Science
Grade Six
Topics A and B
Revised Edition
### Science

#### Grade Six Outcomes

**SKILLS**

<table>
<thead>
<tr>
<th>Science Inquiry</th>
<th>Problem Solving through Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Learner Expectations</strong></td>
<td><strong>General Learner Expectations</strong></td>
</tr>
</tbody>
</table>
| *Students will:*

6-1 Design and carry out an investigation in variables are identified and controlled, and That provides a fair test of the question being investigated.

6-2 Recognize the importance of accuracy in Observation and measurements; and apply suitable method to record, compile, interpret and evaluate observations and measurements.

<table>
<thead>
<tr>
<th><strong>Specific Learner Expectations</strong></th>
<th><strong>Specific Learner Expectation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Students will:</em></td>
<td></td>
</tr>
</tbody>
</table>

**Focus:**
- Ask questions that lead to exploration and investigation.
- Identify one or more possible answers to questions by stating a prediction or a hypothesis

**Explore and Investigate**
- Identify one or more ways of finding answers to given questions.
- Plan and carry out procedures that comprise a fair test

6-3 Design and carry out an investigation of a practical problem, and develop a possible solution.

*Note:* The problem will involve construction or modification of a device that moves through air.
Science Grade 6 Topic A Air and Aerodynamics

Outcomes

- Identify variables:
  - identify the variable to be manipulated
  - identify the variables to be held constant
  - identify the variable that will be observed (responding variable)
- Select appropriate materials and identify how they will be used
- Modify the procedure as needed.
- Work individually or cooperatively in planning and carrying out procedures.
- Identify sources of information and ideas and demonstrate skill in accessing them. Sources may include library, classroom, and community.

Reflect and Interpret

- Communicate effectively with group members in sharing and evaluating ideas, and assessing progress.
- Record observations and measurements accurately, using chart format where appropriate.
- Evaluate procedures used and identify possible improvements.
- State an inference, based on results. The inference will identify a cause and effect relationship that is supported by observations.
- Identify possible applications of what was learned.
- Identify new questions that arise from what was learned.

- Attempt a variety of strategies and modify procedures, as needed (troubleshooting problems)
- Work individually or cooperatively in planning and carryout procedure.
- Identify sources of information and ideas and demonstrate skill in accessing them. Sources may include library, classroom, and community.

Reflect and Interpret

- Communicate effectively with group members in sharing and evaluating ideas, and assessing progress.
- Evaluate procedures used and identify possible improvements.
- Evaluate a design or product, based on a given set of questions or criteria. The criteria/questions may be provided by the teacher or developed by the students. Example criteria include:
  - effectiveness – Does it work?
  - reliability – Does it work every time?
  - durability – Does it stand up to repeated use?
  - effort – Is it easy to construct? Is it easy to use?
  - safety – Are there any risks of hurting oneself in making it or using it?
  - use of materials – Can it be made cheaply with available material? Does it use recycled materials, and can the materials be used again?
  - effect on environment
  - benefit to society
- Identify positive and negative impacts that may arise and potential risks that need to be monitored: What good effects and what bad effects could this solution have? What would we need to look for to be sure that it is working as intended?
- Identify new applications for the design or problem solution.
ATTITUDES

These attitudes apply across the five topics of study identified for Grade 6

General Learner Expectations

Students will:

6-4 Demonstrate positive attitudes for the study of science and for the application of science in responsible ways.

Specific Learner Expectations

Students will show growth in acquiring and applying the following traits:

- curiosity
- confidence in personal ability to learn and develop problem-solving skills
- inventiveness and open-mindedness
- perseverance in the search for understandings and for solutions to problems
- flexibility in considering new ideas
- critical-mindedness in examining evidence and determining what the evidence means
- a willingness to use evidence as the basis for their conclusions and actions
- a willingness to work with others in shared activities and in sharing of experiences
- appreciation of the benefits gained from shared effort and cooperation
- a sense of personal and shared responsibility for actions taken
- respect for living things and environments, and commitment for their care
Topic A: Air and Aerodynamics

Overview

Students explore the characteristics of air and the interaction between moving air and solids. They learn that air is a compressible fluid, that it is composed of many gases, and that moving air can support solid materials in sustained flight. By studying birds and airplanes, they learn a variety of adaptations and designs that make flight possible and that provide for propulsion and control.

General Learner Expectation

Students will:

6-5 Describe properties of air and the interactions of air with objects in flight.

Students will:

1. Provide evidence that air takes up space and exerts pressure, and identify examples of these properties in everyday applications.
2. Provide evidence that air is fluid and is capable of being compressed, and identity examples of these properties in everyday applications.
3. Describe and demonstrate instances in which air movement across a surface results in lift – Bernoulli’s principle.
4. Recognize that in order for devices or living things to fly, they must have sufficient lift to overcome the downward force of gravity.
5. Identify adaptations that enable birds and insects to fly.
6. Describe the means of propulsion for flying animals and for aircraft.
7. Recognize that streamlining reduces drag, and predict the effects of specific design changes on the drag of a model aircraft or aircraft components.
8. Recognize that air is composed of different gases, and identify evidence for different gases. Example evidence might include: effects on flames, the “using up” of a particular gas by burning or rusting, animal needs for air exchange.
Science Grade 6 Topic A Air and Aerodynamics
Outcomes

**Topic B: Flight**

**Overview**

Students apply their knowledge of aerodynamics to design, build and test a variety of flying devices. In constructing models, students develop a basic design, then build it, test it, and solve the problems that inevitably arise. Through teamwork they learn that planning, communication, cooperation and flexibility are important to the overall result, even though parts of a task can be worked on individually. In the process, students learn about the parts of an aircraft, their role in controlled flight and the differences between aircraft and spacecraft.

**General Learner Expectation**

*Students will:*

6-6 Construct devices that move through air, and identify adaptations for controlling flight.

**Specific Learner Expectations**

*Students will:*

1. Conduct tests of a model parachute design, and identify design changes to improve the effectiveness of the design.
2. Describe the design of a hot-air balloon and the principles by which its rising and falling are controlled.
3. Conduct tests of glider designs; and modify a design so that a glider will go further, stay up longer or fly in a desired way; e.g., fly in a loop, turn to the right.
4. Recognize the importance of stability and control to aircraft flight; and design, construct and test control surfaces.
5. Apply appropriate vocabulary in referring to control surfaces and major components of an aircraft. This vocabulary should include wing, fuselage, vertical and horizontal stabilizers, elevators, ailerons, rudder.
6. Construct and test propellers and other devices for propelling a model aircraft.
7. Describe differences in design between aircraft and spacecraft, and identify reasons for the design differences.

**Note:** Model aircraft or rockets may be constructed and used as part of this topic. It is recommended that these models be simple devices of the student’s construction, not prefabricated models. Propulsion of rockets by chemical fuels is neither required nor recommended, due to safety considerations.
Topic C: Sky Science

Overview

Students learn about objects in the day and night sky. Through direct observation and research, students learn about the motions and characteristics of stars, moons and planets. Using simple materials, such as balls and beads, students create models and diagrams which they use to explore the relative position and motion of objects in space. As a result of these studies, students move from a simple view of land and sky, to one that recognizes Earth as a sphere in motion within a larger universe. With new understanding, students revisit the topics of seasonal cycles, phases of the Moon and the apparent motion of stars.

General Learner Expectations

Students will:

6-7 Observe, describe and interpret the movement of objects in the sky; and identify pattern and Order in these movements.

Specific Learner Expectations

1. Recognize that the Sun and stars emit the light by which they are seen and that most other bodies in space, including Earth’s Moon, planets and their moon, comets, and asteroids, are seen by reflected light.
2. Describe the location and movement of individual stars and groups of stars (constellations) as they move through the night sky.
3. Recognize that the apparent movement of objects in the night sky is regular and predictable, and explain how this apparent movement is related to Earth’s rotation.
4. Understand that the Sun should never be viewed directly, nor by use of simple telescopes or filter, and that safe viewing requires appropriate methods and safety precautions.
5. Construct and use a device for plotting apparent movement of the Sun over the course of a day; e.g., construct a sundial or shadow stick.
6. Describe seasonal changes in the length of the day and night and in the angle of the Sun above the horizon.
7. Recognize that the Moon’s phases are regular and predictable, and describe the cycle of its phases.
8. Illustrate the phases of the Moon in drawings and by using improvised models. An improvised model might involve such things as a table lamp and a sponge ball.
9. Recognize that the other eight known planets, which revolve around the Sun, have characteristics and surface conditions that are different from Earth; and identify examples of those differences.
10. Recognize that not only Earth, but other planets, have moons; and identify examples of similarities and differences in the characteristics of those moons.
11. Identify technologies and procedures by which knowledge, about planets and other objects in the night sky, has been gathered.
12. Understand that Earth, the Sun and the Moon are part of a solar system that occupies only a tiny part of the known universe.
Topic D: Evidence and Investigation

Overview

Students sharpen their skills in observing and interpreting what they see by investigating evidence of human and animal activity. They explore and analyze indoor and outdoor environments as they look for footprints, markings, evidence of disturbance and things that are left behind. Through these studies, students learn to pose questions, devise investigations, recognize patterns and discrepancies, and think logically about what they have learned.

General Learner Expectations

Students will:

6-8 Apply observations and inference skills to recognize and interpret patterns and to distinguish a specific pattern from a group of similar practices.

6-9 Apply knowledge of the properties and interactions of materials to the investigation and identification of a material sample.

Specific Learner Expectations

Students will:

2. Observe a set of footprints, and infer the direction and speed of travel.
3. Recognize that evidence found at the scene of an activity may have unique characteristics that allow the investigator to make inferences about the participants and the nature of the activity, and give examples of how specific evidence may be used.
4. Investigate evidence and link it to a possible sources; e.g., by:
   - classifying footprints, tire prints and soil samples from a variety of locations.
   - analyzing the ink from different pens, using paper chromatography.
   - analyze handwriting samples to identify the handwriting of a specific person.
   - compare samples of fabric.
   - classifying fingerprints collected from a variety of surfaces.
Topic E: Trees and Forests

Overview

Students learn about trees as individual plants and as part of a forest ecosystem. By examining local species, they learn to recognize the characteristics of different trees and develop skill in describing and interpreting the structural features of trees. As part of their studies, students learn about a broad range of living things found on, under and around trees and study the complex interaction between trees and the larger environment. In examining human use of forests, they become aware of a broad range of environmental issues and develop awareness of the need for responsible use.

General Learner Expectation

Students will:

6-9 Describe characteristics of trees and the interaction of trees with other living things in the local environment.

Specific Learner Expectations

Students will:

1. Identify reasons why trees and forests are valued. Students meeting this expectation should be aware that forests serve as habitat for a variety of living things and are important to human needs for recreation, for raw materials and for a life-supporting environment.
2. Describe kinds of plants and animals found living on, under and among trees; and identify how trees affect and are affected by those living things.
3. Describe the role of trees in nutrient cycles and in the production of oxygen.
4. Identify general characteristics that distinguish trees from other plants, and characteristics that distinguish deciduous from coniferous trees.
5. Identify characteristics of at least four trees found in the local environment. Students should be familiar with at least two deciduous trees and two coniferous trees. Examples should include native species, such as spruce, birch, poplar, and pine and cultivated species such as elm and crab apple.
6. Describe and classify leaf shapes, leaf arrangements, branching patterns and the overall form of a tree.
7. Interpret growth pattern of a young tree, distinguishing this year’s growth from that of the previous year and from the year before that. Students meeting this expectation should recognize differences in colouration and texture of new growth and old growth, and locate scars that separate old and new growth.
8. Identify human uses of forests, and compare modern and historical patterns of use.
9. Identify human actions that enhance or threaten the existence of forests.
10. Identify an issue regarding forest use, identify different perspectives on that issue, and identify actions that might be taken.
Grade Six

Topic A

Air and Aerodynamics
## Science Grade 6 Topic A Air and Aerodynamics

**Materials List**

### Topic A

**Air and Aerodynamics**

### Materials List By Lesson

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Materials Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>large garbage bag or box, plastic bags with twist ties</td>
</tr>
<tr>
<td>2</td>
<td>globe</td>
</tr>
<tr>
<td>3</td>
<td>sweater or jacket</td>
</tr>
<tr>
<td>4</td>
<td>slices of fruit or vegetables, two test tubes, steel wool, tape, clear glass container, knife</td>
</tr>
<tr>
<td>5</td>
<td>tea light, lighter, jars of three different sizes, stop watch</td>
</tr>
<tr>
<td>6</td>
<td>tea light, lighter, baking soda, vinegar, beaker, shallow baking dish or box lid, measuring spoon, measuring cup</td>
</tr>
<tr>
<td>7</td>
<td>three textbooks</td>
</tr>
<tr>
<td>8</td>
<td>paper towel, plastic glass, medium-sized bowl</td>
</tr>
<tr>
<td>9</td>
<td>two large balloons, wire hanger, tape, Plasticine, string, balance, pin, metre stick</td>
</tr>
<tr>
<td>10</td>
<td>metre stick, newspaper</td>
</tr>
<tr>
<td>11</td>
<td>medium-sized bowl, plastic glass, large index card, water, pitcher</td>
</tr>
<tr>
<td>12</td>
<td>strips of paper (2 cm X 20 cm)</td>
</tr>
<tr>
<td>13</td>
<td>large balloons</td>
</tr>
<tr>
<td>14</td>
<td>soccer ball (or other inflated playground ball)</td>
</tr>
<tr>
<td>15</td>
<td>Balloon, 5 m piece of string, jumbo drinking straw, tape, bulldog clip</td>
</tr>
<tr>
<td>16</td>
<td>plastic bag (produce bag or Kitchen Catcher), balloon, straw, tape, bulldog clip</td>
</tr>
<tr>
<td>17</td>
<td>bicycle tire pump</td>
</tr>
<tr>
<td>18</td>
<td>strips of paper (3 cm X 15 cm)</td>
</tr>
<tr>
<td>19</td>
<td>ping pong ball, large index card, tape, glue</td>
</tr>
<tr>
<td>20</td>
<td>half sheets of paper, tape, 30 cm ruler</td>
</tr>
<tr>
<td>21</td>
<td>sheets of paper</td>
</tr>
<tr>
<td>22</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>
Comprehensive Materials List

Bags: large garbage, grocery, Kitchen catchers, twist ties
Balloons: large round, long (if available)
Ball: soccer or other inflatable playground ball, ping pong
Beakers: various
Bicycle tire pump
Bowl: medium-sized
Candles: tealights
Clips: bulldog type
Coat hanger: wire
Globe
Fruits and Vegetables with whiter flesh light banana, apple, potato
Index cards: large size
Knife
Measuring spoons, cup
Rulers: metre stick, 30 cm
Steel wool
Stop watch
Straws: jumbo (not flexible)
Sweater or jacket
Test tubes
Grade Six
Topic A
Air and Aerodynamics
Mini Textbook
Revised Edition
Contents

Part I: Air

Introduction 4

Using Our Senses to Determine Some of Air’s Properties 5

Where is Air? 6

The Atmosphere 7
   What is Air? 7
   The Layers of the Atmosphere 8

Observations and Inferences 9

More About Gases That Make Up Air 10
   Oxygen 10
   Carbon Dioxide 12

Convection Currents 13

Air Pressure 14

Using Observations to Make Inferences About the Properties of Air 15
   Air Occupies Space 15
   Air Has Mass 17

More About Air Pressure 18
   Does Air Only Press Down? 18
   Downward Air Pressure 19
   Upward Air Pressure 20
   Sideways Air Pressure 21

Let’s Look Back 22
   Activity: Air Occupies Space 23
   Are There Similarities Between Water Movement and Air Movement? 24
   Further Proof That Moving Air Reduces Air Pressure 25
Part II: Aerodynamics

Introduction

Air Can Be Compressed
  What Happens When Air Is Compressed?
  The Connection Between Compressed Air and Air Pressure
  What Happens to Compressed Air?
  Compressed Air Tries to Equalize
  The Mystery of the Moving Egg
  How Does a Tire Pump Work?

The Bernoulli Principle
  The Bernoulli Principle and Transportation
  Demonstrating the Bernoulli Principle
  Creating Lift
  The Airfoil

How an Airplane Flies

Thrust and Drag
  Thrust
  Drag
  Streamlining

Review of the Forces of Thrust, Drag Lift, and Weight

The Helicopter and the Hovercraft

Adaptations That Enable Birds to Fly

Adaptations That Enable Insects to Fly
Air and Aerodynamics

Introduction

Air is everywhere. It is a vital part of our environment. Not only does air surround the entire surface of the Earth, it is also found in the soil and dissolved in water. Without air, no living thing can survive. Humans and other species in the animal kingdom need oxygen from the air. Members of the plant kingdom need gases from the air too. They use carbon dioxide during the daytime and oxygen at night.

This spider monkey lives in the tropical rain forests of Central and South America. It can use its long tail as another arm when swinging through the trees. Like other animals, the spider monkey could not survive without air; neither could the trees and other plants in the forest.

