National Aeronautics and
Space Administration

Educational Product	
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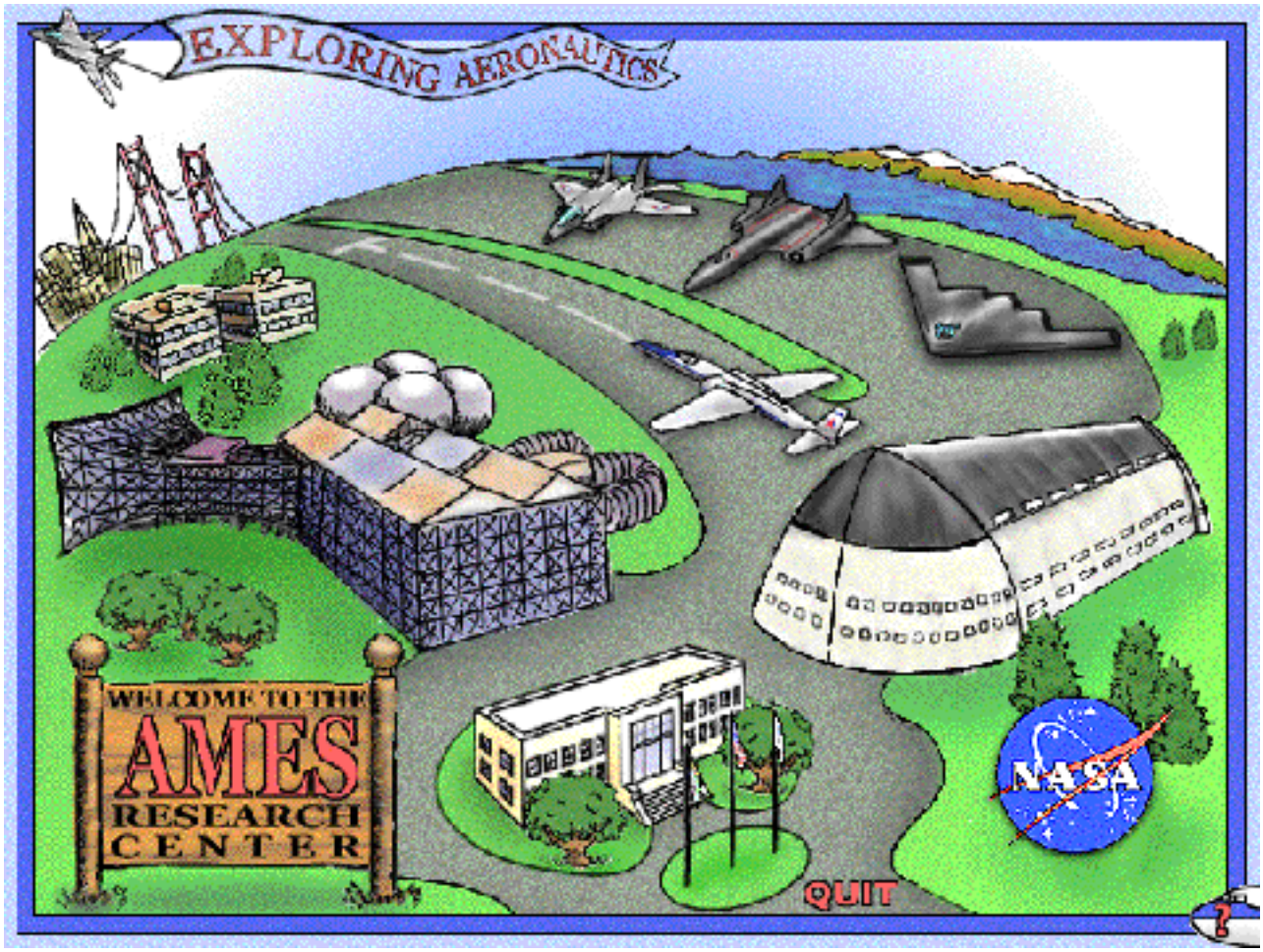
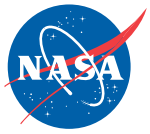
Exploring Aeronautics: Integrating with Aeronautics Educator Guide

An Educator Guide with Aeronautical-Themed Activities in Language Arts, Social Studies, and Mathematics



Part 2

aero-nau-tics \-iks\ n pl but sing in constr **1**: a science of dealing with the operation of aircraft **2**: the art or science of flight



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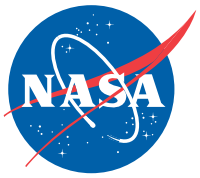
Exploring Aeronautics: Integrating with Aeronautics Educator Guide

Part II
of the Three-Part Series



National Aeronautics and Space Administration
Office of Education

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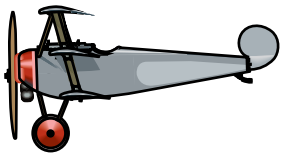

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EXPLORING AERONAUTICS

Part II

Section 1

Introduction

Introduction

Welcome to **Integrating with Aeronautics**, the second part of the NASA series **Exploring Aeronautics**! **Integrating with Aeronautics** is meant to provide supplements to Part I **The Science of Flight** Unit. These supplements are interdisciplinary in nature and encompass Language Arts, Social Studies and Mathematics.

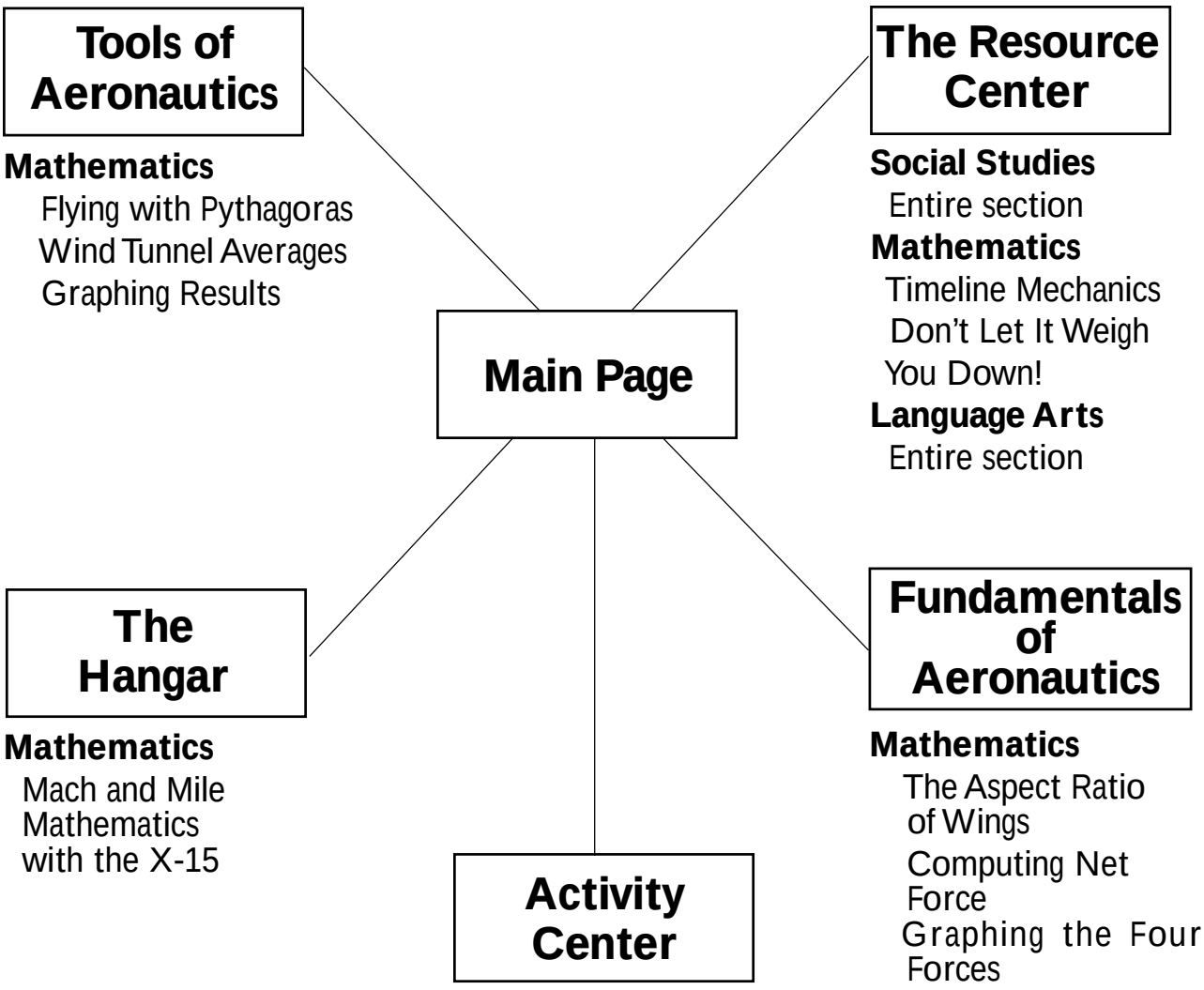
While we recommend that they be used as supplements to the more in-depth study of aeronautics, they may be used on their own, as separate units or lessons. The design of the instructional area supplements is aligned with the current national standards for that area. In cases where prior study of an issue in aeronautics or another discipline is required in order to complete a lesson, references and recommendations are noted. There are very few of these, however.

These supplements also align with the CD-ROM **Exploring Aeronautics**. In the section Making Connections, a graphic is presented that lists the lessons provided in this supplement and the most applicable section of the CD-ROM. In the case of the Social Studies supplement, use of the CD-ROM is necessary to experience the full impact of the lessons.

The best approach to these supplements is to pick and choose the lessons that are most appropriate for your students' grade level, aeronautics background and interest. In addition, always be on the alert for opportunities for connections outside the classroom in the world of aeronautics. These can range from finding current newspaper articles about relevant topics in aeronautics, to finding a speaker who is willing to share their experiences, to taking a field trip to an airport, airplane manufacturer or air museum. All areas of the world have their own aeronautics history. Many of the pioneers of that history are still alive and are more than happy to share their stories with students. We hope that these supplements help you, the teacher, expand your horizons in aeronautics so that you can find more connections outside of aeronautics proper and outside of the classroom to intrigue your students.

Making Connections

The boxes in the diagram below contain the names of each section of the CD-ROM **Exploring Aeronautics**. Underneath the appropriate box are listed the names of lessons found in this document that can be used in conjunction with the named section of the CD-ROM.



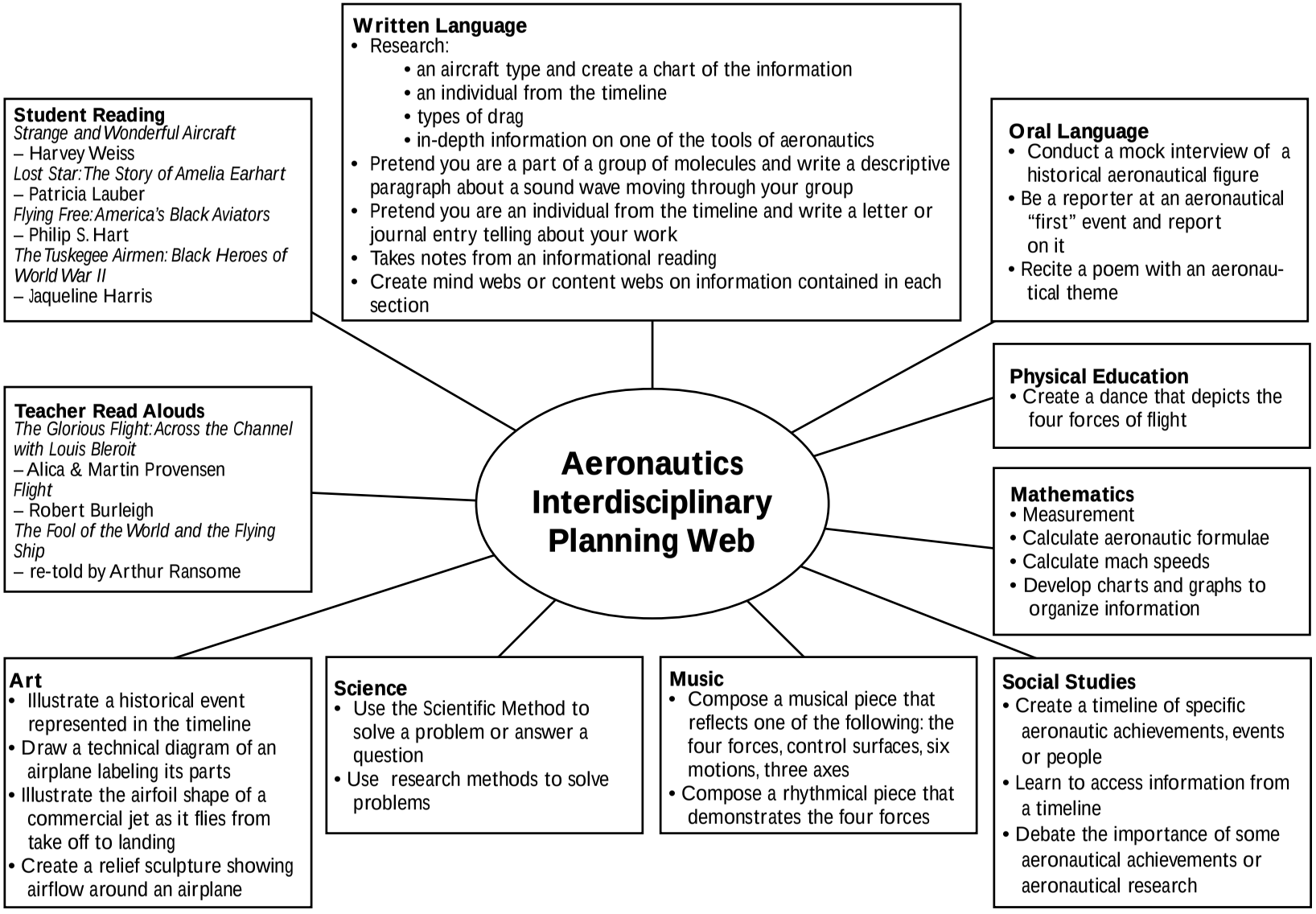
Program Goals

1. To stimulate and increase student awareness of, interest in and achievement in science. Specifically, to stir young people's imagination and fuel their enthusiasm for the study of science, mathematics and technology using fundamental themes of aeronautics.

2. To engage students in interactive multimedia learning activities that increase their understanding of aeronautics-related concepts.

3. To engage students in cross-curricular learning activities that promote their understanding of aeronautics.

Interdisciplinary Planning Web



Multiple Intelligences Culminating Activities

Logical-Mathematical

- Create a paper airplane designed to fly a great distance. Set up a course and perform flight tests, measuring the distance of each flight, developing a chart and graph of the results, and then calculating the average flight distance.

Spatial

- Create a sculpture with the theme of flight.
- Create a mind map about one of the following: aircraft, aeronautics, aeronautic tools.

Musical

- Write a song, rap or instrumental piece that expresses an aspect of flight or aeronautics.

Bodily-Kinesthetic

- Create a dance that demonstrates one of the fundamentals of aeronautics or an aspect of flight.
- Create a play which presents some of the fundamentals of aeronautics.

Interpersonal

- Create a working airplane using people to form the parts, sections and control surfaces. Have them coordinate their movements to perform aerobatics.

Intrapersonal

- Choose an aspect of aeronautics that you enjoyed learning about and research that topic on the Internet. Demonstrate your knowledge by writing a research journal.

Linguistic

- Choose one position from below and write a letter to a politician attempting to inform and influence his/her opinion regarding your position:
  - importance of research to aeronautics;
  - importance of aeronautics to our modern society;
  - supersonic flight and regulations;
  - flight safety.

EXPLORING AERONAUTICS

Part II

Section 2

Language Arts

Correlation to the Standards for English Language Arts

Standard 1

Students read a wide range of print and nonprint texts to build an understanding of those texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.

Standard 4

Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5

Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Standard 6

Students apply knowledge of language structure, language conventions (*e.g.*, spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts.

Standard 7

Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Standard 8

Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 9

Students participate as knowledgeable, reflective, creative and critical members of a variety of literacy communities.

Standard 10

Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion and the exchange of information).

Goals and Objectives

Goal 1

To use the writing process to express ideas related to aeronautics, aeronautical events and people.

Objectives

The Learner will be able to:

- use a pre-write (form) of personal choice to initiate the writing process;
- create a rough draft based on the prompt;
- edit the rough draft;
- revise the rough draft according to the feedback received;
- produce a final draft;
- create a variety of written documents: obituary, newspaper article, poem, diary entry, short story, timeline, song, letter.

Goal 2

To use the specialized vocabulary of aeronautics in written and oral expression.

Objectives

The Learner will be able to:

- complete a lab sheet using the appropriate aeronautical terms;
- explain aeronautical concepts using appropriate aeronautical terms with the help of charts, graphs, diagrams and models.

Goal 3

To perform research on aeronautical events, people and principles.

Objectives

The Learner will be able to:

- use various types of multimedia resources to search for information;
- use various types of print material to search for information;
- use internet resources to search for information;
- create and use note taking guides.

Goal 4

To read about and comprehend the events in a story.

Objectives

The Learner will be able to:

- put the main events of a story in sequence;
- complete a plotline of the story including setting, characters, problem, rising action elements, climax and resolution;
- describe the main characters and their important traits.

Literature Units

Using literature to integrate subjects through thematic instruction has become an effective methodology in the classroom. The following section contains three literature units with the related themes of aeronautics and aviation. Each of these readings were selected because of the brief, yet well written text and the engaging, colorful illustrations. Picture-books with minimal text were chosen so that each classroom would only need one copy which could be read aloud by the teacher. These three literature selections depict aeronautics during three distinct time periods: "dreams of flight", "early flight" and "powered flight".

The first selection, The Fool of the World and the Flying Ship: A Russian Tale, is a Russian folktale retold by Arthur Ransome. This selection contains a short story with gorgeous illustrations which received the Caldecott Award.

The second selection is The Glorious Flight: Across the Channel with Louis Bleriot, written by Alice and Martin Provensen. It portrays the time period of "powered flight". The book tells the story of French aircraft designer and pilot, Louis Bleriot, who became the first to fly across the English Channel in the early 1900s.

The third selection is entitled Flight and is written and illustrated by Robert Burleigh. It recounts the solo flight of Charles Lindbergh across the Atlantic Ocean in the 1930s, and has breathtaking watercolor-like illustrations.

Each of the following literature units is structured using the "Into, Through, and Beyond" format. Each "Into" section contains vocabulary and exercises, introductory activities and discussion topics. The "Through" sections contain comprehension questions with answers, plotline activities, mapping activities and character development activities. The "Beyond" sections include drawing activities, comparison charts and group discussion questions. Writing Experiences are also included with writing prompts, pre-writing maps and writing examples.

The Fool of the World and His Flying Ship
Introduction

"Into" Activities

- Discuss how throughout history humans have yearned to fly. Discuss various stories students have heard or read that included flying.
- Locate the present-day country of Russia on a map.
- Use the accompanying reading, "Life and Times of Russia Under the Czars", to help describe the characteristics of Russian society.
- Review what a moral is and how stories are written to teach a lesson.
- Introduce the following vocabulary which will be used throughout the story: (See accompanying "Crossword Puzzle".)

  bathhouse – a small house designed for taking a bath that was used before indoor plumbing was invented

  czar – ruler of Russia before 1917

  czaritza – wife of a czar

  fagot – bundle of sticks

  gentleman – a noble, someone with lots of money and land

  moujik – Russian word for a simple peasant

  tiller – a lever used to steer the boat by turning the rudder from one side to the other

  verst – a Russian unit of measurement equal to about 1 kilometer or six-tenths of a mile

  whither – to whatever place

"Through" Activities

- Ask and discuss accompanying "Comprehension Questions". Questions can be asked throughout the reading of the story.
- Use the "Plotline" format to keep track of the story as it is read.
- Use the accompanying "Character Chart" to keep track of each character and his unique gift.
- Write a song that the peasants on the flying ship might have sung.

- Discuss who the "ancient old man" is. Is he an angel, fairy godfather, a supreme being or ...?

"Beyond" Activities

- Discuss this question: Does this story remind you of another story that you have heard, read or seen?
- Give the moral of this story.
- Discuss this question: Why do you think this story was told?
- Who do you think enjoyed this story more — gentlemen or moujiks? Explain your reason.
- Design your own flying ship. Show the outside as well as the inside. (See accompanying "Flying Ship Design")
- Discuss: Do you think the Fool gained some confidence in himself by the end of the story? Why or why not? Use examples from the story to justify your answer.

Writing Experiences

- Pretend you are the Fool and have just married the Czar's daughter. Write a letter to your parents telling them about your life since you left home and how you feel about your life now. (See accompanying "Writing Assignment".)
- Rewrite this story making it a modern American tale. (See accompanying "Updating an Old Russian Folktale".)
- Pretend you are the Czar's daughter who has fallen in love with the "Fool". Write a letter to the Fool's parents telling them how you feel about their son.

Daily Lesson Planner

Day 1

- Choose an exercise from the list of "Into" Activities.
- Introduce and discuss vocabulary.

Day 2

- Distribute the "Through" Activities: "Character Chart" worksheet and discuss how some characters are used in stories to help move the story's action along, to help the main character solve a problem, etc.
- Give instructions for completing the "Character Chart".
- Read the first third of the book, The Fool of the World and His Flying Ship, asking "Through" Activities: "Comprehension Questions" as you go, and reviewing vocabulary as needed.

Day 3

- Choose an exercise from the list of "Through" Activities.
- Read the second third of the book, asking the "Comprehension Questions" as you go, and reviewing vocabulary words as needed.
- Have students continue filling in their "Character Chart".

Day 4

- Choose another exercise from the list of "Through" Activities.
- Read the remaining third of the book, asking "Comprehension Questions" as you go, and reviewing vocabulary as needed.
- Have students complete their "Character Chart".

Day 5

- Distribute "Through" Activities: "Plotline" and explain how and why plotlines are used to write and explain stories.
- Read the entire story through in one sitting and have students individually, or with a partner, fill in the "Plotline".
- Have individual students pair up or have pairs form groups of four and discuss why they put the events that they did on their "Plotline".
- Choose an exercise from the list of "Beyond" Activities.

Day 6

- Choose another exercise from the list of "Beyond" Activities.
- Begin one of the Writing Experiences.
- Have student complete the "Into" Activities: "Crossword Puzzle".

Day 7-8

- Allow time as needed to complete the Writing Experience.

"Into" Activity: Life and Times of Russia Under the Czars

At one point in Russia's long history, a lordship and serfdom political and social system developed. While under the rule of the Mongols (who were the overlords), members of a ruling family (named Kievan) took free lands in the northeast part of Russia where Moscow was located. They colonized the land with their serfs. The family offered the serfs protection from the overlords and roving bands of plunderers, in exchange for money and goods.

Each prince of the Kievan family was master of his share of the family domain. He ruled and defended with the help of his servants (called boyars) and his own army. As time went by, weaker rulers outside of the family line were forced into the service of the Kievan family princes.

The serfs had no rights during this rule. If their prince and his boyars wanted them to move to another location, the serfs had to go. The serfs lived in small, one-room shacks near the fields where they raised crops, had small gardens, and kept a small pen for pigs and chickens. The land and the shacks actually belonged to the prince and his boyars. The serfs were forced to work the fields during the day and tend to their own small area in the evening. They also had to pay money and goods to the prince and his boyars, as well as to the overlords. This was known as a "tribute". If a tribute was not paid, the serf could be jailed, killed or kicked off the land. Life was very harsh for the serfs. They were not allowed to own land, did not get to go to school, and were forced to farm. During war, they served in the prince's army.

The prince used the tribute money to feed, clothe and arm his army which swore their allegiance to him. The army served to protect the prince and his lands. It cost a lot of money to maintain a standing army. However, the money was well spent because if the prince could not defend his lands and his people, he would eventually be defeated in battle. He then would lose everything to the winning prince. In that event, the serfs had no choice, but to stay on their lands and pay tributes to their new prince.

The serfs had few choices in life, few rights and no education or power. They were born into poverty, lived a life filled with destitution, and died with little more than the clothing on their backs. A serf could never rise above being a serf.

"Into" Activity: Crossword Puzzle

Directions: Use the vocabulary words from the story The Fool of the World and His Flying Ship to find the answer to the clues below. Double check your spelling before you write your answer in the squares.

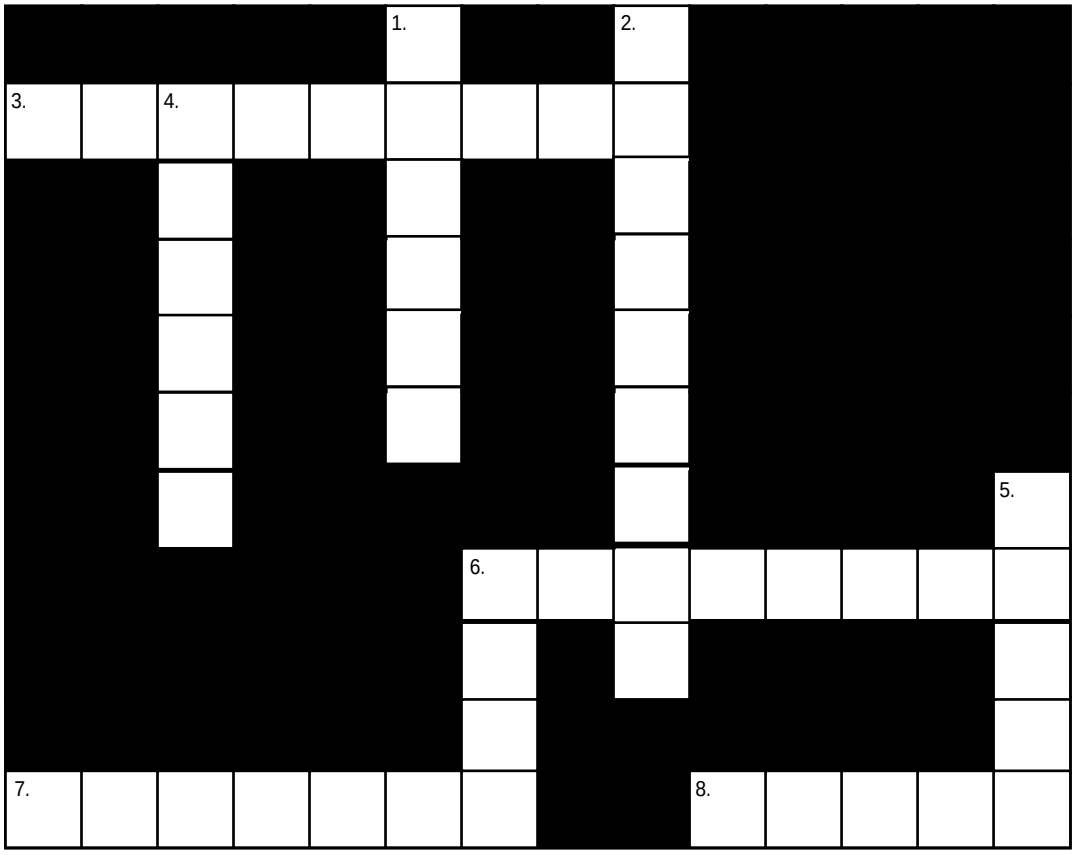
Clues:

ACROSS

3. A small house designed for taking a bath that was used before indoor plumbing was invented.
6. Wife of a czar.
7. To whatever place.
8. A Russian unit of measurement equal to about 1 kilometer or six-tenths of a mile.

DOWN

1. Russian word for a simple peasant.
2. A noble, someone with lots of money and land.
4. A lever used to steer the boat by turning the rudder from one side to the other.
5. Bundle of sticks.
6. Ruler of Russia before 1917.



"Into" Activity: Crossword Puzzle – Key

Directions: Use the vocabulary words from the story The Fool of the World and His Flying Ship to find the answer to the clues below. Double check your spelling before you write your answer in the squares.

Clues:

ACROSS

3. A small house designed for taking a bath that was used before indoor plumbing was invented.
6. Wife of a czar.
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DOWN

1. Russian word for a simple peasant.
2. A noble, someone with lots of money and land.
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5. Bundle of sticks.
6. Ruler of Russia before 1917.

"Through" Activity: Comprehension Questions

1. What was the offer (proclamation) made by the Czar?
   Whoever brought him a flying ship would get to marry his daughter.
2. How do you think the Czar viewed the Fool and his friends when they first arrived?
   As poor peasants who were not very capable.
3. Why do you think the Czar changed the requirements and added another job to his list?
   Because he did not want the Fool to marry his daughter.
   Because of what he thought of him (see answer #2).
4. Do you think the Czar had sound reasons to change his agreement?
   Responses will vary. Make sure students justify their answers with sound reasons.
5. Why do you think the Czar did not want the Fool to marry his daughter?
   See answer to questions 2 and 3.
6. How did the Fool respond to the final request?
   He said he would do it, but that if the Czar did not honor his agreement, the Fool would send his troops to attack.
7. Why do you think the Czar thought he could get rid of the Fool with his last request to gather an army to defend his daughter?
   The Czar did not think that a poor peasant would be able to pay what it would cost to keep an army.
8. How did the Fool respond to the Czar's final request?
   He responded forcefully and with confidence.
9. Why do you think the Fool responded differently to the last request, compared to the response he gave to the first request?
   During this process, he had gained confidence in his abilities.
10. What did the Czar give to the Fool after the Czar's last request was fulfilled?
    The Czar gave him much more respect, probably because he realized that the Fool's troops could defeat his own army.
11. Why do you think the Czar gave more respect to the Fool after his last request was fulfilled?
    See answer to Question 10.

"Through" Activity: Plotline

Directions: Read over each event from the story The Fool of the World and The Flying Ship that is written below. Place the letter of each event in its proper place on the plotline your teacher gives you.

A) The Fool raises his army from the bundle of sticks.

B) The Fool picks up all of his passengers.

C) The Eater and the Drinker eat and drink all the food that the Czar requested them to.

D) The Czar makes the offer of marriage: his daughter for a flying ship.

E) The Czar gives respect to the Fool.

F) The Fool and the Czar's daughter fall in love and get married.

