. Be sure they understand they will be testing each glider model for distance and for maneuverability. They will be doing five trials (sample sizes) for each of their prototype airplanes. For example, if they are testing four prototypes (one Styrofoam and 3 paper), they will be doing 20 test flights for distance and 20 test flights for maneuvers. When you begin your discussion of STEP TWO of the printout, review what position each control surface must be in to achieve the movement required. (This is a review from Topic 3, Lesson 3: Movements of an Airplane.)

Maneuver	Right Aileron	Left Aileron	Rudder	Elevator
Rising Left	*Down*	*Up*	*Left*	*Up*
Rising Right	*Up*	*Down*	*Right*	*Up*
Diving Left	*Down*	*Up*	*Left*	*Down*
Diving Right	*Up*	*Down*	*Right*	*Down*
360º Roll	*Up*	*Down*	*Neutral*	*Neutral*

Following is some additional information about airplane movement.

A SIMPLE EXPERIMENT IN FLIGHT

First, make a paper plane. Take a rectangular sheet of paper (1) and fold it on the dotted line to make (2). With the fold toward you, turn back corner (a) of one side and fold as indicated in (3). Then turn back corner (b) and fold as shown in (4). Corner (c) should be folded back in the same way as in (5). Now make a U-shaped notch in the fin (d) and fold the U to one side to hold the two sections of the fin together (6). Fold upward the back ends of the wings (H) and the model will sail upward as does an airplane when its elevators are up. When the ends of the wings are folded down (I), the plane will sail downward. When the left wing end is up and the right wing end is down (J), the paper plane will make a left roll; by reversing the positions of the tail flaps, it will make a roll to the right. Under diagrams (H) and (I) are sketches showing position of elevators and stick when a plane goes up or comes down. The position of the ailerons in the sketch below (J) enables the pilot to make a right roll.



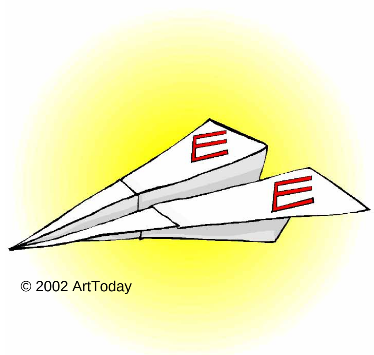
At this time, have the students mark in each box what changes they will have to make to test if their prototype can make the listed maneuvers. **Confirm their answers now.** If they have an incorrect position noted, it makes the test invalid. On the second page of the printout, the answers have been included.

STEP THREE involves modifying their designs. They will be allowed to modify one or two of their models and test them before doing their debriefing. In other words, the scores from the modified prototypes can be used when calculating their best scores. Discuss what types of modifications might be possible, such as changing the fuselage length, changing the shape or length of the wings, changing the tail size, adding a paper clip, changing the surface controls by using aluminum foil, changing the height, length, or shape of the rudder, adding tape to the ailerons or flaps so they can be bent or changed more easily, changing the nose of the model.

STEP FOUR of the printout involves analyzing the data and making inferences and conclusions. Make sure the students go over the debriefing questions in the printout before they start testing. They need to understand that they will be submitting this printout to you.

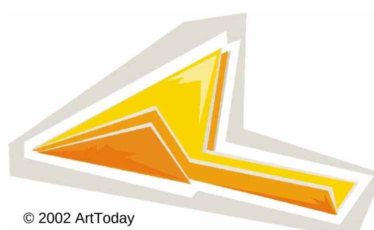
Suggested Rules for Glider Testing

1. Students should be grouped in pairs or groups of three. While one student is testing his or her prototypes, the other acts as the Evaluator/Recorder.



2. Several testing areas need to be set up in advance. Each testing area needs a marked line to ensure each student starts at the same point. On the side of the long, clear testing area a minimum ten-metre measuring tape should be taped to the floor. The only person allowed in the testing area is the Evaluator/Recorder. The Pilot must be behind the starting line and all other observers must be clearly behind the Pilot or in a designated viewing area.

3. Testing is done in three steps. The first two steps, distance and maneuverability, are tested at the same time. First, one partner does his or her five trials on each prototype to determine how far each model can go; then, the other partner completes his or her distance trials. Then the first partner starts the five trials on each prototype for maneuverability testing and then the other partner completes his or her maneuverability tests. While the one student is doing testing, the other partner is responsible for determining the result, calling it out, and recording on the partner’s printout the actual distance for the first set of distance tests. (You may need to review measurement.)