Our knowledge of air's properties helps us to invent devices such as hot air balloons.

Air has unique properties or characteristics. It is invisible. It has no taste or smell. You cannot feel or hear it when it is still. Yet, we know it exists. Because of these properties, we can only study air by observing the effects it has on other things.

In the first part of this unit, you will learn more about the basic properties of air. In the second part of the unit, you will learn more about the properties of moving air. The study of moving air is called aerodynamics.
Part I: Air

Introduction

A property is a quality or trait that a particular thing or substance has. Every substance has a set of properties that makes it unique; that is, makes it different from other substances. Like other things, air has a set of properties that makes it unique.

Knowing about air's properties helps us to better understand the world around us. It also enables us to use this knowledge to improve the quality of our lives.

This soccer ball has been inflated by forcing air into its inside. The particles of air get squeezed together. This causes the particles to push out on the ball's inside to form a spherical object. Being filled with squeezed-together air makes the soccer ball easier to kick and makes it travel farther when kicked. From this information, can you identify one of air's properties?

Using Our Senses to Determine Some of Air's Properties

We can use our senses when thinking about some of air's properties.

1. **Air is invisible.** Look around your classroom. What do you see? Other people? Desks? Walls? Books? Pens and pencils? Notebooks? You probably see all of these and more, but you cannot see the air in the room. This is because it is invisible. This particular property is very important, because if you could see air, you would not be able to see other people and objects as clearly.

2. **Air is tasteless.** Inhale deeply through your mouth. Can you taste air? No. Air does not have a taste.

3. **Air is odourless.** Pure air has no smell. Sometimes the air appears to have a smell when particles of other substances mix with the air in your environment. When you go into the kitchen for lunch, you may be able to figure out what you will be eating by the smell. This is because tiny particles from the food get mixed into the pure air. The same goes when you get close to one of the animal barns. In the end, if the air is pure, it has no smell.
4. **Still air makes no sound.** If you go outside on a day when there is no wind (Wind is simply moving air.), the only sounds you can hear are those made by birds, animals, insects, people, and machinery. When air is not moving, it makes no sound. If still air did make noise, you would not be able to hear other sounds in your environment as clearly.

5. **You cannot feel still air.** Sit still for a moment. Can you feel the air pressing on your skin? The answer is no. You can feel air, but only when it is moving.

Air has many more properties apart from those we can observe directly using our senses. Since air is invisible, odourless, tasteless, soundless, and we cannot feel it, we can only determine most of its other properties by observing its effects on other things. By doing this, we can make inferences about many of air’s properties.

We can use our senses to make inferences about air’s properties.

**Where is Air?**

Where is air? Simply stated, air is all around us. Air is a mixture of gases. You learned in other grades that gases do not have definite shapes or volumes. This means they flow easily from one place to another and fill any empty spaces. As it is composed of gases, air moves into places that are not occupied by other solids, liquids, or gases. Air is between the strands of hair on your head. Small amounts of air are between the pages of books. Air is in the little holes of a sponge and between the fibres in your clothing. Fish and other marine animals and plants can survive because of the air dissolved in water. Air is everywhere.
The Atmosphere

Atmosphere is the name given to the layer of air that surrounds Earth. The atmosphere is less than 1000 km thick, which is relatively shallow compared to the size of the earth, which is about 12 800 km in diameter.

Air’s gases are made up of tiny particles called molecules. The reason we cannot see or feel air is because the molecules are very tiny and far apart from each other. The atmosphere is densest at Earth’s surface and becomes less dense the farther it is from Earth’s surface. At around 400 km from Earth the atmosphere is already extremely thin. On the other hand, 90% of the molecules that make up the atmosphere are located within an 11 km layer next to Earth’s surface.

What is Air?

Air consists of a mixture of gases that extends from the earth’s surface to outer space. Earth’s gravity holds the air in place. The gases of the air move about freely among one another. The principal gases of air are nitrogen and oxygen. Other gases include argon, water vapour, carbon dioxide, neon, methane, lithium, krypton, hydrogen, xenon, and ozone. Nitrogen makes up about 78% of dry air – that is, air from which all water vapour has been removed. Oxygen accounts for about 21%. The remaining 1% consists chiefly of argon, with only extremely small amounts of other gases.
The Layers of the Atmosphere

Scientists divide the earth’s atmosphere into five layers. The layers from lowest to highest are the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. As stated above, the air becomes thinner the farther you go from Earth. This means that it is easier for humans to breathe near the earth’s surface. It becomes more difficult to breathe as elevation (height of the land) increases. This is because there is less oxygen at higher elevations. Mountain climbers must be very careful because their bodies are not used to breathing air at high altitudes.

The Layers of the Atmosphere

The troposphere is the layer of the atmosphere closest to Earth – the layer in which we live. The troposphere contains more than 75% of the earth’s atmosphere. This layer is usually warmest near the earth’s surface because sunlight that passes through the air heats the ground and seas. The ground and seas, in turn, warm the air directly above.

The stratosphere extends from the troposphere to about 48 km above the earth’s surface. Very little moisture enters the stratosphere, and so clouds are very rare. Airline pilots prefer to fly in the stratosphere to stay above the weather disturbances that occur in the troposphere.

The mesosphere extends from the stratosphere to about 80 km above Earth. The temperature of the mesosphere decreases as altitude increases.

The thermosphere begins at the mesosphere and extends about 480 km above the earth. The air in the thermosphere is extremely thin. More than 99.99% of the atmosphere is below it. The temperatures in this layer are extremely high – about 600° C.

The exosphere begins at the thermosphere and eventually thins. There is almost no air in the exosphere. In fact, the air is so thin that many scientists do not even include the exosphere as part of the earth’s atmosphere.
Observations and Inferences

In science the word *observation* is used in a special way. It does not just mean “seeing something with your eyes”. *In science the word observation refers to getting information through any one of the senses: sight, hearing, taste, touch, and smell.* Most scientific observations use the sense of sight, but getting information through the other senses is important too.

If you rub a liquid between your fingers and it feels soapy, you are making an observation. If you smell a substance and find that it has the odour of burnt rubber, you have made an observation. When you pick up an object and it feels smooth, you have used your sense of touch to make an observation. In the same way we can make observations using our senses of sight and hearing.

In our daily lives we are always making observations. It is observations that help us to know what is going on in the environment. They help us make decisions about how we should dress for the day or if a certain food is spoiled and unsafe to eat.

Inferences are different from observations. We use observations to make inferences. *Inferences are conclusions we make based on what we have observed.* For example, if you step outside and smell smoke and the air looks a bluish-black colour, you would infer that something is burning. You may not have seen flames, but from what you observed you make the inference that there is a fire close by.

Examine the photograph. You can make several observations, such as

- two women are sitting on the tailgate of a pickup truck.
- there are boxes, bags, and baskets in the back of the truck.
- there are objects inside the box and the bag.
- On the left hand side someone is resting his or her forearms on the side of the truck box.
- the women have smiles on their faces.
- the women are wearing shawls, dark-coloured jackets, blouses, and dresses that fall well below their knees.

There are many other observations you could make. If you were the one who actually took the picture, you could also make observations using your other senses.

Based on your observations, you could make many inferences. On what observations might these inferences be made?

- The women are Hutterites.
- It is autumn.
- The women are at a farm.
- The women are happy.
More About Gases That Make Up Air

You learned that air is composed of many different gases. Scientists often use inference to show the presence of particular gases. On the next few pages you will learn about how we can know about the presence of two gases that are particularly important to humans. The first, oxygen, is essential for human life. The second, carbon dioxide, is a waste gas that results from animal respiration (breathing) and from combustion (burning).

Oxygen

You are already aware that our bodies need oxygen in order to survive. When we inhale, air fills our lungs. While in our lungs the oxygen is removed from the air and is carried to the cells in our bodies. Oxygen is food for our cells. Without it, they die.

**Oxygen combines easily with other things in the environment.** You can find evidence of this occurring in your everyday life.

1. **Oxygen makes some foods turn brown.** If you leave a slice of apple, potato, or banana out on a table for a few hours, what do you notice? You will most likely see that it is turning brown. This is evidence that substances in these foods are combining with oxygen to make a new substance that is brownish in colour.

When the flesh of many foods, such as apples and pears is exposed to the air, the oxygen in the air combines with substances in these foods. You can tell this is happening because the flesh turns brown. In uncut fruit the skin of these foods prevents the flesh from being exposed to the air. That is why flesh only begins to turn brown when the fruit is sliced open.

2. **Oxygen combines with metals.** Oxygen not only combines with other foods, it also combines with many different metals, such as aluminum, copper, iron, zinc, and tin. Look around the yard. You may come across a rusty nail or a rusty metal can. The rust is the result of oxygen in the air combining with the metal in the nail or can.

Rusty nails and cans are evidence that there is oxygen in the air. Oxygen combines easily with metals to form substances called oxides. The reddish-brown substance that appears on nails and cans that have been left outside is ferrous oxide, a compound made up of iron and oxygen.
3. **Oxygen is necessary for burning.** Burning (also called **combustion**) occurs when oxygen from the air combines with carbon in a substance like wood, gasoline, or natural gas, to produce either carbon dioxide gas or carbon monoxide gas as well as other substances. Without oxygen, combustion cannot take place.

Fire extinguishers work because they cut off the burning substance from the air. Without air, combustion cannot take place because combustion relies on a supply of oxygen. The fire goes out.

**Food being cooked can catch fire.** If a fire extinguisher is not available, you can cover the burning pot with a lid. This cuts the fire off from its oxygen supply.

This woman is pouring water on her campfire. Pouring water on a fire is another way of extinguishing a flame, as smothering the flames with water cuts off the oxygen supply to the fire. **WATER SHOULD NEVER BE USED TO PUT OUT A GREASE OR OIL FIRE,** HOWEVER.
Carbon Dioxide

Carbon dioxide is ever-present in the air. It is produced when animals, such as humans, exhale. Another major contributor of carbon dioxide in the air is combustion. Combustion occurs when motor vehicles burn fuel; when natural gas is burned to heat homes, heat water, and run electricity generators; when factories burn fuels to create new products; when forest burn; and when we burn garbage. The amount of carbon dioxide produced as a result of human activity is increasing every year.

Just as oxygen is essential for combustion to occur, carbon dioxide does not support burning. Carbon dioxide is an invisible gas, so it is difficult to observe. We can only detect its presence by looking for evidence of its presence. Carbon dioxide is heavier than air. For this reason, if you have a container of it, you can actually pour it into a shallow dish and it will settle to the bottom.

Many fire extinguishers, like the one to the right, use carbon dioxide to put out fires. Since carbon dioxide is heavier than air, it settles down over the flames once the extinguisher is sprayed. Carbon dioxide extinguishers are popular because they are environmentally friendly and leave no residue, making for easier clean-up. Extinguishers with carbon dioxide are used mainly in places like computer rooms, laboratories, food storage areas, and processing plants.
Air moves across the surface of the earth in the form of wind. Remember that wind is simply moving air. The sun causes wind because it heats the earth’s surface unevenly. Air above warm areas of the earth expands and becomes lighter. It then rises. Cooler air flows in to take the place of the warm rising air. These movements of air caused by the uneven heating of Earth’s surface are referred to as convection currents.

**SEA BREEZE**

AIR MOVEMENT. Wind results from the differences in the temperature of the air. For example, on a sunny day, the air above an ocean shore is warmer than the air over the water. The warmer air over the shore expands, becoming lighter, and rises. The cooler air from the sea moves in, producing a sea breeze.

*A land breeze occurs at night.* In a land breeze air moves from the land to the sea. Land loses heat much faster than water. So at night the air over the water is warmer than the air over the land. The warmer air over the water rises causing the cooler air over the land to move in to take its place.
Air Pressure

The layers of the atmosphere are rather like the blankets on a bed. If you lie under a lot of blankets, they feel heavy. The large mass of air in the atmosphere is very heavy and presses down hard on the earth. Scientists call this air pressure. Air pressure refers to the force per unit of area that air exerts. When you stand on the seashore, you are at sea level. At sea level air pressure is greatest because you are at a lower elevation and more air presses down on you. We do not usually notice the weight of air because air is much lighter than solids and liquids. Nonetheless, air has mass and presses down on the earth’s surface. Generally, the farther you go away from Earth’s surface, the lower the air pressure.

Air pressure is greatest at Earth’s surface. This is because this is where air is densest. Earth’s gravity pulls air molecules toward its surface.

An instrument called a barometer is used to measure air pressure. Barometers measure air pressure in millimetres of mercury or in units called millibars. The average atmospheric pressure at sea level is 760 millimetres or 1013 millibars.

The atmospheric pressure changes a little each day with the weather. Moving air has lower air pressure than still air. Therefore air pressure is usually lower on stormy wet days than on clear dry days. This is because on stormy days there is usually a lot of air movement. On the other hand, there is usually little air movement on clear, dry days.

You will learn more about air pressure later on in this unit.
Using Observations to Make Inferences About the Properties of Air

Because air is invisible, tasteless, odourless, and cannot be felt or heard, we must make inferences about its properties based on observations. The remaining sections of Part I of Air and Aerodynamics deal with some of air properties. Scientists have determined that air has these properties from what can be inferred.

Air Occupies Space

Air is a type of matter. *Matter is anything that takes up space and has mass.* How do we know that air takes up space? If you invert an “empty” clear plastic cup and then submerge it into a tank of water, you will notice that the water goes up into only the first centimetre or so of the cup. Why does the water not fill the entire cup? We can infer that air is occupying most of the space in the cup, preventing the water from filling it.

You can also tell that air takes up space by thinking about your lungs. When you inhale (breathe in), your lungs fill with air and because of this they get bigger. When you exhale (breathe out), you force air out of your lungs and they get smaller. If air did not occupy space, the size of your lungs would not change.
Here is another activity that can be used to show that air occupies space.

1. Line the lip of a container (like a jar) with modelling clay. Make sure the modelling clay makes a seal around the container’s lip.

2. Set a very small funnel on the modelling clay. Mold the modelling clay so that it makes a seal around the funnel. (Make sure that the only way that air can get in or out of the container is through the hole in the funnel.

3. Pour water **quickly** into the funnel until it is almost full to the brim. You will notice that only a small amount of water actually drips from the funnel and into the container.

4. Then carefully use a pencil to poke a hole through the modelling clay. You will notice that the remaining water in the funnel now easily drains into the container.

![Diagram of the activity](image)

**What happened?**

We can infer that the reason most of the water stayed in the funnel at first was because air had already occupied the space in the container. There was no room for the water. The weight of the water in the funnel was greater than the weight of air. So when the hole was made in the modelling clay, the weight of the water was great enough to push the air out through the hole, making room for the water to take its place.

From the activity, we can infer that air occupies space, can hold things up, takes the shape of its container, and can move easily from one place to another.
Air Has Mass

You learned that air occupies space, but does it have mass? The answer is yes. In fact, at this very moment, your body is supporting the mass of air that is directly above you. You do not notice it because your body has been doing this since birth. It is a normal and ongoing part of your life.

Again, we can use inference to demonstrate that air has mass.

1. Take a wire coat hanger. Straighten it out and trim it to a length of about 50 cm.

2. Use a metre stick to determine the exact centre of the straightened and trimmed coat hanger.

3. Tie a piece of string to the centre of the wire. Make sure the string is tight and secure.

4. Take two balloons, identical in size but of different colours. Tape one of the balloons to each end. Hold up the wire with the string. The wire should balance. If it does not, press a tiny piece of Plasticine onto one end until it does balance.

5. Take off one of the balloons, blow it up, and retape it to the wire.

6. Hold up the wire by the string. What do you observe? (The end of the wire with the inflated balloon goes down.

7. Next blow up the other balloon so it is the same size as the first. Tape it to the wire. Again, if necessary, balance the wire by sticking Plasticine onto one end.

8. While holding the wire by the string, pop one of the balloons with a pin. What do you observe? (End of the wire with the unpopped balloon goes down.)

What happened?

There were two instances where the wire was not balanced. The first was when one end had an inflated balloon and the other an uninflated balloon. The second was when one end had an inflated balloon and the other a popped balloon. In both instances, the end of the wire with the inflated balloon was lower that the balloon with little or no air. Since the inflated balloons contained air and the uninflated or popped balloons contained little or no air, we can infer that the end of the wire with the inflated balloon was lower because there was air in that balloon and that air has mass.
More About Air Pressure

Does Air Only Press Down?

Air exerts pressure equally in all directions and on all surfaces. It seems only to be common sense to think that because gravity pulls air molecules toward the earth’s surface, that air only presses down. However, this is not true. Air does press down, but it also presses sideways. There is also upward air pressure on an object if there is air under the object.

Why does this happen? As you now know, air’s gases are made up of minute particles of matter called molecules. These molecules move around at great speeds and in all directions. They bump into and bounce off each other while they are moving. It is this movement along with the weight of the gases that creates air pressure.

Air presses on objects from all directions.