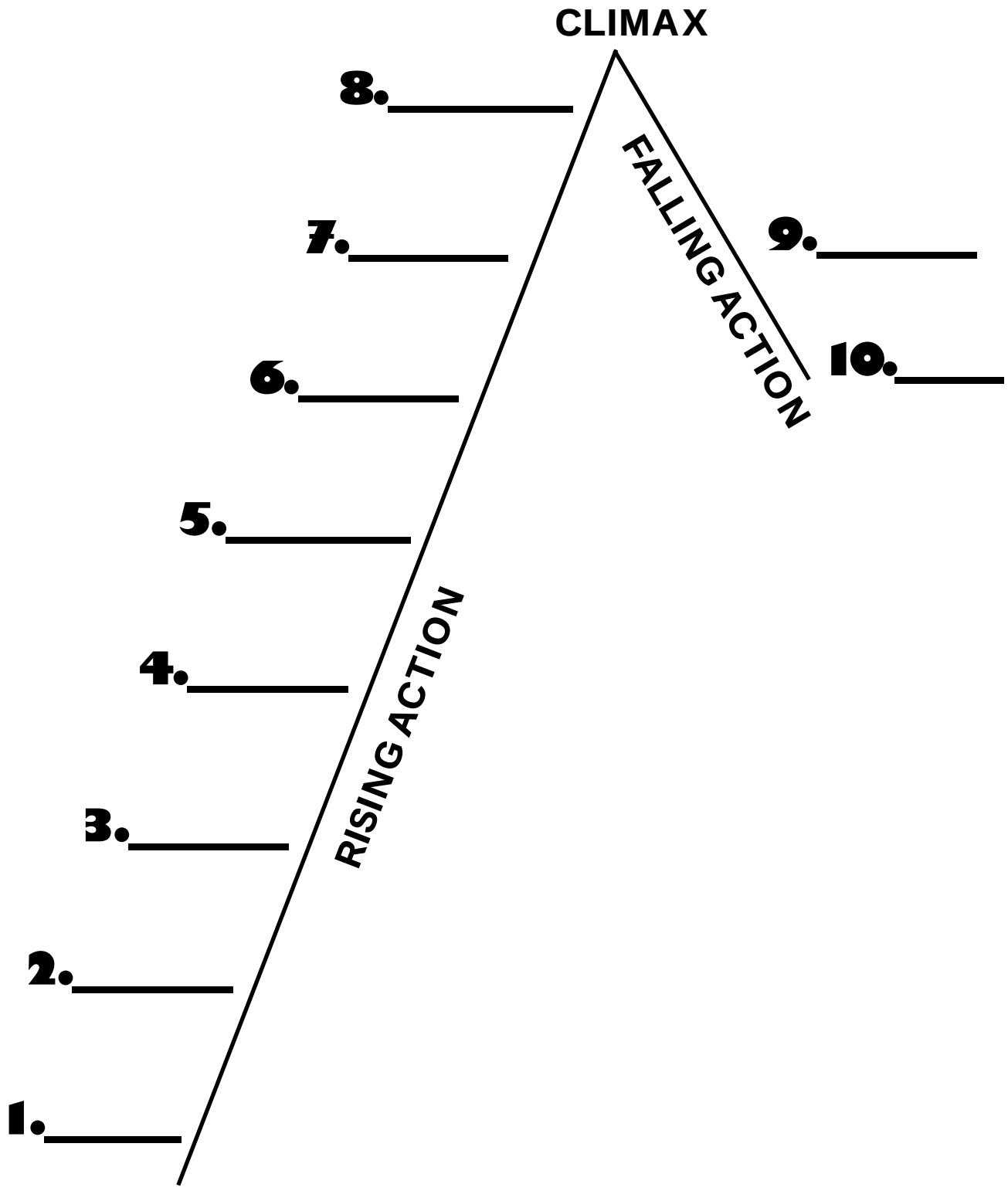
G) The Czar makes a request for the Fool to bring him the magical water of life before his dinner is over.

H) The Czar does not accept the Fool and his Friends when they arrive at the palace.

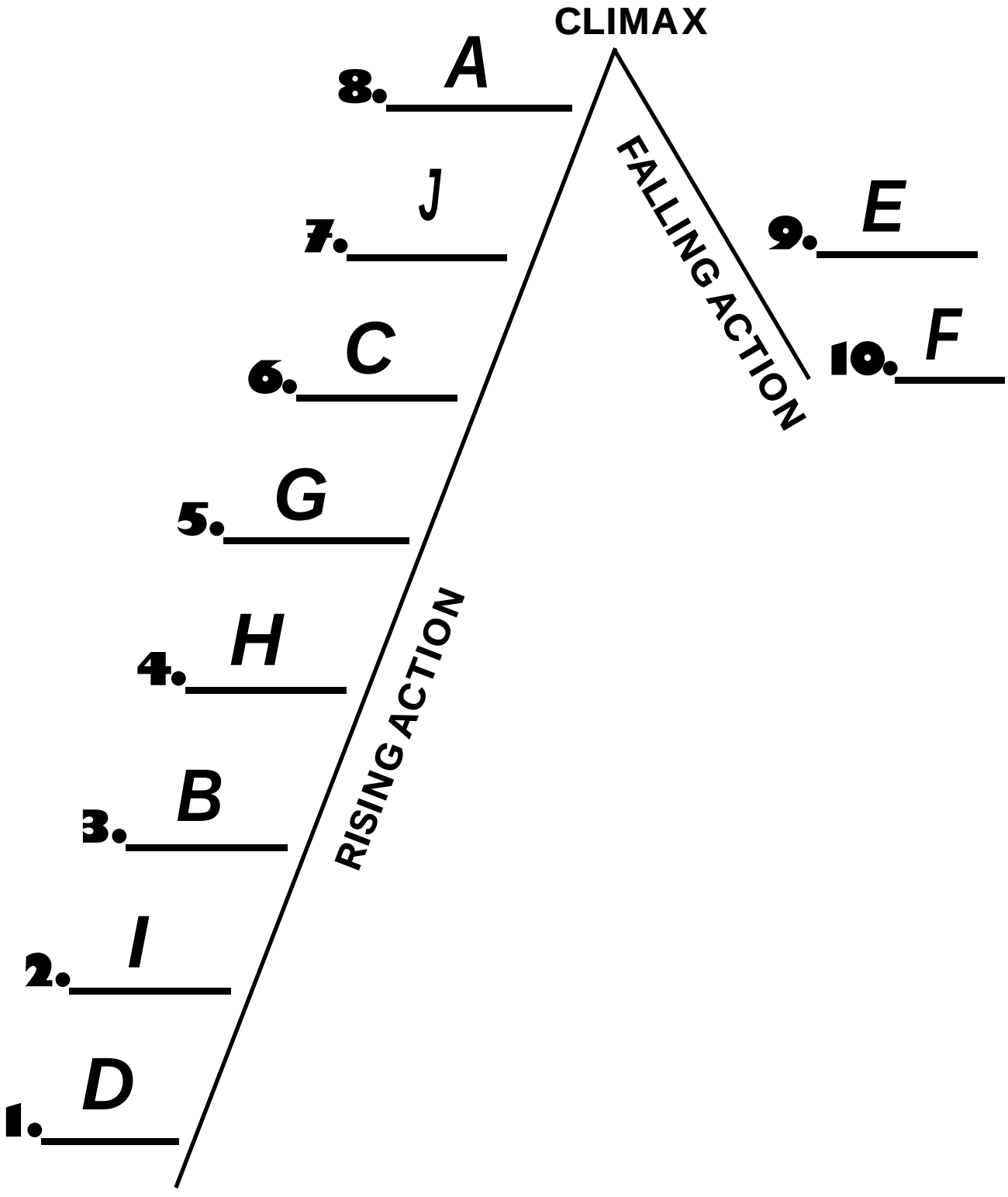
I) The Ancient Man tells the Fool what to do to get the ship.

J) The Fool and the Strawman survive the night in the bathhouse.

"Through" Activity:
Plotline



"Through" Activity: Plotline – Key



“Through” Activity: Character Chart
Flying Ship Passengers

Character Name	Special Gift	Problem or request character could help with	How character helped to solve problem

"Through" Activity: Character Chart – Key
Flying Ship Passengers

Character Name	Special Gift	Problem or request character could help with	How character helped to solve problem
Fool	*Owned ship.*	*Czar wanted a flying ship.*	*Met an ancient old man who told him what to do so that the ship was constructed for him.*
Listener	*Could hear everything going on in the world.*	*Could hear whatever conversation the Czar had with any of his servants as he attempted to keep the Fool from marrying his daughter.*	*Spied on the Czar by listening to his conversations from far away.*
Swift-goer	*Could take huge steps, thus traveling a great distance in a short period of time.*	*Find and bring back the magical water of life before the Czar completed his dinner.*	*He got the water in time for the Fool to give to the Czar before he finished dinner.*

"Through" Activity: Character Chart – Key
Flying Ship Passengers

Character Name	Special Gift	Problem or request character could help with	How character helped to solve problem
Far-Shooter	*Could accurately shoot from very great distances.*	*Getting the magical water of life back to the Czar before he finished dinner.*	*He woke up the swift-goer who, on his return with the magical water of life, had taken a short nap and almost did not wake up in time.*
Eater	*Could eat large portions of food in one sitting.*	*Must devour 12 oxen and as much bread as could be baked in 40 ovens for one single meal.*	*He ate it all in one sitting.*
Drinker	*Could drink a large amount of liquid at one sitting.*	*Must drink 40 barrels of wine.*	*He drank them all in one sitting.*

"Through" Activity: Character Chart – Key
Flying Ship Passengers

Character Name	Special Gift	Problem or request character could help with	How character helped to solve problem
Wood Carrier	*Carried wood that, when shattered, would spring into a fully-armed army.*	*Fool must show he is able to defend the Czar's daughter.*	*Wood Carrier scattered wood on ground and created an entire army.*
Straw Carrier	*Carried straw that, when scattered on the ground, would cause the weather to become cold. Frost and snow would form on the ground.*	*Czar ordered the Fool to bathe in the bathhouse, but the Czar ordered the bathhouse to be made scalding hot. He hoped this would kill the Fool.*	*Straw Carrier covered the floor of the bathhouse with straw and made the bathhouse cooler.*

"Beyond" Activity:
Flying Ship Design

Directions: If you could have your very own flying ship, what would you want it to look like? Sketch a simple design for the outside and do another for the inside of your flying ship.

Outside of Flying Ship:

Inside of Flying Ship:

Writing Experience: The Fool's Letter

Directions: Read the writing prompt below carefully and use the writing process to write a letter.

The Fool's parents did not treat him very well. They considered him harmless and a not-very-quick-thinking young man. They did not encourage him to leave the house and seek his fortune with the Czar because they did not believe he could accomplish the task. They eventually did allow him to go, but they did not give him the same supplies they had given his other brothers (good food and drink, fine clothes). They did not take him seriously, but that did not bother the Fool. He went anyway and was happy to try.

Pretend you are the Fool and you are finally writing a letter home to your parents. You have already fallen in love and married the Czar's daughter, and are now considered a prince. Briefly tell them your story. What else will you tell them? Will you ask them to join you at the palace? Will you forgive them for the way they treated you? Will you ask about your brothers?

Directions: Cluster your pre-write ideas for the letter below.

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Fool	
Listener	
Swift-goer	

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Far-Shooter	
Eater	
Drinker	

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Wood Carrier	
Straw Carrier	
Drinker	

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Czar's Daughter	
Ancient Old Man	
Flying Ship	

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Czar's Deal	
How Fool Gets Flying Ship	
Magical Waters of Life	

Writing Experience: Updating an Old Russian Folktale

An American Fool and His Flying Machine

Directions: Use this sheet as your pre-write to help you rewrite the Russian folktale "The Fool and His Flying Ship". On the left are the original characters and events. On the right, fill in a modern American counterpart to the characters and events.

Original Character	Your new version, with description
Good Appetite Part	
Big Drinking Part	
Too Hot Bathhouse	

Writing Experience: The Czar's Daughter Sends a Letter

Directions: Read the writing prompt below carefully and use the writing process to write a letter.

The Fool's parents and the Czar did not treat the Fool very well. They considered him harmless and a not-very-quick-thinking young man. They did not take him seriously, but that did not bother the Fool. He went ahead anyway to accomplish his goal and was happy to try. Even though the Czar tried to trick the Fool many times, the Fool kept trying and was happy to overcome any obstacle that was placed in his way by the Czar.

Pretend you are the Czar's daughter. You have already fallen in love with the Fool and are about to marry him. Write a letter to the Fool's parents to invite them to the wedding. Briefly tell them what happened to the Fool. Tell them what everyone around the palace now thinks of their son. Then tell them how you have fallen in love with him. Tell them what you like most about their son. Will you invite them to the wedding? Will you invite them to come and stay at the palace? What else will you tell them?

Directions: Cluster your pre-write ideas for the letter below.

The Glorious Flight
Introduction

"Into" Activities

- Show when the flight of Louis Bleriot took place on the CD-ROM timeline.
- Show a video of the early history of flight.
- Show photos or drawings of very early aircraft: biplanes and dirigibles pre-1910.
- Set the geographic location of France, the English Channel, and England. Explain the importance of the English Channel as a natural barrier, protecting England from its enemies. (England was well protected by the Channel up until the time of the invention of aircraft.)
- Color and label a map with the following features: France, Great Britain, Atlantic Ocean, English Channel, Cambrai (city), White Cliffs of Dover. (See accompanying "Places in the Life of Bleriot".)
- Discuss the use of figurative language: onomatopoeia and simile. Some examples from the text are: "crump", "clacketa", "cough", "sputter", "like a chicken", and "like a rabbit". (See accompanying "Figurative Language".)
- Discuss the use of Roman Numerals. (See accompanying "Roman Numerals".)
- Introduce the following vocabulary which will be used throughout the story: (See accompanying "Crossword Puzzle".)

  aeronaut – one who pilots a balloon or dirigible

  aeroplane – older common spelling of the word airplane

  airship – a large dirigible that flies

  glider – an aircraft similar to an airplane that flies without an engine.

  glorious – marked by great beauty or splendor

  inevitable – not able to avoid

  prospect – event

  steering lever – a rigid bar used to guide (steer) an aircraft in a certain direction

  valiant – brave, bold or courageous

"Through" Activities

- Ask and discuss accompanying "Comprehension Questions". (Questions can be asked throughout the reading of the story.)
- Draw a family portrait of the Bleriot family, except set them in modern times and base it upon the title page. Include all the family members mentioned: Louis, Alice, Alceste, Charmaine, Suzette, Jeannot, Gabrielle, the cat, the dog and the bird.
- Draw each of the subsequent "flying ships" that influenced or were a part of Bleriot's life.
- Compare the style of dress of the early 1900's to now. Use the pictures in the book The Glorious Flight to compare men's dress, women's dress or children's clothing. Use a comparison chart to do this activity. (See accompanying "Make Your Own Comparisons".)
- Reading for Information: Use the billboard reprinted in the literature book to answer informational questions. (See accompanying "Reading a Billboard for Information".)

"Through" Writing Experiences

- Write a descriptive paragraph that describes the accident Bleriot had after seeing his first flying aircraft in the air. Use show, not tell, language. (See accompanying "Writing a Descriptive Paragraph".)
- Write a descriptive paragraph that shows what Bleriot saw, heard and felt when he was all alone crossing the Channel. (See accompanying "Writing a Descriptive Paragraph".)
- Pretend you are one of Bleriot's children. Write a letter to your cousins telling them about your father's attempts to fly or your father's trip across the Channel. (See accompanying "Bleriot Letter Writing".)

"Beyond" Activities

- Draw and label a diagram of Bleriot's plane Bleriot XI.
- Make a 3-D replica of Bleriot XI.
- Design a stamp that commemorates Bleriot's crossing of the English Channel. The Post Office has posters that show examples of commemorative stamps they have produced. (See accompanying "Design a Stamp".)

Writing Experiences

- Write a newspaper article that tells of the following: Bleriot's achievement, the trip, the airplane, his experience, his previous flying attempts and all about who he is. (See accompanying "Writing a Newspaper Article".)
- Write an obituary about Bleriot. Do some extra research about his contributions, birth, death, etc. (See accompanying "Writing an Obituary".)
- Describe a time when something caught your fancy and really grabbed your attention, then led you into a new hobby or experience that developed into a passion. (See accompanying "Something Caught My Fancy".)

  This activity can be changed so that the student can interview an adult about such an experience and then write three paragraphs about the interview. Students will need to develop a list of interview questions that are germane to the three paragraph development of the writing assignment. (See accompanying "Writing Experience".)

Daily Lesson Planner

Day 1

- Choose an exercise from the list of "Into" Activities.
- Review vocabulary as needed.

Day 2

- Read the first half the of The Glorious Flight, asking the "Through" Activities: Comprehension Questions" as you go, and reviewing vocabulary as needed.
- Do one of the non-writing exercises listed under the "Through" Activities.
- Complete the book, asking the "Comprehension Questions" and reviewing vocabulary as needed.
- Have students complete the "Into" Activity: "Crossword Puzzle".

Day 3

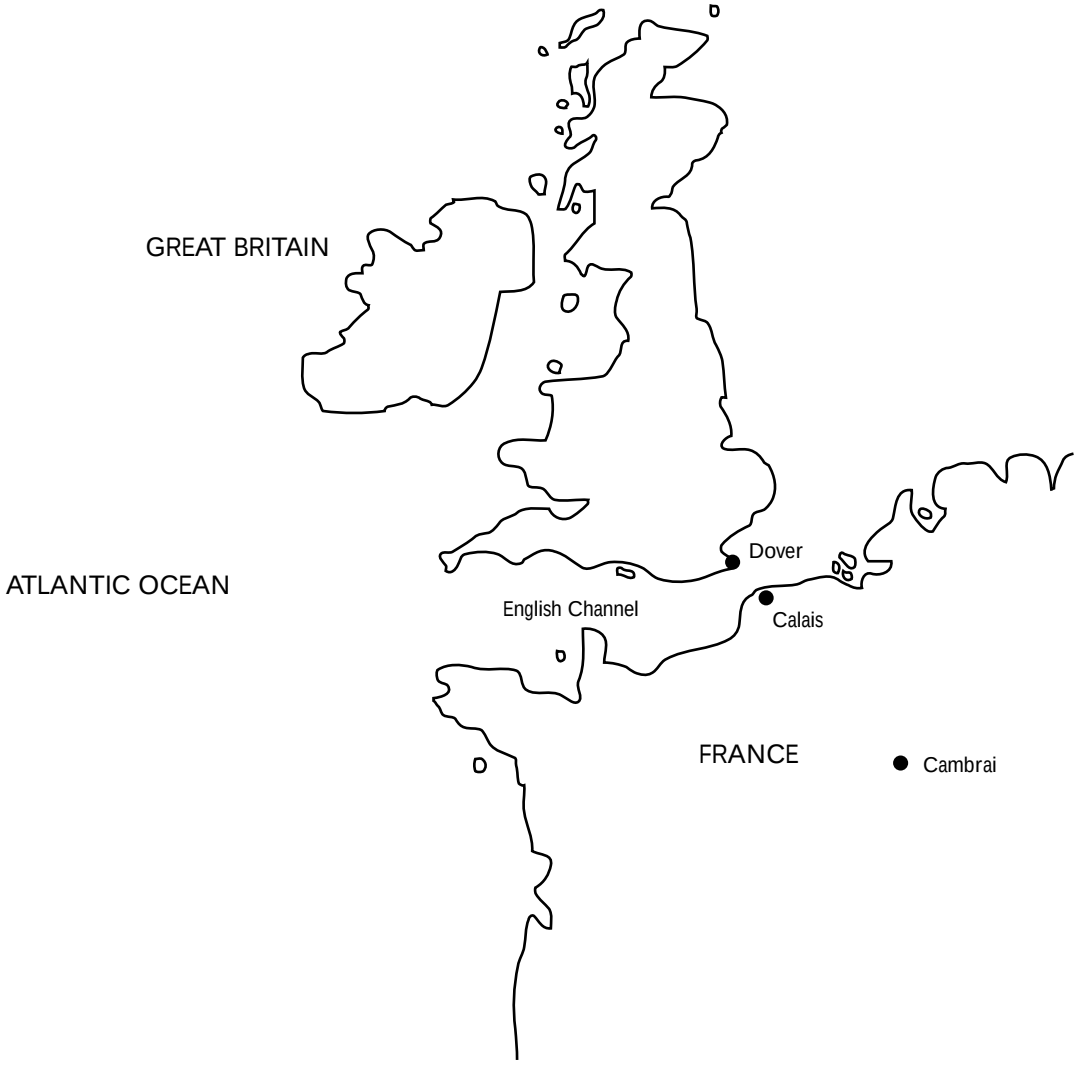
- Choose a writing assignment from the "Through" Writing Experiences.

Day 4 - 6

- Choose exercises from the list of "Beyond" Activities or Writing Experiences.

"Into" Activity:
Places in the Life of Bleriot

"Into" Activity:
Places in the Life of Bleriot – Key



"Into" Activity: Figurative Language Onomatopoeia

Many authors use figurative language to make their words come alive on the page. Figurative language adds so much description that it helps to create a more vivid picture in the reader's mind. Onomatopoeia is a type of figurative language. Onomatopoeia is a word that actually makes the sound it is also describing. For example, *"buzz"* is a word that describes the sound a bee makes and it is also the sound itself!

Below list five other words that are examples of onomatopoeia:

1.

2.

3.

4.

5.

Choose an onomatopoeia and use it in a sentence.

Onomatopoeia Word	Onomatopoeia Sentence
1.	
2.	
3.	
4.	
5.	

"Into" Activity: Roman Numerals

A couple of thousand years ago, a group of people called Romans lived in Italy and conquered the countries all around them. They created a huge empire and developed many advanced ways of doing things. They created their own number system which we still use today. We call that number system Roman Numerals. It is different from our modern number system.

We will discuss only the first three numerals of the Roman Numeral system. They are:

I = one (1) V = five (5) X = ten (10)

There are a few basic rules we will cover:

1. When two or more of the same numeral are repeated, they are added together. For example:

   II = 2 III = 3 XX = 20

2. When a numeral with a higher value is placed to the right of another numeral, they are added together. For example:

   XVI = 16 (10 + 5 + 1 = 16) VI = 6 (5 + 1 = 6)
   VIII = 8 (5 + 1 + 1 + 1 = 8) XII = 12 (10 + 1 + 1 = 12)

3. When a numeral with a lower value is placed in front of a higher numeral, then you must subtract. For example:

   IV = 4 (5 - 1 = 4) IX = 9 (10 - 1 = 9)
   IXX = 19 (20 - 1 = 19)

4. Always write the numeral using the fewest digits possible. For example:

   The number 12 is expressed as XII, not XIIIV.

"Into" Activity: Roman Numerals

Directions: Use Roman Numerals and the rules from the previous page to help you do the following exercises.

1. Count to ten using Roman Numerals:

1	=	6	=
2	=	7	=
3	=	8	=
4	=	9	=
5	=	10	=

2. Write the standard number.

XII	=	XXV	=
XXXI	=	XIV	=
XIX	=	XXXVIII	=

3. Name three ways we still use Roman Numerals.

"Into" Activity: Roman Numerals – Key

Directions: Use the numerals and the rules from the previous page to help you read and write Roman Numerals.

1. Count to ten using Roman Numerals:

1	=	*I*	6	=	*VI*
2	=	*II*	7	=	*VII*
3	=	*III*	8	=	*VIII*
4	=	*IV*	9	=	*IX*
5	=	*V*	10	=	*X*

2. Write the standard number.

XII	=	*12*	XXV	=	*25*
XXXI	=	*31*	XIV	=	*14*
XIX	=	*19*	XXXVIII	=	38

3. Name three ways we still use Roman Numerals.
   Possible answers include, but are not limited to the following:

   - *The year a movie was made (shown at the end of the credits)*
   - *Chapter numbers*
   - *Outlines*

"Into" Activity: Crossword Puzzle

Directions: Use the vocabulary words from the story The Glorious Flight to find the answer to the clues below. Double check your spelling before you write the words in the squares.

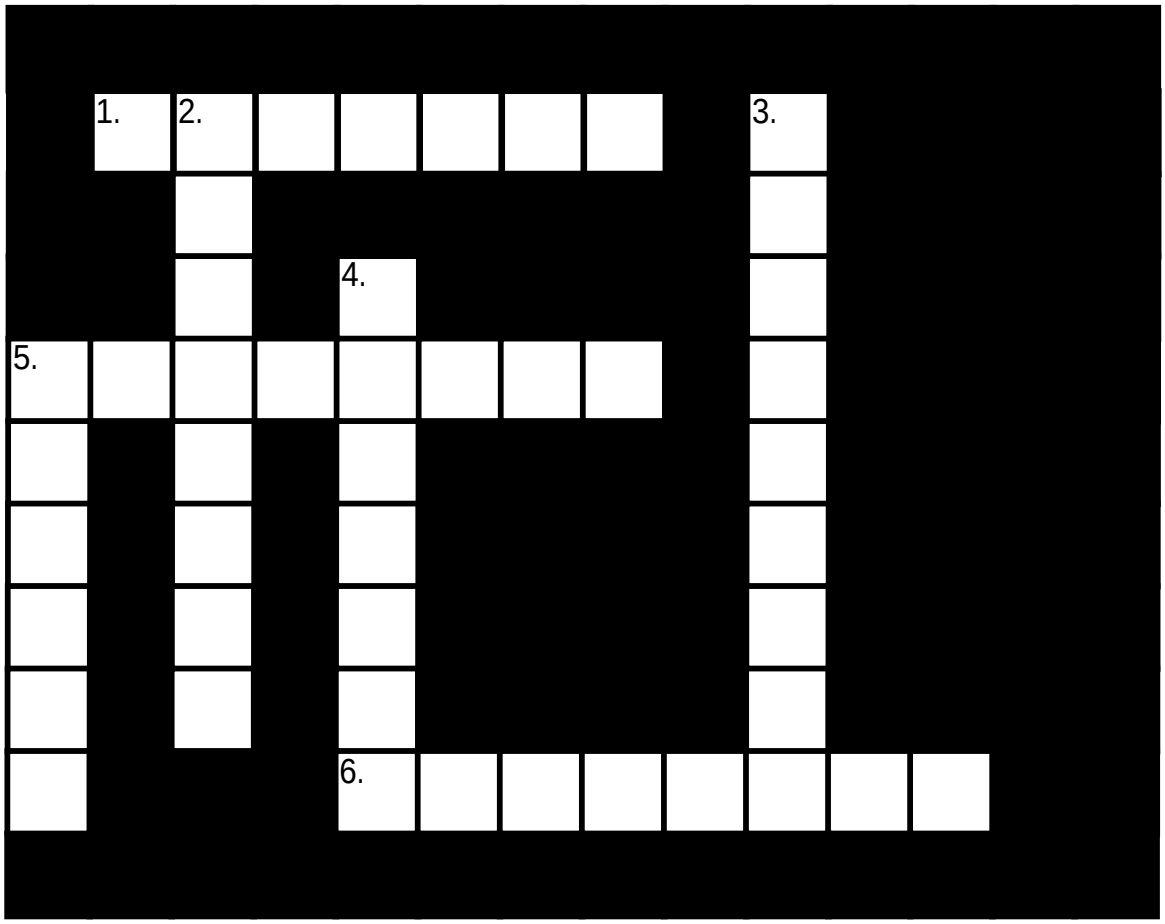
Clues:

ACROSS

1. brave, bold or courageous
5. marked by great beauty or splendor
6. event

DOWN

2. one who pilots a balloon or dirigible
3. older spelling of the word airplane
4. another word for dirigible
5. an aircraft similar to an airplane that flies without an engine



"Into" Activity: Crossword Puzzle – Key

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Clues:

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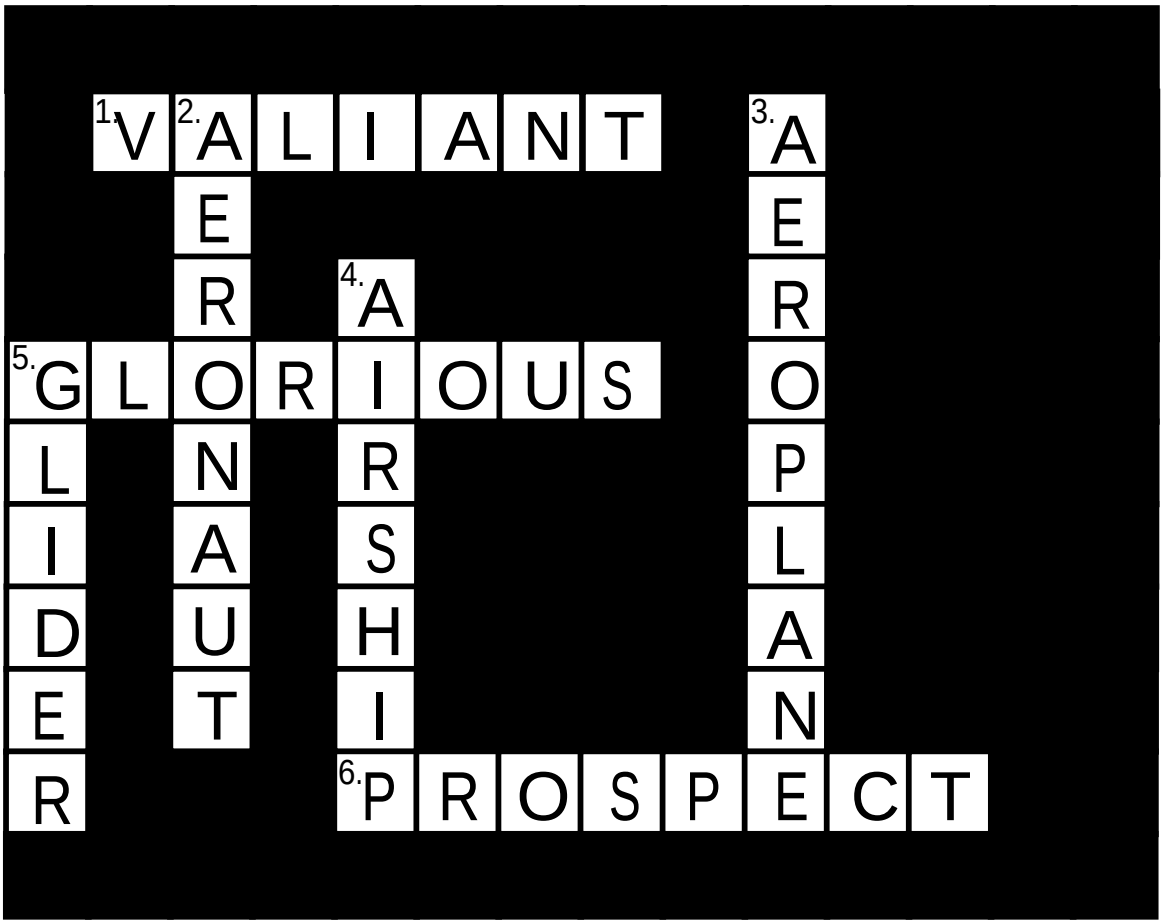


"Through" Activity: Comprehension Questions

1. What caused Bleriot to get into a car accident?

   He was distracted by a dirigible flying overhead.

2. Did Bleriot have a back-up plan in case his plane crashed into the Channel?

   He was followed by a large ship that crossed the Channel with him.

3. Why do you think Bleriot I had the flapping wing design? What aerodynamic principles did Bleriot not fully understand?

   Bleriot mistakenly thought that flapping enabled flight. He did not understand lift, wing camber, and airflow.

4. What powered (or gave thrust to) Bleriot II?

   A boat pulled the plane along the water.

5. Why didn't Louis Bleriot pilot Bleriot II?

   Because he did not know how to fly.

6. How do you think Bleriot learned to fly? When is this approach to learning safe?

   He learned by trying to do it. He also probably got some help from his friend Voisin. It is safe to learn by doing when the consequences are not life-threatening or potentially harmful to you.

7. What was the difference in design between Bleriot III and Bleriot IV?

   The Bleriot IV had twice as many propellers and motors.

8. Why do you think Bleriot IV moved in circles on the water?

   One engine could have been stronger than the other.

9. How many years did it take Louis Bleriot to develop an airplane design that could actually fly?

   About eight years.

10. Describe Bleriot's landing in England.

    It was a bad landing during which he broke his airplane's propeller.

11. Did Bleriot ever get hurt during his attempts to fly?

    He broke a rib, suffered a black eye, and experienced many breaks, sprains and bruises.

12. Why do you think Bleriot attempted the crossing of the English Channel?

    Because it paid money; fame and fortune; to prove it could be done, etc.