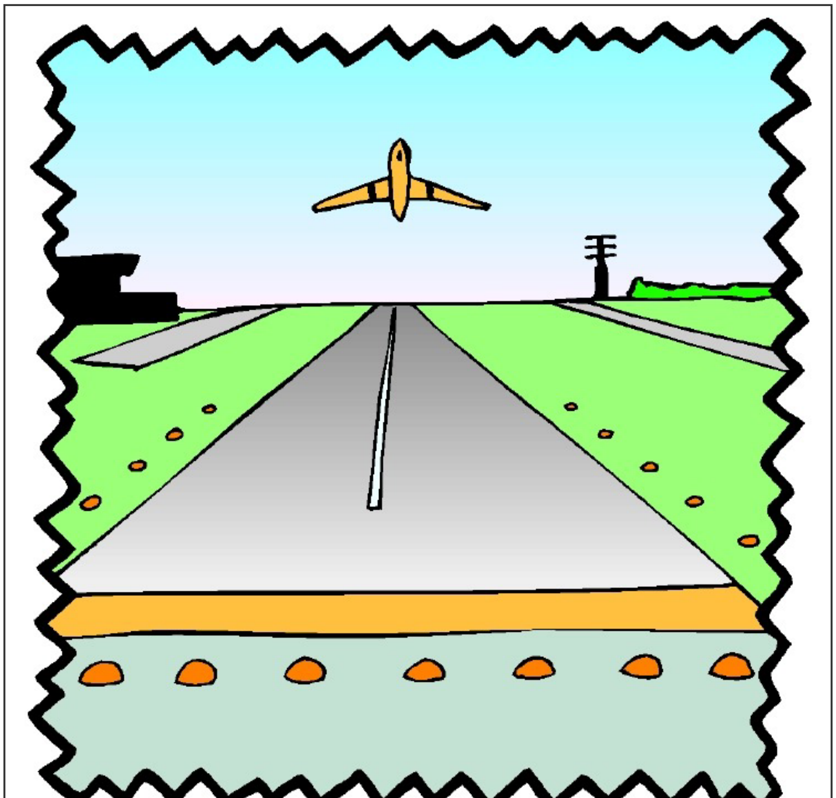
   For the maneuverability tests, as the Pilot makes the appropriate adjustments and performs each of the five test trials on each prototype, the partner needs to record whether the model was successful or not. Each Recorder should use the three-point system indicated when evaluating maneuverability. (Three points are awarded if the maneuver is successful; two points if it was only partially successful; and one point for trying even if it was not successful.)

4. Before the final testing step takes place, students need to work in their groups to discuss their results on the first two sets of tests; then they need to discuss modifications and which two models will be modified to try and improve performance. Each student makes modifications to two of his or her own prototypes and the last set of testing begins. A Design Modification Centre might be set up in advance so students can move to that area at the appropriate time.

5. After the two modified prototypes have each been given five trials, the teams complete their debriefing exercise and submit their findings to their teacher. Be sure they understand how to calculate the average distance. In order to determine which model performed the best at maneuvers, the students need to add up the total point score. The highest total of points can be used to determine the best model. They may want to make careful notes during the debriefing stage about other modifications they may want to experiment with before they compete in the class air show.

When the students have submitted their glider testing printouts, you can easily calculate the testing results by referring to the summaries on the last page. Use the Glider Testing Results Summary Chart that follows for posting the testing results for class review. Students who have been less successful should be encouraged to work on modifications before the class air show. **It is at this point that all students should be encouraged to design their own models and test them.** The student resource links to some additional information about the typical design stages to reinforce what has already been discussed.

Students should be told at this point that they will be allowed to enter a maximum of three gliders in the class air show: two paper and one Styrofoam. **At least one of the paper gliders must be their own design.**



Student Name	**Glider Name**	**Best Distance Score**	**Best Maneuver Score**

Lesson 4: The Air Show

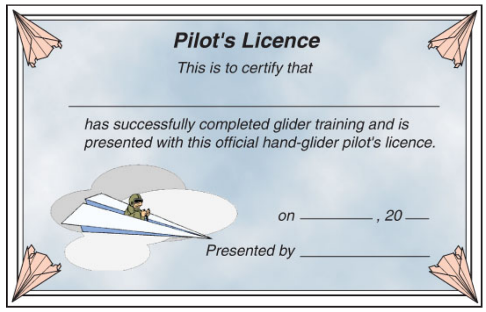
This air show lesson begins with a discussion about the importance of being very clear on an aircraft radio. What could happen if the message was misunderstood?