Why don’t we feel air pressure? Air exerts pressure on all parts of our bodies. This means that air is constantly pushing on our bodies – from the top, from the sides, and from the bottom. Our bodies, in turn, exert the same amount of pressure in all directions, but outward. Our bodies automatically adjust the amount of pressure they exert outwardly to match the amount of pressure air exerts on our bodies. This is vital because if air pressure was greater than the outward pressure exerted by our bodies, our bodies would be crushed.
Downward Air Pressure

You learned that we can neither see nor feel air pressing down. Then how do scientists know that there is downward air pressure. The answer is by using inference.

Scientists use a special machine to remove all the air from a test tube. This creates a vacuum in the test tube. They then invert the test tube into a container of mercury. (Mercury is a metal that is a liquid at room temperature.) They observe that some of the mercury goes up into the test tube. They infer that this happens because air is pressing down on the surface of the mercury, pushing some of it up into the test tube. Note that it is important that no air remain in the test tube before inverting it. If any air was left in the test tube, the mercury could not push up into the test tube. This is because molecules of air are already occupying the space. There would be no room for the mercury.

Here is an activity you can do to demonstrate that air presses down on objects.

1. Put a metre stick on a table with one end sticking out well past the edge of the table.

2. Cover the portion of the ruler that is on the table with a sheet of newspaper.

3. Try to life the sheet of newspaper off the table by hitting the free end of the ruler.

What happens?

You will observe that it is difficult to raise the sheet of newspaper. Why? You can infer that this is because the total amount of force exerted by the air down on the newspaper is much greater than the force of the ruler pushing up on it.

Air pressure is about one kilogram per square centimetre. That means that your open hand is actually holding up about 50 kilograms of air! It is not only your own muscle strength that helps you withstand that kind of force on your hand; it is also the outward pressure exerted by your body.
Upward Air Pressure

Earlier you learned that air exerts pressure on objects from all sides, and this includes from the bottom. It is difficult to prove just from simple observation, but you can infer from observation that indeed air exerts upward pressure on objects.

Read the following:

1. Take a clear plastic cup and fill it with water just until it overflows.

2. Now take an index card (or piece of Bristol board or Manila tag) that is larger than the mouth of the cup.

3. Place the index card on the mouth of the cup and press down firmly, so that the index card sticks to the rim of the cup.

4. Put one hand on top of the card and invert the cup, holding the card in place.

5. Take the hand that was holding the card away slowly.

It is difficult to see, but you will notice that the girl in the photos above does not get wet, even when the cup of water is inverted over her head.

What happens?

The card stays stuck to the cup and so the water stays in the cup. It does not pour out. Why? We can infer that the reason the water stays in the cup is because the total amount of force pressing up on the card is greater than the weight of the water in the cup.
Sideways Air Pressure

Just like we could infer that air presses down on objects and up on objects, we can infer that air presses sideways. In order to do this, it is important to note that moving air has lower air pressure than still air. Furthermore, faster moving air has lower air pressure than slower moving air.

If you hold up a sheet of paper by its top edge, it will hang more or less vertically. This is because the air pressure pushing against it on one side is equal to the air pressure pushing against it from the other side. However, if we reduce the air pressure on one side of the paper only, the paper will no longer hang vertically, but move toward the side with the lower air pressure.

Following is an activity you can do to show that air presses sideways.

1. Take two empty pop cans.

2. Place them about a centimetre apart on a very smooth table.

3. Blow air through a drinking straw with a strong steady force. (Position the straw so that it is about 10 cm from the cans and about half way up the cans. Be sure that the air coming out of the straw is going directly into the space between the cans.)

What happens?

The empty pop cans slide together.

Why? Moving air has less air pressure than still air. When you blow air between the cans using the straw, that air is moving. We can infer that because moving air has less air pressure than still air, the air pressure between the cans is less than the air pressure on the “outside” areas of the cans. This causes the cans to move together.

You can do a similar activity by taking two strips of paper (2 cm X 20 cm) and holding them up by the ends in front of your mouth and blowing a steady stream of air between the strips. (Hold the strips so that they are parallel to each other and stick straight out in front of your mouth. Hold them about 5 cm apart.)

You will notice that the ends of the strips move toward each other. This is because the moving air between the strips has less air pressure than the still air on the outside of the strips. Indeed, air does press sideways.
Let’s Look Back

It is time to think back about what you have learned so far. In this unit called “Air and Aerodynamics” you have read about many different properties of air. If you recall, a property is a characteristic or trait that a substance has. Every substance as a set of properties and it is these properties that many it unique or different form other substances.

Air has many properties. So far you have learned that

- Air is invisible.
- Air is tasteless.
- Air is odourless.
- Air makes not sound when it is still.
- You cannot feel still air.
- Like all forms of matter air occupies space.
- Like all forms of matter air has mass.
- Air exerts pressure downward, sideways, and upward.

Because it is difficult to observe air directly, we must use inference to determine many of its properties.

You also learned other facts about air:

- Air is everywhere.
- Air is mixture of gases.
- Each of the gases that make up air is composed of tiny particles called molecules.
- The air that surrounds Earth is called the atmosphere.
- There are several layers in the atmosphere.
- The atmosphere becomes less dense the farther you go from Earth.

Pages 23, 24, and 25 describe some activities that scientists do to demonstrate some of air’s properties. Your teacher may want you to do one or more of them, but if not, just enjoy reading about them.
Activity: Air Occupies Space

What You Need

plastic glass
ice cream pail or plastic dishpan
medium-sized bowl or container
sheet of paper towelling

What To Do

- Place the bowl inside the ice cream pail or dishpan.
- Fill the bowl about one-third full of water.
- Stuff a piece of paper towelling into the very bottom of the glass. Then turn the glass upside down to ensure that the towel will not fall out and stay in the bottom of the glass.
- Hold the glass upside down and quickly plunge the inverted glass into the bowl of water.
- Count to 10 slowly. Lift the glass out of the water and remove the paper towel.

What Do You Observe?

You will most likely notice that the paper towelling stays completely dry.

What You Can Infer

Water from the bowl cannot get up into the plastic glass because air in the glass was already occupying that space. Also air in the glass exerts pressure down on the water, preventing it from going up into the glass.
Are There Similarities Between Water Movement and Air Movement?

Together liquids and gases form a group of substances called **fluids**. All fluids flow, so that they take the shape of the containers they are in. As you know, water is a liquid and air is composed of a mixture of gases. Scientists use the following activity to demonstrate that water and air can behave in a similar fashion.

**What You Need**

- water tap
- two spoons (plastic is best, but metal will do)

**What To Do**

- Turn on the tap so that a nice steady stream of water flows.
- Hold the spoons loosely by the fingers of each hand. Be sure the spoons are parallel to the stream of water and that you are holding the spoons by the very ends of the handles. The spoons should dangling from your fingers.
- Hold a spoon at either edge of the water stream, with the backs of the spoons against the water. The water should flow over the backs of the spoons.
- Next, move the handles away from each other so that the water only touches the tips of the spoons.

**What Do You Observe?**

When the water flows over the entire backs of the spoons, the spoons push together. When the water flows over just the tips of the spoons, they spoons fall away from each other.

**What Can You Infer?**

Remember that faster moving air has lower pressure than slower moving air. When fluids move over a curved surface, they flow faster than if they flow over a straight surface. When the water flows over the backs of the spoons, it speeds up. This causes the air pressure between the spoons to decrease. The air pressure pushing against the insides of the spoons is than greater than the air pressure pushing against the backs of the spoons, causing the back of the spoons to push together.

When the spoons are pulled apart so that the water touches just the tips, the water no longer has to flow over the curved parts of the spoons. This means that the water no longer flows faster, so that the air pressure on both sides of the spoons is about the same and the spoons no longer push together.

Scientists use the idea of fluids moving faster over curved surfaces compared to straight surfaces to make several inventions, including the airplane wing. Scientists have also learned that nature uses this same principle to enable birds and insects to fly.
Further Proof That Moving Air Reduces Air Pressure

You have learned that the fact that air is invisible has made it necessary for scientists to use inference to determine many of air’s properties. Like the previous activity, the following activity is an example of this.

What You Need

- small tin can (soup size or smaller – paper removed)
- medium-sized pillar candle
- jar lid
- Plasticine (optional)
- large straw (must be relatively large in diameter like milkshake or smoothie straw)
- lighter or matches.

What To Do

- Place the candle on the jar lid. If the candle will not stand upright, use a small piece of Plasticine to secure it.
- Place the candle about 10 cm from the can. Light the candle.
- Point the straw at the front end of the can and blow a steady strong stream of air. Be sure the end of the straw is at the same height as the candle’s flame.

What Do You Observe?

The flame goes out.

What Can You Infer?

The air from the straw is forced around the curved surface of the can. This causes the air to speed up, which results in the fast moving air having lower air pressure than the still air around it. The higher-pressured still air on both sides of the can pushes the lower-pressured, fast-moving air against the can. On the opposite side of the can, the two fast-moving streams of air are forced together. They then joined and extinguish the flame.
Part II: Aerodynamics

Introduction

In Part I of “Air and Aerodynamics” you learned about air and some of its properties. Because we cannot see, taste, and smell pure air and because we cannot feel or hear still air; we rely on inference to determine many of air properties.

In Part I, you also learned that moving air has less air pressure than still air. In Part II you will find out more about the properties of air when it is moving and how humans have used these properties to design and make devices that help do work.

Air Can Be Compressed

The photograph on the left shows a carpenter using a hammer to drive a nail into some wood. To do this he must strike the nail several times. This takes a lot of effort. The photograph on the right shows a carpenter using a pneumatic nail gun. A nail gun does the same work as a hammer, but it requires much less effort from the carpenter. The nail gun works because of another property of air: It can be compressed.
Challenge a friend to move three textbooks just by blowing at them. Of course, he or she will not be able to do it. But you can show your friend that it is indeed possible. Here is what to do:

- Open up a medium-sized plastic garbage bag. Then crumple it up. Finally, lay it on a table.
- Stack three textbooks on the bag. (Leave the open end of the bag sticking out over the edge of the table.)
- Hold the opening of the bag together, leaving a hole as small as possible.
- Blow into the bag. This will take many breaths, so take your time. Do not let any air escape from the bag. Stop and take a rest, if you need to.

You will notice that the stack of books begins to rise as you blow into the bag. The more air you put into the bag, the higher the books will rise. Your friend will be amazed, but you can explain why you were able to do it.

To find out what happened, read the following information.

What Happens When Air Is Compressed?

One of air’s properties is that it can be compressed. When air is compressed, it is squeezed together so that it takes up less space. Solids and liquids cannot be compressed, but gases and mixtures of gases, such as air, can be compressed.

Remember that all matter is made of molecules. In solids and liquids, the molecules are already so close together that they cannot be compressed; that is, the molecules cannot be squeezed any closer together. But gases are a different story. The molecules in gases are very far apart. With pressure they can be squeezed closer together. For this reason compressed gases are denser than gases that are not compressed.

The diagrams on the right show how gases can be compressed. They show how a flat disc called a piston can push down on a container of gas without allowing any of the gas to escape. The uncompressed gas on the left is less dense than the compressed gas on the right.
The Connection Between Compression and Air Pressure

When air is compressed, it is usually in some kind of closed container like a balloon or a metal tank. The more air is compressed, the greater the pressure it exerts on the inside of the container.

When you blow up a balloon, you are forcing air to flow into the balloon and compress. The air molecules push against the sides of the balloon. Because rubber is stretchy, the balloon will expand with increased pressure. The more air you force into the balloon, the more the air inside is being compressed. Compressed air has greater air pressure than non-compressed air. The compressed air exerts pressure on the side of the balloon. If there is too much pressure build-up inside the balloon, it will burst.

After a balloon has been inflated for several hours, you may notice that some of the air has escaped. This is because the air molecules are tiny enough that they can escape through the balloon material, which contains minute holes.

Air molecules trapped inside a closed container, like a balloon, are constantly in motion, hitting each other and the sides of the container. As more air is forced into the container, the molecules become more compressed. The air molecules hit each other and the sides of the container more often and with greater force. This causes increased air pressure.

Now think back to the situation where you showed your friend that you could raise a stack of three textbooks just by blowing. What caused the book to rise? Every time you blew into the garbage bag, the air pressure inside the bag increased. As the air pressure increased, the amount of force pushing out from the bag also increased until it became greater than the weight of the books. At this point the books began to rise up.

This inflated balloon can support the large book because the total amount of force pushing up from the balloon is greater than the weight of the book. The air inside the balloon is compressed, so it has greater air pressure than the air pressure outside the balloon.
What Happens to Compressed Air?

You learned that the air inside an inflated balloon is compressed. It compresses because a large amount of air is forced into the balloon and then trapped inside. If you untie the knot that keeps the balloon inflated, what happens? The air comes gushing out through the balloon’s neck. **Compressed air will always try to de-compress if it can. The air will continue to flow out of the balloon until the air pressure inside the balloon is equal to the air pressure on the outside of the balloon.**

![Compressed air will always try to escape from its container, if possible.](image)

When you allow the compressed air to escape, the balloon seems to shoot off in many different directions. If you watch carefully, you will notice that the deflating balloon never goes backwards; that is, in the same direction as the location of the balloon’s neck. In fact, it most often goes in the opposite direction.

![The compressed air from the balloon escapes through the straw and out the back. This force moves the car in the direction OPPOSITE to the escaping air.](image)

**ISAAC NEWTON.** Over 330 years ago, a British scientist named Isaac Newton, discovered that if a force is exerted in one direction, another force of equal power exerts itself in the exact opposite direction. This is what happens when compressed air shoots out of a balloon. The balloon always moves in the direction opposite to the escaping air.

![In this set up, the deflating balloon travels in the opposite direction from the escaping air.](image)
Now think back to the nail gun from page 26. How does it create enough force to pound a nail into wood? A machine called a **compressor** takes a large amount of air and forces it into a container. This compresses the air. The compressor then releases the compressed air into a hose connected to the nail gun. When the carpenter pulls the trigger on the nail gun, the compressed air enters the nail gun itself. The force created by the compressed air escaping is enough to drive the nail into the wood. If it weren’t for the fact that compressed air is always looking for a way to escape, a nail gun would not work.

![Airplane Image](image)

**Aircraft** like the one in the photograph use a special type of engine called a jet. A jet engine compresses air; then it allows the air to escape out the back. The force of the air shooting out the back is what propels the aircraft forward. The workings of a jet airplane are a good illustration of the findings of Isaac Newton. (Refer to page 29.)

![Rocket Image](image)

When scientists design rockets, they use their knowledge of how compressed air behaves. They also use the findings of Isaac Newton. Can you explain how?
Compressed Air Tries to Equalize

You now know that compressed air will always try to escape if it can. This fact leads to another property of air. **Compressed air always tries to equalize.** This means that if it can, compressed air will continue to flow from its container until the air pressure inside the container is equal to the air pressure outside the container. This process is called **equalizing.**

If air is allowed to flow freely from one container where it is under high pressure into another container where the air is under lower pressure, what do you think will happen? To find out, you could do an activity such as the following:

**What You Need**

- large sturdy balloon
- smaller plastic bag (the size of a grocery produce bag)
- bulldog clip
- straw
- tape

**What To Do**

1. Tape the opening of the plastic bag securely onto one end of the straw so that the open end of the straw is inside the opening of the bag.

2. Blow up the balloon until it is full, and secure the neck with a bulldog clip. You will need to do this as far up the neck as possible.

3. Put the other end of the straw into the balloon’s neck as far up as you can insert it.

4. Tape the straw securely to the balloon’s neck.

5. Release the bulldog clip.

**What Will You Observe?**

You will most likely notice that once you release the clip, the balloon will begin to deflate and the plastic bag will begin to inflate. After a few moments the balloon will stop deflating and the bag will stop inflating.

**What Can You Infer?**

The air pressure inside the inflated balloon is greater than the air pressure inside the plastic bag. When the air is allowed to flow between the balloon and the bag, some of air in the balloon flows into the bag. This air keeps flowing until the air pressure inside the balloon is equal to the air pressure inside the bag because compressed air always tries to equalize.
The Mystery of the Moving Egg

Here is another activity you might want to try. It also has to do with air pressure equalizing. Try to guess what will happen and then try to explain why. The explanation is quite tricky so do not worry if you are not able to offer an explanation. You will find out that it is not just compressed air that tries to equalize. *Whenever there are differing air pressures, air tries to move from an area of higher pressure to an area of lower pressure until the air pressures become equal.*

**What You Need**

Hard boiled egg, shelled
glass bottle with a long narrow neck (The neck should be just slightly smaller than the egg so that the egg can sit on the bottle’s opening without falling in.)
matches

**What To Do**

1. Put the empty glass bottle on a level, sturdy table.

2. Light a match and drop it into the bottle. Repeat three or four more times. (Do it quickly and do not wait for one match to go out before putting in the next lit match.)

3. Quickly set the egg on the mouth of the bottle.

4. Wait for a few minutes.

**What Will You Observe?**

After a few minutes, the egg will get sucked into the bottle.