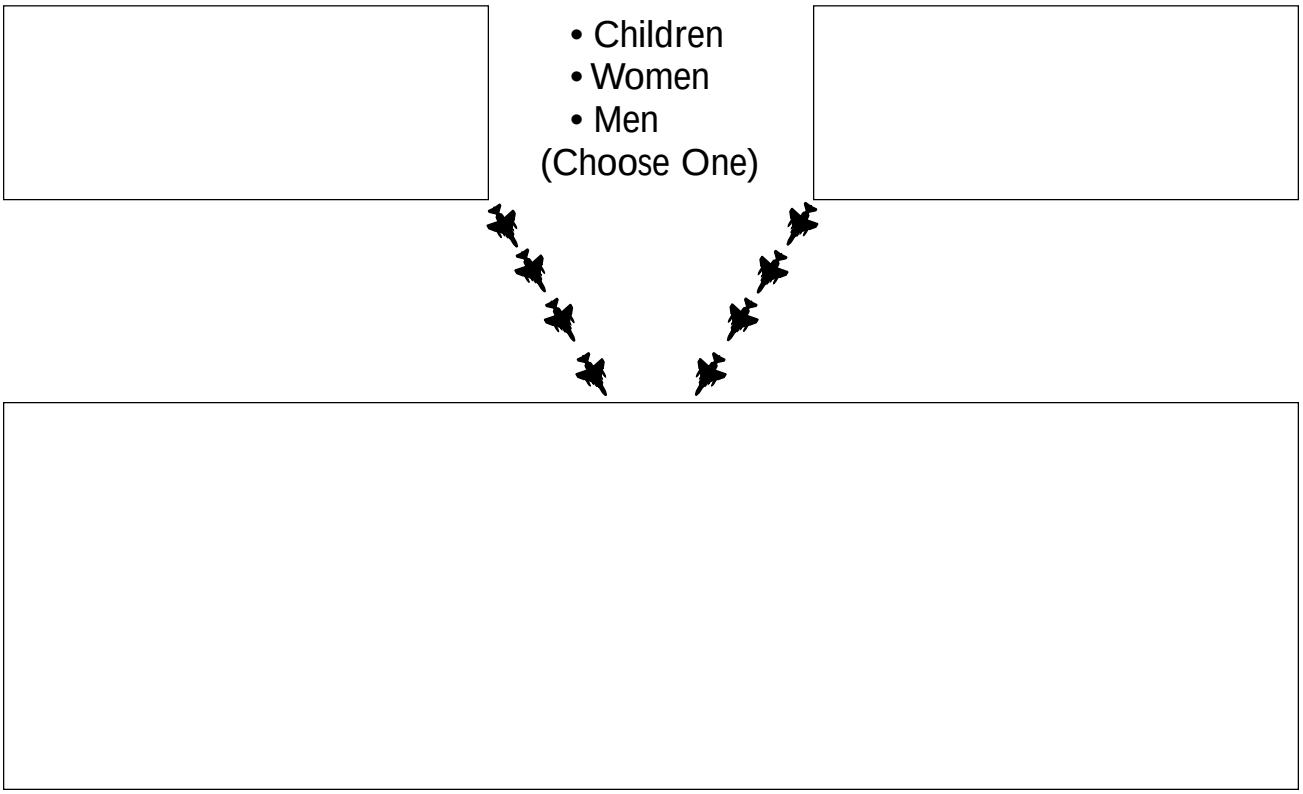
13. Give the date that Bleriot successfully crossed the English Channel and tell how long it took.

    The flight took place on July 25, 1909, and it took 37 minutes.

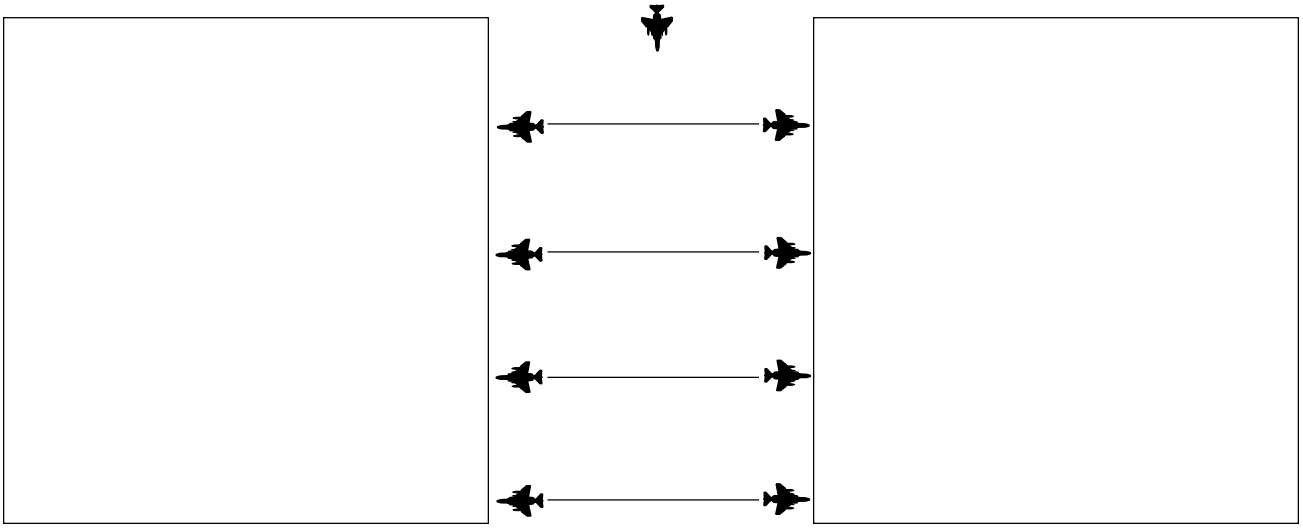
"Through" Activity: Make Your Own Comparison

Directions: Use the pictures from the story, The Glorious Flight, to help you make your comparison.

How Are They Alike?



In What Ways Are They Different?



"Through" Activity: Make Your Own Comparison – Key

Directions: Use the pictures from the story, The Glorious Flight, to help you make your comparison.

How Are They Alike?

Yesteryear's Fashion	• Children • Women • Men (Choose One)	*Today's Fashion*

Women and girls wear dresses

Men and boys wear jackets and pants

Babies wear hats and caps

In What Ways Are They Different?

High standing	Men's shirt collars	*Lower or not at all*
Wore fancy hats when outside	Women's hats	*Most women do not wear fancy hats*
Standard part of dress	Men's vest	*Optional style*
Knickers or shorts	Boy's pants	*No knickers*

"Through" Activity: Reading a Billboard for Information

Directions: Use the replica of the old billboard found on page 27 of the book, The Glorious Flight, to answer the questions below.

1. Write in your own words what contest is being advertised.

2. How much money (British pounds) is being offered to the person who is the first to cross the Channel?

3. Who is offering the prize money for this contest?

4. Does it matter in which direction the pilot flies over the Channel in order to win?

5. Between what times should the flight take place?

6. If someone is interested in doing this, where do they go for more information?

7. Who owns the *London Daily Mail* ?

"Through" Activity: Reading a Billboard for Information – Key

Directions: Use the replica of the old billboard found on page 27 of the book, The Glorious Flight, to answer the questions below.

1. Write in your own words what contest is being advertised.
   The owner of a newspaper is sponsoring a contest. The first person to fly across the English Channel will win a prize of 1,000 pounds.

2. How much money (British pounds) is being offered to the person who is the first to cross the channel?
   1,000 pounds

3. Who is offering the money for this contest?
   The owner of the London Daily Mail.

4. Does it matter which direction the pilot flies in order to win?
   No. You can fly in either direction from France to England or England to France.

5. Between which times should the flight take place?
   The flight should take place between sunrise and sunset.

6. If someone is interested in doing this, where do they go for more information?
   They should inquire at (or go to) the office of the London Daily Mail for more information.

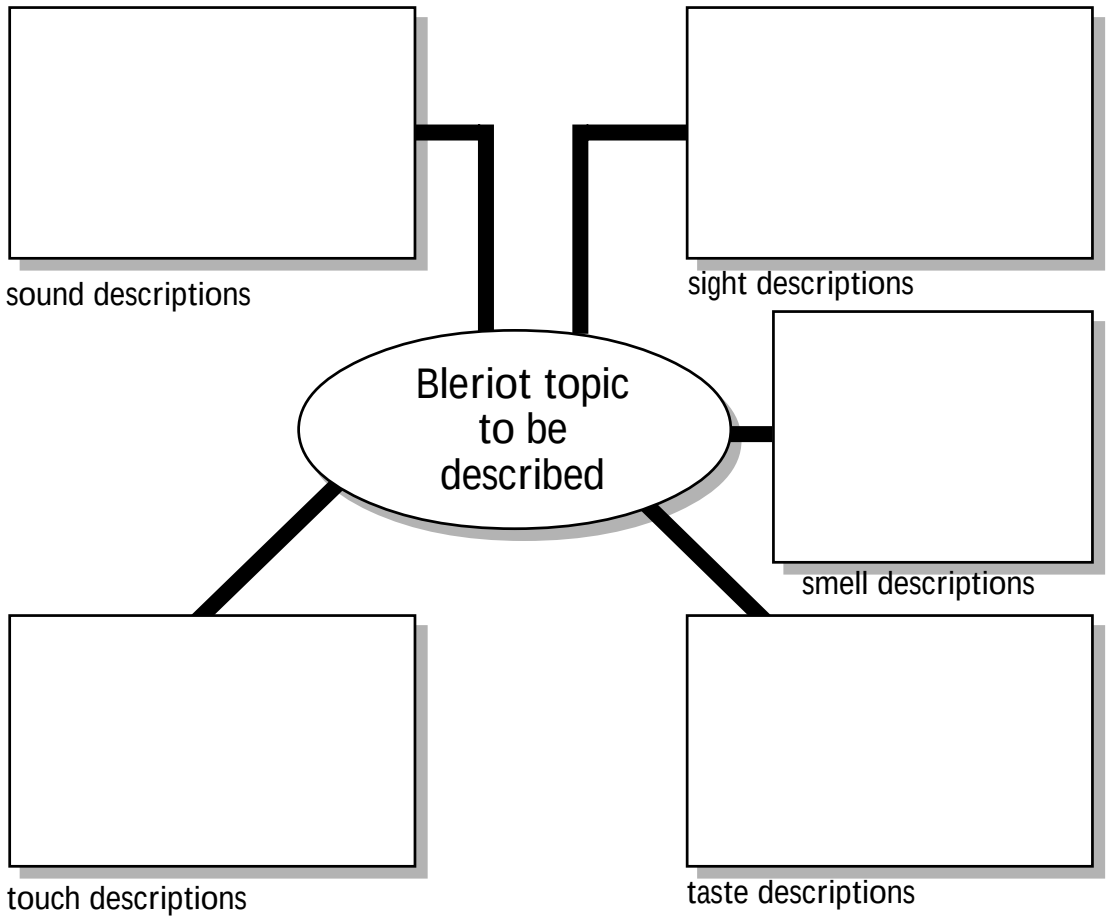
7. Who owns the *London Daily Mail* ?
   A man by the name of Lord Northcliff.

"Through" Writing Experience: Writing a Descriptive Paragraph
Procedure Sheet

A descriptive paragraph is a group of sentences which work together to create a clear picture of a person, place, thing, idea or event. Descriptors include smell, touch (texture), taste, hearing (sounds) and sight (colors, shape). Use the Pre-write chart below to help you organize your descriptors for a descriptive paragraph about Bleriot. Choose one topic from below:

A. Write a descriptive paragraph that details the automobile accident that Bleriot got into when he was distracted by the aircraft flying overhead.

B. Write a descriptive paragraph that details one part of Bleriot's flight across the English Channel. Use your imagination to create a picture of what it would be like to fly through the clouds and mist over the water, or to see the White Cliffs of Dover off in the distance.



"Through" Writing Experience: Bleriot Letter Writing

Directions: Pretend you are Bleriot's son or daughter and you are writing a friendly letter to your cousin. You have not seen your cousin in many years and are filling your cousin in on the work your father has been doing.

Use proper letter writing form. Include an **introductory paragraph**. In the **second paragraph**, describe the building and flying of aircraft that your father has been doing. Tell what encouraged your father to start this work. In the **third paragraph,** tell briefly about his early learning experiences. In the **fourth paragraph,** tell about his success flying across the English Channel. In the **final paragraph,** conclude with how you feel about his flying experiences (Are you proud of him? Are you embarrassed by his learning experiences?).

Use the pre-write on the next page to help you organize your thoughts for the letter you will write. After you complete the pre-write, begin writing your letter.

"Through" Writing Experience: Bleriot Letter Writing Pre-write

Paragraph 1: Introduction with greetings.

Paragraph 2: Describe what encouraged your father to start flying.

Paragraph 3: Briefly describe his early learning experiences with flying.

Paragraph 4: Briefly tell about his success flying across the English Channel.

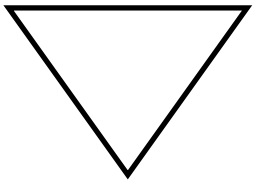
Paragraph 5: Conclude with how his flying really makes you feel. Then, sign your name.

"Beyond" Activity: Design a Stamp

Directions: Design a stamp that commemorates Frenchman Louis Bleriot's crossing of the English Channel. Make sure it includes a date and an image of Bleriot, his airplane and the location.

Writing Experience: Writing a Newspaper Article

Newspaper articles require a different style of writing from what is used when writing a story. When writing a newspaper article, picture a triangle like the one shown.



The newspaper article has all of the important information in the opening paragraph. This information includes **who**, **what**, **when**, **where**, **why** and **how**. It is written this way because most people do not read an entire newspaper article all the way through. So newspaper writers put the most important information at the beginning.

A typical newspaper article contains five (5) parts:

Headline: This is a short, attention-getting statement about the event.

Byline: This tells who wrote the story.

Lead paragraph: This has ALL the who, what, when, where, why and how in it. A writer must find the answers to these questions and write them into the opening sentence(s) of the article.

Explanation: After the lead paragraph has been written, the writer must decide what other facts or details the reader might want to know. The writer must make sure that he/she has enough information to answer any important questions a reader might have after reading the headline and the lead paragraph. This section can also include direct quotes from witnesses or bystanders.

Additional Information: This information is the least important. Thus, if the news article is too long for the space it needs to fill, it can be shortened without rewriting any other part. This part can include information about a similar event.

Writing Experience: Writing a Newspaper Article – Example

Below is an example of a newspaper article:

Headline: High flying escape ends in death

Byline: By Robin Sloan

Lead paragraph: Icarus, son of the famous inventor, Daedalus, plunged into the Aegean Sea and drowned while attempting to escape from the island of Crete early yesterday afternoon. His body has yet to be recovered.

Explanation: Icarus and his father had made wings from wax and bird feathers they had collected over the years while imprisoned on the island of Crete. They attached the homemade wings to their arms and, using a flapping motion, lifted off from the island shortly before noon. While making their escape, Icarus flew too close to the sun. As a result, the heat melted the wax on his wings which caused the feathers to drop off. The wings collapsed and Icarus fell into the sea and drowned.

Additional Information: Daedalus, sobbing from the distant shore where he had landed safely, said, "My last words to Icarus before we left the island was to stay close and not fly too high! He just didn't listen! Why didn't he listen to me?" Daedalus and Icarus had been held prisoner by King Minos on the island of Crete, and had been forced to build a labyrinth at the palace of Knossos. It was known to be the most difficult maze in the world to navigate successfully.

Writing Experience: Write Your Own Newspaper Article

Directions: Write a newspaper article about Bleriot's aeronautical feat of crossing the English Channel. Use the guidesheet below to help you plan the information you will include for your article.

Headline:

Byline: By:

Lead Paragraph: Who:

What:

When:

Where:

Why:

How:

Explanation:

Additional Information:

Writing Experience: Writing an Obituary

After a person dies, a notice is usually put in a local newspaper telling of the person's death. Included with this notice is a short retelling of the person's life. An obituary usually contains the following information:

- person's name
- date, location and sometimes the circumstances of death
- a short statement telling about his/her characteristics
- a short retelling of important contributions he/she made during life
- relatives who are still living
- time and location of memorial service

Below is an example of an obituary:

Icarus

Icarus, 14, drowned in the Aegean Sea while attempting to fly to freedom from the island of Crete.

Icarus' short life was filled with pain and heartache because of his imprisonment on the island of Crete. Despite those hardships, Icarus was a curious and adventurous young man who explored the island whenever he was allowed. He studied under his father and showed signs of artistic ability and inventiveness. He was a fast learner and quickly took to the skies with the wings his father made for their daring escape.

He is survived by his Father, Daedalus, who now lives on the island of Sicily.

A memorial service will be held at noon on Thursday in Sicily at the harbor of Palermo. Instead of flowers, please, make donations to the Aeronautics Research Institute of Sicily.

Writing Experience: Writing an Obituary

Directions: Do some extra research about Bleriot and write an obituary for him. Use the guidesheet below to help you organize the information you will include, then write Bleriot's obituary.

Person's name:

Date, location and circumstances of death:

A short statement telling about his/her characteristics:

A short list of important contributions he/she made during life:

Relatives who are still living:

Time and location of memorial service:

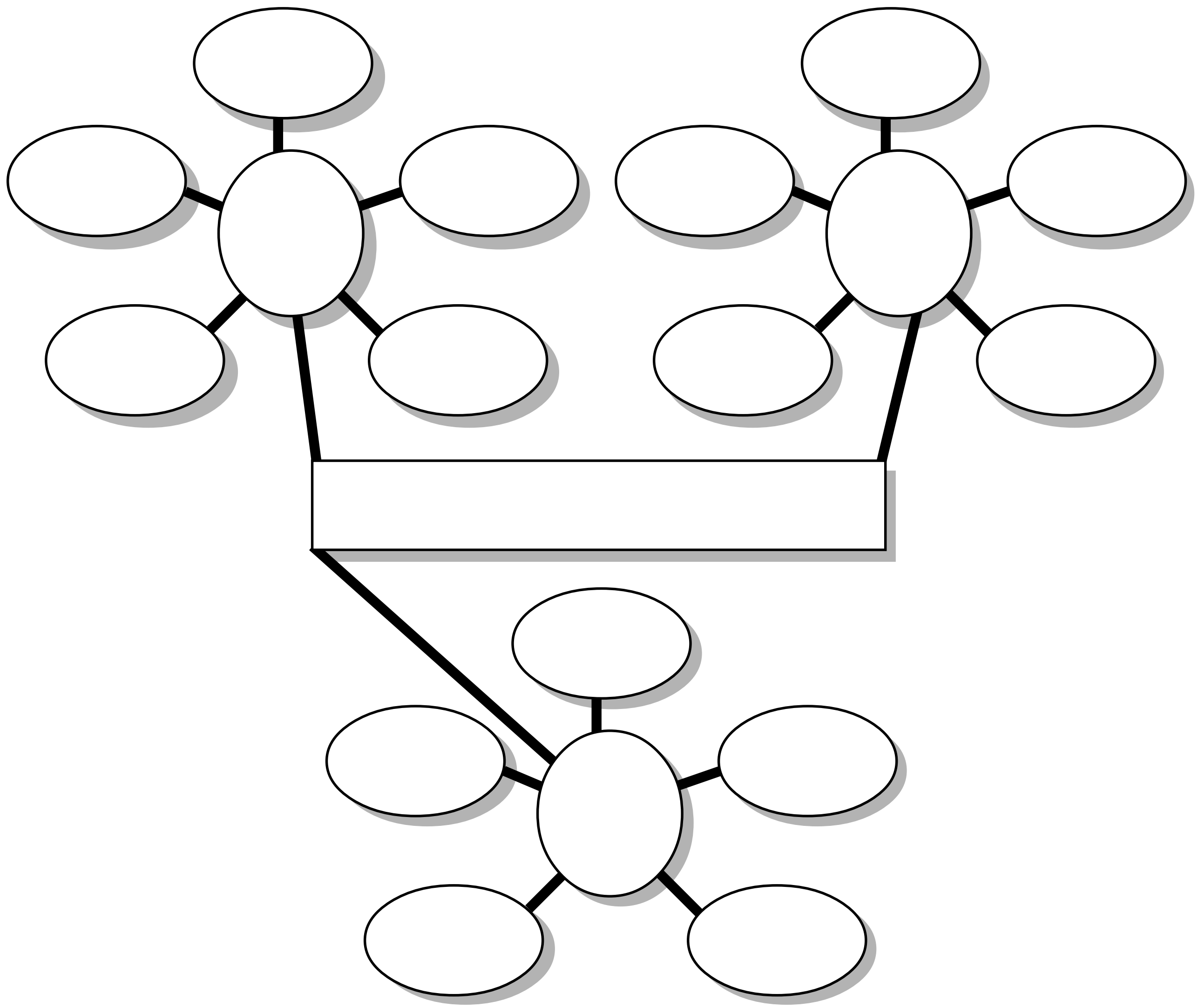
Writing Experience:
Something Caught My Fancy

As Louis Bleriot was driving with his family in their motorcar, he heard a strange sound overhead. He searched the skies for the object making the noise and was surprised to see a great white airship coming out of the clouds. A man was sitting in the airship's basket and driving it through the air. It was a wonderful sight, and it caught Louis' fancy. The sight made a great impression upon him. After this experience, Louis began his experiments with flying machines. These experiments finally led Louis Bleriot to build and fly the first aircraft to cross the English Channel.

Has there ever been a time when you saw something that really caught your fancy; something that caught your eye and really interested you? In three paragraphs, describe something that has caught your fancy. In the first paragraph, briefly describe the event you saw. In the second paragraph, describe what effect it had on you. How did you react when you first saw it happen? How did it make you feel? In the last paragraph, tell what resulted from this experience. Did you end up getting involved in a similar event? Did you spend lots of time learning more about it? How did it work out? It is something you still do today? Is it something you still have a fancy for?

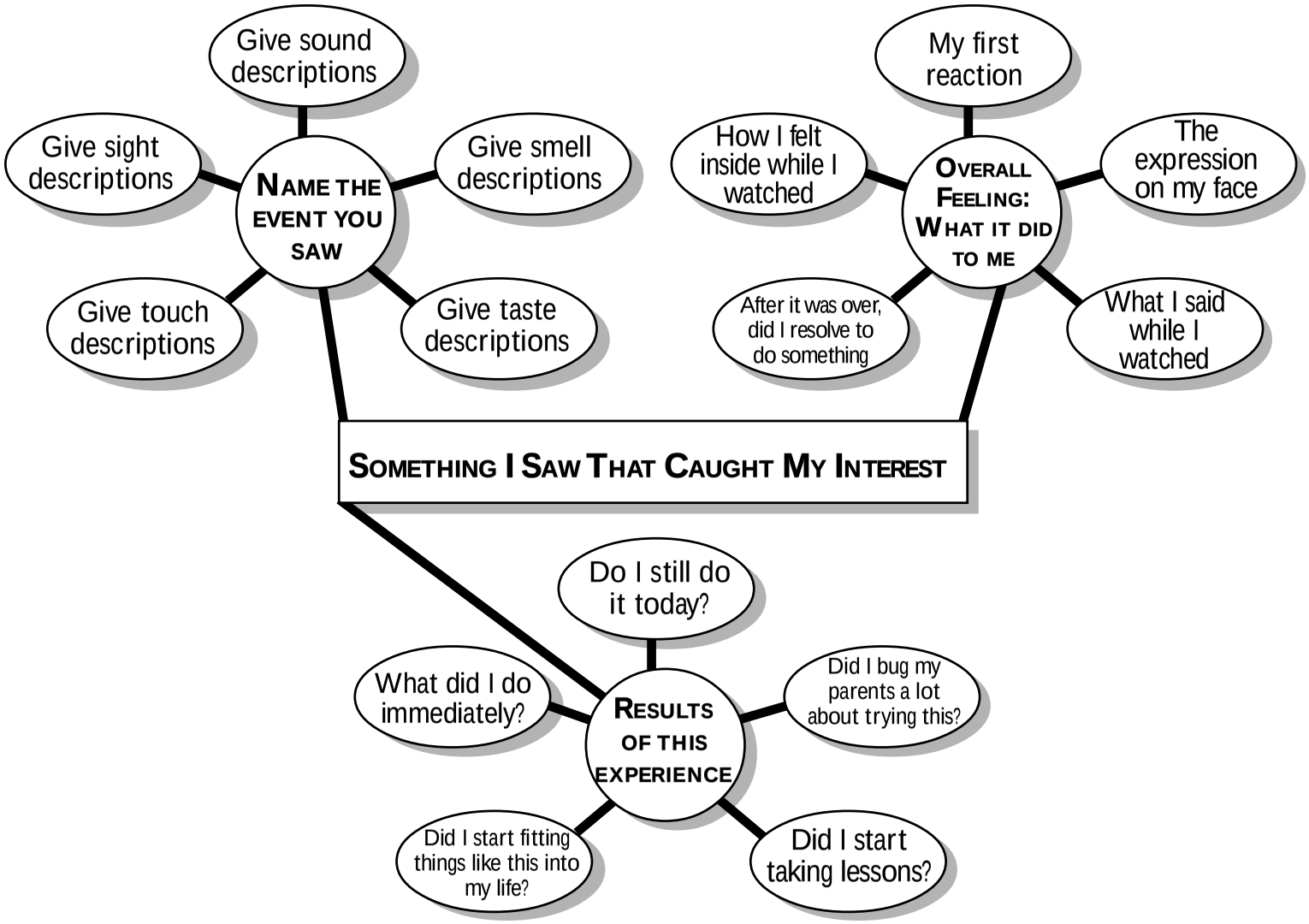
Writing Experience:
Something Caught My Fancy Pre-write

Directions: Use the pre-write cluster below to help you organize your thoughts for your three paragraphs.



Writing Experience:
Something Caught My Fancy Pre-write – Key

Directions: Use the pre-write cluster below to help you organize your thoughts for your three paragraphs.



Flight
Introduction

"Into" Activities

- Show photos of Lindbergh, his plane (*The Spirit of St. Louis*) and facsimile of newspaper headlines. Briefly discuss the event.
- Discuss the types of airplanes being flown during the late 1920s and the limits of the technology at that time.
- Ask what kind of strengths and abilities an individual would need to accomplish such a feat back then. (See accompanying "Strengths and Abilities".)
- Introduce the following vocabulary which will be used throughout the story. (See accompanying "Crossword Puzzle".)

  aloft – up in the air
  aviator(s) – the pilot of an airplane
  ballad – song
  chart – to map a course; or a map
  churning – to move with a violent motion
  concentrate – to focus all one's energy or thought on
  constantly – to happen regularly
  dense – thick
  destination – the final place one intends to go
  ebbing – to fall from a higher level to a lower level
  eternity – seemingly endless or immeasurable time
  goggles – protective glasses that fit snugly against the face
  instrument – device or tool used to help guide a plane
  navigate – to steer a course through air or water
  periscope – a device or tool which uses mirrors and lenses to see around a blocked view
  plunge – to fall downward at high speed
  quicken(s) – to make more rapid
  sentry – another name for a guard
  soggy – heavy with water or moisture
  shimmer – to shine with a soft, wavering light
  throttle(s) – the device used to control the speed of an airplane

"Through" Activities

- Ask and discuss accompanying "Comprehension Questions". (Questions can be asked throughout the reading of the story.)
- Read Flight a first time, all the way through.
- Read Flight a second time and chart Lindbergh's journey as follows:
  - Ensure students have copies of the accompanying map, "Lindbergh's Solo Flight", and the accompanying "Lindbergh's Flight Log".
  - As the story is read, follow Lindbergh's journey and trace it on "Lindbergh's Solo Flight Chart".
  - Mark the hours and locations (by number) as they are mentioned in the story. Place an "X" at Lindbergh's starting location and a "XX" a his destination.
  - Complete the accompanying "Lindbergh's Flight Log". Some calculation of hours and miles will be required.

"Beyond" Activities

- Make a list of ten (10) questions you would have liked to have been able to ask Lindbergh about his flight. (See accompanying "Ten Important Questions".)
- Select your favorite part of this story and illustrate it.
- Create a diagram of the *Spirit of St. Louis* and label its parts.
- Make a three-dimensional model of the *Spirit of St. Louis.*
- Create a diorama illustrating a part of Lindbergh's flight.
- Create a stamp commemorating Lindbergh's historic flight. The Post Office has posters that show examples of commemorative stamps they have produced . (See accompanying "Design a Stamp".)
- Research Lindbergh's other achievements.
- Research how Lindbergh prepared for his flight.
- Create a scrapbook that Lindbergh might have made of his flight. Include items or pictures and annotations.

- Create a time capsule of Lindbergh's trip. Have students place important items into the time capsule that are either symbolic representations or replicas of actual items that he took with him. Have students include an explanation about each item on an index card.

Writing Experiences

- Debate the importance of Lindbergh's flight to aviation history with another student. (See accompanying "Preparing a Debate".)

  Note: For a complete explanation and organizational strategy on how to teach students the art of beginning debate, refer to Organizing Thinking, Book II, by Sandra Parks and Howard Black, from Critical Thinking Press and Software, P.O. Box 448, Pacific Grove CA, 93950, pp. 105 - 124. Phone: 800-458-4849. FAX: 408-393-3277.

  ISBN # 0-89455-355-0.

- Pretend you are Lindbergh and write a diary entry describing your feelings as you fly solo over the Atlantic Ocean during the darkness of the early morning hours. (See accompanying "Writing a Diary Entry".)
- Pretend you are a newspaper reporter and write a brief news article about Lindbergh's solo flight. (See accompanying "Writing a Newspaper Article".)
- Write a poem about Lindbergh's flight. (See accompanying "Writing Concrete Poetry".)
- Write a ballad about Lindbergh's flight. (See accompanying "Writing Your Own Ballad".)

Daily Lesson Planner

Day 1

- Choose exercises from the list of "Into" Activities.
- Introduce and discuss vocabulary.

Day 2

- Distribute "Through" Activities: "Lindbergh's Flight Log" and go over how to fill in the information.
- Read the book Flight, taking time out to ask the "Through" Activities: "Comprehension Questions" as you go. Review vocabulary and discuss information to be filled in on the "Flight Log".
- Have students complete the "Into" Activities: "Crossword Puzzle".

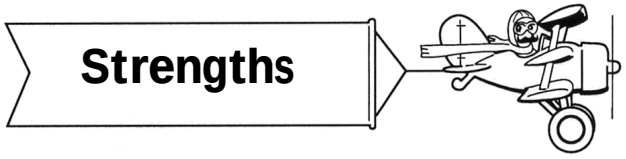
Day 3 - 6

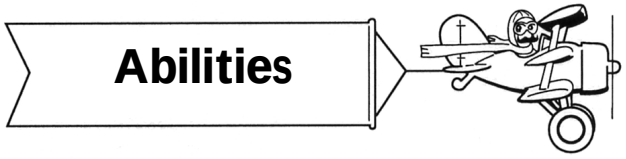
- Choose exercises from the list of "Beyond" Activities.
- Choose exercises from the list of Writing Experiences.

"Into" Activity: Strengths and Abilities

Directions: Strengths are those positive qualities that a person has that are part of his/her character. These strengths can be patience, understanding, perseverance, etc. Abilities are those skills that a person can learn to do well.

List below the strengths and the abilities that you think Charles Lindbergh had that helped to make his flight so successful.

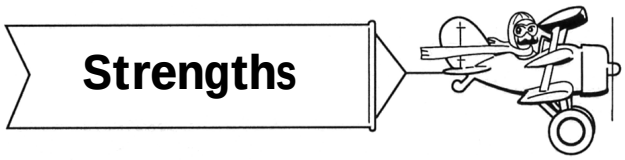




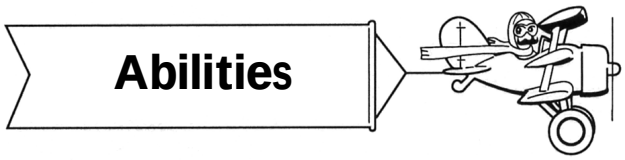
"Into" Activity:
Strengths and Abilities – Key

Directions: Strengths are those positive qualities that a person has that are part of his/her character. These strengths can be patience, understanding, perseverance, etc. Abilities are those skills that a person can learn to do well.