When transmitting over the aircraft radio, all groups of letters, aircraft call signs, location indicators and other important data must be spelled out using the phonetic alphabet. Anyone using an aircraft radio must learn the phonetic alphabet by heart.

The students have an opportunity to **printout a copy of the International Phonetic Alphabet.**

It might also be mentioned in the discussion that all numerals are spoken digit-by-digit using established pronunciations. For example, the number, 198.7 is pronounced like this: wun niner ait dayseemal seven. To standardize time used internationally, aviation uses UNIVERSAL CO-ORDINATED TIME (formerly Greenwich Mean Time) and the 24-hour clock.

Also, at this time, students can printout information about **Call Signs** and have an opportunity to make their own call sign using the form provided. Students are encouraged to add their call signs to their prototype models they plan to use in the air show.



Included in the Appendix is a special, coloured **Pilot's Licence certificate** for you to print, (it is better if printed in colour) fill in, and distribute to each student who has successfully completed Glider Testing (Training). Students will need to have their licences with them when competing in the air show.

The students are asked to printout a copy of the **Air Show Rules**. You will need to go over the rules carefully with the students, in addition to sharing the following information.
Be sure you read the following air show procedural steps before you discuss them with the students, and after you have discussed them in class, hand out the **Air Show Questions printout** to confirm their understanding.

Conducting the Air Show

1. Like the Glider Testing, the Air Show includes two parts: Best Distance and Best Maneuvering Performance. For the Distance Tests, four trials will be used for each model. The Maneuvering part has two separate obstacles: a “bridge,” which could be a table and a “mountain” (a chair covered in a blanket). Each obstacle allows for three trials only.

   A minimum of six prizes should be awarded for the Air Show: First and Second Place for Best Overall Glider (awarded to glider with best average for that glider for distance **and** most success maneuvering); First and Second Place for Best Distance (awarded for the glider with the best **average** distance); First and Second Place for Glider with Best Maneuvering Performance (the glider with the most successes– if there are ties, a playoff can be held using the bridge obstacle but increasing the distance or decreasing the bridge clearance. If nine prizes are available, a Third Place can be added to each of the three prize categories.

2. Only one testing zone is required for the Air Show. It needs to be a long, clear passage with space on the sides for observers. A **Flight Zone Diagram** printout has been included in the Appendix for your reference. (A copy is not included in the student resource.) The flight line needs to be marked with tape and all areas defined and explained to students. There needs to be room on the flight line for four or five students to launch their models at the same time. Measuring tapes should be taped in place on both sides of the Flight Zone. (If a classroom is used, desks should be moved to both sides and used as the "Hangar Areas.")

3. Students should be organized into groups of four or five. The group launch order should be posted for everyone's attention. Only those launching should be in the launch area. If room, the next group up should be standing in the on-deck waiting area, at least one metre behind the launch area. The other pilots should be in the Hangar Areas on the sidelines.

4. You will need to assign special duties to three parent volunteers or aides:

Ground or Flight Control Person	Sits beside the flight line; views each pilot's license; upon request, provides launch and retrieval permission; has the power to revoke any pilot's licence if rules are violated
Official Recorder	Needs copies of the **Air Show Results printout** for each competing student attached to a clipboard. The students' names and call signs should already be entered and the sheets should be in launch order.
Recorder's Assistant	Is responsible for determining and announcing the measurement. This person needs to understand that the measure must be taken from the launch or flight line to the place the plane hits the ground, NOT the place it comes to rest.

   Your job will be to oversee the show and announce when the next group should move up to the launch area and the subsequent group to the on-deck waiting area.

5. Once the Distance Part is completed, the Recorder and the Recorder's Assistant tally the results of those scores on the **Air Show Results printout** while students assemble the bridge for the first leg of the maneuvering tests.

6. Students launch their first Personally Designed Paper Model. The glider must go completely under the bridge without hitting the bridge in order to be considered successful. After retrieval, the next group does the same. Once all groups have completed their first launches, the groups start again doing their second launch of their second paper glider. Again, after all groups have completed their second launches, the cycle is repeated with their third and final Styrofoam gliders. In order to be successful in the mountain part, the glider must show some turning ability and must not hit the mountain. (In other words, a Pilot cannot simply launch his or her glider in a straight line attempting to go over the mountain; students must adjust their control surfaces appropriately with the intent to turn right or left to avoid the mountain by going around it. The other option would be to build a "tall mountain" and award points if the students go **either** around it or over it.)