**What Can You Infer?**

The lit matches heat up the air inside the bottle. When air is heated, it expands and takes up more room. As the heated air expands, some of it escapes out of the bottle. When the matches go out, the air inside the bottle starts to cool and contract. The cooled air takes up less space. This creates an area of lower pressure inside the bottle compared to the pressure outside the bottle. The greater pressure outside the bottle forces the egg to get sucked into the bottle.

**NOTE:** To get the egg back out of the bottle, tilt the bottle and blow air into it. Make sure you get out of the way because the egg may shoot out!
How Does a Tire Pump Work?

A bicycle tire pump works on the ideas that air is compressed when it is forced into a closed container. It also uses the idea that compressed air will escape if there is an opening and will continue to do so until the air pressure in the container is equal to the air pressure in the surrounding area.

BICYCLE PUMP

This hand-powered pump forces air into a storage tank or tire. On the downstroke of the piston, the air already in the cylinder is forced through the outlet check valve, while the inlet check valve is held closed by the internal pressure. When the pump handles is raised, air is sucked into the pump cylinder through the inlet check valve, and the outlet check valve is held shut.
How a Tire Pump Works

Introduction

A tire pump is a most useful device. It is usually used to inflate smaller tires like those you would find on a bicycle. It can be used to get air into wheelchair tires and playground balls. If need be, a tire pump can even be used to inflate an automobile tire.

A tire pump works on two properties that have to do with air. The first is that air can be compressed. The other is that air tries to escape from an area of high pressure to an area of low pressure until the pressure in both areas is equal.

Tire Pump Design

A tire pump is composed of a long thin hollow cylinder that stands up on its base. A piston is attached to a rod, which is in turn, is attached to a handle. A piston is a flat disk. When a person pulls the handle up, the piston moves up inside the cylinder. When the person pushes the handle down, the piston moves down inside the cylinder.

There is a little flapper on one part of the piston called the inlet valve. A valve is a device that can open and close. On the other side of the cylinder near the bottom there is another valve called the outlet valve. The outlet valve is attached to a flexible hose. The hose is what carries the air from the tire pump to the object it is going to inflate.

When the handle is pulled up, the piston moves up, the inlet valve opens, the outlet valve closes, and air enters the lower part of the cylinder.

When the handle is pushed down, the piston moves down, the inlet valve closes, the outlet valve opens, and air moves out through the hose.

How a Tire Pump Works

When the handle is lifted up, the outlet valve closes and the inlet valve opens. This allows air to fill the cylinder below the piston. When the handle is pushed down, the inlet valve closes. As the piston is pressed down, it compresses the air in the cylinder. The more the air compresses, the greater the air pressure. The compressed air forces the outlet valve open. The air then flows from the cylinder, through the hose, and into the tire. This continues until so much air has been forced into the tire that the amount of air pressure in the tire is nearing the amount of air pressure created in the tire pump cylinder.

Conclusion

The tire pump is quite a simple machine that uses properties of air to work. These principles are the same as those used to make tools like pneumatic nailers and drills work.
The Bernoulli Principle

Daniel Bernoulli was a scientist. He was born in the Netherlands to a Swiss family. Many in his family were mathematicians and scientists. One of Bernoulli’s areas of interest was fluid dynamics. Fluid dynamics is the study of moving fluids. (Remember: Fluid is term used to refer to both liquids and gases.) Through his research and experimentation, Bernoulli discovered an important property of fluids: *The pressure in a fluid decreases as the speed of its flow increases.* Today we know this particular property of fluids as the *Bernoulli Principle.*

Since air is a fluid, the Bernoulli Principle applies to moving air. The Bernoulli Principle has helped us to understand the following:

- When air moves, air pressure decreases.
- The faster air moves, the lower its pressure becomes.
- Faster moving air has lower air pressure than slower moving air.
- Moving air has lower pressure than still air.

Have you ever been passed by a large truck and had the frightening feeling of being sucked in by the truck? The Bernoulli Principle can explain why this happens. The air immediately next to the truck is moving quickly, resulting in creating an area of low pressure. The area on the other side of your car is not moving as quickly so the pressure is greater. This area of high pressure pushes against you toward the area of low pressure beside the truck.
The Bernoulli Principle and Transportation

Scientists and engineers have used the Bernoulli Principle to help in their design of many forms of transportation.

This is a photo of the world's largest passenger jet, the A380, which is manufactured by a company called Airbus. It can carry up to 875 passengers and crew. It is taller than an eight-storey building. The design of the wings of this aircraft, as well as the wings of all other airplanes, was created using the Bernoulli Principle. It is the design of the wings that gives the airplane lift. Lift is the force that keeps an aircraft afloat.

Helicopters can move forward, backward, sideways, up, and down. They can also hover (stay in one spot in the air). The blades on the rotors are shaped with the Bernoulli Principle in mind.

Unlike most other watercraft, the hovercraft skims along the surface of water. It creates a layer of air between the itself and the water. The way it moves along the water's surface uses the Bernoulli Principle.

This race car has a rear spoiler. The spoiler helps the car to grip the road.

Scientists have found that the Bernoulli Principle is evident in nature. Flying insects and birds can stay afloat because their wings are shaped in a particular way.
Demonstrating the Bernoulli Principle

The Bernoulli Principle: As a fluid increases in speed, its pressure decreases.

If two people push their hands together with the same amount of force, their hands stay in the same position. However, if one person uses more force than the other, the position of the hands changes; they do not stay in one place.

This is similar to the effects of the Bernoulli Principle when it applies to moving air. You learned in Part I of Air and Aerodynamics that air presses on objects from all sides. As long as the air pressure is close to the same on all sides of the object, the object stays in the same place. However, like the forces put forth by the hands described above, if the air pressure on one side of an object is greater than the air pressure on the other side, the object will move. Of course, if the object is very heavy, the difference in air pressure must be very great to make the object move.

In the drawing (below left), the boy has placed a card across two books of equal thickness. He tries to blow the card off the books by blowing a steady stream of air below the card. He cannot do it. Why?

As long as the air above the card and below the card is still, the air pressure above and below the card is the same. The card does not move. However, when the boy blows air under the card, it is moving faster than the air above the card. Since moving air has less pressure than still air, there is more force pressing down on the card than there is pushing up on it. The result is that the card pushes down on the books. So they boy is unsuccessful in blowing the card off the books.
Creating Lift

In order for an airplane to travel forward and stay in the air, two forces must be at work, thrust and lift.

**Thrust** is the force that makes the airplane move forward. On some aircraft, the motor turns a propeller and it is the propeller that provides the airplane with thrust. On other aircraft, the thrust is provided by a jet engine. The engine takes in air and compresses it. It then allows the compressed air to shoot out the back, propelling the airplane forward.

**Lift** is the force that keeps the airplane up in the air. The parts of an airplane that are responsible for creating lift are the wings. A cross-section cut of an airplane wing shows that its shape is an airfoil. An airfoil is designed to create an area of lower air pressure above and an area higher air pressure below. This results in the aircraft being pushed up.

Cross-section cut of an airplane wing. This shape is called an airfoil.

An airfoil helps give an aircraft lift because as it goes through the air, the air going over the wing moves faster than the air going under the wing. This results in higher air pressure under the wing than above the wing.

Basically, there are two pairs of opposite forces that are involved when it comes to flying an aircraft: lift and gravity, thrust and drag. In order to stay in the air and move forward:

- **Lift must be greater than gravity.**
- **Thrust must be greater than drag.**

**Gravity** is the force that pulls the aircraft down. **Drag** is the resistance the aircraft encounters as it goes through the air. If you have ever tried to run into the wind, you have experienced drag.

Diagram showing forces involved in flight:

- LIFT
- DRAG
- THRUST
- GRAVITY
The Airfoil

There are several different types of airfoils. Regardless of their shapes, all airfoils are designed to create lift.

As the wing moves through the air, the air divides to pass around the wing. The airfoil is curved so that the air passing above the wing moves faster than the air passing beneath. Fast-moving air has lower air pressure than slow-moving air. The air pressure is therefore greater beneath the wing than above it. This difference in air pressure forces the wing upward. Since the wings are fixed to the body of the aircraft, the whole airplane rises. This upward force is called lift.

The principle used to design airplane wings is also used to design such things as helicopter blades, propellers, spoilers (on race cars), ship’s stabilizers, and hydrofoils. The place on the airfoil where air first hits is called the leading edge. The back end of the airfoil is called the trailing edge.

On many aircraft, the pilot can actually change the shape or the angle of the airfoil slightly. He or she can do this sitting in the cockpit. The shape and angle of the airfoil affect the amount of lift the aircraft has as it moves through the air.
How an Airplane Flies

This page is a summary of what you have learned so far about how an airplane flies.

**FOUR FORCES** act on an airplane when it is flying.

- **Lift** is an upward force that holds an aeroplane in the air.
- **Thrust** is the force that moves the aeroplane forward.
- **Drag** is air resistance that holds the aeroplane back.
- **Weight** is the force that pulls the aeroplane down.

**An aeroplane's wings**
The wings of an aeroplane are a special shape, called an aerofoil. The top of the wing is curved and the bottom of the wing is straight.

**Flying Facts**

An airplane can go up and down, turn sideways, and roll over.

All airplanes have wings. The shape of the wings depends on how fast and how high an airplane is designed to fly.
Thrust and Drag

You have learned that in order to remain airborne, the force lifting an airplane must be greater than the force of gravity pulling it toward drag. It is the airfoil shape of the wings that create lift.

Thrust

It is now time to examine the forces of thrust and drag. It is thrust that enables an aircraft to move forward. In aircraft, thrust can be created in several different ways.

Propellered Aircraft. A propeller is attached to an engine. When the engine turns, the propeller rotates. The rotating propeller pushes air back, which results in the aircraft moving forward. (Remember what Sir Isaac Newton discovered?)

Jet Aircraft. Blades within the engine rotate, drawing air in. Inside the engine, the air is compressed and then allowed to shoot out the back. This propels the aircraft forward.

Birds and Flying Insects. As the wings beat up and down, they push air backwards, which propels birds and insects forward.
Drag

Drag is created by any force that opposes or resists thrust. As an aircraft speeds through the air, it pushes up against the air. This creates drag. **In order for an aircraft to move forward, thrust must be greater than drag.**

As you walk to and from school each day, you experience a small amount of drag. This is the force of air as it pushes up against your body. Your body’s muscles are so strong that they can easily overcome this resistance.

---

This man is walking into the wind. He is leaning forward as he walks to overcome the great amount of resistance created by the wind. The man’s muscles provide the thrust. The force of the wind as he walks creates drag.

---

The car’s engine creates thrust (driving force). As it travels, it pushes up against the air, which creates resistance (drag). In order for the car to move forward, the power of the engine pushing the car forward must be greater than the air pushing against it.

---

When a massive object like an airplane tries to move through the air, it needs a lot of energy to move the air it encounters out of the way. This is why airplane engines must be very powerful. The direction of the drag force is opposite the direction of the flight. The thrust force is aligned (lined up) to counter the drag force.
Streamlining

Streamlining is the shaping of an object, such as an aircraft body or wing, to reduce the amount of drag or resistance to motion through a stream of air. When an aircraft has a streamlined shape, it increases the difference between thrust and drag. The greater this difference, the more efficiently the aircraft can move through the air.

A curved shape allows air to flow smoothly around it. A flat shape fights air flow and causes more drag or resistance. To produce the least amount of drag, the leading edge of the object should be well-rounded and the body should gradually curve back from the midsection to a tapered rear section.

Scientists who study aerodynamics have discovered that air swirls around in the space immediately following the trailing edge of an object. This area is called the wake. They have also found that the smaller the wake region, the less drag on the object. For this reason, an object with a teardrop shape (diagram b) creates less resistance than an object with a more rounded shape (diagram a).

The following diagrams show how the shapes of objects affect the amount of resistance created when an object flows through the air.
A: A tractor-trailer without aerodynamic devices installed produces a large amount of drag (shown as shaded area)

Notice how the streamlined design of tractor-trailer units affects the amount of drag created.

Examine each of the following. Notice how the shapes of the objects are streamlined.

This high-speed train in Spain can travel at speeds greater than 350 km/h

The designers of these cars had reducing drag in mind.
A jumbo jet like the one pictured uses a tremendous amount of fuel to create thrust. Its streamlined design helps to reduce drag. This makes the jet more fuel efficient.

**Streamlining in Sports.** The whole idea of decreasing drag through streamlining is used by athletes. They want to position their bodies so that there is the least amount of resistance created as they travel. Notice how in each case the athlete and his or her equipment together make a streamlined shape.
Review of the Forces Thrust, Drag, Lift, and Weight

It is time to review.

**Thrust** is the force that propels an object through the air.

**Drag** is the force that opposes thrust. It is created by air resistance.

**Lift** is the force that raises an object up.

**Weight** is the force opposite lift. It is created when gravity pulls an object toward Earth.

---

Following are a few terms typically used when talking about the movement of objects through the air.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>accelerate</strong></td>
<td>speed up</td>
</tr>
<tr>
<td><strong>ascend</strong></td>
<td>go up</td>
</tr>
<tr>
<td><strong>hover</strong></td>
<td>stay suspended in one place</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>decelerate</strong></td>
<td>slow down</td>
</tr>
<tr>
<td><strong>descend</strong></td>
<td>go down</td>
</tr>
</tbody>
</table>

The relationships between the forces of thrust, drag, lift, and weight affect how an object moves.

- If lift becomes greater than weight, the object **ascends**.
- If thrust becomes greater than drag, the object **accelerates**.
- If lift becomes less than weight, the object **descends**.
- If thrust becomes less than drag, the object **decelerates**.
- If lift and weight are equal and thrust and drag are equal, the object **hovers**.
The Helicopter and the Hovercraft

The helicopter and hovercraft use some of the same technology to move through air as other modes of transportation.

The helicopter uses rotors, which are type of propeller. It uses one rotor (mounted on top) to create lift and the other (mounted at the rear) to create thrust. Helicopters are not really built for speed. Instead the main advantage of a helicopter is its ability to turn sharply and change direction quickly and in a relatively small amount of space. It is one of the few human-made devices that can hover.

The hovercraft is designed to travel over the surface of the water. It does this by creating a layer of air between itself and the water. It uses a set of propellers to create the necessary lift off the water’s surface. On the diagram below you can see these propellers mounted on top. However, in most hovercraft they are not quite as visible. Another set of propellers creates thrust, so that the hovercraft can move forward.
Adaptations That Enable Birds to Fly

Birds fly by flapping their wings up and down. This flapping gives them lift and thrust. Some birds run along the ground or water to gain momentum so that lift off is possible, just like an airplane does taking off down a runway. Their bodies are streamlined to reduce drag and their bones are hollow to reduce weight.

In the case of hovering birds (such as hummingbirds), forward motion can also start by a shallow dive. Once the bird gets going, it will then flap its wings as it flies away, relying on the backward push of air on each downstroke for thrust.

Birds have many adaptations that enable them to fly.

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>How It Enables Birds to Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth streamlined body</td>
<td>Reduces drag</td>
</tr>
<tr>
<td>Airfoil-shaped wings</td>
<td>Create lift</td>
</tr>
<tr>
<td>Large powerful muscles</td>
<td>Create thrust</td>
</tr>
<tr>
<td>Hollow bones</td>
<td>Decrease weight</td>
</tr>
<tr>
<td>Wishbone-shaped collar bone</td>
<td>Keeps shape rigid so it can withstand the force of muscles when wings are flapping</td>
</tr>
<tr>
<td>Tail that is flexible</td>
<td>Allows bird to steer itself</td>
</tr>
<tr>
<td>Tightly fitting wing feathers</td>
<td>Trap air so that can create a strong, but light-weight shape</td>
</tr>
<tr>
<td>Wings that can change shape</td>
<td>Help create thrust</td>
</tr>
<tr>
<td>Wing-tip feather can pull apart</td>
<td>Help reduce drag</td>
</tr>
</tbody>
</table>

---

48
Adaptations That Enable Insects to Fly

Many species of insects have behaviours and bodies that enable them to fly, just like birds. You have probably noticed that insects can begin flight very quickly, even more quickly than birds.

You may have observed that some insects have one pair of wings and others have two pairs. Because it is almost impossible for a human to examine an insect's wings during flight, you may not have noticed that its wings change shape as they are flapping.

Insects have many adaptations that enable them to fly.