List below the strengths and the abilities that you think Charles Lindbergh had that helped to make his flight so successful.



- ***Eye for detail***
- ***Perseverance***
- ***Patience***
- ***Organization***
- ***Alertness***



- ***Navigation***
- ***Pilot an airplane***
- ***Make changes in airplane design***

"Into" Activity: Crossword Puzzle

Directions: Use the vocabulary words from the story Flight to find the answer to the clues below. Double check your spelling before you write the word in the squares.

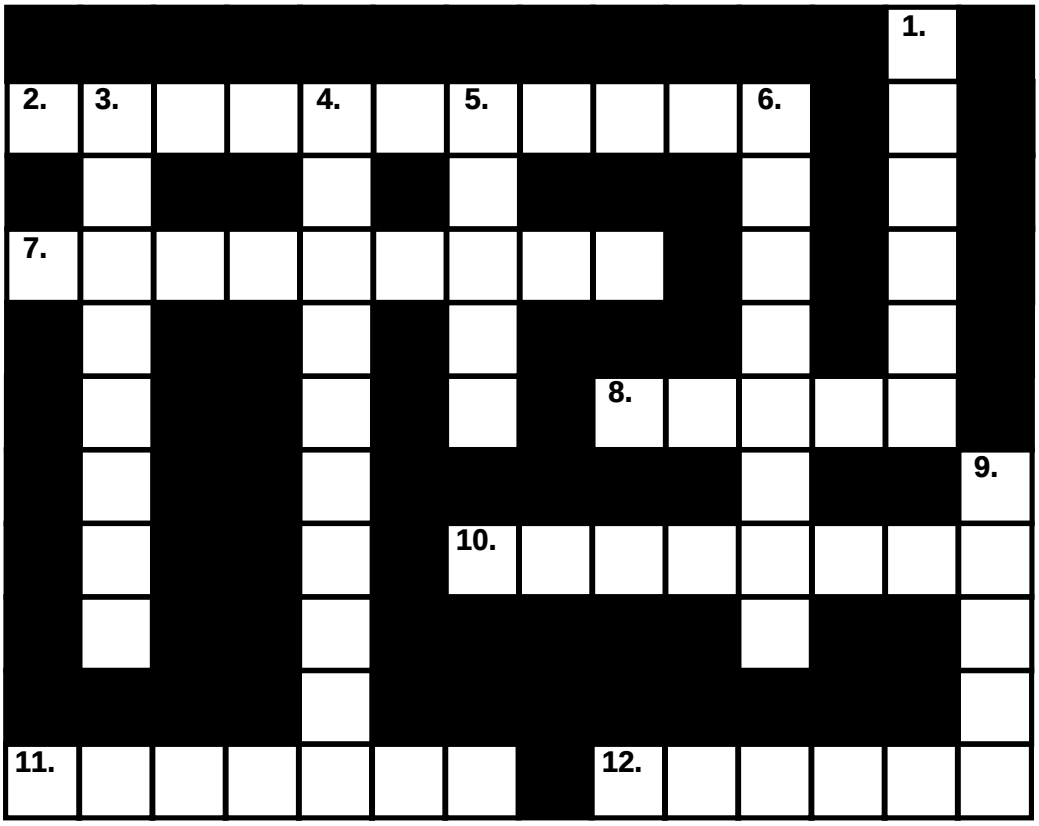
Clues:

ACROSS

2. the final place one intends to go
7. tool or device that uses mirrors and lenses to see around a blocked view
8. heavy with water or moisture
10. a device used to control the speed of an airplane
11. the plot of an airplane
12. to fall downward at a high speed

DOWN

1. guard
3. seemingly endless or immeasurable time
4. device or tool used to help guide a plane
5. up in the air
6. to steer a course through air or water
9. thick



"Into" Activity: Crossword Puzzle – Key

Directions: Use the vocabulary words from the story Flight to find the answer to the clues below. Double check your spelling before you write the word in the squares.

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DOWN

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9. thick

"Through" Activity: Comprehension Questions

1. Who was the young man?
   The young man was Charles Lindbergh.

2. What was it he was trying to accomplish?
   He was trying to become the first person to fly solo across the Atlantic Ocean from New York to Paris.

3. What was the weather like when he began?
   It was cloudy and drizzling.

4. Where was the starting point of his trip?
   He started his trip from New York.

5. What route dids he follow?
   He followed a northern route along the coast of North America and then across the Atlantic Ocean.

6. How many miles did he travel?
   He traveled about 3,600 miles.

7. Why did he have to use a periscope?
   Lindbergh changed the design of the plane so he could add an extra fuel tank to carry enough fuel to allow him to cross the ocean. The extra fuel tank blocked his vision, so he could not see out of the front window of the plane. In order to see where he was going, he used a periscope extended from his side window to view the front of the airplane.

8. What was his average speed during this flight?
   His average speed was 100 miles per hour.

9. Why did he choose to fly lower and closer to the ocean, rather than higher?
   The plane would encounter less turbulence at this altitude, which would save on fuel.

10. How high above the water did Lindbergh fly his plane?
    He flew his plane about ten feet above the water.

11. What do you think would have happened had Lindbergh flown off course for even a brief period of time?
    He would have run the risk of using too much fuel. If he had, he might have run out of fuel and needed to land earlier than he had planned.

12. What did he do along the way, besides pilot the plane?
    He kept a journal of his trip so that everyone would know all that he observed and all that happened.

13. How did he describe icebergs?
    He described them as white pyramids and sentries of the Arctic.

14. Why do you think he used those terms to describe icebergs?
    Icebergs can be pointed on the top like a pyramid and may have the same shape as pyramids. A sentry is a person who stands guard. Therefore, icebergs serve as landmarks warning that you are getting close to the frigid Arctic. The icebergs stand like guards at the entry to the Arctic.

15. What did Lindbergh use to help him navigate?
    He used two compasses and the stars to help him navigate.

16. How are those navigation tools different from tools used today?
    In addition to compasses and stars, today we use radios, a global positioning system and computers, to help navigate.

17. Why did he decide to fly his airplane at a higher altitude?
    He was caught in a bad storm and wanted to get out of the rain and clouds.

18. What was the weather like at the higher altitude?
    At the higher altitude it was clearer, but the rain had turned to ice because the air temperature was colder.

19. What happened when he flew his plane to 10,500 feet?
    Ice began forming on the wings.

20. Why did Lindbergh decrease his altitude and fly back into the storm?
    Ice forming on the wings was dangerous, and Lindbergh did not want his instruments icing up. So, he flew to a lower altitude where the air was warmer.

21. What do you think would have happened had Lindbergh remained at that higher

altitude?

The ice on the wings would have made the wings heavier. He probably would have crashed.

22. What happened after Lindbergh had been awake for more than fifty hours?

He became sleepy and fell asleep momentarily. He did not know how long he had fallen asleep and was afraid he had flown off course.

23. What did Lindbergh do to keep himself awake?

He leaned his face near the open window where the cold air kept him awake. He held his eyelids up with his fingers. He thought about things like growing up on the farm, being a trick pilot, and the people in St. Louis who paid for his plane. He drank only water and did not eat because he thought it was easier to stay awake on an empty stomach.

24. How did Lindbergh feel with 1,300 miles left to fly?

He felt completely alone in the world, like he was "flying through eternity" or flying through time all by himself.

25. What did Lindbergh long for as he passed over fishing boats with 1,000 miles to go?

He longed for a warm welcome from the people he passed because he had been alone for such a long time.

26. Why did Lindbergh choose not to end his flight in Ireland?

Lindbergh's dream was to fly from New York to Paris. If he stopped in Ireland he would not be fulfilling his dream or reaching his goal.

27. What was he flying over during his 31st hour of flight?

He was crossing over England.

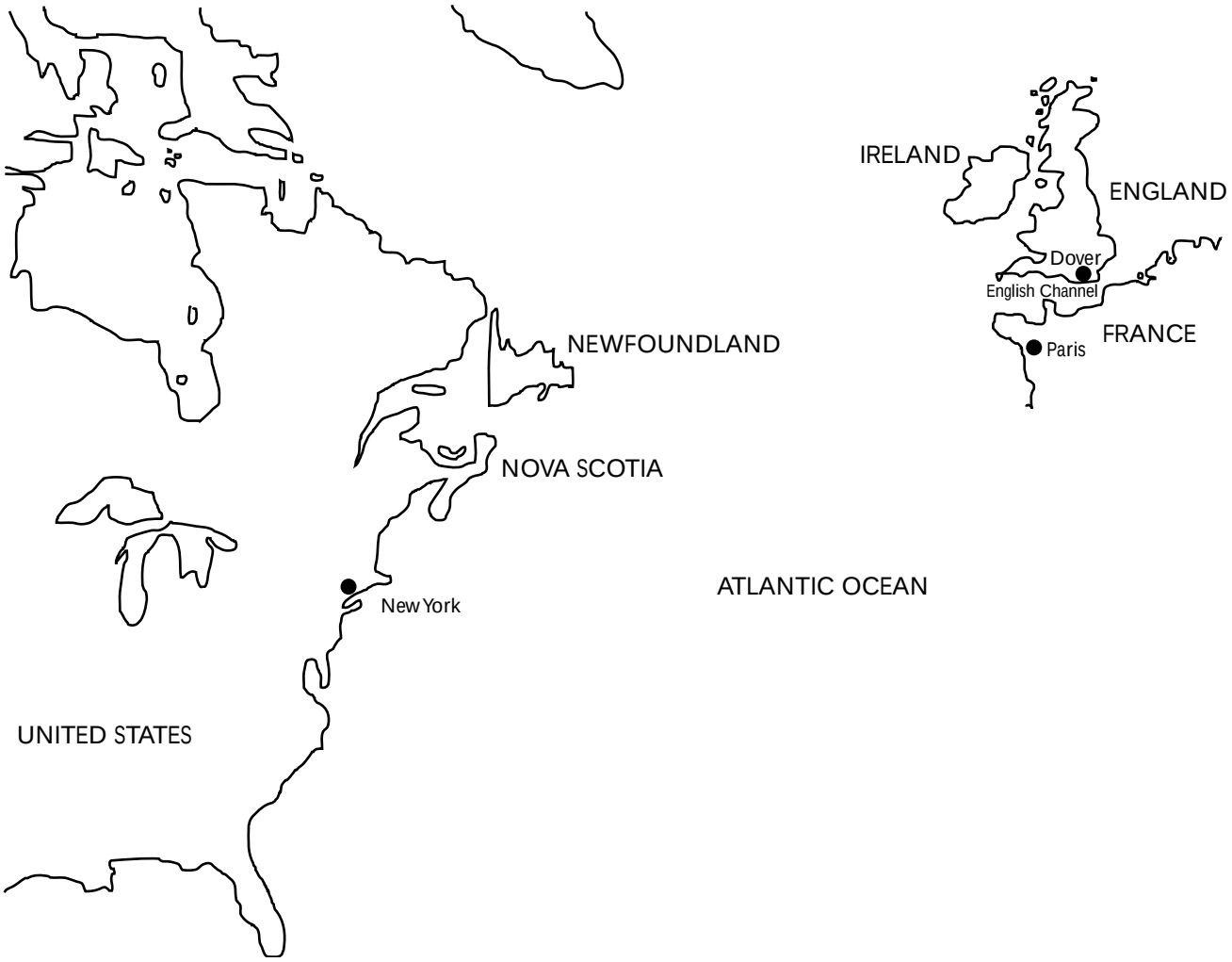
28. How long did the flight from New York to Paris take?

It took 33-1/2 hours

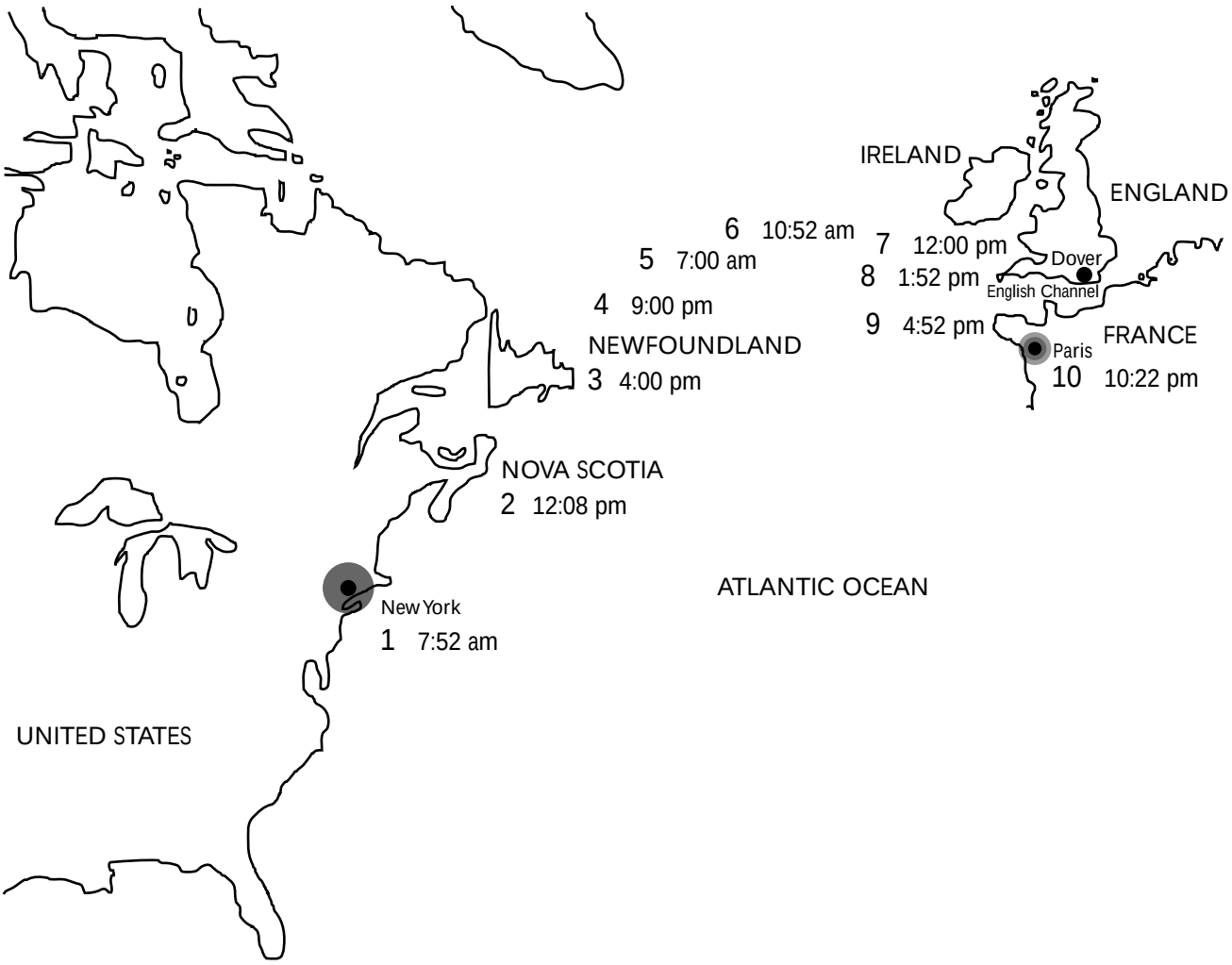
29. How did the world acknowledge his aviation feat?

The world acknowledged his achievement with newspaper headlines, parades, medals and speeches.

"Through" Activity: Lindbergh's Solo Flight Chart



"Through" Activity: Lindbergh's Solo Flight Chart – Key



"Through" Activity: Lindbergh's Flight Log

Directions: Using the information from the story Flight, complete the chart for each numbered location on the map.

Number on map				
Location				
Hours into flight				
New York Time				
Number of miles flown				
Description of weather				
Description of what was seen				
Description of how Lindbergh felt				

"Through" Activity: Lindbergh's Flight Log – Key

Directions: Using the information from the story Flight, complete the chart for each numbered location on the map.

Number on map	1	2	3	4
Location	*New York*	*Nova Scotia*	*Coast of Newfoundland*	*Northeast Atlantic Ocean*
Hours into flight	*0 (just beginning)*	*4*	*8*	*13*
New York Time	*7:52 a.m.*	*12:08 p.m.*	*4:00 p.m.*	*9:00 p.m.*
Number of miles flown	*0*	*400*	*800*	*1,300*
Description of weather	*Cloudy with drizzle*	*Cloudy*	*Cloudy*	*Patchy clouds*
Description of what was seen	*Field from where he took off*	*Coastline*	*Coastline of Newfoundland amid icebergs*	*Darkness*
Description of how Lindbergh felt	*Far away, even from people who were standing close*	*Wanted to remember everything*	*Wondered what lay ahead*	*He felt like he must conquer two oceans: one of water and one of darkness*

"Through" Activity: Lindbergh's Flight Log – Key

Directions: Using the information from the story Flight, complete the chart for each numbered location on the map.

Number on map	5	6	7	8
Location	*Somewhere over the Atlantic Ocean*	*1,000 miles from Paris (over northwest part of ocean)*	*Ireland (southern tip)*	*England*
Hours into flight	*23*	*27*	*28 (?)*	*31*
New York Time	*Approx. 7:00 a.m.*	*10:52 a.m.*	*12:00 p.m. (?)*	*1:52 p.m.*
Number of miles flown	*2,300*	*2,700*	*2,800*	*3,100*
Description of weather	*Foggy, clouds that occasionally broke*	*Clear under the cloud cover*	*Clear*	*Clear*
Description of what was seen	*Clouds changing color with dawn, fog, ocean below*	*He flew closer to water and saw porpoise, seagull, fishing boats with people*	*Low mountains in distance, cows, people in horse-drawn carts*	*England, water of the English Channel, and land (probably France)*
Description of how Lindbergh felt	*Felt as if he were flying through all eternity because of mist. He felt completely alone.*	*He felt that there was no alternative to success but death and failure. He longed for a wave from someone.*	*Awake with a new hope. He was glad because he was right on course.*	***Great Joy!***

"Through" Activity: Lindbergh's Flight Log – Key

Directions: Using the information from the story Flight, complete the chart for each numbered location on the map.

Number on map	9	10		
Location	*Over France, getting closer to Paris*	*Paris, France*		
Hours into flight	*33+*	*33-1/2*		
New York Time	*4:52 p.m.*	*10:22 p.m. (Paris time)* *5:22 p.m. (New York time)*		
Number of miles flown	*3,300*	*3,600+*		
Description of weather	*Some clouds mostly clear*	*Clear*		
Description of what was seen	*Children waving at him by their houses, glow of the lights of Paris.*	*Dark, but many small lights on the ground.*		
Description of how Lindbergh felt	*Felt strange closeness to the clouds and sky, like he didn't want the flight to end.*	*Dazed for a moment.*		

"Beyond" Activity: Ten Important Questions

Directions: If you had been alive when Lindbergh made his historic crossing, what kind of questions would you have wanted to ask him about his experience? Below, write down 10 questions that you would have liked Lindbergh to answer. Write questions that cannot be answered with a single word or just a yes or a no.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

"Beyond" Activity: Design a Stamp

Directions: Design a stamp that commemorates American Charles Lindbergh's solo New York to Paris crossing of the Atlantic Ocean. Make sure it includes a date and an image of Lindbergh, his airplane and the location you select.

Preparing a Debate

In order to properly prepare a debate, you should follow these steps:

1. select a topic
2. state the proposition
3. have each person or team take a position:
   yes position **or** no position (circle the position you will be taking)

Each team or person then:

4. lists the arguments (no more than five)
5. predicts the opponent's arguments (no more than five)
6. selects the three strongest arguments for both
7. does research and gathers evidence about both positions
8. writes a summary statement for their own position
9. practices their presentation

The debate:

10. both teams present their positions
11. audience listens to both
12. audience decides how well each team presented its case and debated

Writing Experience: Preparing a Debate

Directions: Debate the importance of Lindbergh's flight to aviation history. Research Lindbergh's flight and the impact it had on history. Use the information below to guide you in preparing your debate for your class.

What is a debate?

A debate is a way to look closely at a complex issue. It encourages people to thoughtfully analyze both sides of the issue and make a well-reasoned decision. Individuals (or teams) take opposite viewpoints and try to persuade a group of neutral people to agree with their position.

Each person (or team) carefully researches and writes a short speech that makes a claim and then gives evidence to support why that claim is correct. Each side also needs to explain why the other position is incorrect.

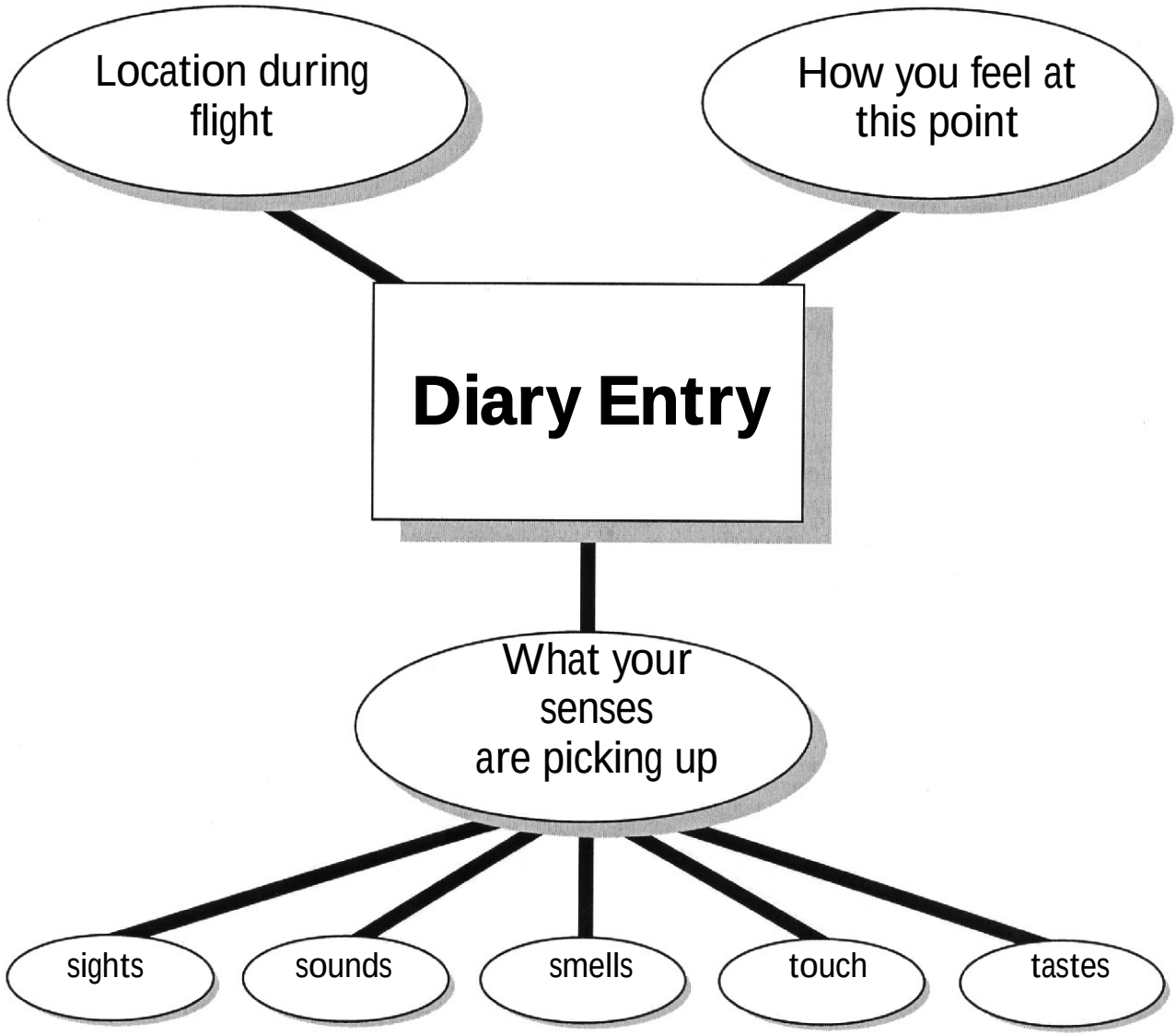
Each opposite viewpoint has the same amount of time to present their position. This is done in an organized manner, and people take turns politely.

After both sides speak, the audience then decides which one presented their position the most persuasively.

Writing Experience: Writing a Diary Entry

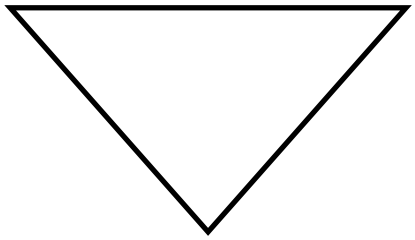
Directions: Pretend you are Charles Lindbergh and write a diary entry describing your feelings as you are flying solo over the Atlantic Ocean during the darkness of the early morning hours. Include in your entry a brief description of where you are in your trip, what you are sensing (sight, sound, smell, touch, taste) and how you feel at this point in the flight.

Use the pre-write below to help you organize your thoughts for the diary entry.



Writing Experience: Writing a Newspaper Article

Newspaper articles require a completely different style of writing from what is used when writing a story. When writing a newspaper article, picture a triangle like the one shown.



The newspaper article has all of the important information in the opening paragraph. This information includes **who**, **what**, **when**, **where**, **why** and **how**. It is written this way because most people do not read an entire newspaper article all the way through. So, newspaper writers put the most important information at the beginning.

A typical newspaper article contains five (5) parts:

Headline: This is a short, attention-getting statement about the event.

Byline: This tells who wrote the story.

Lead paragraph: This has ALL the who, what, when, where, why and how in it. A writer must find the answers to these questions and write them into the opening sentence(s) of the article.

Explanation: After the lead paragraph has been written, the writer must decide what other facts or details the reader might want to know. The writer must make sure that he/she has enough information to answer any important questions a reader might have after reading the headline and the lead paragraph. This section can also include direct quotes from witnesses or bystanders.

Additional Information: This information is the least important. Thus, if the news article is too long for the space it needs to fill, it can be shortened without rewriting any other part. This part can include information about a similar event.

Below is an example of a newspaper article:

Headline: High flying escape ends in death

Byline: By Susanne Ashby

Lead paragraph: Icarus, son of the famous inventor, Daedalus, plunged into the Aegean Sea and drowned while attempting to escape from the island of Crete early yesterday afternoon. His body has yet to be recovered.

Explanation: Icarus and his father had made wings from wax and bird feathers they had collected over the years while imprisoned on the island of Crete. They attached the homemade wings to their arms and, using a flapping motion, lifted off from the island shortly before noon. While making their escape, Icarus flew too close to the sun. As a result, the heat had melted the wax on his wings which caused the feathers to drop off. The wings collapsed and Icarus fell into the sea and drowned.

Additional Information: Daedalus, sobbing from the distant shore where he had landed safely, said, "My last words to Icarus before we left the island was to stay close and not fly too high! He just didn't listen! Why didn't he listen to me?" Daedalus and Icarus had been held prisoner by King Minos on the island of Crete, and had been forced to build a labyrinth at the palace of Knossos It was known to be the most difficult maze in the world to navigate successfully.

Writing Experience: Write Your Own Newspaper Article

Directions: Write a newspaper article about Lindbergh's aeronautical feat of crossing the Atlantic Ocean solo. Use the guidesheet below to help you plan the information you will include for your article.

Headline:

Byline: By:

Lead Paragraph: Who:

What:

When:

Where:

Why:

How:

Explanation:

Additional Information:

Writing Experience: Writing Concrete Poetry

Concrete poetry is an artistic expression of written language. Concrete poets make designs out of letters and words. Even though the visual pattern (shape) can really catch our eye, it is the language itself that makes a poem poetic.

There are different kinds of concrete poetry. We will try a type of concrete poetry that combines two couplets with a visual image. A couplet has two lines in which each line ends with words that rhyme. Read the two couplets below:

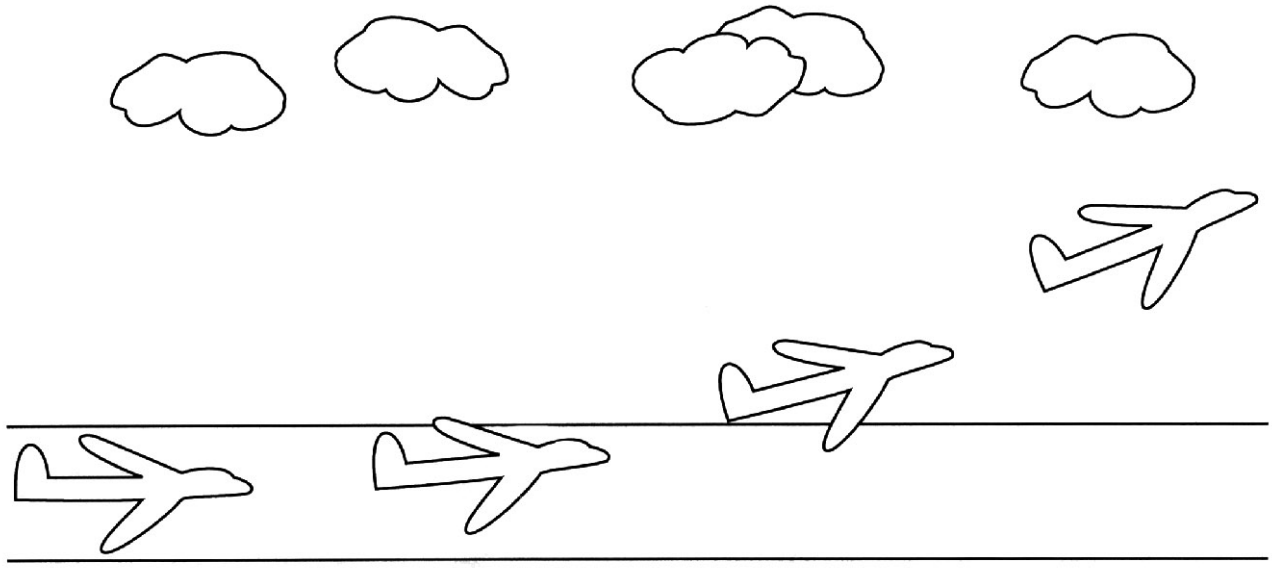
A click, a sputter, a whoosh— to **roar!** *line 1*

A flick, a shudder, a push— to **soar!** *line 2*

The wings held steady; the nose held **high;** *line 3*

The plane is ready to touch the **sky!** *line 4*

In the first two lines, the words **roar** and **soar** rhyme. In the second two lines, the words **high** and **sky** rhyme. Lines one and two form the first couplet. Lines three and four form the second couplet. These are then grouped on the page in such a way that it appears the plane is starting its engines, moving down the runway and then lifting up into the sky. See the concrete poem on the next page.



Writing Experience: Concrete Poem

Takeoff

a sputter
a click to roar
a whoosh

a shudder
a flick to soar
a push

the wings
the nose held high
steady

to touch is ready
the plane
the sky

Writing Experience: Writing Your Own Concrete Poem

1. Draw a sketch of a simple image that comes to your mind when you think of Lindbergh's flight.

2. Write the first couplet about the early part of his flight. If you want, you can use the pairs of rhyming words listed on the next page.

3. Write the second couplet about the last part of his flight. If you want, you can use the pairs of rhyming words listed on the next page.