7. The Recorder's Assistant announces whether each trial is successful or unsuccessful.

8. Once both the Maneuvering Test Parts are completed, the Recorder and the Recorder's Assistant tally the results of those scores on the **Air Show Results printout** and continue to find out the best of both sets of scores.

9. After Pilots are finished competing in all trials for both distance and maneuvering, they need to complete the **Air Show Summary Report printout** and submit it to you.

10. Prizes are awarded appropriately by the Air Show Staff.

Before the Air Show starts, be sure to have the students complete the Air Show Questions printout which reinforces the rules for the competition. This printout is only in this guide (not in the student resource.) Suggested responses:

1. Pilot's Licence	2 at the launch or flight line	3. at least one metre back or in the hangar areas
4. one launch	5. the designated hangar area	6. Pilot's Licence is revoked (taken away).

Topic 5: Summary

Topic 5 ends with a couple of extra fun ideas for students to further test their piloting skills and their glider designs.

For the target practice, you can hang exercise hoops or baskets, or make bull's-eye targets on the floor (like a curling rink).

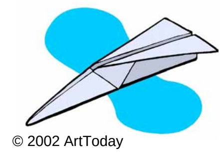
A more elaborate version is provided as Glider Golf. For this you need to set up nine "Holes." Students can help plan the challenge for each hole. The students have to count how many attempts it took them to succeed. The lowest score wins! **A Glider Golf printout scorecard** is available in both the student resource and in this Appendix.

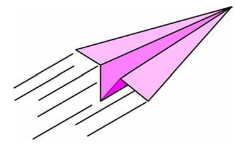
More Information

Annotated Paraglider and Hang Glider Web Sites

http://www.sewhgpgc.co.uk/began.html The SE Wales Hang Gliding & Paragliding Club	This page includes mostly info on the history and beginnings of paragliding and hang gliding.
http://www.sewhgpgc.co.uk/intro2.html	This site includes several individual's accounts of learning to paraglide and hang glide.
http://www.usppa.org/	The official site of the United States Powered Paragliding Association. Includes interesting photos, as well as info on powered paragliding.
http://aviation.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fwww.danwashburn.com%2Fhangglide.html	An entertaining account of one man's tandem hang gliding adventure.

Annotated Paper Airplane Web Sites





http://www.zurqui.com/crinfocus/paper/airplane.html	This site is called Build the Best Paper Airplane in the World; the DC-3; it has excellent step-by-step instructions.
http://www.geocities.com/daretofly2001/	This is a class site involving an engaging project mixing paper airplanes, forces of flight, and math concepts.
http://www.paperairplanes.co.uk/index.html	This popular site is called Alex's Paper Airplanes
http://teams.lacoe.edu/documentation/projects/math/airplane.html	This site focuses on a Great Paper Airplane Challenge and has links to information on a wide variety of topics related to paper airplanes, including a paper airplane hangar section.
http://www.paperplane.org/paero.html	This site contains information about Paper Airplane Aerodynamics.
http://explorer.scrtec.org/explorer/explorer-db/html/783750895-447DED81.html	This site contains a Paper Airplane Science Lesson Plan.
http://www.geocities.com/ResearchTriangle/Node/3483/PAAEnter/PAAMain/paamain.html	This site is by the Paper Aircraft Association. It includes records, links page, and other interesting facts.
http://create.familyeducation.com/article/0%2C1120%2C4-2894%2C00.html	Site is by the Family Education Network and has Paper Airplanes; an article for parents about how to construct paper airplanes with their children and includes various sections that describe how to build different types of paper airplanes.
http://www.monroe2boces.org/shared/esp/kite.htm	Kites and Paper Airplanes includes ideas for science activities involving wind and air. It also contains links to various additional resources. The links are very informative and include "paper airplanes you can fold".
http://www.2learn.ca/currlinks/NetSteps/Public/NetStepView.asp?page=1028&returnpage=../netstepmenu.asp	This 2Learn: Flight site contains links to pages describing the various aspects of paper airplanes and paper airplane flying. It also includes a brief introduction/summary for each link.
http://www.cyberbee.com/paper.html	Flying Free – Paper Airplane Science includes links to a variety of paper airplane sites.
http://dir.hotbot.lycos.com/Arts/Crafts/Origami/Paper_Airplanes/	HotBot Directory/ Arts Entertainment,_Crafts/ Origami/ Paper consists of links to various other web pages about paper airplanes and how to build them.
http://www.webwombat.com.au/wwdir/WW96537.HTM	Web Wombat Internet Directory includes quite a few links to different sites about how to build various types of paper airplanes.
http://www.proteacher.com/110069.shtml	ProTeacher! has activities for students and teachers involving airplanes and aeronautical concepts.
http://www.discoverengineering.org/eweek/cool_things/jet/jet_cool_thing_sites.htm	Welcome to Discover Engineering Online is a site that includes links about paper airplanes, model planes, home build planes, and more.