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>How It Enables Insects to Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small and lightweight body</td>
<td>Less weight means it can create the lift necessary for flight more easily.</td>
</tr>
<tr>
<td>Can flap their wings.</td>
<td>Flapping helps insects to create both thrust and lift.</td>
</tr>
<tr>
<td>Wings are thinner and flatter than birds’ wings.</td>
<td>Because they are thinner and flatter, it is easier for the wings to “bend” when flapping.</td>
</tr>
<tr>
<td>When in flight, wings become curved on top and flat the bottom.</td>
<td>The wings essentially become an airfoil, which helps the insect create lift.</td>
</tr>
<tr>
<td>Some insects with two pairs of wings, join the front and back wings together.</td>
<td>This makes a bigger surface area to push against the air, creating greater thrust and lift.</td>
</tr>
<tr>
<td>Specialized flight muscles.</td>
<td>Help insects to move wings easily to create lift and thrust.</td>
</tr>
</tbody>
</table>
Topic A

Air and Aerodynamics

Revised Edition
Science
Grade Six

Topic A: Air and Aerodynamics

Contents

Part I: The Properties of Air

Lesson One  Air is a substance with unique properties.
Lesson Two  The Atmosphere
Lesson Three  Observations and Inferences
Lesson Four  Inferring the Presence of Oxygen
Lesson Five  Burning Uses Up Oxygen
Lesson Six (Hands On)  Inferring the Presence of Carbon Dioxide
Lesson Six (Non Hands On)
Lesson Seven  Convection Currents
Lesson Eight  Air Pressure
Lesson Nine  Air Occupies Space
Lesson Ten  Air Has Mass
Lesson Eleven  Air Presses in All Directions
Lesson Twelve  Air Pressure (Downward)
Lesson Thirteen  Air Pressure (Upward)
Lesson Fourteen  Air Pressure (Sideways)
Lesson Fifteen  The Properties of Air: Review and Extension
Lesson Sixteen  Air and Aerodynamics – Part I Review
Lesson Seventeen  Air and Aerodynamics – Part I Test
Part II: Aerodynamics

Lesson Eighteen  Air Can Be Compressed  27
Lesson Nineteen  Air and Compressibility  28
Lesson Twenty   Compressed Air Tries to Escape  29
Lesson Twenty-one  Compressed Air Tries to Equalize  30
Lesson Twenty-two  How a Tire Pump Works  31
Lesson Twenty-three  The Bernoulli Principle  32
Lesson Twenty-four  Demonstrating the Bernoulli Principle  33
Lesson Twenty-five  Creating Lift: The Airfoil  34
Lesson Twenty-six  More About the Airfoil  35
Lesson Twenty-seven  Thrust and Drag  36
Lesson Twenty-eight  Streamlining  37
Lesson Twenty-nine  Surface Area Affects Drag (Optional Lesson)  38
Lesson Thirty  Review of Thrust, Drag, Lift, and Weight (Gravity)  39
Lesson Thirty-one  Adaptations That Enable Birds to Fly  40
Lesson Thirty-two  Adaptations That Enable Insects to Fly  41
Lesson Thirty-three  Air and Aerodynamics – Part II Review  42
Lesson Thirty-four  Air and Aerodynamics – Part II Test  43
Part I of Air and Aerodynamics focuses on air: its composition and properties. It does touch briefly on some aspects of aerodynamics: convection currents and the fact that when air moves, air pressure decreases. Part I consists of a mixture of hands-on and non-hands-on activities. For those lessons where the teacher opts not to have students participate in hands-on activities, a non-hands-on alternative is provided, where possible.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On?</th>
<th>Non Hands On Option?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air is a substance with unique properties.</td>
<td>4 – 6</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>The Atmosphere</td>
<td>7 - 8</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Observations and Inferences</td>
<td>9</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Inferring the Presence of Oxygen</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Burning Uses Up Oxygen</td>
<td>11</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Inferring the Presence of Carbon Dioxide</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Convection Currents</td>
<td>13</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Air Pressure</td>
<td>14</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Air Occupies Space</td>
<td>15 – 16</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Air Has Mass</td>
<td>17</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>Air Presses in All Directions</td>
<td>18 - 21</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Air Pressure (Downward)</td>
<td>19</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>Air Pressure (Upward)</td>
<td>20</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>Air Pressure (Sideways)</td>
<td>21</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>15</td>
<td>The Properties of Air: Review/ Extension</td>
<td>22 - 25</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Air and Aerodynamics – Part I Review</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>Air and Aerodynamics – Part I Test</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson One

Concept: Air is a substance with unique properties. It can only be studied through observing its effect on other things.

Resources/Materials: Mini Textbook, pages 4 – 6
large garbage can or box
1 plastic bag with twist tie (one per student, if doing hands on)
Worksheet #6A.1a OR Worksheet #6A.1b (student copies)

Introduction: Tell the class that you have brought a sample of some material for them to study. Ask a student to take the empty garbage can or box to the front of the room. Have a student come forward to observe the contents of the garbage can. Ask him/her what he/she sees. Insist that there is something in the can. Move your hand around in the can and confirm that the substance is still in the can.

Procedure:
1. “What is the substance that you had difficulty identifying?” (air)
2. “What is air? Can you describe it? How much air is there in this container?”
3. Open the plastic bag and put it into the container, so it fills with air. Tighten one end and secure it shut with a twist tie. Then ask, “Do you think there is any more air in the can?”
4. Challenge students to describe the bag of air using their five senses. (invisible, tasteless, no odour, cannot be felt when it is still, makes no noise when still)
5. Conclude: It is difficult to study air just by looking at it, smelling it, etc. Air has to be studied by examining its effects on other things.
6. Although we cannot see the air itself, we know there is air in the plastic bag because we can see that it makes the plastic bags puff out.
7. Explain that this science unit is all about air and aerodynamics. Aerodynamics is the study of moving air. Write the definition of aerodynamics of the board and have students copy it into their notebooks.
8. Distribute Worksheet #6A.1a. Go over the directions, if necessary.
10. OPTIONAL. If you like, have students make a title page for this unit.

Assignments:
1. OPTIONAL. Make a title page.
2. Write the definition of aerodynamics into your notebook.
3. Do Worksheet #6A.1a.
4. OR Read Mini Textbook, pages 4 – 6 and do Worksheet #6A.1b.
What's in the Bag?

1. Fill a plastic bag with air. Then twist it closed.

2. Think about the substance in your plastic bag. Describe your observations by filling in the chart.

<table>
<thead>
<tr>
<th>Sense</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>See</td>
<td></td>
</tr>
<tr>
<td>Hear</td>
<td></td>
</tr>
<tr>
<td>Feel</td>
<td></td>
</tr>
<tr>
<td>Smell</td>
<td></td>
</tr>
<tr>
<td>Taste</td>
<td></td>
</tr>
</tbody>
</table>

3. Was there a substance in the bag? Tell how you know.

   ____________________________________________________________
   ____________________________________________________________

4. Name the substance. _______________________________________

5. Which sense was most useful in investigating the properties of the substance that was in the bag? Why do you say this?

   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
Directions: Use Mini Textbook, pages 4 and 5 and the top section of page 6 to help you answer these questions.

1. Explain why living things need air.

2. Define aerodynamics.

3. In science, what does the word property mean?

4. We can make observations about air's properties by using our senses. For each sense, tell about one of air's properties.
   a. sight
   b. smell
   c. hearing
   d. touch
   e. taste

5. We cannot see, smell, hear, touch, or taste air, yet we know it exists. Tell about two ways you can tell that air exists.
   a. 
   
   b. 

Worksheet #6A.1b
Science Grade 6 Topic A Air and Aerodynamics – Part I
Worksheets

**What’s in the Bag?**

1. Fill a plastic bag with air. Then twist it closed.

2. Think about the substance in your plastic bag. Describe your observations by filling in the chart.

<table>
<thead>
<tr>
<th>Sense</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>See</td>
<td><em>Air filled the bag.</em> as this would be an <em>and not an observation</em></td>
</tr>
<tr>
<td></td>
<td><em>could not see anything in the bag / box / garbage can</em></td>
</tr>
<tr>
<td></td>
<td><em>plastic bag puffed up</em></td>
</tr>
<tr>
<td>Hear</td>
<td><em>could not hear anything</em></td>
</tr>
<tr>
<td>Feel</td>
<td><em>could not feel anything</em></td>
</tr>
<tr>
<td>Smell</td>
<td><em>could only smell any odours of the garbage can / box itself</em></td>
</tr>
<tr>
<td>Taste</td>
<td><em>could not taste anything</em></td>
</tr>
</tbody>
</table>

*Answers may vary.*

3. Was there a substance in the bag? Tell how you know.

   Yes. The bag puffed up when filled with the substance from the garbage can / box.

4. Name the substance. *air*

5. Which sense was most useful in investigating the properties of the substance that was in the bag? Why do you say this?

   Probably **sight**. You see how the bag puffed up when filled, but you could not observe changes of any kind using the other senses.
Science Grade 6 Topic A Air and Aerodynamics – Part I
Worksheets

The Properties of Air

Directions: Use Mini Textbook, pages 4 and 5 and the top section of page 6 to help you answer these questions.

1. Explain why living things need air.
   - Both animals and plants need oxygen from the air.
   - Plants need carbon dioxide from the air

2. Define aerodynamics.
   - study of moving air

3. In science, what does the word property mean?
   - a quality or trait that a particular thing or substance has.

4. We can make observations about air’s properties by using our senses. For each sense, tell about one of air’s properties.
   a. sight invisible
   b. smell odourless
   c. hearing makes no sound
   d. touch cannot be felt
   e. taste tasteless

5. We cannot see, smell, hear, touch, or taste air, yet we know it exists. Tell about two ways you can tell that air exists. Answers may vary.
   a. can feel air when it moves.
   b. air makes balloons or plastic bags puff out
   - without air we cannot breathe.
Lesson Two

Concept: The Atmosphere

Resources/Materials: Mini Textbook, pages 7 and 8
- globe
  - Worksheet #6A.2 (student copies)

Introduction: Ask students how far they could run before becoming short of breath. Then explain that if they lived near the top of a mountain, they would become short of breath much more quickly. Have students offer possible reasons why. Explain that in today’s lesson they will find out more about the air that surrounds Earth.

Procedure:

1. Explain that air is really a mixture of gases. Most of the air is made up of nitrogen gas, followed by oxygen. Remind students that when we inhale, our body takes out the oxygen from the air in our lungs and transports it to the cells in our body.

2. Explain that the layer of air that surrounds the earth is called the **atmosphere**. Use a globe to shows that the atmosphere covers the entire Earth, but is relatively shallow. Explain also that scientists divide the atmosphere into several smaller layers.

3. Tell students that today, they will be reading some information about air. Then they will be copying some notes and answering some questions.

4. Have students turn to textbook, page 7. If you think students are able, have them read pages 7 and 8 independently; otherwise, guide the reading of the pages.

5. Distribute Worksheet #6A.2. Explain that there are four different activities outlined on the worksheet. Direct students to read and follow the directions.

Assignments:


2. Do Worksheet #6A.2.
ACTIVITY 1 [Notes]: To be copied

What Is the Atmosphere?

Atmosphere is the term used to describe the layer of gases that surrounds a heavenly body. Like many other heavenly bodies, Earth has an atmosphere that we call air. Our atmosphere stretches to about 1000 km above the surface of the earth. The air surrounding Earth is composed of many different gases. More than three-quarters of our air is made up of nitrogen gas. About one-fifth is oxygen, the most important gas to humans. Air contains many other gases, but they make up less than one percent of the total.

Air’s gases are made up of tiny particles called MOLECULES. The reason we cannot see or feel air is because the molecules are very small and far apart from each other. However, when the wind blows, we can feel air rushing past us.

ACTIVITY 2 [Research]: Use the article called “The Atmosphere” on Mini Textbook, pages 7 and 8 to answer the following questions. Copy each question into your notebook; then write the answer below it.

1. What do we mean by atmosphere?

2. What is the composition of air? [What gases does it contain?]

3. Why do you suppose air becomes less dense as you go away from Earth’s surface? [Hint: It has to do with Earth’s gravitational pull.]

4. Why is it more difficult to breathe at the top of Mount Everest than at sea level?

ACTIVITY 3 [Pie Chart]: Copy the pie chart from the bottom of Mini Textbook, page 7. Give your pie chart a title.

ACTIVITY 4 [Diagram]: Make sketch showing the different levels of atmosphere surrounding Earth. Label your diagram.
Lesson Three

Concept: Observations and Inferences

Resources/Materials: Mini Textbook, page 9
sweater or jacket
Worksheet #6A.3 (student copies)

NOTE: Put the sweater or jacket on BEFORE class begins.

Introduction: With the class review some of the facts about air from last class. Sometime during this review CASUALLY remove your sweater or jacket. Once the review is finished, asked students what they observed during the review.

Procedure:

1. As students suggest their observations, lead the discussion to the idea that in science, the term observation is used to refer to information we get from our environment using our senses. Observations basically tell “what”.

2. Inferences are conclusions we come to based on observations. Inferences offer possible explanations and tell such things as “why”, “how come”, or “what next”.

3. To illustrate the distinction between observation and inference, recall with students that you removed your sweater/jacket. Discuss that an observation would be that you removed your sweater/jacket. An inference would be that you felt it was too warm in the room (or that the sweater/jacket was somehow uncomfortable).

4. Have students turn to Mini Textbook, page 9. Have students read the page (or guide the reading if students are not able to read it independently).

5. Distribute Worksheet #6A.3. Go over the directions, if necessary.

6. ALTERNATELY. In notebooks, have students make a T-chart. On the left hand side have them write ten observations from the classroom. On the right hand side, have them write appropriate inferences.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorothy turned around.</td>
<td>She might have heard a noise behind her.</td>
</tr>
</tbody>
</table>

Assignments:

2. Do Worksheet #6A.3.
3. ALTERNATELY. Make a T-chart with observations and inferences.
Inferences and Observations

Directions: Use Mini Textbook, page 9 to help you answer the questions.

1. Define the terms.
   - observation _______________________________________________________
   - inference _______________________________________________________

2. Examine the photo below. Write five observations and three inferences.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6A.3
Directions: Use Mini Textbook, page 9 to help you answer the questions.

1. Define the terms.

   observation: information obtained through one of the senses
   inference: conclusion based on an observation or observations

2. Examine the photo below. Write five observations and three inferences.

   Answers may vary.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Students sitting at desks</td>
<td>· students are in school</td>
</tr>
<tr>
<td>· One girl has pencil in hand</td>
<td>· man is the German teacher</td>
</tr>
<tr>
<td>· A man is standing with hands on hips</td>
<td></td>
</tr>
<tr>
<td>· Two globes on a cabinet</td>
<td></td>
</tr>
<tr>
<td>· Pictures on walls</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Four (Two Separate Days, preferable with a one- or two-day interval)

Concept: Inferring the Presence of Oxygen

Resources/Materials: Mini Textbook, page 10
- slice of banana (or potato)
- slice of apple
- knife
- steel wool
- two test tubes
- clear glass container
- cold water
- tape
- something rusty like a nail or tin can
- Worksheets #6A.4a and #6A.4b (student copies)
- OR Worksheets #6A.4c and #6A.4d (student copies)

Introduction: Hold up the rusty nail or can. Ask students to explain what the reddish substance is and how it was formed. Discuss oxidation – the combining of oxygen with another substance to form a new substance. Tell students that we will be examining two instances of oxidation, one where fruit oxidizes and the other where iron oxidizes. Rust is the oxidation process where oxygen and iron combine.

Procedure:

1. Slice the banana and the apple. Leave them exposed to the air for at least an hour (or better yet, until the next day.)

2. Rinse the steel wool. Shake out the excess water.

3. Stuff a wad of the steel wool into the end of the test tube. The wad must be tight enough to stay at the end of the test tube.

4. Fill the glass container almost full of water.

5. Invert the test tube and place it in the container of water. Secure the test tube to the side of the container with tape.

6. Distribute copies of Worksheets #6A.4a and #6A.4b. Have students complete the first section of each worksheet.

7. NON HANDS-ON OPTION. Show the students a “browned” slice of fruit and a rusty nail or can. Explain that they are both signs that oxidation has occurred. Then guide the reading of Mini Textbook, page 10.

   Distribute Worksheets 6A.4c and #6A.4d. Go over the directions, if necessary.

Assignment:

1. HANDS ON. Complete the first sections of both Worksheet #6A.4a and #6A.4b to record predictions.

2. NON HANDS-ON OPTION. Read Mini Textbook, page 10.

   Do Worksheets #6A.4c and #6A.4d.
Lesson Four (continued) **The Next Class** (Hands-On)

1. **Apple and Banana**

   Make observations. Then discuss:

   **What caused the apple and banana to “rust”?**
   Foods such as apples, bananas, pears, and potatoes contain substances called **phenols**. When the flesh inside those foods is exposed to the air, the oxygen in the air reacts with the phenols to form a new substance, which just happens to be brown in colour. When the fruit or vegetable is bruised, the cells of the protective outer layer are damaged, allowing the oxygen in the air to enter the inside and react with the phenols.

   **How can you prevent or slow down the oxidation of the phenols? That is, how can you prevent the phenols from combining with oxygen?**
   Oxidation can be slowed by ensuring there is some ascorbic acid coating the fruit. Adding oranges or canned grapefruit will help. Also brushing the fruit with lemon juice can work. Finally, covering the bowl with plastic wrap can lessen the exposure to air.