4. Now combine your two couplets (four lines) and shape it like your sketch.

Writing Experience: Writing Your Own Concrete Poem
Rhyming Pairs List

light - night	cold - hold	wing - sing
high - sky	dry - fly	low - slow
day - way	ice - slice	navigate - debate
star - far	flight - sight	awake - make
plane - wane	wave - crave	slowly - lowly
course - remorse	hour - power	cloud - loud
ahead - instead	ocean - motion	roar - more
air - care	crazily - lazily	sleep - deep
rise - eyes	blue - new	bright - fight
land - stand	near - here	dream - stream
hope - scope	out - about	twilight - by night

Add some rhyming pairs of your own below:

Writing Experience: Writing Your Own Ballad

Songs have been used for many years and are actually poetry put to music. This combination can produce a very pleasant or meaningful experience. Most songs are made up of **stanzas**. A **stanza** is a group of lines with a pattern that is repeated throughout the song. Each stanza has the same rhyme pattern.

Songs often use a very simple rhyme pattern like couplets. A ballad is a song that uses a pattern called a **ballad stanza**. The stanza has four lines in which the second and fourth lines share the rhyme, but the first and the third lines do not share a rhyme with any line in that stanza. Each line also uses a specific amount of syllables. The first line and the third line use 8 syllables and the second and fourth lines use 6 syllables.

Line 1 - 8 syllables

The engine makes the thrust to go.

Line 2 - 6 syllables/last word rhymes with line 4

Wings make lift, pulling high!

Line 3 - 8 syllables

My fuselage is sleek and strong.

Line 4 - 6 syllables/last word rhymes with line 2

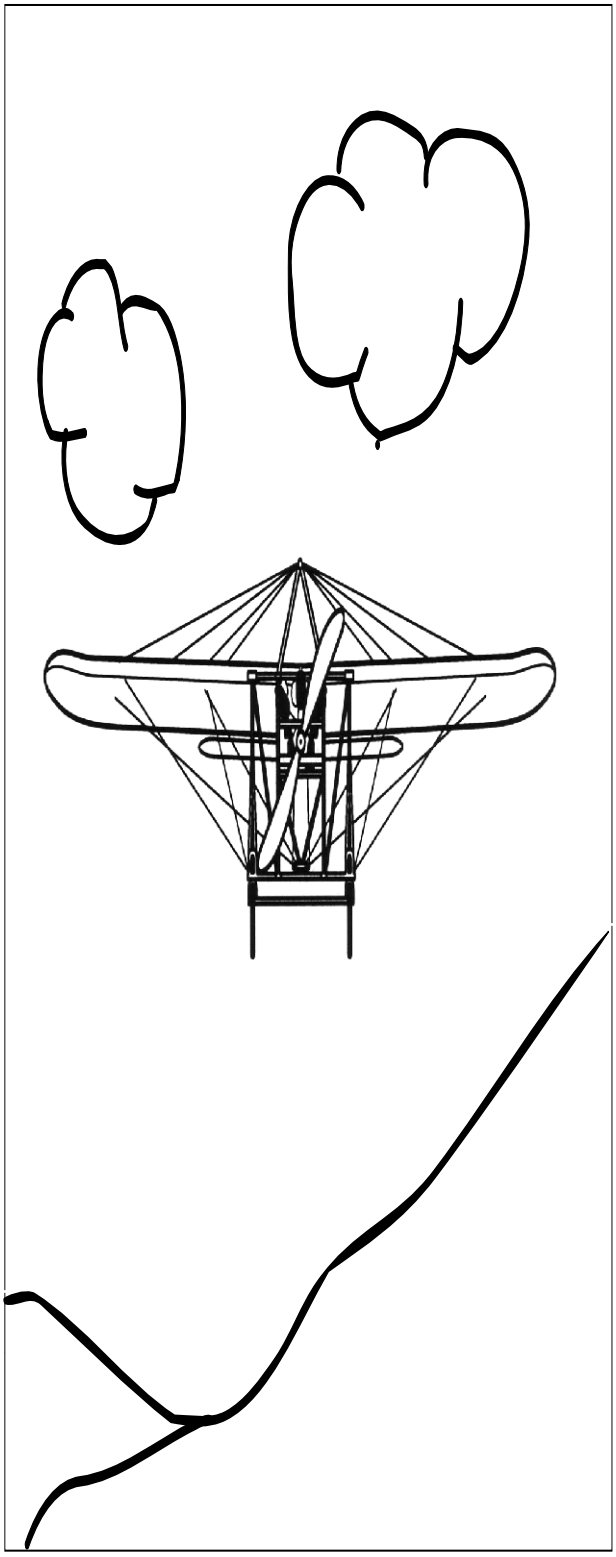
Rise above weight - I fly!

Read the ballad on the next page which uses ballad stanzas.

Writing Experience: Bleriot's Dream

BY SUSANNE ASHBY

For years he toiled on the ground
over a crazy scheme.
He yearned to make a machine fly;
that was his absurd dream.
He drew, he built, he flew, he crashed;
'times he went round and round.
No matter the bruises, breaks, sprains;
his hope was still profound.
Then came that morning in July
when his craft was ready.
To prove how good it really was
must fly true and steady.
Twenty miles wide, the Channel was
a daring flight to make.
From France to England by airplane
there was a lot at stake.
The motor coughed, the prop did roar,
down the field it did speed.
Quickly climbing into the sky
Pegasus, winged steed!
The French coast disappeared beneath
as swirling mist embraced.
The waves reached up as he flew by
and clouds tried to give chase.
Alone in the sky he flew on
to make his vision true.
White Cliffs of Dover flashed below;
O'er England's coast he flew!
Landing was rough — a broken prop —
loud shouts came from the crowd!
Thirty-seven hours in flight —
the people were quite wowed!
Louis went down in history
as the first one to fly
Across the Channel in a plane;
his dream flight ne'er to die!



Writing Experience: Writing a Ballad Guidesheet

Directions: Follow the steps below to guide you in creating your own three stanzas about Lindbergh's flight.

Step 1: The beginning of the flight

This stanza will set the scene and help the reader to visualize the initial part of his flight. You could describe any combination of these ideas:

- what his plane looked like
- the takeoff
- the weather conditions
- the flight path he took
- his feelings at the time

Step 2: The middle of the flight

This stanza will describe the loneliest part of his journey, flying at night across the Atlantic Ocean. You could describe any combination of these ideas:

- leaving land behind
- watching the sun setting and being left in darkness with mist and stars
- crossing two oceans: night and water
- ice on wings
- storms
- cold
- endless fog
- his feeling of being completely alone in the world

Step 3: The last leg of the flight

This stanza will describe the daylight hours as he crossed over England and the English Channel and then saw, in the evening hours, the lights of France. You could describe any combination of these ideas:

- no alternative, but death and failure
- sun rising and the colors of the sky changing
- he flies closer to the water and what he sees
- how he longs for a wave from someone
- seeing land and people
- the greeting from the crowd upon landing

EXPLORING AERONAUTICS

Part II

Section 3

Social Studies

Note: All references to the "History" subsection in this unit refer to the CD-ROM **Exploring Aeronautics.** To find the "History" subsection:

1. Start the CD-ROM.
2. After the introduction, click on the building with the three flags waving. This is known as The Resource Center.
3. Click on the "History" button at the upper left hand corner of the The Resource Center main page.
4. The first page of the "History" subsection will be displayed.

Connections: This section (Part II, Section 3, Social Studies), which involves working with a historical timeline, coordinates very well with Part II, Section 4, Mathematics. In Section 4 you will find a lesson on the mathematics involved in making a historical timeline. It is called "Timeline Mechanics".

Correlation to the National Social Studies Standards

I. Culture

- explore and describe similarities and differences in the ways groups, societies and cultures address similar human needs and concerns;
- give examples of how experiences may be interpreted differently by people from diverse cultural perspectives and frames of reference;
- describe ways in which language, stories, folktales, music and artistic creations serve as expressions of culture, and influence behavior of people living in a particular culture.

II. Time, Continuity and Change

- demonstrate an understanding that different people might describe the same event or situation in diverse ways, citing reasons for the differences in views;
- read and construct simple timelines; identify examples of change; and recognize examples of cause and effect relationships;
- compare and contrast different stories or accounts about past events, people, places, or situations, identifying how they contribute to our understanding of the past;
- identify and use various sources for reconstructing the past, such as documents, letters, maps, textbooks, photos and others;
- demonstrate an understanding that people in different times and places view the world differently;
- use knowledge of facts and concepts drawn from history, along with elements of historical inquiry, to inform decision-making about and action-taking on public issues.

III. People, Places and Environments

- use appropriate resources, data sources, and geographic tools such as atlases, data bases, grid systems, charts, graphs, and maps to generate, manipulate and interpret information.

IV. Individual Development and Identity

- identify and describe ways family, groups, and community influence an individual's daily life and personal choices;

- explore factors that contribute to one's personal identity such as interests, capabilities and perceptions;
- analyze a particular event to identify reasons individuals might respond to it in different ways;
- work independently and cooperatively to accomplish goals.

V. Individuals, Groups and Institutions

- identify examples of institutions and describe the interactions of people with institutions;
- give examples of the role of institutions in furthering both continuity and change;
- show how groups and institutions work to meet individual needs and to promote the common good.

VI. Power, Authority and Governance

- explore the role of technology in communication, transportation, information-processing... or other areas as it contributes to or helps resolve conflicts.

VII. Production, Distribution and Consumption

- describe how we depend upon workers with specialized jobs and the ways in which they contribute to the production and exchange of goods and services.

VIII. Science, Technology and Society

- identify and describe examples in which science and technology have changed the lives of people...;
- identify and describe examples in which science and technology have led to changes in the physical environment;
- describe instances in which changes in values, beliefs and attitudes have resulted from new scientific and technological knowledge.

IX. Global Connections

- give examples of conflict, cooperation and interdependence among individuals, groups and nations;
- examine the effects of changing technologies on the global community.

X. Civic Ideals and Practices

- locate, access, organize and apply information about an issue of public concern from multiple points of view;
- recognize that a variety of formal and informal factors influence and shape public policy.

Goals and Objectives

Goal 1

To use an aeronautical timeline for a variety of purposes.

Objectives

The Learner will be able to:

- locate information on a timeline;
- recognize cause and effect from the information found on a timeline;
- perform basic research for information to be placed on such a timeline;
- organize research information to construct a simple timeline;
- identify major developments or issues found on such a timeline;
- interpret the information found on such a timeline;
- identify aeronautical researchers and their contributions;
- identify aviators and their contributions;
- identify important aircraft of each time period.

Goal 2

To understand that the progression of the science of aeronautics was and continues to be influenced by the technology of the time and historic events, as well as individuals and agencies or groups who worked to solve problems.

Objectives

The Learner will be able to:

- gather information from a variety of resources;
- identify important aspects of aeronautical history according to a specified category;
- chronicle important events, discoveries and innovations in aeronautics in a variety of formats.

Goal 3

To understand the role a government agency, such as NASA, plays in our evolving society.

Objectives

The Learner will be able to:

- identify the research contributions made by NASA;
- describe the impact NASA's aeronautical research has had and continues to have on everyday life;
- describe some of the various jobs in aeronautics;
- compare and contrast early aeronautics to modern aeronautics;
- cite examples of how NASA research has contributed to the aviation industry;
- describe how NASA has developed and used technology to improve aeronautics.

Goal 4

To understand how people's view of flying has changed over time and has increased our knowledge of aeronautics.

Objectives

The Learner will be able to:

- give examples of how mankind viewed flight during each age covered in the aeronautical "History" subsection;
- cite examples that demonstrate how the global community has been positively affected by the improvements in flight;
- use a variety of documents and sources to reconstruct major aeronautical events from different viewpoints.

Daily Lesson Planner

Preparation:

- Read the Teacher Informational Reading.

Day 1

- Facilitate a discussion of the history of flight.
- If possible, use a computer with television/projector connection to demonstrate how to navigate through the "History" subsection. See the first page of this section for instructions.

Day 2 - 6

- If you have access to more than one computer, partner students and assign each team a worksheet on the history of flight (see Student Worksheets in this section) and have students search through the "History" subsection to answer the questions (like a scavenger hunt!). The full assortment of five worksheets can be used to do this same activity for five sessions.

Day 7

- Do the "Bulletin Board Timeline" activity from the "Additional Student Activities" section.

Day 8

- Use the overhead of the NASA mission patches and their corresponding descriptions (See "Additional Student Activities".) to discuss the importance of the mission patches.
- Do the "Design a Patch" activity from the "Additional Student Activities" section.

Day 9

- Have students create their own history of flight crossword puzzle. (See "Student Crossword" in "Additional Activities".)
- Have students complete the "Brief History of Flight Timeline". (See "Student Worksheets" in this section.)

Day 10 - 12

- Have students use additional resources and the "History" subsection to research information about a historic aeronautical event. Have them create a "Radio Report" and record it on audio tape. (See the "Additional Student Activities" section.)

Day 13 - 14

- Have students research a famous aviator and write a poem about his/her achievement(s). (See "Poetry Writing" in the "Additional Student Activities" section.)

Day 15 - 16

- Have students create their own timelines. See "Other Timeline Topics" in this section which suggests some timeline themes.

  In section 4, Mathematics, a lesson entitled "Timeline Mechanics" can be used to help students with the mathematics involved in measuring out timelines.

Teacher Informational Reading
A Concise History of Flight

The beginning of aeronautics can be traced to the legends, myths and oral histories handed down through early civilizations (Chinese, Greek, Norse, African, Polynesian). Humankind's desire to fly has propelled us through the skies in many fashions. The Chinese entertained themselves with kites and early rocketry; others attempted to imitate the motion of birds in order to escape to freedom; and European tower jumpers, covered in feathers, attempted flight from high places. All of these innovators belonged to a unique group of dreamers.

The dreamers gave way to visionaries who made careful studies of bird flight, gravity and motion, which developed into principles and designs that slowly began laying the foundation for aeronautics and aerodynamics. Around 1500, Leonardo da Vinci correctly concluded that it was the shape and position of the bird's wing with respect to the air that enabled a bird to fly. Through his observations, he devised the first ornithopter (a mechanical bird) and also designed a lifting screw which was like a helicopter. In the late 1600s, Sir Isaac Newton formulated laws of gravity and motion which later provided the theoretical basis for rocketry and lift. Bernoulli's observations regarding air flow and air pressure furthered the understanding of lift. The lighter-than-air studies finally gave way to sustained flight when incorporated into a balloon design. The first design simply used hot air to fill and then lift a balloon. This was followed by the utilization of the lighter-than-air gas, hydrogen, to provide sustained lift. The contributions of the Montgolfier brothers and Professor Charles during the late 1700s enabled humans to not only rise above the ground for brief periods of time, but to control their up and down movement. However, they still could not control lateral movement (left and right) or any of the rotational motions (roll, pitch, and yaw).

The late 1800s brought continued experimentation in aerodynamics which produced the understanding of how wings really work, as well as improvements in wing design. Men like Penaud, Hargrave, Wenham, Phillips, Cayley and Chanute contributed greatly to the mass of research that was being compiled. Pioneers, like Lilienthal and the Wright Brothers, made the first momentous leaps into the world of flight. Lilienthal was the first to develop and fly manned gliders. Though some of Lilienthal's observations were incorrect, the Wright Brothers expanded his knowledge of aerodynamics through their own experimentation and launched the United States into the realm of powered flight. The continued research of Prandtl, Karman, Junkers, Moss and Rohrbach, plus other general technical and mechanical improvements, were embraced with enthusiasm by the leading aircraft manufacturers of the time. Fokker, Bleriot, Voisin, Curtiss and the Wright Brothers

all continued to contribute to improvements in wing, tail, propeller and fuselage design, which enabled planes to become faster and easier to maneuver.

The age of the great airships was ushered in and led by Zeppelin until safety factors began to outweigh the usefulness of the aircraft. Meanwhile, distance records were being broken. Bleriot crossed the English Channel (1909), Rodgers flew across the continental United States (1911), and the female aviator, Quimby, also crossed the English Channel (1912). The advent of World War I sent a message to all governments that airplanes would become an important force in battle. Curtiss continued his efforts to utilize aircraft launched from large ships. The need for additional research to assist in improving aircraft design was met with the institution of the National Advisory Committee for Aeronautics (NACA). At the same time, barnstormers of the 1920s were busy spreading the word about aviation to the public. The Stinson Sisters and African-American pilots like the "Flying Hobos", Banning and Allen, as well as Bullard and Coleman, promoted the importance of aviation across the country as they amazed the crowds with daredevil antics and aerobatics. The daring travels of Lindbergh, Byrd, Earhart, Amundsen and Batten continued to fire imagination, inspire courage and push the envelope of the study of aerodynamics. During this period the first autogyro, invented by de la Cierva, became the precursor to the modern helicopter.

The work of Goddard laid the foundation for future rocketry while aeronautics was still in its infancy, albeit maturing quickly. Research became prominent as more solutions were needed for the problems posed by extended flights, adverse weather conditions, higher-altitude flying and increased speed and maneuverability. The advent of World War II and the United States' impending involvement made the need for such solutions critical. Improvements in propellers and instrumentation, as well as the development of the jet engine, greatly expanded the variety of uses for aircraft. The development of the first practical single-rotor helicopter by Sikorsky added a new dimension to flight.

Research continued to pave the way for even greater aeronautical success with solutions provided by wind tunnel work. The deicing problem was solved after the refrigerated wind tunnel was invented. Wind tunnel work provided new designs for fuselage (the "wasp shape") and wing shape (the forward-sweep wing, the sweepback wing, and the oblique wing design created by R.T. Jones). Further research made it possible to "break the sound barrier" in 1947, as well as to continue on at speeds up to Mach 6.

The launching of the Russian space satellite, *Sputnik,* in 1957 brought a call to broaden NACA's mission to include space, and the National Aeronautics and Space Administration (NASA) was born in 1958. The "Space Race" went into high gear as research provided the information necessary to put a human into orbit.

The creation of the modern flight simulator in the late 1950s broadened the ability to research aerodynamic principles more safely. The improvements in computing led to Computational Fluid Dynamics (CFD – the study of how air flows around an object by programming a computer to model an aircraft design in various conditions). CFD made new aircraft development less costly during the design and testing phases. The creation of the supercomputers continued to influence and improve the work done in flight simulation and CFD.

Even though humankind has shifted their gaze from the azure skyline to the distant pinpoints of light seen in the night sky, aeronautics is still an extremely important field of engineering, and research is still a vital part of that field. The field of aeronautics continues to seek improved and safer ways to build and fly aircraft for not only subsonic, but also supersonic and hypersonic flight. Continued success in aircraft design and future space flight lies in further research and development of the aeronautical principles which were initiated more than three thousand years ago with the first kite.

Accompanying Materials

Student Worksheet: The Firsts in Flight

Directions: Use the **Exploring Aeronautics** CD-ROM, "History" subsection to answer the following questions about first-time events in the history of flight. Answer each question by writing the information in the blank.

_____ 1. The first powered aircraft was flown by whom?

_____ 2. The first manned balloon was flown by the Montgolfiers in what year?

_____ 3. Who was the first African-American to pilot an airplane?

_____ 4. In 1881, Lilienthal piloted the first successful flights of what aircraft?

_____ 5. Who flew the first powered aircraft in Europe?

_____ 6. Who was named the first female commercial airline captain in 1968?

_____ 7. Who was the first aviator to fly solo around the world in 1933?

_____ 8. Quimby was the first female pilot to cross what channel in 1912?

_____ 9. The first parachute descent was made by Garnerin in what year?

_____ 10. The first ornithopter was developed by Hargrave in what year?

Student Worksheet: The People of Flight

Directions: Use the **Exploring Aeronautics** CD-ROM, "History" subsection to answer the following questions about the people who made tremendous contributions to the field of aeronautics. Write the name of the individual described in the blank.

_____ 1. This person invented the four stroke engine.

_____ 2. This German developed the great airships which flew in the early 1900s.

_____ 3. This Italian created early concept drawings of helicopters, but never built or flew them.

_____ 4. This scientist developed the "blunt nose" principle.

_____ 5. This scientist made many contributions to the development of aeronautical principles in the late 1800s.

_____ 6. This man is credited for being the "Father of Naval Aviation."

_____ 7. This woman was a glider test pilot for the Germans during WWII.

_____ 8. This researcher from NASA Ames Research Center developed the swept-back, swept-forward and oblique wing design.

_____ 9. This pioneer researcher invented the airfoil.

_____10. This aviation pioneer experimented in rocketry.

Student Worksheet: Dates in the History of Flight

Directions: Use the **Exploring Aeronautics** CD-ROM "History" subsection to find the year in which the events described below happened. Write the year in the blank.

_____ 1. The Supersonic Airliner, *Concorde*, flew its maiden voyage.

_____ 2. Charles Lindbergh made his historic solo flight across the Atlantic Ocean.

_____ 3. Louis Bleriot made his flight across the English Channel.

_____ 4. Sikorsky built the first practical single-rotor helicopter.

_____ 5. The Russian satellite, *Sputnik,* was launched.

_____ 6. The space shuttle was launched in this year.

_____ 7. Whittle invented the jet engine.

_____ 8. Airplane cabins were pressurized.

_____ 9. The first aircraft powered only by a human was flown.

_____10. Yeager broke the sound barrier.

Student Worksheet: Aircraft

Directions: Use the CD-ROM's "History" subsection to answer the following questions. Write the aircraft's name that is described in the blank.

_____ 1. The British and French governments built and still fly this supersonic airliner.

_____ 2. The explosion and fire of this dirigible ended the Age of Great Airships.

_____ 3. This satellite was launched by the U.S.S.R. in 1957 and began the "Space Race."

_____ 4. This airplane featured the first fully pressurized cabin in 1945.

_____ 5. This airplane was the first jumbo jet and was flown in 1970.

_____ 6. This airplane was designed to land and take off from the water, and featured a Curtiss water-cooled engine.

_____ 7. This airplane was designed as a long-range, reconnaissance plane, and was flown in 1966.

_____ 8. This airplane is considered by aviation experts to be one of the most important commercial transport planes of this time.

_____ 9. This airplane was used to fly across the English Channel in 1909 by its designer.

_____10. This experimental airplane design will help to define the next generation of space planes.

Student Worksheet: Technology and Aeronautics

Directions: Use the **Exploring Aeronautics** "History" subsection to find the year when the specified new technology was developed in the field of aeronautics. Write the year in the blank next to the description.

_____ 1. The supercomputer, *Cray-2*, was developed to run computations for new aircraft designs.

_____ 2. The swept-back wing design was perfected by Jones.

_____ 3. The jet engine was invented by Whittle.

_____ 4. Whitcomb designed the "wasp shape" fuselage.

_____ 5. The German dirigible *Hindenburg* was destroyed.

_____ 6. The "blunt nose" principle was developed which helped in the design of the *Mercury* capsule.

_____ 7. Rodert solved the deicing problem.

_____ 8. The "stressed skin" concept was developed by Rohrbach to decrease drag.

_____ 9. The boundary layer concept was fully developed which led to improved aircraft design for supersonic flight.

_____ 10. Phillips' early research on the airfoil laid the ground work for the understanding of how wings work.

Student Worksheet: Brief History of Flight Timeline

Directions: Use the **Exploring Aeronautics** "History" subsection to help you complete the entries on the blank timeline. Place the letter listed next to the event description in the blank on the timeline showing when the event took place.

A) Juan de la Cierva develops the first airworthy autogyro.

B) Rutan and Yeager fly the first non-stop, circumglobal flight in the *Voyager*.

C) Count von Zeppelin invents the airship.

D) Santos-Dumont flies the first aircraft in Europe.

E) Goddard begins his pioneering work in rocketry.

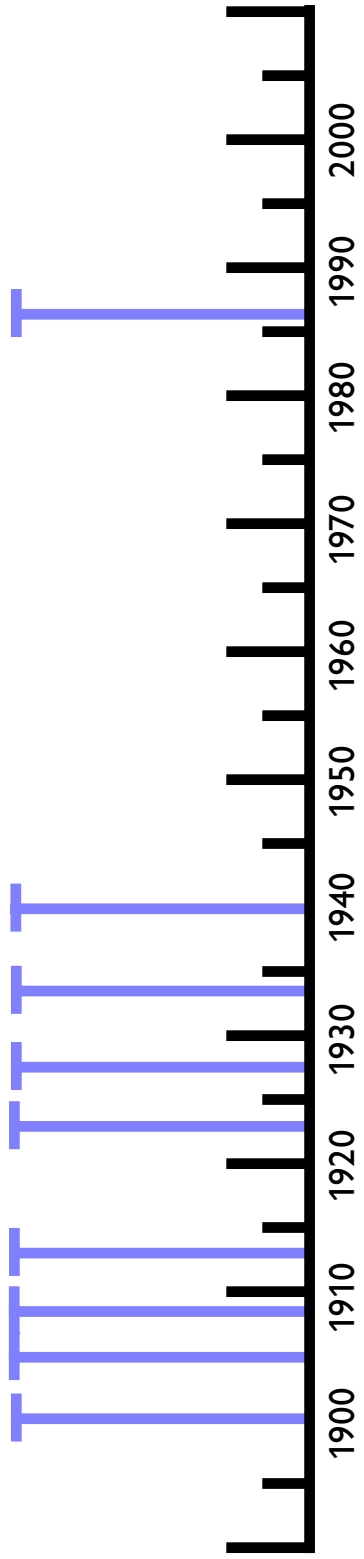
F) The Tuskegee Airmen perform successful air combat duty.

G) Wiley Post is the first to fly around the world solo.

H) Curtiss invents the hydroplane.

I) Bleriot crosses the English Channel in an airplane.

Student Worksheet: Brief History of Flight Timeline



Student Worksheet Keys

The Firsts in Flight

1. *Wright Brothers*
2. *1783*
3. *Bullard*
4. *glider*
5. *Santos-Dumont*
6. *Sintes*
7. *Post*
8. *English*
9. *1797*
10. *1893*

The People of Flight

1. *Otto*
2. *Hindenburg*
3. *da Vinci*
4. *Allen*
5. *Chanute*
6. *Curtiss*
7. *Reitsch*
8. *Jones*
9. *Phillips*
10. *Goddard*

Dates In The History of Flight

1. *1975*
2. *1927*
3. *1909*
4. *1939*
5. *1937*
6. *1981*
7. *1930*
8. *1940*
9. *1977*
10. *1947*

Aircraft

1. *Concorde*
2. *Hindenburg*
3. *Sputnik*
4. *Boeing 307-B Stratoliner*
5. *Boeing 747*
6. *hydroplane*
7. *SR-71*
8. *Boeing 777*
9. *Bleriot IV*
10. *X-33*

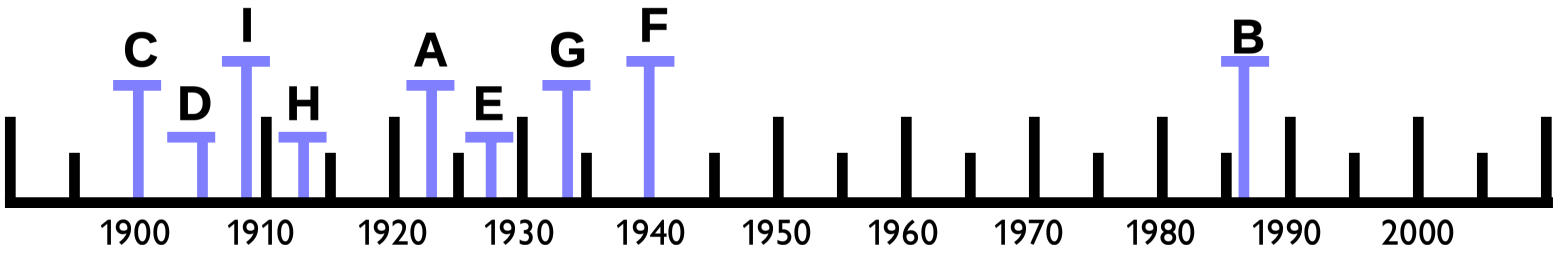
Technology and Aeronautics

1. *1984*
2. *1945*
3. *1933*
4. *1944*
5. *1937*
6. *1952*
7. *1942*
8. *1919*
9. *1904*
10. *1893*

Brief History of Flight Timeline

A. *1923*
B *1986*
C. *1900*
D. *1906*
E. *1926*
F. *1940*
G. *1933*
H. *1911*
I. *1909*

Student Worksheet:
Brief History of Flight Timeline
Key



Activity:
Bulletin Board Timeline

Place an oversized timeline on a wall, covering the dates from 1000 BC to 2015 AD. This timeline will act as a bulletin board. Have the students (as individuals, as partners, or in small groups) take notes on events in aeronautical history. Give the students fact cards to fill out with the information found in the "History" subsection. Students should then illustrate the event and place the fact card and the illustration at the appropriate place on the bulletin board timeline. Upon completion of this activity, the classroom will have a wall-size timeline for display throughout the unit.

Aeronautical Fact Card

Who:

What:

When:

Where:

Describe what happened:

Why do you think this is important:

Aeronautical Fact Card

Who:

What:

When:

Where:

Describe what happened:

Why do you think this is important:

Activity: Timeline Topics

Female Aviators Timeline

By using the information contained in the **Exploring Aeronautics** CD-ROM "History" subsection, students can design and illustrate a timeline that contains only the information about female aviators.

Technological Timeline

By using the information contained in the "History" subsection, students can design and illustrate a timeline that contains only the information dealing with breakthroughs in technological development which helped improve aviation and added to the research information being gathered on aeronautics.

Parallel Timeline

Create a parallel timeline that, on one side records the life and achievements of a famous aviator (Lindbergh, Yeager, a Wright Brother), and on the other side records historical aviation events or breakthroughs that occurred during the aviator's lifetime. This will require additional research on the part of the student.

Activity:
Design a Patch

Directions: Display NASA patches that commemorate each NASA space flight. Four examples from the Space Shuttle Program can be found on the next page. Discuss the intention of the patch design in that it is meant to reflect the work done on that particular mission. Point out the differences and similarities of the patches and then develop the requirements for a patch:

- graphics that show the primary work done on the mission;
- names of those involved;
- aircraft and its name pictured or featured;
- the mission's date.

Ask students to choose one aviation event found in the "History" subsection and illustrate it on a patch.

NASA Space Shuttle Flight Mission Patches

1. STS-31

2. STS-45

3. STS-48

4. STS-78

NASA Space Shuttle Flight Mission Patches
Background Information

1. STS-31

The mission insignia for STS-31 features the Hubble Space Telescope (HST) in its observing configuration against the background of the universe it will study. The cosmos includes a stylistic depiction of galaxies in recognition of the contribution made by Sir Edwin Hubble to our understanding of the nature of galaxies and the expansion of the universe. It is in honor of Hubble's work that this great observatory in space bears his name. The Space Shuttle trails a spectrum symbolic of both the red shift observations that were so important to Hubble's work and the new information which will be obtained with the HST. Encircling the scene are the names of the STS-31 crew members.

2. STS-45

This patch depicts the Space Shuttle launching from the Kennedy Space Center into a high inclination orbit. From this vantage point, the ATLAS (Atmospheric Laboratory for Applications and Science) payload can view Earth, the sun and their dynamic interactions against the background of space. Earth is prominently displayed and is the focus of the mission's space plasma physics and Earth science observations. The colors of the setting sun, measured by sensitive instruments, provide detailed information about ozone, carbon dioxide, and other gases which determine the Earth's climate and environment. Encircling the scene are names of the STS-45 flight crew members. The additional star in the ring containing the crew names is to recognize Alternate Payload Specialists and the entire ATLAS-1 team for their dedication and support of this "Mission to Planet Earth."