http://www.paperplane.org/	Ken Blackburn has an interesting site that includes world records, paper airplanes you can fold, your questions answered, teaching resources, and more.
http://www.sciencespiders.com/aedusites.htm	Educational Web Sites from The Science Spiders™ includes several interesting links under the “aeronautics” and “earth & space” categories.

Topic 5: Glossary

aeronautic tools	tools are devices or processes used to do some kind of work. A calculator is a tool for doing mathematics accurately and quickly. Aeronautic tools are processes such as wind tunnel testing, flight simulation, and flight-testing. These processes use special devices to perform research.
data	data is information that is collected from an experiment. For example, an engineer in a wind tunnel may collect data about how much lift is created by a certain wing shape.
diagonal	a straight line joining two opposite corners; crossing a straight-sided figure, corner to corner
dihedral angle	The upward angle of the wings that is formed where the wings connect to the fuselage
glider	an aircraft that does not have an engine, but rides the wind currents for lift
horizontal	at right angles to the vertical; parallel to the plane of the horizon (the line at which the earth and sky appear to meet)
hypothesis	a prediction that needs to be tested to tell if it is correct. You might offer the hypothesis that by adding a paper clip to the nose of a model airplane will improve the model’s distance. Your hypothesis must then be tested to determine if it is correct.
maneuver	also spelled *manoeuvre*; planned or controlled movement of a vehicle or body of troops; agile, skilful movement
model	A simpler, smaller, or less expensive version of a final design
mountain fold	a fold whereby a peak is formed similar to a mountain, an upside-down letter V looks like a mountain fold
parallel	lines that are continuously side-by-side and equidistant; for example, in gymnastics – parallel bars; railway tracks and lines on a page may be considered parallel
phonetic alphabet	a special alphabet with designated words used to represent each alphabetical letter; for example, Romeo represents “R”; all transmissions over aircraft radio are required to use the phonetic alphabet for groups of letters and aircraft call signs
research	a carefully planned and performed investigation, searching for previously unknown facts
sample	a small representative part or quantity
sink fold	a double fold whereby a trough is formed similar to a ditch, the letter M looks like a mountain fold; it is sometimes referred to as an accordion fold when many are done in a row (like for a fan)
streamline	the design of an object that reduces drag
trial	preliminary operational test; a test

vertical	at right angles to a horizontal plane; in direction from top to bottom; if a pipe is standing straight up and down, it would be considered to be in a vertical position; if the pipe is laying down, it would be considered to be in a horizontal position
valley fold	a single paper fold creating a V shape (a single trough or ditch)

Topic 5: FAQs

1. How do you steer a hang glider? Shifting the pilot's weight with respect to the glider controls hang gliders. Pilots are suspended from a hang strap connected to the glider's frame (hence the name "hang" glider). By moving forward and backward and side-to-side at the end of this hang strap, the pilot alters the center of gravity of the glider. This then causes the glider to pitch or roll in the direction of the pilot's motion and thus allows both speed control and turning.

2. How high/far can a hang glider go? This depends a lot on the conditions in which they are flown, but flights in excess of 480 kms (300 miles) in length and altitudes of well over 5250 m (17,999 ft) MSL (mean sea level) have been recorded. More typically, pilots in the summer in the west part of North America will frequently achieve altitudes of 1524 m to 3,048 m (5,000 to 10,000 ft) AGL (above ground level) and fly for over 160 km (100 miles).

3. How long do flights last? Again this depends on conditions, but a high altitude flight is frequently several hours in duration. On good days, pilots don't have to land until the sun goes down.