2. **Steel Wool**

   Make observations. Then discuss:

   **Why didn’t all the steel wool rust?**
   All of the steel wool did not rust because only part of the air is oxygen(1/5). Once the oxygen was used up, no more rusting could take place.

   **Why did the water rise into the test tube? Why didn’t it go any higher?**
   The water rose up into the test tube because the oxidation process used up the oxygen in the air. In doing that it reduced the volume in the air, making room for the water to rise up and take its place. Over time, approximately 1/5 of the test tube would be filled with water.

   **How could you slow down the oxidation process?**
   Layers of oil or grease, painting, and galvanizing (coating with zinc) can slow down the rusting process.

   **Conclude:** We cannot see oxygen. But we can tell it is present in the air because it makes cut fruit and vegetables turn brown and steel wood become rusty. We cannot actually observe oxygen, we can only infer that it is present.

**Assignment:**

1. Complete the second sections of Worksheets #6A.4a and #6A.4b.
Part A
Draw and colour a diagram of this investigation.

Predict what will happen to the cut-up pieces of fruit and vegetables after one day.

Part B
Draw and colour a diagram of your observations after one day.

Record your observations.

Why did this happen? (You must use the word oxygen in your response.)
Part A
Draw and colour a diagram of this investigation.

Predict what will happen to the steel wool after one day.

Part B
Draw and colour a diagram of your observations after one day.

Record your observations.

Why did this happen? (You must use the word oxygen in your response.)
What caused the apple and banana to brown?
Foods such as apples, bananas, pears, and potatoes contain substances called phenols. When the flesh inside those foods is exposed to the air, the oxygen in the air reacts with the phenols to form a new substance, which just happens to be brown in colour. When a piece of fruit or vegetable is bruised, the cells of the protective outer layer are damaged, allowing the oxygen in the air to enter the inside and react with the phenols.

How can you prevent or slow down the oxidation of the phenols? That is, how can you prevent the phenols from combining with oxygen?
Oxidation can be slowed by ensuring there is some ascorbic acid coating the fruit. Citrus fruits, such as lemons contain ascorbic acid, so adding oranges or canned grapefruit will help. Also brushing the fruit with lemon juice can work. Finally, covering the bowl with plastic wrap can lessen the exposure to air.

3. Answer the following.

a. If you left a slice of potato or pear out on the kitchen table overnight, what would you most likely observe?

b. What can you infer about why the change takes place? (You must use the words oxygen, phenols, and oxidation in your answer.)

5. Pretend you stuffed some steel wool into the bottom of a test tube and left it for a few days; then you inverted the test tube in a dish of water, like in the diagram below. Examine the diagram and read the information in the box.

![Diagram of steel wool before and after test](image)

**Some of the steel wool rusted, but why didn’t all of it rust?**
All of the steel wool did not rust because only one-fifth of the air is oxygen. Once the oxygen was used up, no more rusting could take place.

**Why did the water rise into the test tube? Why didn’t it go any higher?**
The water rose up into the test tube because the oxidation process used up the oxygen in the air. In doing that it reduced the volume in the air, making room for the water to rise up and take its place. Over time, approximately 1/5 of the test tube would be filled with water.

**How could you slow down the oxidation process?**
Layers of oil or grease, painting, and galvanizing (coating with zinc) can slow down the rusting process.

6. Answer the following.

   a. What would you observe after a few days?

   [Blank line]

   [Blank line]

   b. What can you infer about why rust formed?

   [Blank line]

   [Blank line]

   c. Why do you think painting helps to slow down oxidation?

   [Blank line]
Part A
Draw and colour a diagram of this investigation.

Answers will vary. Students should draw and label slices/pieces of fruit, such as apple, pear, banana, or vegetables, such as potato, turnip, parsnip.

Predict what will happen to the cut-up pieces of fruit and vegetables after one day.

Answers will vary. (Turn brown, blue, depending on fruits/vegetables used)

Part B
Draw and colour a diagram of your observations after one day.

Answers will vary

Record your observations.

Answers will vary

Why did this happen? (You must use the word oxygen in your response.)

Oxygen combined with the flesh of the fruit/vegetable.
Part A
Draw and colour a diagram of this investigation.

Predict what will happen to the steel wool after one day.

Answers will vary

Part B
Draw and colour a diagram of your observations after one day.

Record your observations.

The steel wool became rusty. The water rose a little in the test tube.

Why did this happen? (You must use the word oxygen in your response.)

The iron in the steel wool combined with the oxygen to form rust.

Oxygen in the test tube was used up, so water rose to take the oxygen's place in test tube.

Worksheet #6A.4b
Inferring the Presence of Oxygen in the Air

Directions: Use Mini Textbook, page 10 as well as the information on Worksheets #6A.4c and #6A.4d to help you with the questions.

1. Read Mini Textbook, page 10 up to and including the section “Oxygen makes some foods turn brown.”

2. Pretend you had left an apple and a banana slice out overnight. The following information explains why the slices of fruit turned brown.

**What caused the apple and banana to brown?**
Foods such as apples, bananas, pears, and potatoes contain substances called **phenols**. When the flesh inside those foods is exposed to the air, the oxygen in the air reacts with the phenols to form a new substance, which just happens to be brown in colour.
When a piece of fruit or vegetable is bruised, the cells of the protective outer layer are damaged, allowing the oxygen in the air to enter the inside and react with the phenols.

**How can you prevent or slow down the oxidation of the phenols? That is, how can you prevent the phenols from combining with oxygen?**
Oxidation can be slowed by ensuring there is some ascorbic acid coating the fruit. Citrus fruits, such as lemons contain ascorbic acid, so adding oranges or canned grapefruit will help. Also brushing the fruit with lemon juice can work. Finally, covering the bowl with plastic wrap can lessen the exposure to air.

3. Answer the following.

   a. If you left a slice of potato or pear out on the kitchen table overnight, what would you most likely observe?

      **turn brown**

   b. What can you infer about why the change takes place? (You must use the words oxygen, phenols, and oxidation in your answer.)

      **Answers will vary slightly.**

      **Phenols in fruits/vegetable combine with oxygen in the air in a process called oxidation.**
4. Read the rest of Mini Textbook, page 10.

5. Pretend you stuffed some steel wool into the bottom of a test tube and left it for a few days; then you inverted the test tube in a dish of water, like in the diagram below. Examine the diagram and read the information in the box.

Some of the steel wool rusted, but why didn’t all of it rust?
All of the steel wool did not rust because only one-fifth of the air is oxygen. Once the oxygen was used up, no more rusting could take place.

Why did the water rise into the test tube? Why didn’t it go any higher?
The water rose up into the test tube because the oxidation process used up the oxygen in the air. In doing that it reduced the volume in the air, making room for the water to rise up and take its place. Over time, approximately 1/5 of the test tube would be filled with water.

How could you slow down the oxidation process?
Layers of oil or grease, painting, and galvanizing (coating with zinc) can slow down the rusting process.

6. Answer the following.

a. What would you observe after a few days?
   Some of steel wool became rusty

b. What can you infer about why rust formed?
   Oxygen combined with iron in the steel wool.

c. Why do you think painting helps to slow down oxidation?
   Paint helps prevent oxygen getting to metals such as iron, thus preventing rust formation.
Lesson Five

Concept: Burning Uses Up Oxygen

Resources/Materials: Mini Textbook, page 11  
tea candle  three glass jars of different sizes  
stop watch matches/lighter  
lid  
Worksheet #6A.5a (student copies)  
OR Worksheets #6A.5b and #6A.5c (student copies)

Introduction: Review that oxygen from the air combines with other substances. Discuss how you can pour water onto a fire to extinguish it. *Then discuss that many people think that the fire goes out simply because water cools the fire down. Actually the fire goes out because the water cuts off the supply of oxygen.* The oxygen combines with the carbon in a fuel to form carbon dioxide and carbon. Evidence of the carbon is the black smoke and some kind of black residue.

Procedure:

1. Tell students that we will be testing to see if the amount of oxygen in a closed container affects how long a candle will burn.

2. Distribute Worksheet #6A.5a. Ask students to predict how long the candle will burn in each jar before it uses up all the oxygen and goes out. (Show students the three jars. *The greater the variation in size of jars, the better.*)

3. Starting with the smallest jar, light the candle. Place the jar upside down over the candle and begin timing.

4. Have students record the time on Worksheet #6A.5a.

5. Repeat for the other two jars.

6. Discuss the relationship between the amount of oxygen and combustion (burning) time.

7. Have students complete Worksheet #6A.5a.

8. NON HANDS ON OPTION. Guide the reading of Mini Textbook, page 11. Then distribute Worksheets #6A.5b and #6A.5c. Go over the directions, if necessary.

Assignments:

2. In notebook, write the heading Oxygen and Burning.
3. Write a paragraph explaining the relationship between the amount of oxygen available and burning time.
4. NON HANDS-ON OPTION. Read Mini Textbook, page 11  
   Do Worksheets #6A.5b and #6a.5c.
How long will the candle burn?

<table>
<thead>
<tr>
<th>Size of Jar</th>
<th>Prediction (Burning Time)</th>
<th>Observation (Burning Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biggest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Inference (Why did the burning times vary?)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Worksheet #6A.5a
Directions: Use Mini Textbook, page 11 to help you with the questions.

1. What is combustion?

2. Besides some kind of fuel, what other substance is necessary for combustion?

3. Fuels are substances that burn. Name four different fuels.

4. Follow each direction.

   □ In each box draw a jar that has been inverted. Make the jar in box C as large as the box; the jar in box B about a centimetre shorter; and the jar in box A another centimetre shorter.

   □ Draw a lit candle inside each jar. Be sure that all three candles are the same size.

   □ Answer the questions on the following page.
5. Pretend that the three jars were placed over the burning candles at exactly the same time. If you watched the candles burning in the jars for a few minutes, what would you observe?

   

6. Explain why you would observe what you observed?

   

7. Explain why pouring water on a fire is usually a good way to extinguish the fire.

   

8. Substances like gasoline and oil are lighter than water. In fact if you mixed oil and water, the oil would rise to the top and the water would settle to the bottom.

   Say you were heating oil on the stove to do some deep frying and the oil caught fire. Why would it not be a good idea to put the fire out with water?

   

   What would be a better way to put out the fire? Explain why.
How long will the candle burn?

<table>
<thead>
<tr>
<th>Size of Jar</th>
<th>Prediction (Burning Time)</th>
<th>Observation (Burning Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Answers will vary</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biggest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Inference (Why did the burning times vary?)

Basically, the burning times directly correlate with the amount of oxygen in the jar. The larger the jar the longer the burning time because the larger jars have more air and consequently more oxygen.
Oxygen and Combustion

Directions: Use *Mini Textbook*, page 11 to help you with the questions.

1. What is *combustion*?
   
   burning

2. Besides some kind of fuel, what other substance is necessary for combustion?
   
   oxygen

3. Fuels are substances that burn. Name four different fuels.
   *Answers may vary.*
   
   wood
   gasoline
   coal
   diesel fuel
   propane

4. Follow each direction.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td><strong>B</strong></td>
<td><strong>C</strong></td>
</tr>
<tr>
<td>Small inverted jar + lit candle</td>
<td>medium-sized inverted jar + lit candle</td>
<td>large inverted jar + lit candle</td>
</tr>
</tbody>
</table>

☐ In each box draw a jar that has been inverted. Make the jar in box C as large as the box; the jar in box B about a centimetre shorter; and the jar in box A another centimetre shorter.

☐ Draw a lit candle inside each jar. Be sure that all three candles are the same size.

☐ Answer the questions on the following page.
5. Pretend that the three jars were placed over the burning candles at exactly the same time. If you watched the candles burning in the jars for a few minutes, what would you observe?

Candle under largest jar burned longest followed by medium-sized jar and then smallest jar.

6. Explain why you would observe what you observed?

Candle under largest jar burned longer because it had the largest supply of oxygen.

7. Explain why pouring water on a fire is usually a good way to extinguish the fire.

Water cuts off supply of oxygen to the fire.

8. Substances like gasoline and oil are lighter than water. In fact if you mixed oil and water, the oil would rise to the top and the water would settle to the bottom.

Say you were heating oil on the stove to do some deep frying and the oil caught fire. Why would it not be a good idea to put the fire out with water?

Oil would rise above water and continue burning. The water may cause the oil to spread out more, making the fire spread.

What would be a better way to put out the fire? Explain why.

Use a fire extinguisher. It will cut off oxygen supply without spreading oil.

Or put a lid on the pot, thus cutting off oxygen supply.
Lesson Six  (Hands On Option)
(Non Hands On option on page 12)

Concept: Inferring the Presence of Carbon Dioxide

Resources/Materials: baking soda vinegar
400 ml glass beaker tea candle
matches/lighter shallow baking dish or cardboard box (at least 9” X 13”)
measuring spoons measuring cup
Worksheet #6A.6a (if students will not be writing up the activity in notebooks)

Introduction: Challenge students to tell you how you can use the baking soda and vinegar to extinguish a candle.

Procedure:

1. Add 3 or 4 heaping teaspoons of baking soda to a beaker.
2. Light the candle and place it at one end of the tray.
3. Add 50 – 60 ml of vinegar to the baking soda and set the beaker down at the other end of the tray.
4. Wait for the carbon dioxide to fill up the tray and put out the candle.

Note: This activity must be done in a place that is relatively draft free.

5. With students, discuss what they observed and make inferences.

For the Teacher
The baking soda and vinegar combine. One of the substances this reaction produces is carbon dioxide. Carbon dioxide is an invisible gas, so it is difficult to observe it. We can only detect its presence by looking for evidence of its presence. Carbon dioxide is heavier than air so it pours out of the beaker and settles into the bottom of the baking dish. As the tray fills up, it reaches the height of the flame, choking off the supply of oxygen and putting it out. Carbon dioxide does not support burning.

6. Explain that the flame going out is evidence that carbon dioxide was present.

Assignment HANDS ON OPTION:

Have students write up this activity in their notebooks, or use Worksheet #6A.6a. (See sample write-up of this activity on the following page.)

Question:
What We Did:
What We Observed:
What We Can Infer:
SAMPLE WRITE UP OF ACTIVITY

Question: Does carbon dioxide support burning?

What We Did:
1. We poured three heaping teaspoons of baking soda into a beaker.
2. We then placed the beaker at one end of a paper box lid.
3. We took a tea candle and placed it at one end of a paper box lid. Then we lit the candle.
4. We poured 50 mL of vinegar into the beaker.

What We Observed:

When we added the vinegar to the baking soda, it created a fizzy mixture that overflowed the beaker. After a few moments the candle went out. Our teacher told us that when vinegar and baking soda combine, they produce carbon dioxide. He also told us that carbon dioxide is heavier than air.

What We Can Infer:

We can infer that the candle went out when carbon dioxide gas travelled from the beaker to the candle. Carbon dioxide does not support burning.
Question:  

What We Did:  

What We Observed:  

Diagram  

What We Can Infer:  

Worksheet #6A.6a
Question: Does carbon dioxide support burning?

What We Did:
We placed some baking soda and vinegar in a container and set it at one end of a paper box lid. We placed a lit candle at the other end of the paper box lid.

What We Observed:
After about a minute the flame went out.

Diagram

What We Can Infer: 

Worksheet #6A.6a
Lesson Six (Non Hands On Option)

Concept: Inferring the Presence of Carbon Dioxide

Resources/Materials: Mini Textbook, page 12
paper lunch bags (optional, one per student)
Worksheets #6A.6b and #6A.6c (student copies)

Introduction: Ask students what they think would happen if they breathed in and out of a small bag for five minutes. (Assuming that no outside air was allowed to enter the bag, students would notice that it gets harder to breathe.) Have students try it using a paper lunch bag, if you like. Review that we inhale air so that our bodies can remove the oxygen and we exhale to get rid of carbon dioxide which is a waste product from our cells. Breathing becomes more difficult as the oxygen in the bag is used up. Review that carbon dioxide is one of the gases that makes up air.

Procedure:

1. Explain that like oxygen, carbon dioxide gas is invisible, odourless, tasteless, etc. so it is difficult to observe. We can only infer that it is present.

2. Explain that scientists have discovered that carbon dioxide does not support burning. They have also found that it is heavier than air. For these reasons, many fire extinguishers use carbon dioxide to put out fires. The carbon dioxide is forced into the extinguisher so that it is under pressure. When it is released, it sprays onto the flames.


4. Distribute Worksheets #6A.6b and #6A.6c. Go over the directions, if necessary.

Assignments NON HANDS ON OPTION:

1. Read Mini Textbook, page 12.

2. Do Worksheets #6A.6b and #6A.6c.
Directions: Use *Mini Textbook*, page 12 to help you with the questions.

1. Write **P** if the phrase or sentence tells about producing carbon dioxide and **U** if it tells about using carbon dioxide.

   _____ A horse gallops around a pasture.
   _____ A baby sleeps in its crib.
   _____ Plants in the garden grow leafier.
   _____ A forest fire is started by a carelessly discarded cigarette.
   _____ A combine is harvesting wheat and barley.
   _____ Spruce trees do not grow new needles until June.
   _____ We use natural gas to heat water for our homes.