3. STS-48

This patch represents the Orbiter Discovery in orbit about the Earth after deploying the Upper Atmosphere Research Satellite (UARS) depicted in block letter style. The stars are those in the Northern Hemisphere as seen in the fall and winter when UARS will begin its study of the Earth's atmosphere. The color bands on the Earth's horizon, extending up to the UARS satellite, depict the study of the Earth's atmosphere. The triangular shape represents the relationship between the three atmospheric processes that determine upper atmospheric structure and behavior: chemistry, dynamics, and energy. This continuous process brings life to our planet and makes our planet unique in the solar system.

4. STS-78

This mission links the past with the present through a crew patch influenced by Pacific Northwest Native American art. Central to the design is the Space Shuttle Columbia whose shape evokes the image of an eagle, an icon of power and prestige and the national symbol of the United States. The eagle's feathers, representing both peace and friendship, symbolize the spirit of international unity on STS-78. An orbit surrounding the mission number recalls the traditional NASA emblem.

The Life Sciences and Microgravity Spacelab (LMS) is housed in Columbia's payload bay and is depicted in a manner reminiscent of totem art. The pulsating sun, a symbol of life, displays three crystals representing STS-78's three high-temperature microgravity materials processing facilities. The constellation Delphinus recalls the dolphin, friend of sea explorers, each star representing one member of STS-78's international crew. The color thrust rings at the base of Columbia signify the five continents of Earth united in global cooperation for the advancement of all humankind.

Activity:
Crossword Puzzle

Using the crossword puzzle template (see next page) or a crossword puzzle-making software program, students can create clues and answers based upon the "History" subsection and place them into a crossword puzzle format. In addition to the puzzle, students also need to create an answer key. These student-designed crossword puzzles can then be reproduced and worked by other students.

Activity:
Student Crossword Puzzle

Directions: Use the guide below to create your puzzle. Fill in the grid with the answers. Make sure that your answer in the grid shares the same number as the clue and that the word is spelled out in the appropriate way (across or down). Double check your spelling before you write the answer in the grid!

Clues:

ACROSS

1.

2.

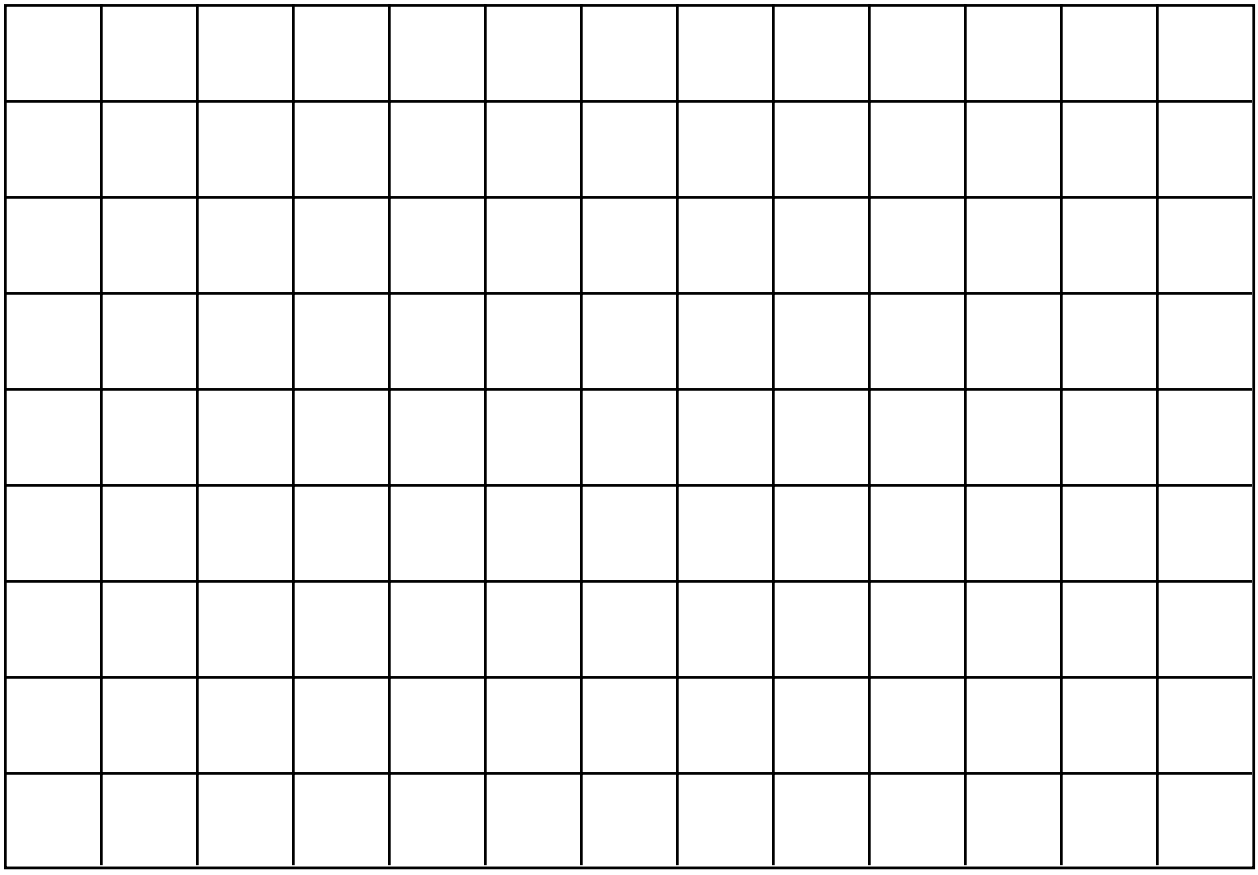
3.

DOWN

4.

5.

6.



Activity:
Radio Report

View a photograph of the Hindenburg disaster (or of Charles Lindbergh upon completion of his historical flight) and listen to a radio commentator's description of the event (or a radio interview done with Lindbergh after his historic solo crossing of the Atlantic). Students can work with a partner to do research and then compose a script in which one student portrays a famous aviator referred to in the "History" subsection and the other acts as an interviewer.The aviator has just completed his/her major accomplishment and is now being interviewed by a reporter.

Note: Some CD-ROM encyclopedias have an abbreviated version of the Hindenburg disaster with video and audio (Grolier's, for example).

Activity:
Historical Radio Interviews

Directions: You and a partner will choose an event from the "History" subsection, research that event and write an interview that will cover the important parts of the event. Make sure your information is historically accurate. Use the note taking guidesheet to help you organize your research on the event you have chosen. Then use the information to write an interview. One of you will be the aviator researcher, the other will be the interviewer.

Note Taking Guidesheet

Event:

Date:

People involved:

Special preparations (training, research) for event:

Weather during event:

Any particular problems encountered before and during the event:

A brief description of what this event was like for the people involved:

Activity: Writing a Cinquain

A cinquain is a popular form of poetry. It is similar in spirit to the image writings of the Japanese. It was created by the American poet Adelaide Crapsey and maintains a very strict syllable count. It is a five-line poem that follows this form:

Line 1: two syllables

Line 2: four syllables

Line 3: six syllables

Line 4: eight syllables

Line 5: two syllables

None of the lines are required to rhyme. The only requirement is the syllable count for each line. The title is separate from the five lines of the poem. Read the example of a cinquain below, about a method of flying described in the "History" subsection.

Parabolas

by Susanne Ashby

Up, down

Pull up, soar down

Feeling funny, floating

Liberated from gravity

Down, up

Choose an event or a person from the "History" subsection and create a cinquain.

Critical Thinking Questions

1. Why do you think scientists needed to create a refrigerated wind tunnel to do their research?
2. Why is having the airplane's cabin pressurized important to pilots and passengers?
3. Why do you think the box kite design is important to aerodynamics?
4. What problems did scientists have to solve before they could put an engine onto an airplane?
5. What were two problems of early flight?
6. Why is research still important to aeronautics?
7. What problems did scientists need to solve before they could break the sound barrier?
8. Why was the "blunt nose" principle important to future space flight?
9. What problems do you think scientists will have to solve before they can create a space plane that can take off from a runway on Earth, orbit the Earth, and land safely back on Earth?
10. Use a comparison chart to discuss the differences and similarities between bird flight and airplane flight.
11. During the early days of aeronautics what misconceptions did airplane designers have about flight?
12. Even though Chanute did not invent an airplane, why do you think he is important to aeronautics?
13. Summarize significant contributions that women have made to aeronautics.
14. Examine the relationship between the Soviet satellite's (*Sputnik*) launch in 1957 and the beginning of NASA in 1958.
15. Formulate a reason why we did not "break the sound barrier" until 1947.

EXPLORING AERONAUTICS

Part II

Section 4

Mathematics

Correlation to National Mathematics Standards

Standard 1 Mathematics as Problem Solving

- develop and apply a variety of strategies to solve problems, with emphasis on multi-step and non-routine problems;
- verify and interpret results with respect to the original problem situation;
- generalize solutions and strategies to new problem situations;
- acquire confidence in using mathematics meaningfully.

Standard 2 Mathematics as Communication

- model situations using oral, written, concrete, pictorial, graphical, and algebraic methods;
- reflect on and clarify thinking about mathematical ideas and situations.

Standard 3 Mathematics as Reasoning

- recognize and apply deductive and inductive reasoning;
- understand and apply reasoning processes, with special attention to spatial reasoning.

Standard 4 Mathematical Connections

- explore problems and describe results using graphical, numerical, physical, algebraic and verbal mathematical models or representations;
- value the role of mathematics in our culture and society.

Standard 5 Number and Number Relationships

- understand, represent, and use numbers in a variety of equivalent forms in real world and mathematical problem situations;
- develop number sense for whole numbers, fractions, decimals, integers and rational numbers;
- represent numerical relationships in one and two dimensional graphs.

Standard 6 Number Systems and Number Theory

- understand and appreciate the need for numbers beyond whole numbers;
- develop and apply number theory concepts in real world mathematical problem situations.

Standard 7 Computation and Estimation

- compute with whole numbers, fractions, decimals, integers and rational numbers;
- develop, analyze and explain procedures for computation and techniques for estimating;
- select and use appropriate method for computing from among mental arithmetic, paper-and-pencil, calculator and computer methods;
- use estimation to check the reasonableness of results.

Standard 8 Patterns and Functions

- describe and represent relationships with tables, graphs and rules.

Standard 9 Algebra

- understand the concepts of variable, expression and equation;
- represent situations and number patterns with tables, graphs, verbal rules and equations, and explore the interrelationships of these representations;
- analyze tables and graphs to identify properties and relationships.

Standard 10 Statistics

- systematically collect, organize and describe data;
- construct, read, and interpret tables, charts and graphs;
- develop an appreciation for statistical methods as powerful means for decision making.

Standard 12 Geometry

- identify, describe, compare and classify geometric figures;
- represent and solve problems using geometric models;
- develop an appreciation of geometry as a means of describing the physical world.

Standard 13 Measurement

- extend understanding of the process of measurement;
- estimate, make and use measurements to describe and compare phenomena;
- select appropriate units and tools to measure the degree of accuracy required in a particular situation;
- understand the structure and use of systems of measurement;
- extend understanding of the concepts of perimeter, area, volume, angle measure, capacity, and weight and mass.

Goals and Objectives

Goal 1

To familiarize students with the relationship between mathematics and aeronautics.

Objectives

The Learner will be able to:

- identify general ways in which mathematics is used in aeronautics;
- identify general ways in which mathematics is used to solve aeronautical problems.

Goal 2

To use mathematics and mathematical tools to solve aeronautical problems.

Objectives

The Learner will be able to:

- use a calculator to convert Mach speeds to feet and miles per hour;
- use a calculator and measuring devices to create an aeronautical timeline;
- use the computer to check a hypothesis regarding the lift and drag of a wing;
- use a graph to compute the net force;
- use a measuring device, computer, calculator and graph to compute averages gathered on data from lift and drag tests as well as distance in flight tests.

Goal 3

To introduce students to mathematical formulae used in aeronautics.

Objectives

The Learner will be able to:

- use volume and weight formulae for computing how much cargo can be carried;
- use the formula for averages to convert data;
- use the formula for aspect ratio to compute induced drag;
- use the Pythagorean Theorem for graphing and computing the four forces for flight;
- understand how the lift to drag ratio is used.

Daily Lesson Planner

Day 1 - 25

- It is recommended that you offer an instructional unit on measurement prior to using these mathematics lessons.
- Listed below are the mathematics lessons included in this section. The lessons are sorted according to the section on the CD-ROM **Exploring Aeronautics**, with which they are compatible. A brief idea of the content of each lesson is given as well.

CD-ROM Section	Lesson	Description
The Resource Center: History	Timeline Mechanics	design a timeline with appropriate units and tic marks
	Don't Let It Weigh You Down!	use a formula to determine how much cargo a lighter-than-air balloon can carry
The Hangar	Mach and Mile Mathematics with the X-15	convert speed to Mach numbers (and vice versa), convert feet to miles, learn about the speed of sound
Fundamentals of Aeronautics	The Aspect Ratio of Wings	use division to help determine how much lift and drag a wing will create
	Computing the Net Force	use addition and subtraction to calculate the net force, given two forces
	Graph the Four Forces	use a graph to understand the net force, given four forces
	Flying with Pythagoras	use the Pythagorean Theorem to find distance
	Wind Tunnel Averages	use averages to determine forces on a wind tunnel model
	Graphing Results	use a bar graph to analyze wind tunnel data

Mathematics Lessons
Timeline Mechanics
Teacher-Led Exercise

Connections: This lesson involves using mathematics to create a timeline. It coordinates very well with Part II, Section 3: Social Studies. In Section 3: Social Studies, you will find lessons involving how to create and use a timeline based on events in aeronautical history. In Section 3, points on the timeline are chosen by a simple relationship between the years (for example, 1783 happened long before 1910). In this lesson, a method of calculating the length of and appropriate marks for a timeline is presented.

Directions: When designing your own timeline, you need to plan and measure carefully. It is always best to do a rough draft first before doing a final draft, so your final draft is neat and accurate. Use the following dates, and follow the steps below for making your own timeline.

Montgolfier	1783
Post	1933
Bleriot	1909
Yeager	1947
NASA	1958

Step 1: Find the earliest year from the dates you will be working with and round it down to the nearest decade (tens). Write the result below. This result will be the first date on your timeline.

Step 2: Find the latest year from the dates you will be working with and round it up to the nearest decade (tens). Write the result below. This result will be the last date on your timeline.

Step 3: Subtract the result from Step 1 from the result in Step 2. Write the result below. This result is the number of years on your timeline.

Step 4: Timelines are divided into units of time. Decide how you will show the years on your timeline.

A) Will you mark every year on your timeline? There may be too many years to show each one!

or

B) Will you mark every five years?

or

C) Will you mark every ten years?

or

D) Will you mark every twenty years?

or

E) Make another choice: _____

Step 5: Write your final choice here:

I will mark every _____ years on my timeline.

Step 6: Divide the total number of years on your timeline (your result from Step 3) by the number you have chosen in Step 5. The result will be how many marks you will draw on your timeline.

$$\frac{\text{result from Step 3}}{\text{result from Step 5}} = \text{number of marks you will have on your timeline}$$

Step 7: Decide how you will measure your timeline. Will your result from Step 5 be measured in:

A) inches B) half inches C) centimeters

or

Write in another possibility: _____

Step 8: Write your final choice here:

_____ years will equal one _____ on my timeline.
result from Step 5 result from Step 7

Step 9: Calculate how long your timeline will be. Take your result from Step 6 and multiply it by your choice of measurement (your result from Step 7)

result from Step 6 X result from Step 7 = total length of your timeline

Step 10: On a piece of scratch paper, draw a rough draft of your timeline using the results from the steps above.

Timeline Mechanics

Student Exercise

Directions: When designing your own timeline, you need to plan and measure carefully. It is always best to do a rough draft first before doing a final draft, so your final draft is neat and accurate. Using the following dates, and follow the steps below for making your own timeline.

Sikorsky	1939
Zeppelin	1900
Quimby	1912
Coleman	1921
Sputnik	1957

Step 1: Find the earliest year from the dates you will be working with and round it down to the nearest decade (tens). Write the result below. This result will be the first date on your timeline.

Step 2: Find the latest year from the dates you will be working with and round it up to the nearest decade (tens). Write the result below. This result will be the last date on your timeline.

Step 3: Subtract the result from Step 1 from the result in Step 2. Write the result below. This result is the number of years on your timeline.

Step 4: Timelines are divided into units of time. Decide how you will show the years on your timeline.

A) Will you mark every year on your timeline? There may be too many years to show each one!

or

B) Will you mark every five years?

or

C) Will you mark every ten years?

or

D) Will you mark every twenty years?

or

E) Make another choice: _____

Step 5: Write your final choice here:

I will mark every _____ years on my timeline.

Step 6: Divide the total number of years on your timeline (your result from Step 3) by the number you have chosen in Step 5. The result will be how many marks you will draw on your timeline.

$$\frac{\text{result from Step 3}}{\text{result from Step 5}} = \text{number of marks you will have on your timeline}$$

Step 7: Decide how you will measure your timeline. Will your result from Step 5 be measured in:

A) inches B) half inches C) centimeters

or

Write in another possibility: _____

Step 8: Write your final choice here:

_____ years will equal one _____ on my timeline.
result from Step 5 result from Step 7

Step 9: Calculate how long your timeline will be. Take your result from Step 6 and multiply it by your choice of measurement (your result from Step 7)

result from Step 6 X result from Step 7 = total length of your timeline

Step 10: On a piece of scratch paper, draw a rough draft of your timeline using the results from the steps above.

Timeline Mechanics

Teacher-Led Exercise Key

Step 1: *1783 -> 1780*

Step 2: *1958 -> 1960*

Step 3: *1960 - 1780 = 180 years*

Step 4: *answers will vary*

Step 5: *answers will vary, example: 10*

Step 6: *180 years / 10 years = 18 marks on your timeline*

Step 7: *answers will vary, example: inches*

Step 8: *10 years will equal 1 inch on my timeline*

Step 9: *18 marks x 1 inch = 18 inches*

Step 10: *answers will vary*

Student Exercise Key

Step 1: *1900 ->1900*

Step 2: *1957 -> 1960*

Step 3: *1960 - 1900 = 60 years*

Step 4: *answers will vary*

Step 5: *answers will vary, example: 10*

Step 6: *60 years / 10 years = 6 marks on your timeline*

Step 7: *answers will vary, example: inches*

Step 8: *10 years will equal 1 inch on my timeline*

Step 9: *6 marks x 1 inch = 6 inches*

Step 10: *answers will vary*

Mach and Mile Mathematics with the X-15

Connections: Portions of this lesson involve calculating the speed of an aircraft in terms of the Mach number. Mach numbers are used to define the "regimes" of flight: subsonic, supersonic, transonic and hypersonic. Another volume in the NASA series **Exploring Aeronautics**, entitled The Regimes of Flight, explores the regimes of flight indepth and would provide an excellent follow-on unit for this section. The Regimes of Flight is available from the NASA Educator Resource Centers.

Background: The National Aeronautics and Space Administration (NASA) conducts space flight research to collect data on high speed aerodynamics. The X-15 aircraft was used extensively from 1959 - 1968 to fly faster and higher than any aircraft had before. The X-15 was the first aircraft to fly to the edge of space and return to Earth. The results of many X-15 test flights would later be used to design the Space Shuttle.

People who fly and work with high speed aircraft often use the term "Mach number" to describe the speed of an aircraft. "Mach number" was named after an Austrian physicist named Ernst Mach (1838-1916) who studied sound. A Mach number is special because it takes into account both the speed of the aircraft and the environmental condition of the air through which the aircraft is flying. The Mach number is

calculated by dividing the speed of the aircraft by the speed of sound at the altitude the aircraft is flying. Remember to keep the units for speed of the aircraft and the speed of sound the same!

$$\frac{\text{speed of the aircraft in miles per hour}}{\text{speed of sound in miles per hour}} = \text{Mach number}$$

If an aircraft is flying at Mach 1, we say that it is flying at the speed of sound. If an aircraft is flying at Mach 2, we say that it is flying twice the speed of sound. If an aircraft is flying at Mach 6, we say that it is flying six times the speed of sound.

Also, for these exercises you will need to remember that:

one mile = 5,280 feet

Mach and Mile Mathematics with the X-15

Exercise 1

Directions: The X-15 had a very unique way of starting its flights. It was mounted on the belly of a B-52 and flown to an altitude of 45,000 feet, where it was launched at a speed of 500 miles per hour. A rocket in the X-15 would then provide thrust for roughly 120 more seconds, and then the X-15 would glide over 200 miles back to a runway. Navy Test Pilot, A. Scott Crossfield, was the first to fly the X-15.

Many test pilots flew the X-15 during the years it was tested, but two pilots broke world records during their flights. On August 22, 1963, NASA test pilot, Joseph A. Walker, flew the X-15 to an unofficial world altitude record of 354,200 feet. On October 3, 1967, Major William Knight, an Air Force Test Pilot, set the world speed record for winged aircraft. He flew 4,520 miles per hour. One year later, after 199 test flights, the X-15 was retired on October 24, 1968.

Question 1: The world altitude record, set by Test Pilot Walker, was 354,200 feet. What was his altitude in miles?

Question 2: The flight plan for Test Pilot Walker's record-breaking flight called for him to point the nose almost straight up and provide maximum rocket thrust after he was launched from the B-52. If the B-52 launched the X-15 at an altitude of 45,000 feet, how many feet up did he fly to break the altitude record?

Question 3: How many <u>miles</u> upward did he fly to break the altitude record?

He gained almost 90% (that is, almost all!) of his total altitude after he was launched, almost straight up, from the B-52 - in only 120 seconds! How would you like to have gone along for that ride?

Question 4: Can you think of a town that is between 58 and 67 miles away from your hometown? You can check the distance on a map. Does that town seem far away? Imagine going that distance, but going straight up! It might be fun to draw a picture of Test Pilot Walker's record-breaking flight!

Question 5: Test Pilot Major Knight had an equally exciting flight when he broke the world speed record! The old speed record was 4,486 miles per hour. By how many miles per hour did Major Knight beat the old record?

Question 6: The speed limit on most United States highways is 65 miles per hour. How many times faster did Major Knight fly than your car can legally go on the highway?

Question 7: The "speed of sound" is a measure of how fast sounds travel through the air. The "speed of sound" on earth, when the air temperature is 59 degrees, is 762 miles per hour. So, when a friend calls to you from across the schoolyard, the sound comes out of his/her mouth and enters your ears at 762 miles per hour!

The speed of sound changes as altitude and air temperature change. The speed of sound at the altitude at which Major Knight made his record-breaking flight was 87 miles per hour slower than on the ground. What was the speed of sound at Major Knight's altitude?

Question 8: Now that you know the speed of sound at Major Knight's altitude can you calculate the Mach number of the record-breaking flight?

Question 9: If Major Knight was flying Mach 6.7, how many times faster than the speed of sound was he flying?

Mach and Mile Mathematics with the X-15

Exercise 2

Directions: Based on what you learned in Exercise 1, Mach 1 would be one times the speed of sound. At sea level this is roughly 762 miles per hour.

Have you ever traveled at Mach 1?

Probably not! The fastest commercial jet airplanes in the United States generally fly below 500 miles per hour. However, there is a European airliner built by the French, the *Concorde*, that does fly just above Mach 1. If you have flown the *Concorde*, say from Paris to New York, then you are one of a fairly small group of people that has flown faster than the speed of sound!

Most of us have had to be content with driving, riding or flying at less than Mach 1. To see just how far below Mach 1 we generally travel, answer the following questions.

Remember that the speed of sound changes for two reasons. It changes according to altitude and the environmental condition of the air. You will need the following table for your calculations:

Altitude Range	Air Environmental Conditions	Speed of Sound
sea level	59 degrees F	762 miles per hour
20,000 - 30,000 feet	-30 degrees F	693 miles per hour
top of the atmosphere	-67 degrees F	662 miles per hour
350,000 - 360,000 feet		675 miles per hour
outer space	there is no air!	0

Question 1: In the United States the maximum speed limit on a freeway is 65 miles per hour. Assume that this freeway runs right along the ocean and it is a cool day. At what Mach number are you driving if you are driving at the speed limit?

Question 2: Say that you are a very accomplished mountain climber and you have decided to climb Mount Everest, the highest mountain on earth. It takes you many days, but finally you are standing at "the top of the world"! While you are standing there, trying to keep warm in -30 degree F weather, you see an F-14 flying at the same altitude you are standing! As she whizzes past you, the pilot gives you a "thumbs up" to congratulate you for making it to the top. If the pilot was flying at Mach 1, use the table above to determine how many miles per hour he/she was flying. Hint: Mt. Everest is 29,028 feet tall.

Question 3: How many miles per hour slower did the pilot of the F-14 have to go to achieve Mach 1 at the altitude of Mt. Everest, than you would have to go at sea level?

Question 4: In Exercise 1, Test Pilot Joseph Walker, broke a speed record in the X-15 at an altitude of 354,200 feet. If you were still standing on Mr. Everest, how many feet higher would Test Pilot Crossfield have been than you?

How many miles would that be?

If you were to travel the same number of miles by land from your hometown, where would you be? (Use a map to help you determine your answer.)

Question 5: The Space Shuttle flies at approximately 3,111 miles per hour right before it escapes from our atmosphere and enters outer space. What Mach number is this?

A tricky question: If the Space Shuttle flies 17,000 miles per hour in space, what is its Mach number? (Hint: Remember that the Mach number is a representation of the speed of sound. Think carefully about what affects the speed of sound!)

Question 6: A world class marathon runner can easily run at 15 miles per hour. What mach number is this? Assume he/she is running on the beach.

If he/she were running on the top of Mt. Everest, how much slower could he run to stay at Mach .02?

Mathematics with the X-15

Exercise 1 Key

1: *354,200 feet / 5,280 feet/mile = 67.08 miles*

2: *354,200 feet - 45,000 feet = 309,200 feet*

3: *309,000 feet / 5,280 feet/mile = 58.6 miles*

4: *answers will vary*

5: *4,520 miles/hour - 4,486 miles/hour = 34 miles/hour*

6: *4,520 miles per hour / 65 miles per hour = 69.5 times faster!*

7: *762 miles/ hour - 87 miles/ hour = 675 miles/hour*

8: *4,520 miles hour / 675 miles/hour = Mach 6.7*

9: *6.7 times the speed of sound*

Exercise 2 Key

1: *65 miles/hour / 762 miles/hour* = Mach .085*
**from table*

2: *from table: for altitude range of 20,000 - 30,000 feet, the speed of sound in the stated air conditions is 693 miles/hour. When the pilot is flying at Mach 1, he/she is flying at the speed of sound, or 693 miles/hour.*

3: *762 miles/hour at sea level - 693 miles/ hour at 29,028 feet = 69 miles/hour*

4: *354,200 feet - 29,028 feet = 325,172 feet*
325,172 feet / 5,280 feet = 61.6 miles
answers will vary

5: *3,111 miles/hour / 662 miles/hour = Mach 4.7*

6: *15 miles per hour / 762 miles per hour = Mach .02*
That's two one-hundredths of the speed of sound!
Mach .02 X 693 miles/hour = 13.86 miles/ hour

Don't Let It Weigh You Down!

Background: When flying in a lighter-than-air balloon, the load you carry cannot weigh more than what the balloon can carry. Many years ago, through trial and error, methods were developed to accurately predict how much weight a balloon could carry. These methods use four measurements:

- the size of the inside of the balloon and how much gas it can carry - called the "volume" of the balloon
- how much the equipment weighs (including the balloon itself, ropes, gondola, and the gas)
- how much the aeronaut and passengers weigh
- the density of the gas

Say that you are an aeronaut who had planned to take your three cousins on a balloon ride to see the countryside from the air. You also planned to bring a picnic lunch to feed everyone (including yourself!) and, since it is cooler up in the air, you wanted to bring some blankets to keep everyone warm. Just when you had everything ready to go, your cousin from far away paid a surprise visit and wanted to go along also. Given all the facts below, can your cousin go along?

In preparation for the flight, you had calculated the total weight of all the people and equipment you expected to bring along. Your calculations were as follows:

Item	Weight
You (the aeronaut)	80 pounds
Cousin Susanne	65 pounds
Cousin Phil	70 pounds
Cousin Andrew	75 pounds
balloon	250 pounds
gondola	300 pounds
ropes and other equipment	50 pounds
lunch for four people	20 pounds
blankets for four people	8 pounds
Total	**918 pounds**

Your balloon, with brilliant red, white and blue stripes, is as tall as a three-story building and can carry 89,000 cubic feet of gas. You can say that the volume of your balloon is 89,000 cubic feet. You also know from your study of chemistry that the density of helium is .011 pounds per cubic foot.

To calculate how many pounds your balloon could carry, you multiplied the density of the helium by the volume of the balloon.

Density of the helium = .011 pounds per cubic foot

Volume of the balloon = 89,000 cubic feet

.011 pounds per cubic foot X 89,000 cubic feet = 979 pounds

So, based on your calculations, you could carry 979 pounds on your flight. On the list above, where you totaled the weight of all the items you expected to carry, you expected to carry 918 pounds.

Would you be able to fly your three cousins, plus lunch and blankets on your balloon? Yes, because they weighed 918 pounds and you could carry 979!

But what about your cousin Bryant who wanted to come along? Bryant tells you that he weighs 85 pounds. You add Bryant's weight to the total weight of all the items you expected to carry:

918 pounds + 85 pounds = 1,003 pounds

Oh, no! Bryant cannot fly with you! Can you tell why?

That's right! The reason is that with the addition of Bryant the total weight of the items you want to carry becomes too big for the balloon you have.

What can you do so Bryant can go along? Well, you calculated that your balloon could carry 979 pounds. How much over that limit are you if Bryant comes along?

1,003 pounds - 979 pounds = 24 pounds

So, you must remove 24 pounds from your weight list. Obviously you cannot remove the people, the gondola, the balloon or the ropes and other equipment. What's left?

The total weight of the lunch and blankets is:

20 pounds + 8 pounds = 28 pounds

So, if you left the lunch and blankets at home, the total weight you need to carry is:

1,003 pounds - 28 pounds = 975 pounds

Without the lunch and blankets the total weight of 975 pounds is less than the 979-pound limit that your balloon can carry. You need to make a decision! Bryant may come along on the flight and the lunch and blankets stay home, or the lunch and blankets come along and Bryant stays home. What will you do?

Use the following template to help you complete the exercises below.

Don't Let It Weigh You Down!

Template

Step 1: Fill in the following weight list table. List the items you want to take along in the left-hand column, and the weight of each item in the right-hand column.

Item	Weight
Total	

Step 2: Calculate the total weight your balloon can carry. Assume that you will fill your balloon with helium gas.

Density of the helium = .011 pounds per cubic foot

Volume of the balloon = _____cubic feet

.011 pounds per cubic foot X _____ cubic feet = _____ pounds

Step 3: Determine whether the balloon can carry all of the items you want to take with you.

Is the total weight of all the items you want to carry greater than, less than, or equal to the weight the balloon can carry? Circle the correct answer

_____ pounds		is less than	
total weight of items		is greater than	_____ pounds
		is equal to	weight balloon can carry

Will the balloon carry all of the items you want to take? _____ (yes/no)

Step 4: If your answer was "yes", then Bon Voyage!

If your answer was "no", then you need to go back to your Weight Table and figure out what can be left at home, then redo your Weight Table and Step 3.

What are some other steps you could take to lighten the load?