4. Where can gliders launch and land? Pretty much any slope that is relatively free from obstructions is steeper than about 6 to 1 and faces into the wind can be used to foot launch a hang glider. The pilot just runs down the slope and takes off when the air speed reaches 24 to 32 km/h. (or 15 to 20 mph). Alternatively, towing by trucks, stationary winches, and ultralight aircraft allows gliders to get into the air when no hills are available.

   Where a hang glider can be landed depends somewhat on the skill of the pilot. An experienced pilot should be able to put a glider safely into any flat spot clear of obstructions bigger than about 15 m x 60 m (50 by 200 ft. This area requirement can vary somewhat, though, depending on wind conditions and the surrounding terrain.

5. How safe are hang gliders? Hang gliders are as safe as the person flying them. Like any form of sport aviation, hang gliding can be dangerous if pursued carelessly. Gliders are now certified for airworthiness, and hang gliding instruction has been standarized. Students learn from certified instructors using a thorough gradual training program. Despite these advances, people still make judgment errors and aviation is not very forgiving of such. The majority of pilots fly their entire careers without sustaing a serious injury.

6. What is a Paraglider? A paraglider is a foot-launched, ram-air, aerofoil canopy, designed to be flown and landed with no other energy requirements than the wind and gravity.

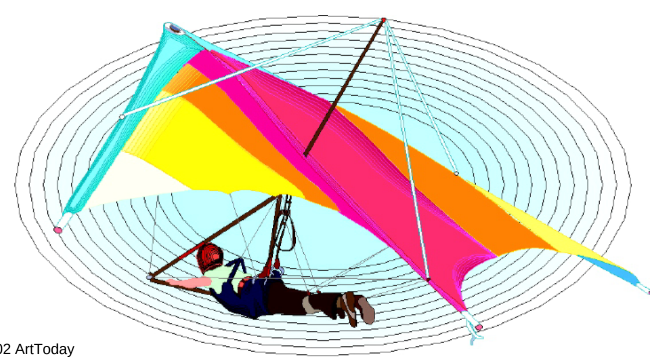
7. What are the main component parts of a Paraglider? A canopy (the actual "wing"), risers (the cords by which the pilot is suspended below the canopy), and a harness are the main components. In addition, the brake cords provide speed and directional control and carabiners are used to connect the risers and the harness together.

8. Is a Paraglider the same thing as a parachute? No. A Paraglider is similar to a modern, steerable skydiving canopy, but different in several important ways. The Paraglider is a foot-launched device, so there is no "drouge," 'chute, or "slider," and the construction is generally much lighter, as it doesn't have to withstand the sudden shock of opening at high velocities. The Paraglider usually has more cells and thinner risers than a parachute.

9. What is the difference between a Hang-glider and a Paraglider? A Hang-glider has a rigid frame maintaining the shape of the wing, with the pilot usually flying in a prone position. The Paraglider canopy shape is maintained only by air pressure and the pilot is suspended in a sitting or supine position. The Hang-glider has a "cleaner" aerodynamic profile and generally is capable of flying at much higher speeds than a Paraglider.

10. Why would anyone want to fly a Paraglider when they could fly a Hang-glider? A Paraglider folds down into a package the size of a largish knapsack and can be carried easily. Conversely, a Hang-glider needs a vehicle with a roof-rack for transportation to and from the flying site, as well as appreciable time to setup and stripdown. It's also somewhat easier to learn to fly, as a Paraglider flies at much slower speeds.

11. What are research flights? A research flight is usually one of the last steps in the airplane design process. After a new type of airplane has been planned on paper and on a computer screen, a full-size working version (prototype) is built. These prototypes are tested several times by specially trained research pilots. Before research flights are made, the technology and design of the prototype are thoroughly tested with flight simulators and wind tunnels.



The Thrill of Flight Summary

Through discussion, review the main concepts of the unit. Aviation doesn't have a really long history, but a lot has been achieved. Early aviators took great risks to achieve goals. What kinds of accomplishments did they make?

Air is an important factor in flight. How does air in motion behave? What are the basic principles of flight? Is Bernoulli's Principle the only important factor?

Airplanes are more complicated than cars, but not as complicated as helicopters. Remember the basic parts of an airplane? How are they different from a space shuttle or a helicopter? What controls the movements of an airplane? What are the advantages of a helicopter?

Designing, testing, and modifying airplanes is all part of aircraft design. What have you learned about the design of successful gliders? Think about penguins . . . .