2. Read the following information. Then answer the questions on Worksheet #6A.6c.

Here are a few facts about carbon dioxide:

When you combine baking soda and vinegar, one of the substances created is carbon dioxide. Carbon dioxide is an invisible gas, so it is difficult to observe. We can only detect its presence by looking for evidence of its presence.

Carbon dioxide is heavier than air, so you can actually pour a beaker full of it into a container and it will settle to the bottom of that container. Carbon dioxide does not support combustion. For this reason it is often used in fire extinguishers.

Linda and Ruth did the following activity:

1. First, they put four heaping teaspoons of baking soda into a beaker.
2. They put a lit tea light candle at one end of a shallow paper box lid.
3. Next they added 60 mL of vinegar to the baking soda in the beaker.
4. They then set the beaker down in the paper box lid at the opposite end from where they placed the tea light.
3. Draw and label a diagram of what Linda and Ruth did.

4. What do you think Linda and Ruth observed?

5. Explain why you think this happened.

6. Linda and Ruth tried this activity outside when there was a breeze blowing. They did not get the same result. Why do you suppose this is?
Directions: Use *Mini Textbook*, page 12 to help you with the questions.

1. Write P if the phrase or sentence tells about producing carbon dioxide and U if it tells about using carbon dioxide.

   - P A horse gallops around a pasture.
   - P A baby sleeps in its crib.
   - U Plants in the garden grow leafier.
   - P A forest fire is started by a carelessly discarded cigarette.
   - P A combine is harvesting wheat and barley.
   - U Spruce trees do not grow new needles until June.
   - P We use natural gas to heat water for our homes.

2. Read the following information. Then answer the questions on Worksheet #6A.6c.

Here are a few facts about carbon dioxide:

   When you combine baking soda and vinegar, one of the substances created is carbon dioxide. Carbon dioxide is an invisible gas, so it is difficult to observe. We can only detect its presence by looking for evidence of its presence. Carbon dioxide is heavier than air, so you can actually pour a beaker full of it into a container and it will settle to the bottom of that container. Carbon dioxide does not support combustion. For this reason it is often used in fire extinguishers.

   Linda and Ruth did the following activity:

1. First, they put four heaping teaspoons of baking soda into a beaker.
2. They put a lit tea light candle at one end of a shallow paper box lid.
3. Next they added 60 mL of vinegar to the baking soda in the beaker.
4. They then set the beaker down in the paper box lid at the opposite end from where they placed the tea light.
3. Draw and label a diagram of what Linda and Ruth did.

![Diagram of a box with baking soda and vinegar reacting to produce CO2, which extinguishes a tea light under a lid.]

4. What do you think Linda and Ruth observed?

   Baking soda and vinegar fizzed up. Soon tea light went out.

5. Explain why you think this happened.

   Baking soda and vinegar combined, producing carbon dioxide. Since CO2 is heavier than air it settled in box lid, eventually extinguishing the tea light.

6. Linda and Ruth tried this activity outside when there was a breeze blowing. They did not get the same result. Why do you suppose this is?

   Answers may vary. Breeze itself could have blown out tea light before enough CO2 was formed. Breeze could have cause CO2 produced to mix with air so that insufficient amount of CO2 made its way to the tea light.
Lesson Seven

Concept: Convection Currents

Resources/Materials: Mini Textbook, page 13
Worksheets #6A.7a and #6A.7b (optional, student copies)

Introduction: Review that wind is simply moving air. Discuss that the main cause of wind is the fact that the Sun heats Earth’s surface unevenly. This is due to several reasons, which will be discussed in more detail in the unit called Weather Watch.

Next, discuss that air movements resulting from uneven heating are called convection currents. Convection currents are going on at this very moment in the classroom. This is because some parts of the classroom are warmer than others. (e.g., in winter, the area by a window is usually cooler than interior parts of the room)

Procedure:

1. Discuss that was air warms, the molecules become more active and move farther apart. This causes the air to become less dense.

2. As air becomes less dense, it rises. If there is cooler air nearby, it swoops into to take the place of the rising air.

3. Discuss that near large bodies of water there is always a breeze blowing. Have students speculate as to why.


5. Note that land heats up and cools down at a quicker rate than does water. At night near a large body of water, there is a land breeze where the wind blows from the land to the water.

6. In notebooks, have students make notes on convection currents. They should include labelled diagrams of sea and land breezes.

7. ALTERNATELY. Distribute Worksheets #6A.7a and #6A.7b. Go over the directions, if necessary.

Assignments:


2. Make notes on convection currents. OR Do Worksheets #6A.7a and #6A.7b.
Directions: Use *Mini Textbook*, page 13 to help you with the questions.

1. What is wind? ____________________________________________

2. What happens to air as it warms up? ________________________
   _________________________________________________________

3. What happens to air as it cools down? ______________________
   _________________________________________________________

4. Why do convection currents form? _________________________
   _________________________________________________________

5. In the space below draw and label a diagram of a sea breeze.
6. In the space below draw and label a diagram of a land breeze.

7. Write L for land breeze, S for sea breeze, or B for both.
   _____ wind blows from the land to the water
   _____ wind blows from the water to the land
   _____ are caused when convection currents form
   _____ occur during the day time
   _____ occur during night time
   _____ land is warmer than the water
   _____ water is warmer than the land
   _____ air above water is less dense than air above land
   _____ air above land is less dense than air above water
   _____ caused by uneven heating
Science Grade 6 Topic A Air and Aerodynamics – Part I
Worksheets

Convection Currents

Directions: Use Mini Textbook, page 13 to help you with the questions.

1. What is wind? moving air

2. What happens to air as it warms up? expands, becomes lighter (less dense), and rises

3. What happens to air as it cools down? becomes heavier (denser), falls

4. Why do convection currents form? uneven heating of Earth's surface

5. In the space below draw and label a diagram of a sea breeze.
6. In the space below draw and label a diagram of a land breeze.

7. Write L for land breeze, S for sea breeze, or B for both.
   
   L  wind blows from the land to the water
   S  wind blows from the water to the land
   B  are caused when convection currents form
   S  occur during the day time
   L  occur during night time
   S  land is warmer than the water
   L  water is warmer than the land
   L  air above water is less dense than air above land
   S  air above land is less dense than air above water
   B  caused by uneven heating
Lesson Eight

Concept: Air Pressure

Resources/Materials: Mini Textbook, page 14
three textbooks
Worksheets #6A.8a and #6a.8b (optional, student copies)

Introduction: Have a student hold both arms out (elbows bent with palms up). Place a textbook on his/her hands. Discuss that the book has weight because of Earth’s gravitational pull. Stack another book on top of the first and discuss that force of gravity is now greater. Repeat with the third textbook. Explain that at this moment air molecules are pressing down on every object and living thing on Earth, just like the textbooks are pressing down.

Procedure:

1. Recall with students that warmer air is less dense than cooler air. This means that with cool air, the molecules are close together. Explain that Earth’s gravitational pull attracts air molecules. Because of Earth’s gravity, air is denser as altitude decreases or conversely, the greater the altitude, the less dense the air. Discuss why. (Earth’s gravitational pull is strongest in locations where elevation is lowest.)

2. If necessary, discuss the difference between the terms force and pressure. (A force is a push or a pull. Force is measured in grams, kilograms, tonnes, etc. Pressure refers to the amount of force per unit of area. Pressure is measured in g/cm², kg/m², etc.)


4. Have students make point-form notes about air pressure in their notebooks OR distribute Worksheets #6A.8a and #6A.8b. Go over the directions, if necessary.

Assignments:

2. Make point-form notes on air pressure OR do Worksheets #6A.8a and #6A.8b.
Directions: Use *Mini Textbook*, page 14 to help you with the questions.

1. What is air pressure?

2. Examine the diagram. Then answer the questions. (NOTE: kPa is the symbol for a widely-used unit of pressure called the kilopascal.)

What is the relationship between elevation and air’s density?

What is the relationship between elevation and air pressure?

Why is air pressure greater where you are right this moment compared to if you were flying high up in an airplane?
3. What is a barometer?

4. If there is a blizzard outside, would a barometer show that the air pressure is rising or falling? Tell why.

5. Air is pressing down on you right all the time. Why is it that we do not notice it?

6. A marshmallow is full of tiny pockets of air. If you transported it to the top of a really high mountain, it would actually expand. Tell why.
Directions: Use *Mini Textbook*, page 14 to help you with the questions.

1. What is *air pressure*?

   force per unit of area that air exerts

2. Examine the diagram. Then answer the questions. (NOTE: kPa is the symbol for a widely-used unit of pressure called the kilopascal.)

   ![Diagram showing air pressure levels at different elevations]

   What is the relationship between elevation and air's density?

   Air's density decreases as elevation increases.

   What is the relationship between elevation and air pressure?

   Air pressure decreases as elevation increases.

   Why is air pressure greater where you are right this moment compared to if you were flying high up in an airplane?

   In airplane you are at a higher elevation compared to where you presently are.
3. What is a barometer?
   Instrument used to measure air pressure.

4. If there is a blizzard outside, would a barometer show that the air pressure is rising or falling? Tell why.
   Air pressure would be falling
   → There is wind when it is blizzarding; therefore air is moving causing air pressure to decrease.

5. Air is pressing down on you right all the time. Why is it that we do not notice it?
   We are accustomed to air pressing down
   (Also our bodies exert pressure out to neutralize overall effect.)

6. A marshmallow is full of tiny pockets of air. If you transported it to the top of a really high mountain, it would actually expand. Tell why.
   Air pressure inside the pockets of air would become greater than surrounding air as you increased altitude. Air pressure inside marshmallow would thus push out on the marshmallow causing it to swell.
Lesson Nine

Concept: Air Occupies Space

Resources/Materials: Mini Textbook, pages 15 and 16
(one set per group, if the activity is to be done independently)
plastic glass sheet of paper towelling
medium-sized bowl or container
Worksheet #6A.9a (if students will be doing the activity independently)
Worksheet #6A.9b (can be used instead of notebooks to write up the activity.)
Worksheet #6A9c (non hands-on option, student copies)

Introduction: You learned that air presses down, up, and sideways. This pressing is called air pressure. Do you think air occupies space? Today, you will find out.

Note: This activity can be done independently. Students will need the teacher’s guidance to help them make the appropriate inferences.

Procedure:

1. Fill the ice cream pail one-third full of water.

2. Stuff a piece of paper towel into the bottom of the glass. Turn the glass upside down to ensure that the towel will not fall out and stays well in the bottom of the glass.

3. Hold the glass upside down and quickly plunge the inverted glass into the pail of water.

4. Count to 10, slowly. Lift the glass out of the water and remove the paper towel.

5. What did you observe? What can you infer?

For the Teacher
The paper towel stays dry. Water could not get up into the glass because the air in the glass occupies space. Also the air in the glass exerts pressure down on the water, preventing it from going up into the glass.

6. NON HANDS-ON OPTION. Have one of the boys show how when you inhale, your chest puffs out. Discuss that the reason for this is that air fills your lungs. It takes us space. Have students turn to Mini Textbook, page 15. Guide pages 15 and 16. Then distribute Worksheet #6A.9c. Go over the directions, if necessary

Assignments:
1. HANDS ON OPTION. Write this activity up in your notebook, using the following headings (or use Worksheet #6a.9b):
   Question: Does air occupy space?
   What We Did:
   What We Observed:
   What We Can Infer:

2. NON HANDS ON OPTION. Read Mini Textbook, pages 15 and 16. Do Worksheet #6A.9c.
Does Air Occupy Space?

Do this activity to find out.

Materials:  ice cream pail or tub
            paper towel
            plastic glass
            water

1. Fill the ice cream pail one-third full of water.

2. Stuff a piece of paper towel into the bottom of the glass. Turn the glass upside down to ensure that the towel will not fall out and stays well in the bottom of the glass.

3. Hold the glass upside down and quickly plunge the inverted glass into the pail of water.

4. Count to 10, slowly. Lift the glass out of the water and remove the paper towel.

5. What did you observe?

6. What can you infer?

7. Write this activity up in your notebook, using the following headings:

   Question: Does air occupy space?

   What We Did:

   What We Observed:

   What We Can Infer:
Question: ____________________________________________________________

____________________________________________________________________

What We Did: _______________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

What We Observed: _________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

Diagram

____________________________________________________________________

What We Can Infer: _________________________________________________

____________________________________________________________________
Directions: Use Mini Textbook, pages 15 and 16 to help you with the questions.

1. For each sentence write T for true and F for false.

   ___ Matter is anything that takes up space and has mass.

   ___ Air is not considered to be matter because it is invisible.

   ___ When we inhale, our chests puff out. This demonstrates that air has mass.

   ___ Soap bubbles are filled with air.

   ___ An air mattress, like the one pictured below, feels cushiony when you lie on it because air takes up space.

   ![Air mattress image]

2. Once the potato chips are put into the bags, each bag is filled with air and then sealed. Explain why potato chip makers do this.

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

3. Explain why your lungs expand when you inhale.

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________
4. Think about the activity described on page 16. How does it demonstrate that air occupies space?

5. Examine the diagram below. Explain why the tissue paper does not get wet.

![Diagram of a glass with water and tissue paper](image)
Question: Does air occupy space?

What We Did:
- crumpled up sheet of a paper towel and stuck it into bottom of glass
- turned glass upside down
- pushed inverted glass into container of water

What We Observed:
- Water only went a little ways up into glass
- Paper towel stayed dry.

Diagram

What We Can Infer: The water did not go up into the glass because air occupied the space in the glass
Air Occupies Space

Directions: Use Mini Textbook, pages 15 and 16 to help you with the questions.

1. For each sentence write T for true and F for false.

   T  Matter is anything that takes up space and has mass.
   F  Air is not considered to be matter because it is invisible.
   F  When we inhale, our chests puff out. This demonstrates that air has mass.
   T  Soap bubbles are filled with air.
   T  An air mattress, like the one pictured below, feels cushiony when you lie on it because air takes up space.

2. Once the potato chips are put into the bags, each bag is filled with air and then sealed. Explain why potato chip makers do this.

   Air takes up space. When air is added to the bag, it protects the potato chips from getting crushed.

3. Explain why your lungs expand when you inhale.

   When you inhale, your lungs fill with air. Since air occupies space, your lungs expand in order to hold all the air you breathe in.
4. Think about the activity described on page 16. How does it demonstrate that air occupies space?

- When Plasticine sealed the funnel to the jar, air could not escape from the jar.
- When funnel was filled with water, it could not drain into jar because air already occupied the space in the jar.
- When hole was poked in the Plasticine, air in the jar could escape when water was poured into the funnel, allowing the water to drain into the jar.

5. Examine the diagram below. Explain why the tissue paper does not get wet.

Air occupies the space in the jar. When the inverted glass is pushed into the container of water, the water cannot enter the glass because air already occupies the space. Thus, the tissue paper stays dry.
Lesson Ten

Concept: Air Has Mass

Resources/Materials: Mini Textbook, page 17
NOTE: If students will do this activity independently, each group will need its own set of materials and apparatus. (Straighten and cut the wire coat hangers for the students.) They should use Worksheet #6A.3 to guide them.

- two balloons (similar size)
- tape
- Plasticine
- pin
- wire coat hanger (straightened and cut to 50 cm)
- string (20 cm)
- balance scale
- metre stick
- Worksheet #6A.10a (student copies, if students are doing the activity independently.)
- Worksheet #6A.10b (optional, student copies)

Introduction: Ask students how a balance scale works. (Demonstrate if you feel it is necessary.) Tell students they will use this same principle to demonstrate that air has weight.

Procedure:

This activity can be done independently by students; however, you may want to do it with them to model good scientific procedures.

IF YOU PLAN TO HAVE STUDENTS DO THE HANDS ON ACTIVITY INDEPENDENTLY, have students read Mini Textbook, page 17 independently first so they have an idea about what to do.

1. Use the metre to stick to find the middle of the straightened wire hanger.

2. Tie the piece of string to the centre so that it is tight and secure.

3. Hold the wire up and adjust the position of the string until the wire is balanced (level).

4. Tape a balloon onto each end of the wire.

5. Again, hold up the wire by the string. It should balance. If it does not, stick a small piece of Plasticine to one end so it does.

6. Take off one of the balloons, blow it up, and retape it to the wire.

7. Hold up the wire by the string. What do you observe? (End of wire with the blown-up balloon goes down.)

8. Next blow up the other balloon so it is the same size as the first. Tape it to the wire. Again balance it by sticking Plasticine to one end to make it balance.

9. Pop one of the balloons using the pin. What do you observe? (Unpopped end goes down.) What can you infer? (Air has mass.)

(continued next page)
10. Have students write up the activity in their notebooks as follows or on Worksheet #6A.G-1):
   
   **Question:** Does air have mass?
   
   **What We Did:** Describe and include diagrams.
   
   **What We Observed:**
   
   **What We Can Infer:**

**Assignments:**

1. Read *Mini Textbook*, page 17 (optional).
2. Do the activity described on Worksheet #6A.10a
3. Write the activity up **as shown below** OR on Worksheet #6A.10b.