Exercises

1: Congratulations! You have just bought a brand new balloon! Your new balloon weighs 200 pounds, the gondola weighs 300 pounds and the ropes and other equipment, 75 pounds. You'd like to take your Aunt and Uncle along for a ride. Your Aunt weighs 110 pounds and your Uncle weighs 160 pounds. You weigh 90 pounds. Your Aunt's favorite candy is chocolate truffles, so you want to bring along a 5-pound box of candy for her. The volume of your balloon is 86,000 cubic feet. Can your balloon carry all the people, equipment and candy you want to carry?

2: The National Weather Service (NWS) often launches balloons to carry instruments into the atmosphere. One day, during mid-August, radar detects a huge storm brewing. The NWS needs to send a balloon up to help them figure out if the storm is really going to be as big as it appears. The balloon will not have any passengers - only instruments will be on board. The instruments weigh 335 pounds. The gondola weighs 105 pounds. Are there any other weights that you need? If so, go back to the very first example problem and choose what you need from the weight table. Next, decide what size balloon you need to launch the instruments.

3: You and a friend are going to give a birthday party for one of your classmates. You want to decorate with lots of balloons. You go to the store and buy a package of 100 different colored balloons. The volume of each balloon in the package is 9 cubic feet. How many pounds of helium must you buy to fill up all the balloons?

If the helium comes in 3-pound canisters, how many canisters must you buy?

Exercises Key

1: Congratulations! You have just bought a brand new balloon! Your new balloon weighs 200 pounds, the gondola weighs 300 pounds and the ropes and other equipment, 75 pounds. You'd like to take your Aunt and Uncle along for a ride. Your Aunt weighs 110 pounds and your Uncle weighs 160 pounds. You weigh 90 pounds. Your Aunt's favorite candy is chocolate truffles, so you want to bring along a 5-pound box of candy for her. The volume of your balloon is 86,000 cubic feet. Can your balloon carry all the people, equipment and candy you want to carry?

weight of all people, etc. = 940 pounds
.011 lbs/cubic foot X 86,000 cubic feet = 946 lbs
your balloon can carry everything

2: The National Weather Service (NWS) often launches balloons to carry instruments into the atmosphere. One day, during mid-August, radar detects a huge storm brewing. The NWS needs to send a balloon up to help them figure out if the storm is really going to be as big as it appears. The balloon will not have any passengers - only instruments will be on board. The instruments weigh 335 pounds. The gondola weighs 105 pounds. Are there any other weights that you need? If so, go back to the very first example problem and choose what you need from the weight table. Next, decide what size balloon you need to launch the instruments.

from example table: balloon = 250 lbs; ropes, etc. = 50 lbs
total weight = 740 lbs
740 lbs / .011 lbs/cubic foot = 67,273 cubic feet

3: You and a friend are going to give a birthday party for one of your classmates. You want to decorate with lots of balloons. You go to the store and buy a package of 100 different colored balloons. The volume of each balloon in the package is 9 cubic feet. How many pounds of helium must you buy to fill up all the balloons?

.011 lbs per cubic foot X 900 cubic feet = 9.9 lbs

If the helium comes in 3-pound canisters, how many canisters must you buy?

9.9 lbs / 3 lbs = 3.3 canisters - so you need to buy 4.

The Aspect Ratio of Wings

Review: As air flows over and under a wing, we know from our study of lift that the air flowing over the top flows faster than the air that flows under the wing. We also know from Bernoulli's Principle that the air that flows faster applies less pressure to the surface it is flowing over. Therefore, since the air flowing over the top of a wing has less pressure (because it is flowing faster), the air pressure on top is less than on the bottom of the wing. The higher air pressure on the bottom "lifts" the wing.

Background: When engineers design a new airplane, the size and shape of the wings are a very important issue. Wings provide the majority of the lift for the airplane, but they also cause drag. Remember that drag is a force that opposes the thrust force. Engineers are always trying to find ways to increase lift and reduce drag caused by the wings.

In addition to flowing faster, the air that flows over the top of the wing also tends to flow inward, toward the fuselage. The air that flows over the bottom is flowing more slowly and tends to flow outward. As these two airflows meet along the trailing edge of the wing, they form a rotating column of air that extends from the wing tip. This is called a wing-tip vortex.

If they are lucky, passengers riding behind the wing of an airplane can sometimes see a wing-tip vortex - particularly if they are flying in the morning or on a slightly humid day. It looks like a long, slim whirlwind that extends from the tip of the wing.

Unfortunately, while they are fun to watch, the same characteristics of the airflow that create wing-tip vortices (the plural of vortex is vortices) also create drag.

Teacher - Led Exercise

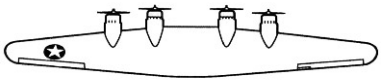
Directions: In their efforts to increase lift and reduce drag, engineers use a mathematical formula called the "aspect ratio". The "aspect ratio" is simply a comparison between the length and width of the wing:

$$\frac{\textit{length of the wing}}{\textit{width of the wing}} = \textit{aspect ratio}$$

Experiments have shown that a wing built with a higher aspect ratio tends to create less drag than a wing built with a smaller aspect ratio - even when their area remains the same!

Examine the three wings drawn below, calculate the area and aspect ratio of each wing, and fill in the following table. Then, rank the wings according to the drag that each will create, given their aspect ratios. Rank the wing with the least drag, number 1 and the greatest amount of drag, number 3.

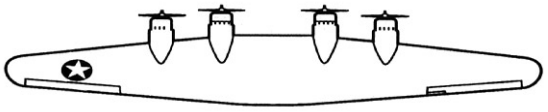
Wing "A"



5 units

20 units

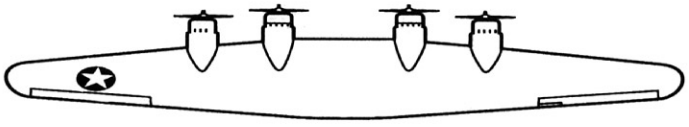
Wing "B"



4 units

25 units

Wing "C"



2 units

50 units

Wing	length	width	area	aspect ratio	drag ranking
A					
B					
C					

Exercise 2

Step 1: Create and draw your own wings below. Shape them like airfoils and give each the same area of 200 square units.

Wing A **Wing B**

Step 2: Label the length and width of each wing.

Step 3: Calculate the aspect ratio for each wing and fill in the table below. Don't forget to include the units!

Wing	length	width	area	aspect ratio	drag ranking
A					
B					

Step 4: Rank the wings according to the drag that each will create, given their aspect ratios. Rank the wing with the least drag, number 1 and the one with the greatest amount of drag, number 2.

The Aspect Ratio of Wings

Teacher - Led Exercise Key

Wing "A": *length: 20 units width: 5 units*

Wing "B": *length: 25 units width: 4 units*

Wing "C": *length: 50 units width: 2 units*

Wing	length	width	area	aspect ratio	drag ranking
A	*20 units*	*5 units*	*100 square units*	*4*	*3*
B	*25 units*	*4 units*	*100 square units*	*6 R1*	*2*
C	*50 units*	*2 units*	*100 square units*	*25*	*1*

Even though each wing has the same area, 100 square units, Wing "C" has the greatest aspect ratio, and Wing "A" has the smallest aspect ratio. This implies that Wing "A" creates more drag than Wing "C".

Maybe you've wondered why sailplanes and gliders have long, slim wings. Since they don't have engines to provide thrust, their wing shape helps to provide the greatest amount of lift with the least amount of drag. Check out the ER-2 in The Hangar section of the CD-ROM. The ER-2 is a rocket-powered glider!

Exercise 1 Key

Step 1: *Possible wing dimensions and aspect ratios:*

length = 9 width = 8 aspect ratio = 1 R1
length = 12 width = 6 aspect ratio = 2
length = 36 width = 2 aspect ratio = 18
length = 24 width = 3 aspect ratio = 8
length = 18 width = 4 aspect ratio = 4 R2

Wing	length	width	area	aspect ratio	drag ranking
A	*9 units*	*8 units*	*72 square units*	*1R1*	*2*
B	*12 units*	*6 units*	*72 square units*	*2*	*1*

Exercise 2 Key

Step 1: *Possible wing dimensions and aspect ratios:*

length = 100 width = 2 aspect ratio = 50
length = 50 width = 4 aspect ratio = 12 R2
length = 20 width = 10 aspect ratio = 2
length = 25 width = 8 aspect ratio = 3 R1

Wing	length	width	area	aspect ratio	drag ranking
A	*100 units*	*2 units*	*200 square units*	*50*	*1*
B	*20 units*	*10 units*	*200 square units*	*2*	*2*

Computing the Net Force

Review: One way to start a class dialog on "force" is to ask students to give examples from their own experience of a "force". Responses might include a "hit" or some sort of forceful contact; others might be more group-oriented, like the "Air Force"; another possibility is "The Force" from the Star Wars movies. There are very few wrong answers to this question, and some reflection on their own experiences often helps students when they try to grasp the slightly more formal definition below.

A force is defined in its simplest sense as a "push" or a "pull". These definitions do not imply a direction. Students can "pull" in any direction as they can "push" in any direction! The terms are frequently used because students can readily identify with the actions of pushing and pulling, and the fact that these actions usually have an effect on what they are pushing or pulling.

Review with students that there are two parts to the definition of a force. In fact, when a force is defined it must have both parts - one is not enough! The two parts are: magnitude (a quantity that can be measured) and direction. The direction of a force is self-explanatory, and again, has nothing to do with the terms "push" or "pull".

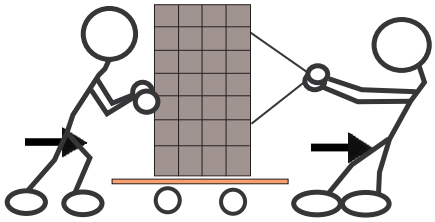
The magnitude of a force can be described as "how hard the force is", or "how much power the force has". For example, a force of magnitude 10 can be described as a "stronger" force than one of magnitude 2, which can be described as a "weaker" force.

Special note: When working with this lesson, it is very important that students learn to draw accurate pictures of the events described!

Background: When two forces act in parallel, in either the same or opposite direction, measuring them is simply a matter of adding or subtracting their magnitudes. When two forces are acting in parallel and in the same direction, measure them by adding the magnitudes together.

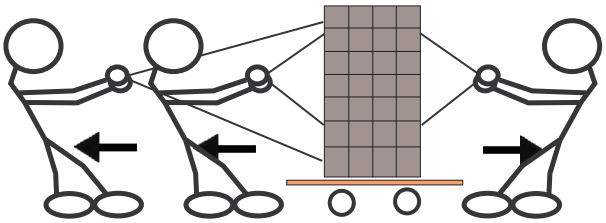
In the example below, a "push" of magnitude 1 added to a "pull" of magnitude 1 equals a net force of magnitude 2. The cart will then move in the direction of the greatest magnitude - in this case to the right.

Push 1 + Pull 1 = Net Force 2 to the right



When two forces act in parallel in the opposite direction, measure them by subtracting the magnitudes. In the example below, a pull of magnitude 1 is acting opposite to a pull of magnitude 2. The cart will move in whichever direction has the greatest magnitude. In this case the cart will move to the left.

Push 2 - Pull 1 = Net Force 1 to the left



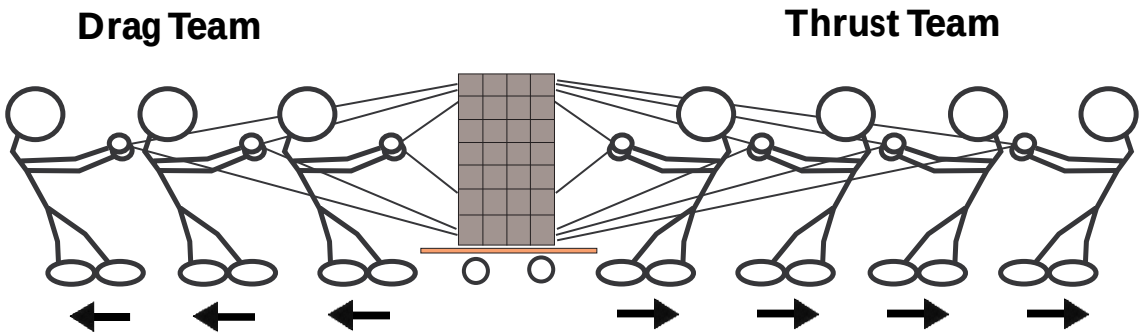
You may want to walk the students through a similar process using ropes or string and students of equal size to demonstrate the concept.

Forces that act in opposite directions are called "oppositional" forces. Four of the forces in aeronautics (lift, drag, weight, and thrust) can be thought of as "oppositional" pairs.

thrust acts in a direction opposite to drag

lift acts in a direction opposite to weight

The oppositional forces can be introduced as a game of tug-of-war. Teams can be named as the four forces. For example, a tug-of-war can be set up between a "thrust" team and a "drag" team.



In the above graphic, the "Thrust Team" has a magnitude of 4 and the "Drag Team" has a magnitude of 3. The net force will be

Thrust 4 - Drag 3 = Net Force 1 to the right

Since the "Thrust Team" has the greater magnitude, the cart will move in the direction that the "Thrust Team" is pulling, in this case to the right.

Worksheet

Question 1: Define the word "force".

Question 2: Complete the sentences below by filling in the blanks.

A force can move in different _____.

A force has "strength" or _____ that can be _____.

Parallel forces can be added or _____.

Question 3: An F-14 is flying west. Its engines are creating a thrust force of magnitude 4,000. A strong headwind is blowing to the east creating a drag force on the F-14 of magnitude 1,000.

What is the net force on the F-14? _____

In what direction will the F-14 fly? _____

Draw a picture of this event. Make sure you include the F-14, the wind, arrows to represent the magnitudes, and the equation that gives the net force. Draw one arrow for each 1,000 units of magnitude.

Question 4: After the Space Shuttle is launched, its huge rocket engines lift it upward with incredible force. As it blasts through the top of the atmosphere into outer space, the engines are creating a force pushing up into space with a magnitude of 6 times the force of gravity. We write this as "6g".

The gravity force is pulling the Shuttle back down in the direction of the earth with a magnitude of 1 times the force of gravity. We write this as "1g".

What is the net force on the Space Shuttle? _____

Draw a picture of this event to help you answer the question. Be sure

to include the Shuttle, the Earth, arrows to represent which direction the engines and the earth are pulling, and the equation that gives the net force. Draw one arrow for each g.

Question 5: Four people are pulling on ropes attached to a cart. Each person is pulling with a magnitude of 1. Two people are pulling to the right and two people are pulling to the left.

What is the magnitude of the net force? _____

In which direction will the cart move? _____

Draw a picture of this event to help you answer the questions. Be sure to include the cart, the people, arrows to represent the directions that the people are pulling, and the equation that gives the net force. Draw one arrow for each unit of magnitude.

Worksheet Key

Question 1: *A force is a "push" or a "pull". It has two parts: magnitude and direction.*

Question 2: *directions*
magnitude, measured
subtracted

Question 3: *3,000*
West
thrust 4,000 - drag 1,000 = net force 3,000 in the direction of thrust

Question 4: *5g*
up 6g - down 1g = net force 5g in up direction ***or***
lift 6g - weight 1g = net force 5g in direction of lift

Question 5: *0*
neither
pull 1 - pull 1 = net force 0

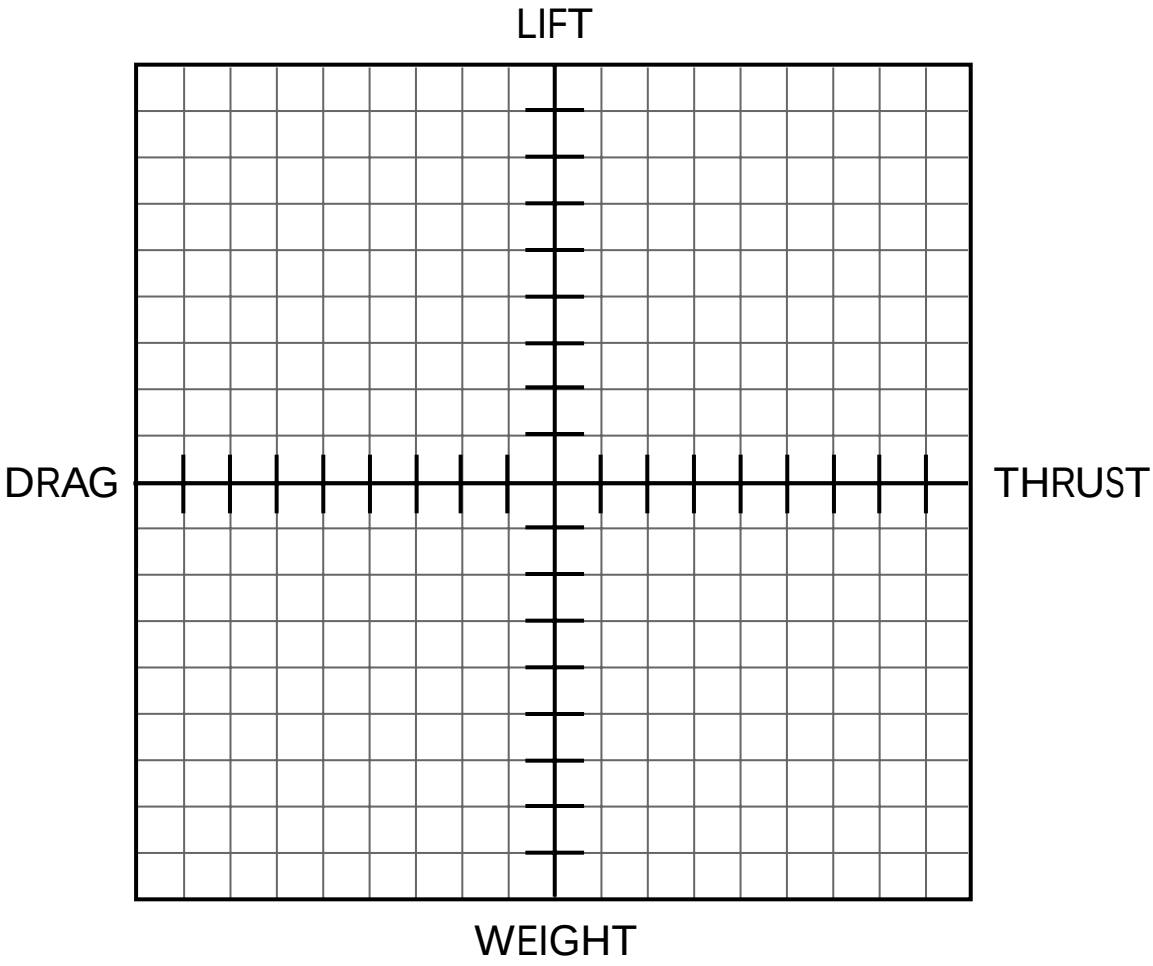
Graphing the Four Forces

Background: The concept of force can be effectively represented on a graph using the Cartesian coordinate system. By representing four of the aeronautical forces (lift, drag, thrust, weight) on a graph, students can visualize both parts of the definition of force: magnitude and direction.

In the lesson, Computing the Net Force, students learned how to calculate the magnitude and direction of the net force, given two parallel forces. In this lesson, students will use information about four forces to make a decision about whether or not an airplane is (theoretically!) able to fly.

This lesson concentrates on the actual representation of the forces on a graph. If, after combining the four forces, the net force is plotted in the upper right quadrant of the graph, then we will draw the conclusion that the airplane is able to fly.

Directions: Have students examine the graph on the following page. Point out that lift is "up toward the top of the paper", weight is "down toward the bottom of the paper", thrust is "forward toward the right of the paper" and drag is "back toward the left of the paper".


LIFT
DRAG
THRUST
WEIGHT

Using the magnitudes below, follow the steps and plot your points on the graph on the previous page.

Weight	3 units
Lift	7 units
Drag	2 units
Thrust	5 units

The forces can be plotted in any order. For example:

Step 1: Start at the origin and count down three squares (for Weight). Plot a small dot.

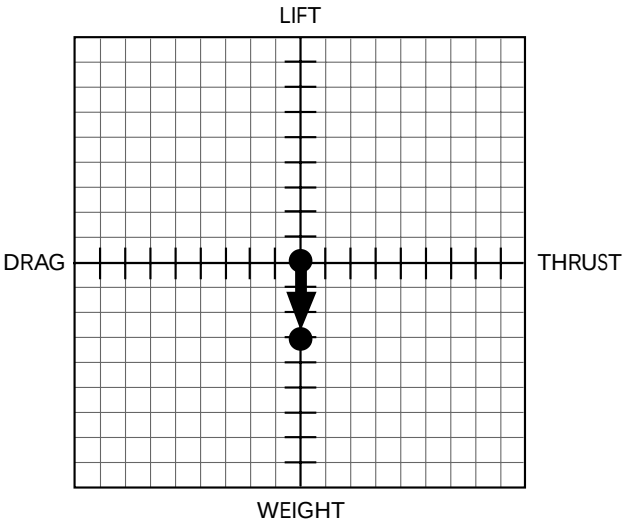
Step 2: From that small dot (do not start again from the origin!) count up seven squares (for Lift). Plot another small dot.

Step 3: From that small dot (do not start again from the origin!) count to the left two squares (for Drag). Plot another dot.

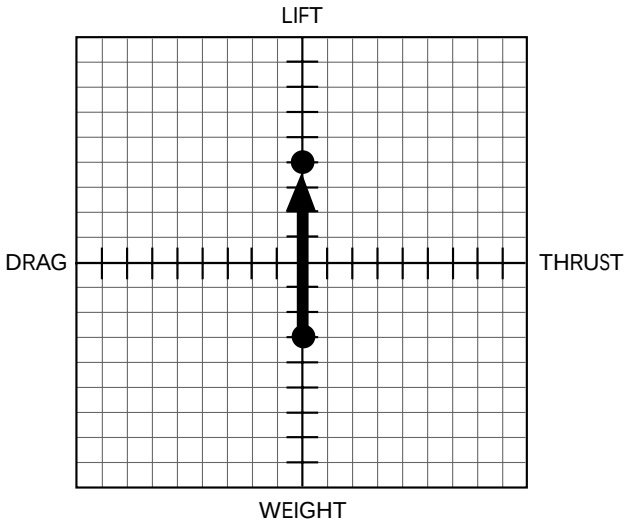
Step 4: From that small dot (do not start again from the origin!) count to the right 5 squares (for Thrust). Plot a large dot. This is the representation of the net force.

See the graphs on the following page for guidance, then continue.

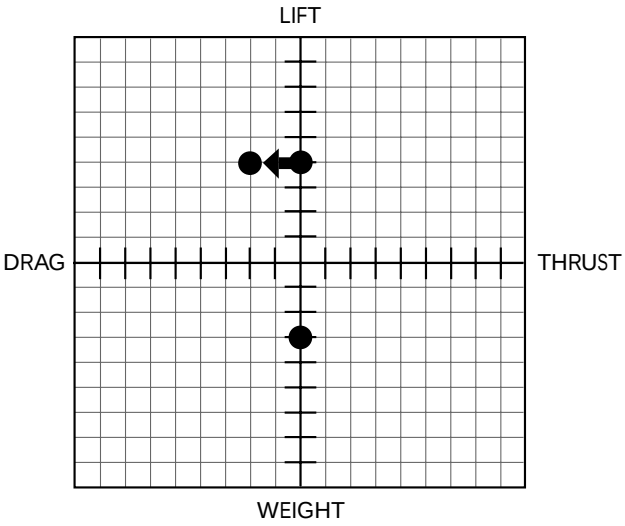
Step 1: Down 3



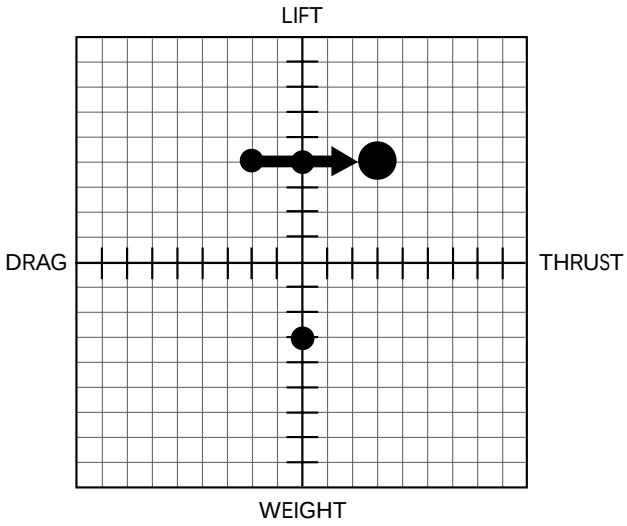
Step 2: Up 7



Step 3: Left 2



Step 4: Right 5



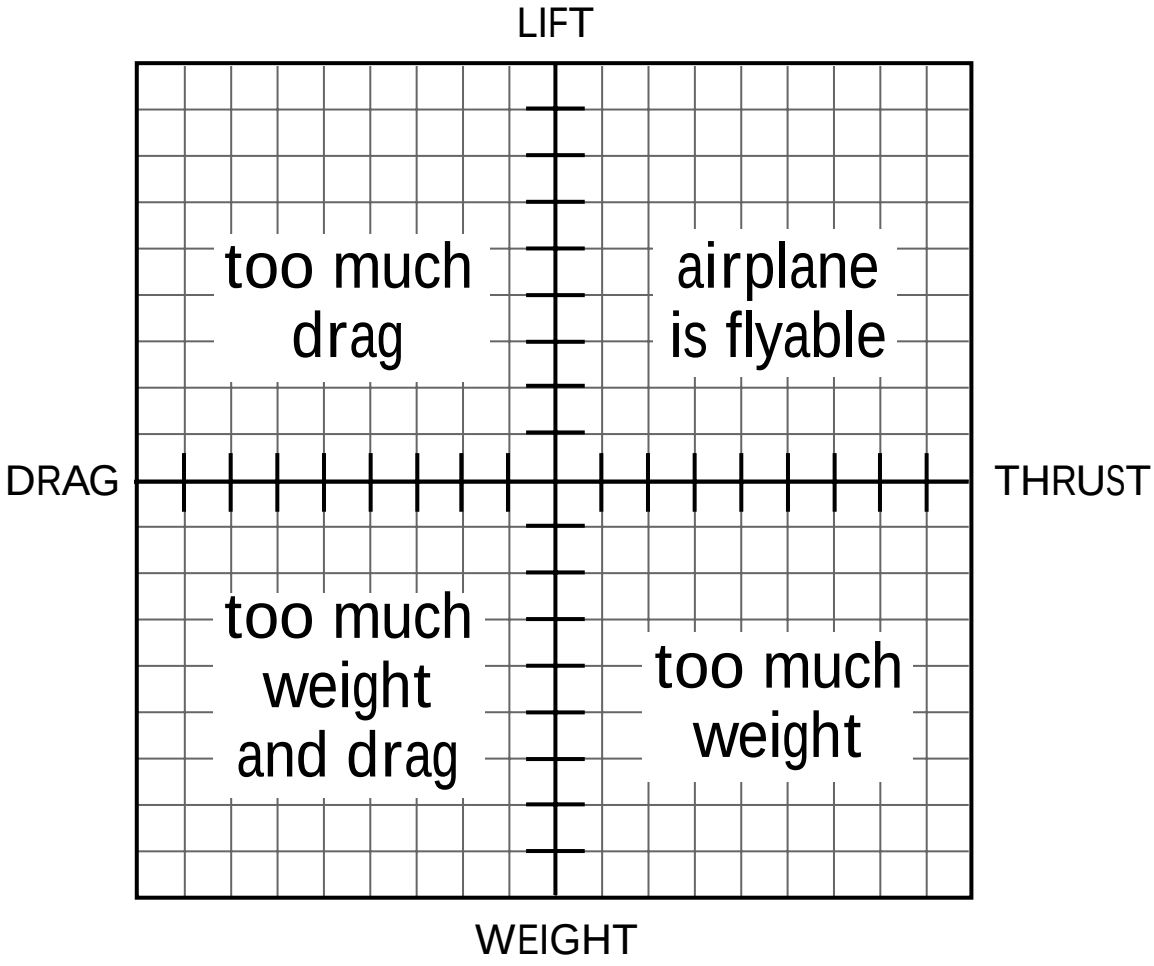
Step 5: Determine whether or not the airplane is flyable.

If the net force is plotted in the upper right quadrant, the airplane is flyable.

If the net force is plotted in the upper left quadrant, the airplane is not flyable - it has too much drag.

If the net force is plotted in the lower left quadrant, the airplane is not flyable - it has too much drag and weight.

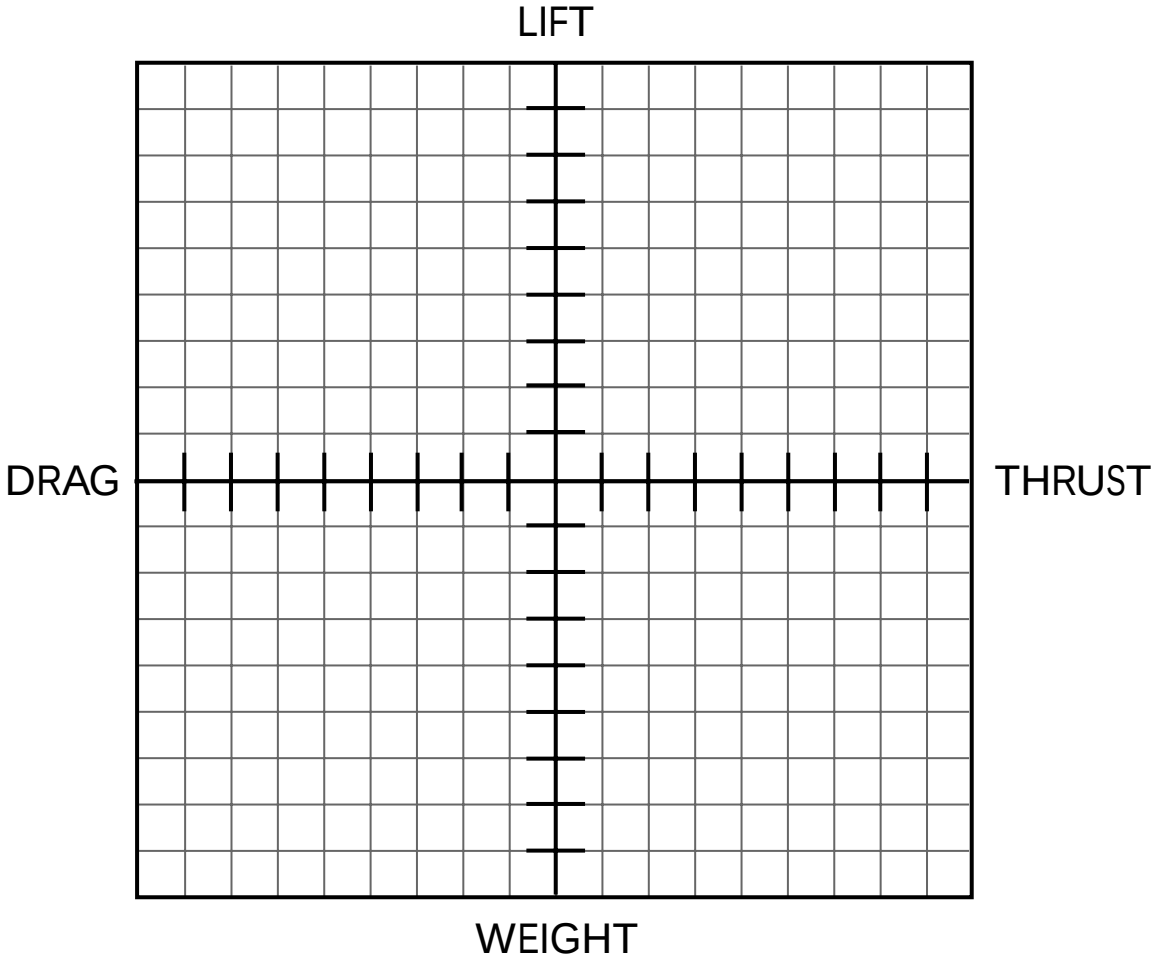
If the net force is plotted in the lower right quadrant, the airplane is not flyable - it has too much weight.