Now that you have completed *The Thrill of Flight,* the Learning Technologies Branch of Alberta Learning would appreciate you and your students' feedback. Completed questionnaires can be:

- e-mailed to LTBgeneral@gov.ab.ca
- mailed to The Learning Technologies Branch
  P.O. Box 4000
  Barrhead, Alberta T7N 1P4
- sent via facsimile to (780) 674-6561

Use the Word format if you would like to complete the questionnaire electronically and send it in via e-mail. Use the pdf file if you plan to either mail or fax the questionnaire.

Appendix Listing

Note: Resources listed in this Appendix are found in the Student Resource and the Teacher Guide unless indicated as only in the "Teacher Resource".

Topic/ Lesson*	File Name.pdf	Title	Teacher Resource Only
1/2	00_Timeline	Alberta Aviation Time Line (For class or group reference)	**x**
1/2	01_AviationTimeline	Timeline of Alberta, Canada, and World Aviation Events	**x**
2/1	02_Huff N Puff	Activity: Huff N' Puff	
2/1	02_Huff N Puff	Activity: Air Force	
2/1	03_Fruity Oxidation	Activity: Fruity Oxidation	
2/1	03_Fruity Oxidation	Activity: A Slow Burn	
2/1	03_Fruity Oxidation	Activity: All Mixed Up	
2/1	07_Balancing Act	Activity: A Balancing Act	
2/1	08_Heating Air	Activity: Heating Air	
2/1	09_Hot Air Balloon	Hot Air Balloon Design	**x**
2/2	10_Magnetic Paper	Activity: Magnetic Paper	
2/2	11_Lift and Bernoulli	Lift and Bernoulli	
2/3	13_Flat Cardboard	Flat Cardboard Wings	
2/3	16_Things That Fly	Activity: Things That Fly	
3/1	17_Parachutes	Activity: Parachutes	
3/2	18_Parts of an Airplane	Parts of an Airplane	
3/2	20_WordSearch	Parts of an Airplane, Word Search	**x**
3/2	21_Crossword Puzzle	Parts of an Airplane, Crossword Puzzle	**x**
3/3	22_Control Surfaces	Summary: How to Move an Airplane	**x**
3/5	23_Types of Airplanes	Types of Airplanes	
3/5	24_Airplanes	Commercial Airplane	
3/5	24_Airplanes	Private Airplane	
3/S	25_Rocket Engine	Rocket Engines, Space Shuttle Launch Configuration	
3/S	25_Rocket Engine	Space Shuttle Stages	

Topic/ Lesson*	File Name.pdf	Title	Teacher Resource Only
3/S	26_Bird to Fly	What Adaptations Enable a Bird to Fly?	
3/S	27_QuickStartTips	Quickstart Tips for F/A-18 Korea Gold (Mac and PC)	
4/1	28_Parts of a Helicopter	Parts of a Helicopter	
4/I	29A_Early Helicopters	Early Days of Helicopters	**x**
4/2	29_Rotor Blades	Helicopter Rotor Blades and Make Your Own Paper Helicopter	
5/2	30_Basic Square	Basic Square Paper Airplane	
5/2	31_Egret	Egret Paper Airplane	
5/2	32-Flex	Flex Paper Airplane	
5/2	33_Condor	Condor Paper Airplane	
5/2	34_Straw	Straw Glider	
5/2	35_Basic Styrofoam	Basic Styrofoam Glider	
5/2	36_Glider Testing	Glider Testing	
5/4	37_Phonetic Alphabet	The Air Show: International Phonetic Alphabet	
5/4	38_Call Signs	The Air Show: Call Signs	
5/4	39_Pilot's Licence	The Air Show: Pilot's Licence	**x**
5/4	40_Air Show Rules	The Air Show: Air Show Rules	
5/4	41_Air Show Questions	The Air Show: Questions	**x**
5/4	42_Flight Zone	The Air Show: Flight Zone Diagram	**x**
5/4	43_Air Show Results	The Air Show Results	
5/4	44_Pilot Report	The Air Show Summary Report	
5/S	45_Golf Score Card	Glider Golf Card	
5/S	46_Student Survey	Student Survey	**x**
5/S	48_Teacher Questionnaire	Teacher Questionnaire	**x**

Key to Topic/Lesson Column

5/4 = Found in Topic 5, Lesson 4
3/S = Found in Summary Section for Topic 3
3/I = Found in Introduction Section for Topic 3