Exercise 1

Directions: Use the steps from the previous example to plot the following magnitudes. After you plot the net force, make a decision about whether or not the airplane is flyable.

Weight	4 units
Lift	10 units
Drag	2 units
Thrust	10 units



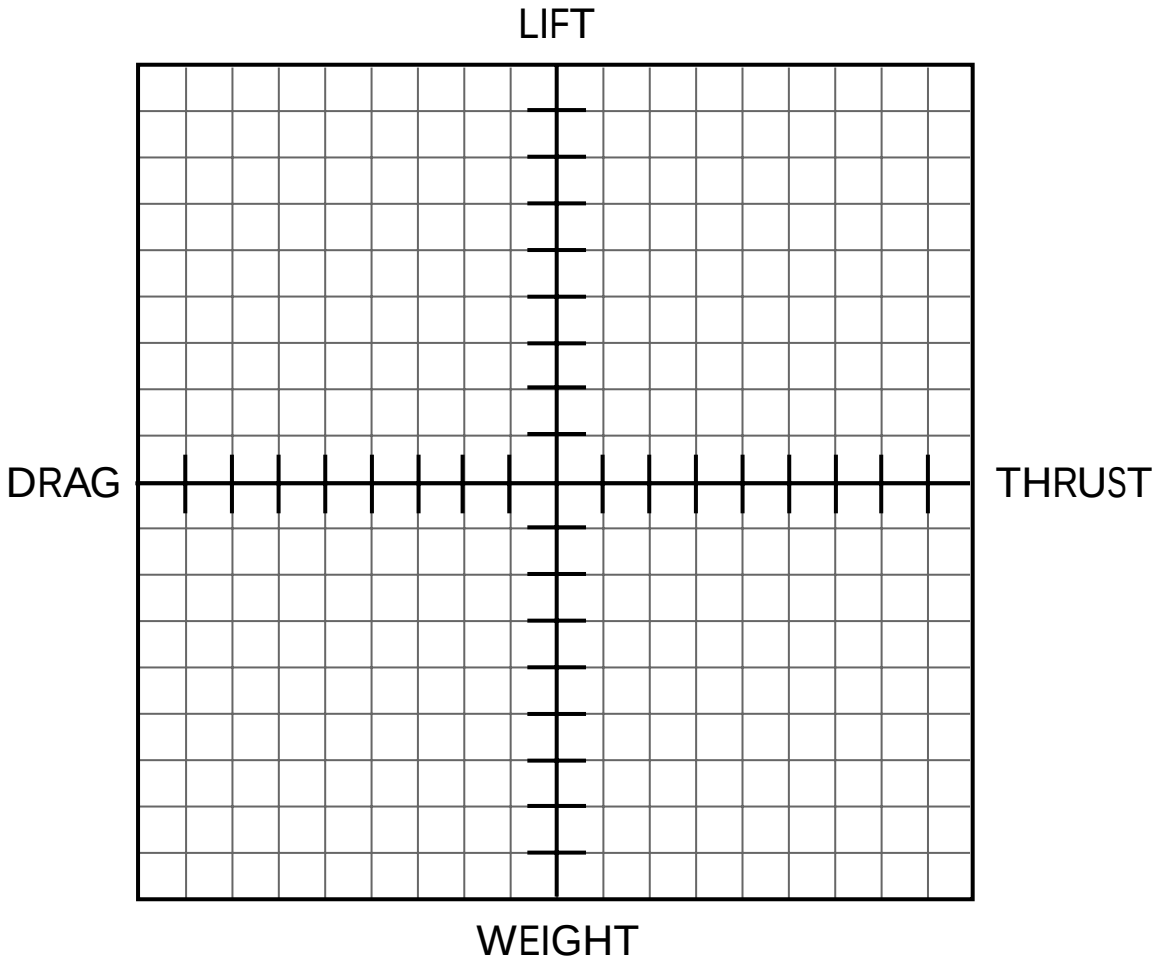
Question 1: This plane is / is not flyable.

Question 2: If it is not, tell what force or forces are too great for the airplane to fly.

Exercise 2

Directions: Use the steps from the previous example to plot the following magnitudes. After you plot the net force, make a decision about whether or not the airplane is flyable.

Weight	8 units
Lift	4 units
Drag	6 units
Thrust	4 units



Question 1: This plane is / is not flyable.

Question 2: If it is not, tell what force or forces are too great for the airplane to fly.

Graphing the Four Forces

Exercise 1 - Key

Starting at the origin:

the end of the weight arrow will be at (0,-4)
the end of the lift arrow will be at (0,6)
the end of the drag arrow will be at (-2,6)
the end of the thrust arrow will be at (8,6)

since (8,6) is in the upper right quadrant, the airplane is flyable

Note: the arrows may be drawn in any order, you will always end up at the same place!

Exercise 2 - Key

Starting at the origin:

the end of the weight arrow will be at (0,-8)
the end of the lift arrow will be at (0,-4)
the end of the drag arrow will be at (-6,-4)
the end of the thrust arrow will be at (-2,-4)

since (-2,-4) is in the lower left quadrant, the airplane is not flyable

both weight and drag are too great

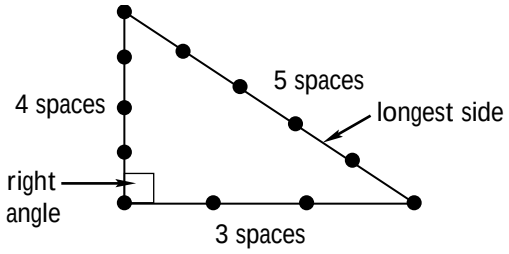
Flying With Pythagoras

Preparation: Students should be familiar with the concepts of squares and square roots. They should be able to use their calculators to square numbers and find the square roots of numbers.

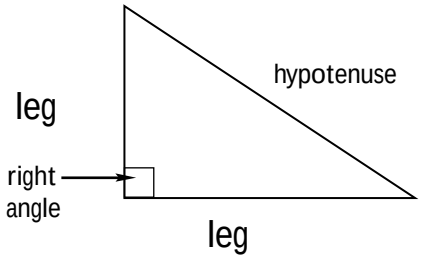
Background: In the 6th century BC, a Greek philosopher named Pythagoras lived in the village of Samos. He started a school where philosophy and religion were studied, in addition to astronomy, mathematics and music. The students from his school were called Pythagoreans. Central to Pythagoras' teaching was the idea that all physical relationships could be expressed by mathematical relations. One of the most famous discoveries of the Pythagoreans was a proof for a distance relationship that had been developed many years before by the Egyptians.

The Nile River flows through Egypt. This huge river is a source of life in an otherwise barren, desert land. During the rainy season, the Nile floods regularly. After each flood the surveyors would have to reset the boundaries of the farmers' fields. Land was sectioned into squares, so it was critical that the surveyors knew how to mark a right angle (because squares have four right angles).

The clever Egyptians took a rope and tied twelve evenly-spaced knots in it. They then made a triangle with the rope. One side had three spaces between the knots, another had four spaces between the knots, and the longest had five. This triangle was very special. The angle opposite from the longest side was always a right angle. Using this rope, the surveyors were able to show that the boundaries they marked were indeed in the shape of a square.



Many years later, the Pythagoreans named a triangle that contained a right angle, a "right triangle". They also named some of the parts of a right triangle. They called the longest side, opposite the right angle, the hypotenuse. The sides next to (or adjacent to) the right angle were called the legs.



The Pythagoreans discovered that the legs and hypotenuse of a right triangle did not always have to have lengths of 3, 4 and 5. But the numbers did have to work in a special formula. The special formula is called the Pythagorean Theorem. The Pythagorean Theorem goes like this:

If you take the length of a leg of a triangle (say "a" in the graphic above) and multiply it by itself (or "square" it);

$a \times a$ or a^2

then, do the same with the length of the other leg ("b" in the graphic above);

$b \times b$ or b^2

and add the results together;

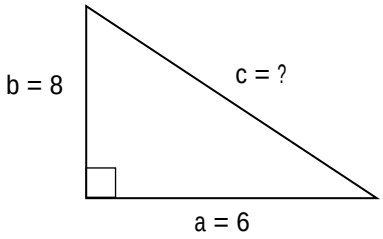
$a^2 + b^2 =$

your final result will be equal to the length of the hypotenuse ("c" in the graphic above) multiplied by itself (or "squared").

$a^2 + b^2 = c^2$

The Pythagoreans also discovered that if they knew the lengths of the two legs of a right triangle, they could use the Pythagorean Theorem to find the length of the hypotenuse.

Say that one leg of a right triangle has a length of 6 units and another has a length of 8 units. What is the length of the hypotenuse?



We know from the Pythagorean Theorem that

$a^2 + b^2 = c^2$

In our example, a = 6 and b = 8. So,

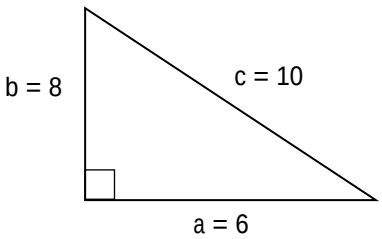
$a^2 + b^2 = c^2$

$6^2 + 8^2 = c^2$

$36 + 64 = c^2$

$100 = c^2$

Since the square root of 100 is 10 (that is, 10^2 equals 100) the length of the hypotenuse must equal 10.



Exercises

Directions: Use the information given and the Pythagorean Theorem to solve the following problems.

Problem 1: The length of leg "a" of a right triangle is 9, the length of leg "b" is 12. What is the length of the hypotenuse?

Draw the triangle. Make sure you mark the lengths of the two legs and the hypotenuse, and tell which angle is the right angle.

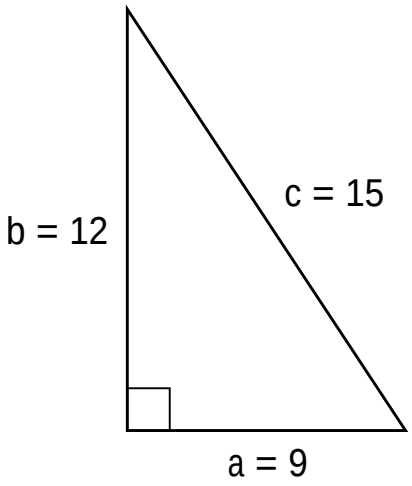
Problem 2: NASA Test Pilot Loren Haworth is instructed to fly the following mission in a brand new aircraft, the X-99. He will be testing the aircraft's ability to follow a flight path very precisely. Test Pilot Haworth is instructed to fly North from San Antonio, Texas to Sioux Falls, South Dakota, a distance of 1,000 miles. He is instructed to then fly east to Scranton, Pennsylvania, a distance of 1,200 miles. After reaching Scranton, he is supposed to fly directly back to San Antonio. What is the distance he must fly from Scranton to San Antonio? Hint: Draw his route and label the distances on the map below to help you find the return distance.

Problem 3: One day the Space Shuttle blasts off from the launch pad at the Kennedy Space Center in Florida. Unfortunately, a computer malfunctions and, after reaching an altitude of 4 miles, the Shuttle must return to earth and land on a runway. The runway is 5 miles away from the launch pad. How far must the Shuttle fly from its highest altitude to the runway? Hint: Draw a picture and label the mileages of the Space Shuttle's route to help you find the return distance.

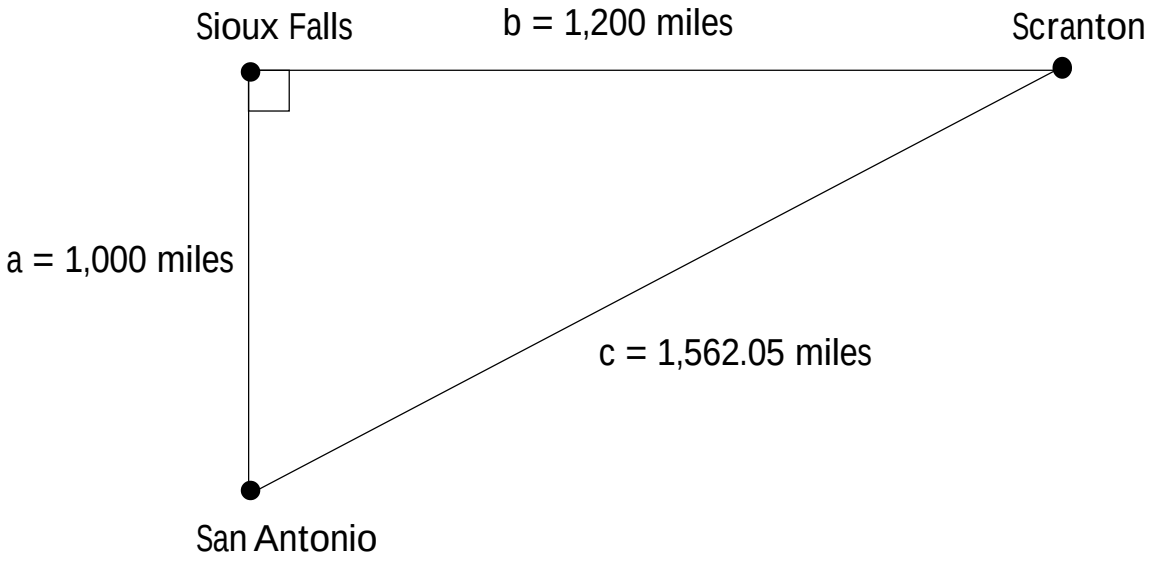
Flying With Pythagoras

Exercises Key

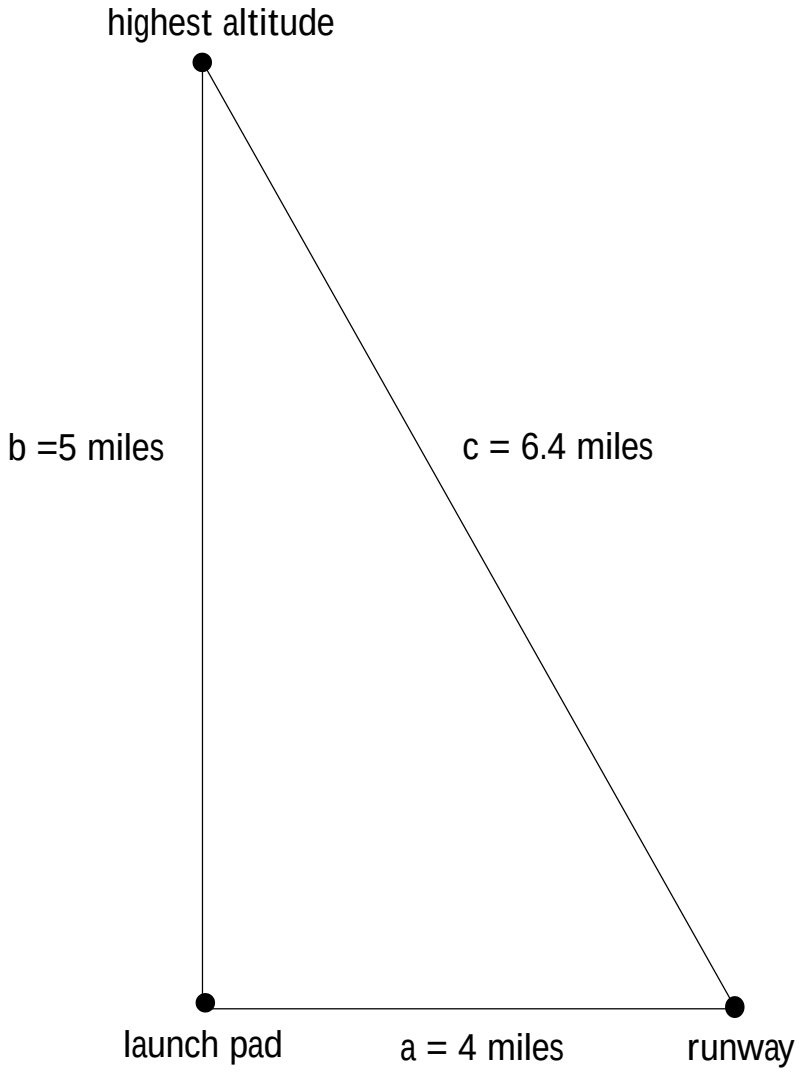
1: *The length of the hypotenuse is 15.*



2: *The distance from Scranton to San Antonio is 1,562.05 miles.*



3: *The Shuttle must fly 6.4 miles from its highest altitude to the runway.*



Wind Tunnel Averages

Background: When engineers perform wind tunnel tests to measure the forces of drag and lift on a model, they use a unit of measurement called a "newton". Newtons are named after the famous English physicist, Sir Isaac Newton. A newton is the unit of force it takes to change the velocity of a mass of 1 kilogram, by 1 meter/second over 1 second. Think of a 1 kilogram section of a wing, flying at 250 meters per second. A force of 1 newton would change the velocity of the wing section from 250 meters per second to 251 meters per second, in one second.

If, for instance, a researcher wishes to test the lift experienced by a section of a wing, he or she will embed sensors in various parts of the wing. Each sensor will measure the force of lift on a specific area of the wing. After those values are fed into a computer, the computer will display them in newtons. The researcher can then average all of the values and find the average lift over the entire wing. This same approach can be used for drag.

Directions: An average is a way to approximate a value for a large set of numbers. For example, to find the approximate length of the steps you take when you walk, we could measure three, four or ten of your usual walking steps. Then we could average them to find out how long a stride you usually take.

To find an average, follow these two steps:

Step 1: Add all of the numbers together.

Step 2: Divide the sum by the number of numbers.

The result of this division is the average of the numbers.

For example, let's say an engineer embedded three sensors in a wind tunnel model to measure the lift force. The computer reported the following values from each sensor:

250 newtons
300 newtons
350 newtons

Say that the engineer wanted to find the average of the lift forces over the entire wing. He/She would perform the following steps:

Step 1: 250 newtons + 300 newtons + 350 newtons = 900 newtons

Step 2: $\frac{900 \text{ newtons}}{3} = 300 \text{ newtons}$

The average lift force over the entire wing was 300 newtons.

Exercise

Directions: A researcher wanted to find out the quantity of the lift force experienced by different wing types during a wind tunnel test. She embedded three sensors in each of three types of wings: delta, straight, and tapered straight. Her results can be found in the table below. Your task is to find the average lift force for each of the three wing types. Put your answers in the appropriate squares in the table.

Lift Tests

Wing / Sensor #	1	2	3	Sum	Average
delta	600 newtons	611 newtons	610 newtons		
straight	328 newtons	350 newtons	270 newtons		
tapered straight	390 newtons	433 newtons	440 newtons		

She performed the same experiment again, except that she measured the drag force from the sensors. Her results can be found in the table below. Find the average drag force for each of the three wing types. Put your answers in the appropriate squares in the table.

Drag Tests

Wing / Sensor #	1	2	3	Sum	Average
delta	26 newtons	32 newtons	23 newtons		
straight	65 newtons	55 newtons	60 newtons		
tapered straight	40 newtons	44 newtons	39 newtons		

Question 1: Which wing shows the greatest amount of average lift?

Question 2: Which wing shows the least amount of average lift?

Question 3: Which wing shows the highest individual lift sensor reading?

Question 4: Which wing shows the greatest amount of average drag?

Question 5: Which wing shows the lowest individual drag sensor reading?

Question 6: If you were to build an airplane, which wing would you use? Why?

Wind Tunnel Averages

Exercise 1 Key

Lift Tests

Wing / Sensor #	1	2	3	Sum	Average
delta	600 newtons	611 newtons	610 newtons	*1821 newtons*	*607 newtons*
straight	328 newtons	350 newtons	270 newtons	*948 newtons*	*316 newtons*
tapered straight	390 newtons	433 newtons	440 newtons	*1263 newtons*	*421 newtons*

Drag Tests

Wing / Sensor #	1	2	3	Sum	Average
delta	26 newtons	32 newtons	23 newtons	*81 newtons*	*27 newtons*
straight	65 newtons	55 newtons	60 newtons	*180 newtons*	*60 newtons*
tapered straight	40 newtons	44 newtons	39 newtons	*123 newtons*	*41 newtons*

Question 1: *delta: 607 newtons*

Question 2: *straight: 316 newtons*

Question 3: *delta: sensor #2 = 611 newtons*

Question 4: *straight: 60 newtons*

Question 5: *delta: sensor #3 = 23 newtons*

Question 6: *The delta because it has the highest lift and the lowest drag. Other answers may be appropriate if the reasoning is good.*

Graphing Results

Preparation: The lesson Wind Tunnel Averages should be completed prior to starting this lesson.

Background: When using the four Tools of Aeronautics, engineers create many billions of numbers, which altogether are called data. Wind tunnel tests, flight simulations, Computational Fluid Dynamics and flight tests all produce huge amounts of data. It is very difficult for a human to sift through and analyze millions and millions of numbers. Larger and larger computers have been built to help engineers perform their analysis tasks. One of the fastest modern computers can perform a billion mathematical operations in one second. It would take a human 406 days (without a break!) to do the same task. However, even though the computer can process the massive volumes of data generated by the Tools of Aeronautics, a human engineer is still needed to make decisions based on the data. Computers can display information in many different ways. One of the most effective methods of displaying numerical data is on a graph. Using graphs, engineers can very rapidly analyze and make decisions based upon very large amounts of data.

Directions: In this lesson, students will learn how to create a bar graph based on the averages calculated in the lesson Wind Tunnel Averages.

A bar graph has three basic parts:

Title
All bar graphs need a title that tells what kind of data is being shown.

Label for Horizontal Axis
The horizontal axis needs to have a label that identifies the type of data being displayed on that axis (for example, test flights of the X-99).

Label for Vertical Axis
The vertical axis needs to have a label that identifies the units of measurement being used (for example, the maximum altitude reached during a test flight)

Scale for Vertical Axis
The vertical axis needs to have a scale that lists the units of the measurement used (for example, one mark equals 5,000 feet)

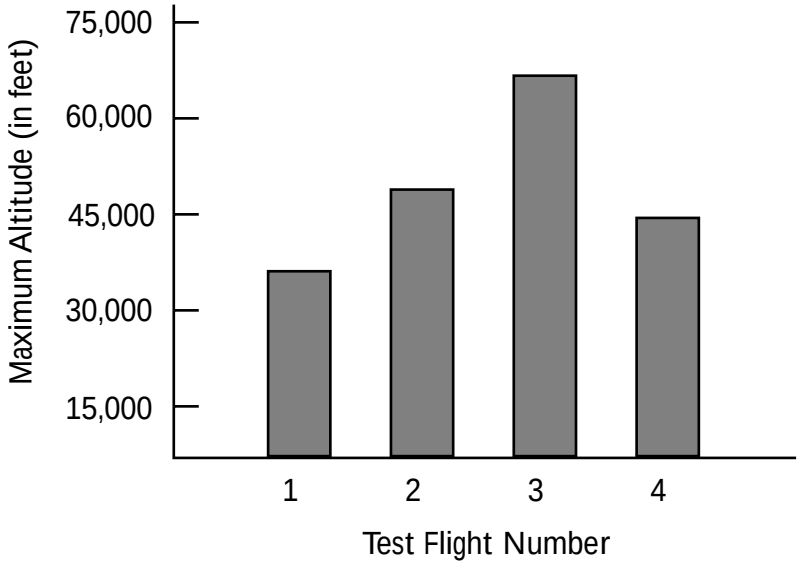
The following information has been used for the graph below.

Title - "X-99 Flight Test Results"

Label for Horizontal Axis - "Test Flight Number"

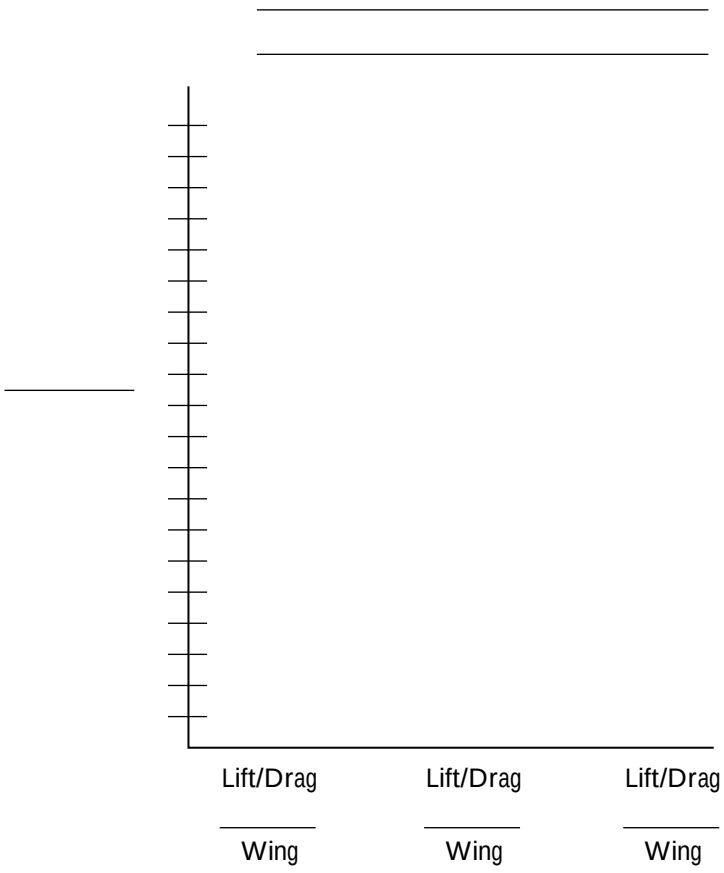
Label for Vertical Axis - "Maximum Altitude"

Example bar graph
X-99 Flight Test Results

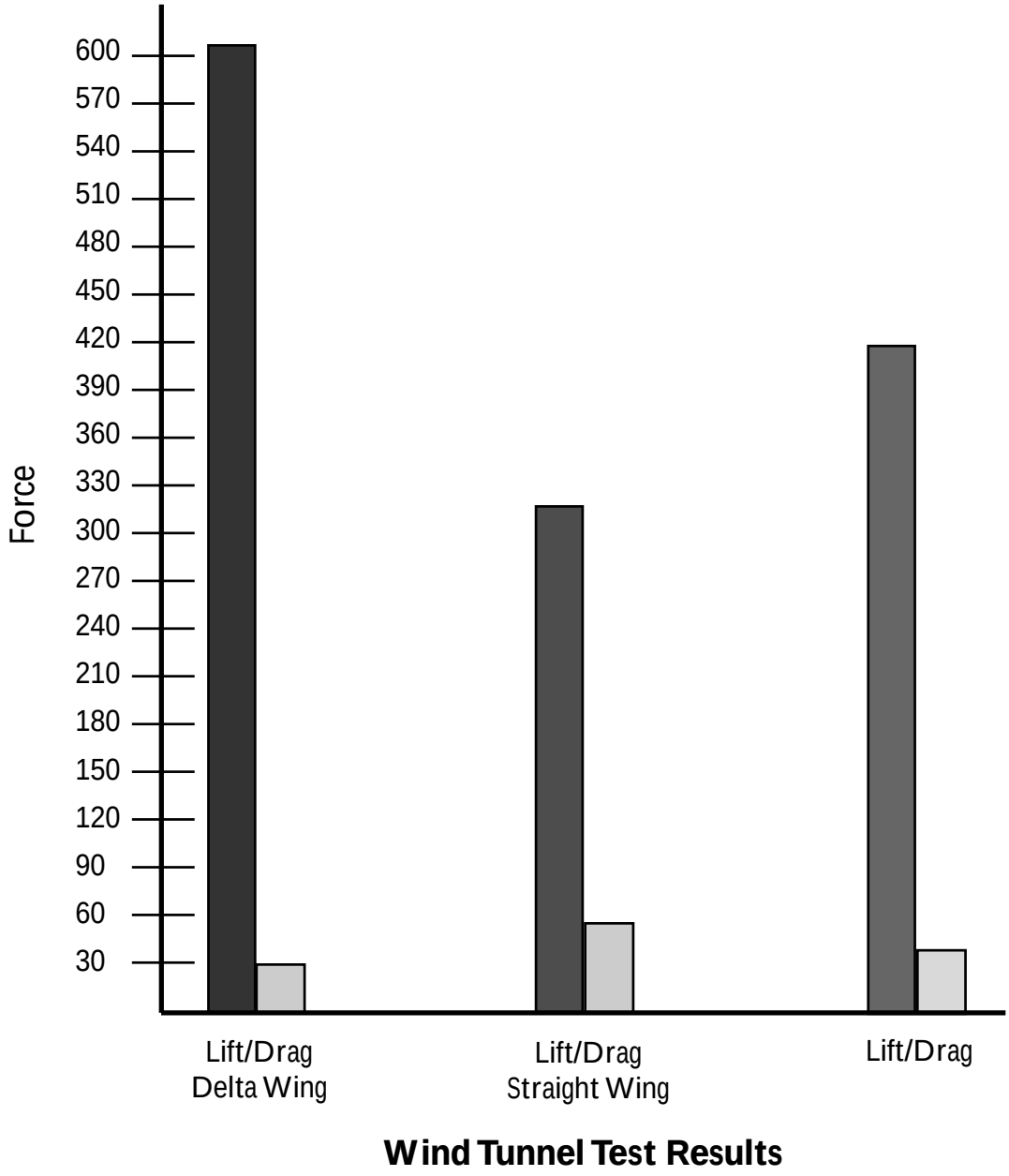


Exercise 1

Directions: Create a bar graph from the averages calculated in the lesson *Wind Tunnel Averages*. Use the template below to create your bar graph. The bar graph should display the average lift and drag for each wing type. Unlike the example bar graph, you will draw two bars for every wing type — one for lift and one for drag.



Exercise 1 – Key
Wind Tunnel Test Results



Wind Tunnel Test Results

Exploring Aeronautics: Integrating with Aeronautics Educator Guide
Aeronautical-themed Activities in Language Arts, Social Studies, and Mathematics

EDUCATOR REPLY CARD

To achieve America's goals in Educational Excellence, it is NASA's mission to develop supplementary instructional materials and curricula in science, mathematics, and technology. NASA seeks to involve the educational community in the development and improvement of these materials. Your evaluation and suggestions are vital to continually improving NASA educational materials.

Please take a moment to respond to the statements and questions below. You can submit your response through the Internet or by mail. Send your reply to the following Internet address:

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Otherwise, please return the reply card by mail. Thank you.

1. With what grades did you use the educator guide?
   Number of Teachers/Faculty:
   _____ K-4 _____ 5-8 _____ 9-12 _____ Community College
   College/University - _____ Undergraduate _____ Graduate

   Number of Students:
   _____ K-4 _____ 5-8 _____ 9-12 _____ Community College
   College/University - _____ Undergraduate _____ Graduate

   Number of Others:
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2. What is your home 5- or 9-digit zip code? __ __ __ __ __ — __ __ __ __

3. This is a valuable educator guide?
   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

4. I expect to apply what I learned in this educator guide.
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5. What kind of recommendation would you make to someone who asks about this educator guide?
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   ❑ Demonstrate NASA Materials
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   ❑ Integration Into Existing Curricula
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   ❑ Lecture
   ❑ Science and Mathematics Standards Integration
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10. Additional comments:
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