---

**SAMPLE WRITE-UP OF THE ACTIVITY**

**Question:** Does air have mass?

**What We Did:**

1. We tied a string to the centre of a wire and made it balance.
2. We tied two uninflated balloons to the ends of the wire.
3. We blew up one of the balloons
4. We blew up the other balloon as well.
5. We popped one of the balloons.

**What We Observed**

When one of the balloons was inflated, the wire dipped down on the side of the inflated balloon.

When both balloons were inflated, the wire balanced.

When one of the balloons was popped, the blown-up balloon end went down.

**What We Can Infer**

The end of the wire with the blown-up balloon went down because it was filled with air, and air has mass.
Do this activity to find the answer.

**Materials:**
two balloons (same size)  
tape  
Plasticine  
metre stick  
wire coat hanger, straightened and cut to 50 cm  
string (20 cm)  
pin

1. Use the metre stick to find the centre of the wire.
2. Tie the string to the centre of the wire so it is secure.
3. Hold up the wire by the string. If the wire does not balance, adjust the position of the string until it does.
4. Tape a balloon to either end of the wire. (The balloons should not be blown up.)
5. Hold up the wire to make sure it balances. If it does not, stick a small piece of Plasticine to one end. Adjust the size of the Plasticine, as necessary.
6. Untape one of the balloons and blow it up. Retape it to the wire. Hold up the wire by the string. What do you observe? What can you infer?
7. Untape the other balloon and blow it up until it is the same size as the one on the wire. Retape it to the wire. Hold up the wire by the string. Again, if it does not balance, use a small piece of Plasticine to make it balance.
8. Hold up the balanced wire by the string. As you are holding, pop one of the balloons with a pin. What do you observe? What can you infer?
9. Write this activity up in your notebook, using these headings:

**Question:** Does air have mass?

**What We Did:**
(Tell what you did in steps. Draw and label diagrams.)

**What We Observed:**

**What We Can Infer**
Science Grade 6 Topic A Air and Aerodynamics – Part 1
Worksheets
Air Has Mass

Question:  

What We Did:  

What We Observed:  

Diagram  

What We Can Infer:  

Worksheet #6A.10b
Question: Does air have mass?

What We Did:
1. Tied a string to centre of a wire and made it balance
2. Tied two uninflated balloons to the ends of the wire
3. Blowed up one of the balloons, then both and made them balance
4. Popped one of the balloons

What We Observed:
- When one of the balloons was inflated, the wire dipped down on the side of the inflated balloon.
- When both balloons were inflated equally, the wire balanced.
- When one balloon was popped, the inflated balloon end went down.

Diagram

What We Can Infer: The end of the wire with the inflated balloon went down because it contained air. Air has mass.
Lesson Eleven

Concept: Air Presses in All Directions

Resources/Materials: Mini Textbook, pages 18 – 21
Worksheets #6A.11a and #6A.11b (student copies)

Introduction: Have a student put out one of his/her hands, palm up. With your palm press down firmly. Explain that you are pressing down on the student’s hand with a force. Then stop pressing and remove your hand altogether. Ask students how much force is pressing down on the student’s hand now. (Most will say “none”.) Explain that there is actually 50 kg of force pressing down on the student’s hand. That is the same as the weight of 50 dictionaries or encyclopaedia volumes!

Procedure:

1. Explain that air is always pressing on our bodies. We do not feel the 50 kg of force pressing down on our hands because there is also that same amount of force pressing up at the same time.

2. Explain that air presses equally on all sides of any object. Air presses down, up, and sideways.


4. Distribute Worksheets #6A.11a and #6A.11b. Go over the directions, if necessary.

Assignments:

1. Read Mini Textbook, pages 18 – 21.

2. Do Worksheets #6A.11a and #6A.11b.
More About Air Pressure

Directions: Use Mini Textbook, pages 18 – 21 to help you with the questions.

1. Fill the spaces with words that make sense.

   Air exerts pressure equally in all ________________ and on all surfaces. The molecules that make up air move around at great ________________. When the molecules of air bump against the surface of objects, they create ______ ________.

   Air exerts pressure on all surfaces of our bodies. Our bodies do not get crushed by air pressure because our bodies exert the same amount of ________________ outward.

2. Pretend you are doing the activity using the newspaper and ruler that is described on page 19 to determine whether or not air presses down. Complete the following:

   Question: ____________________________________________

   What We Did:

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

   What We Observed:

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

   What We Can Infer:

   ____________________________________________
   ____________________________________________
   ____________________________________________
3. Read the activity described on *Mini Textbook*, page 20. Then explain why you must do each of the following.

   a. Use an index card that is larger than the mouth of the cup.

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

   b. Fill the cup with water until it overflows slightly.

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

   c. Ensure that the index card sticks to the rim of the cup before you invert the cup.

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

4. Explain why the card stays stuck to the cup.

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

5. Read *Mini Textbook*, page 21. Then do the following.

   a. In the left-hand box, draw two balloons of equal size hanging from strings. The balloons should be about two cm apart. Then in the right-hand box draw what these balloons would look like if you blew air in the space between the balloons.

   ________________________________________________________________
   ________________________________________________________________

   b. Explain why the balloons behave the way they do.

   ________________________________________________________________
Directions: Use Mini Textbook, pages 18 – 21 to help you with the questions.

1. Fill the spaces with words that make sense.

   Air exerts pressure equally in all directions and on all surfaces. The molecules that make up air move around at great speeds. When the molecules of air bump against the surface of objects, they create air pressure.

   Air exerts pressure on all surfaces of our bodies. Our bodies do not get crushed by air pressure because our bodies exert the same amount of pressure outward.

2. Pretend you are doing the activity using the newspaper and ruler that is described on page 19 to determine whether or not air presses down. Complete the following:

   Question: Does air press down?

   What We Did:

   1. Placed a ruler on a table so that part of it stuck over the edge.
   2. Placed a sheet of newspaper on the table so that it covered ruler.
   3. Hit the free end of ruler to try to lift up newspaper.

   What We Observed:

   When we hit free end of the ruler, the other end could only be raised a few centimetres in the centre.

   What We Can Infer:

   Ruler could not lift newspaper off table very far because air is pressing down on newspaper.
3. Read the activity described on *Mini Textbook*, page 20. Then explain why you must do each of the following.

   a. Use an index card that is larger than the mouth of the cup.
      - must be large enough to cover opening of cup

   b. Fill the cup with water until it overflows slightly.
      - want to ensure there is no air left in cup.
      - water helps to seal card to rim of cup

   c. Ensure that the index card sticks to the rim of the cup before you invert the cup.
      - do not want water to be able to leak out once card is in place.

4. Explain why the card stays stuck to the cup.
   - Force of air pressing up on card is greater than weight of water
     pushing down on the card.

5. Read *Mini Textbook*, page 21. Then do the following.

   a. In the left-hand box, draw two balloons of equal size hanging from strings. The balloons should be about two cm apart. Then in the right-hand box draw what these balloons would look like if you blew air in the space between the balloons.

   ![Balloons](image)

   b. Explain why the balloons behave the way they do.
   - When you blow air in space between balloons, the air pressure between the decreases. Now air pressure on far outer surfaces of balloons is greater than air pressure on inner surfaces.
NOTE: Do Lessons Twelve, Thirteen, and Fourteen only if you did not do Lesson Eleven.

Lesson Twelve

Concept: Air Pressure (Downward)

Resources/Materials: Mini Textbook, page 19
(one set of materials per group, if the activity is to be done independently)
metre stick
Worksheet #6A.12a (student copies – if the activity is to be done independently)
a sheet of newspaper
Worksheet #6A.12b (student copies – can be used instead of writing up the
activity in their notebooks.

Introduction: “How strong are you?” Do you think you can use a ruler to lift a sheet of newspaper?
Today, you will get a chance to test your strength.” If you like, have students turn to Mini Textbook, page
19. Guide the reading of the page before having them do the hands on activity.

Procedure:
NOTE: This activity can be done independently. However, students may need the teacher to help
them make the appropriate inference. If students will be doing the activity independently, give each
group a set of materials and a copy of Worksheet #6A.12a.

1. Tell students they will need to observe what is happening and then be ready to infer why.

2. Put the ruler on a table with one end over the edge.

3. Cover the portion of the ruler that is on the table, with newspaper.

4. Try to lift the paper off the table by hitting the free end of the ruler.

5. What did you observe? What can you infer?

For the Teacher
The newspaper is difficult to raise up because of the air pressure on the newspaper. Air pressure is about
1 kg per square cm. That means that your open hand is actually holding up about 50 kg of air. The reason
we are not crushed by the pressure of the air is that there is also air inside us that is pressing outward and
upward with the same amount of pressure, so it equals out.

Assignments:

1. Read Mini Textbook, page 19 (optional)
2. Write up the activity in your notebooks using the following headings (OR use Worksheet
   #6A.12b):
   
   Question: Does air press down?
   
   What We Did:
   
   What We Observed:
   
   What We Can Infer:
Science Grade 6 Topic A Air and Aerodynamics – Part I
Worksheets

Does Air Press Down?

Do this activity to find out.

Materials: metre stick sheet of newspaper, unfolded

1. Put the ruler on a table with half of it sticking out over the edge.

2. Cover the portion of the ruler that is on the table with the newspaper.

3. Try and lift the newspaper sheet off the table by hitting down on the free end of the ruler.

4. What did you observe?

5. What can you infer?

6. Write this activity up in your notebook, using the following headings:

Question: Does air press down.

What We Did:

What We Observed:
(include a diagram)

What We Can Infer:
Downward Air Pressure

Question: ____________________________________________________________
__________________________________________________________
__________________________________________________________

What We Did:

__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________

What We Observed:

__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________

Diagram

What We Can Infer:

__________________________________________________________
__________________________________________________________
__________________________________________________________
Question: Does air press down?

What We Did:
We placed a ruler on a table so that part of it stuck over the edge.
We placed a newspaper on the table so that it covered the ruler.
We hit the free end of the ruler to try to lift the newspaper up.

What We Observed:
When we hit the free end of the ruler, the other end could only raise the centre of the newspaper a couple of centimetres.

Diagram

![Diagram of ruler and newspaper on a table.]

What We Can Infer:
The ruler could not lift the newspaper very far off the table because air is pressing down on the newspaper.
Lesson Thirteen

Concept: Air Pressure (Upward)

Resources/Materials: Mini Textbook, page 20
m  medium-sized bowl
pl  plastic glass
pl  pitcher
    index card
    water
Worksheet #6A.13a (student copies – if activity is to be done independently)
Worksheet #6A.13b (student copies – can be used instead of writing up the
activity in notebooks.)

Introduction: Remind students that in the last activity, they found that air presses down. But, does it
press up? They will find out today.

Note: This activity can be done independently by students, using Worksheet #6A.13a. However, students
will need the teacher to guide the inference.

Procedure:

1. Put the glass at the bottom of the ice cream pail.

2. Carefully fill the glass with water so that the water overflows slightly.

3. Carefully place the index card on top of the glass. Press down on the card to make sure the card is
   sticking to the glass all the way around. (Press down on the index card and run your finger all
   around the rim.)

4. Use one hand to hold the glass, the other to firmly hold the index card in place. Quickly, but
carefully, turn the glass upside down.

5. Gently, let go of the index card.

6. What did you observe? What can you infer?

7. If you like, have students read Mini Textbook, page 20 independently. The information on this
   page will explain why the index card stays in place.

Assignment:

Write up the activity in you notebook, using these headings (or use Worksheet #6A.13b):

Question: Does air press up?
What We Did:
What We Observed:
   (include diagram)
What We Can Infer:
Does Air Press Up?

Do this activity to find the answer.

**Materials:**
- plastic glass
- ice cream pail or tub
- water
- index card
- container that can be used to pour water

1. Place the glass in the bottom of the pail.
2. Carefully, pour water to fill the glass until it overflows slightly.
3. Carefully, place the index card on the top of the glass. Press down slightly to ensure that the card is touching the glass all the way around its rim.
4. Use one hand to hold the glass, the other to hold the index card in place. Quickly, but carefully turn the glass upside down. *Make sure the index card stays in place, Do not bend the index card.*
5. Gently, let go of the index card.
6. What did you observe?
7. What can you infer?
8. Write this activity up in your notebook, using the following headings:

  **Question:** Does air press up?
  
  **What We Did:**
  
  **What We Observed:**
  
  **What We Can Infer:**

---

Worksheet #6A.13a
Science Grade 6 Topic A Air and Aerodynamics – Part I
Worksheets

Upward Air Pressure

Question: ________________________________________________________________

______________________________________________________________________

What We Did:
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

What We Observed:
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Diagram

What We Can Infer:
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Worksheet #6A.13b
Question: **Does air press up?**

**What We Did:**
- We filled a glass with water just until it overflowed.
- We placed an index card over the mouth of the glass and pressed down.
- We placed one hand over the index card and used the other hand to turn the glass upside down.

**What We Observed:**
- When we turned the glass upside down, the index card stayed in place.

**Diagram**

```
index card
  /
/  
water

  
  
glass

index card

  
  
glass

  

water
```

**What We Can Infer:**
- The index card stayed in place because air pressed upward on it, preventing it from falling off.
Lesson Fourteen

Concept: Air Pressure (Sideways)

Resources/Materials: Mini Textbook, page 21
(one set of materials for each group, if the activity is to be done independently)
Two strips of paper (2 cm X 20 cm)
Worksheet #6A.14a (one copy per group, if it is to be done independently)
Worksheet #6A.14b (can be used instead of notebooks to write up the activity)

Introduction: You have found that air presses down and also up. Does it press sideways? You will find out today.

Note: This activity can be done independently. The students will need guidance to make the appropriate inferences, however.

Procedure:

1. If you like, guide the reading of Mini Textbook, page 21 as an introduction to this activity.

2. Put one strip of paper in each hand and hold by the end of the strip.

3. Hold the strips of paper in front of your mouth, so they are about 5 cm apart, with the short ends by your mouth.

4. Blow steadily between them. 

5. What do you observe?

6. What can you infer?

For the Teacher

Blowing between the strips caused the air to move. The moving air between the strips has less air pressure than the still air on the outside of the strips. Therefore, the force of the still air on the outside of the strips is greater than that of the moving air inside the strips, causing the strips to come together.

Assignments:

Write this activity up in your notebook, using the following headings (or use Worksheet #6A.G-1):

Question: Does air press sideways?

What We Did:

What We Observed:

What We Can Infer:
Does Air Press Sideways?

Do this activity to find out.

**Materials:** two strips of paper (2 cm X 20 cm)

1. Put one strip of paper in each hand and hold by the ends of the strips.
2. Hold the strips of paper in front of your mouth, so they are about 5 cm apart, with the short ends by your mouth.
3. Blow steadily between them.
4. What do you observe?
5. What can you infer?

6. Write this activity up in your notebook, using the following headings:

   **Question:** Does air press sideways?

   **What We Did:**

   **What We Observed:**

   **What We Can Infer:**
Sideways Air Pressure

Question: ____________________________

What We Did: ____________________________________________________________________

What We Observed: __________________________________________________________________

Diagram

What We Can Infer: __________________________________________________________________
Question: Does air press sideways?

What We Did:
We held two strips of paper in front of our mouths about 5 cm apart.
We then blew steadily between the strips.

What We Observed:
The ends of the strips moved together.

Diagram

What We Can Infer:
Air pressed the strips together.
Lesson Fifteen (Optional)

Note: *Mini Textbook*, pages 23 – 25 describes three activities that you may want your students to try. However, this is optional and can be done as time permits.

Concept: The Properties of Air: Review and Extension

Resources/Materials: Mini Textbook, pages 22 – 25
  Worksheets #6A.15a and #6A.15b (student copies)

Introduction: Explain that so far in Topic A students have learned about many properties of air. Recall that we must use inference to determine many of them. Without looking in the mini textbook, challenge them to come up with as many of air’s properties as possible. Write them on the board as they are suggested.

Procedure:

1. Have students compare the list on the board with the ones on *Mini Textbook*, page 22.

2. Then have students read (independently if they are able) *Mini Textbook*, pages 23 – 25.

3. Distribute Worksheets #6A.15a and #6A.15b. Go over the directions, if necessary.

Assignments:


2. Do Worksheets #6A.15a and #6A.15b
Directions: Use Mini Textbook, pages 22 – 25 to help you with the questions.

1. Write O if the sentence tells about an observation and I if it tells about an inference.

   ______ Air presses equally on an object from all directions.

   ______ If you inhale deeply, you cannot smell air if it is pure.

   ______ Air is made up of tiny particles called molecules.

   ______ If you blow air between two Christmas balls that are close together, they will move toward each other.

   ______ Air takes up space.

   ______ Moving air has less air pressure than still air.

   ______ The atmosphere is pulled to Earth by Earth’s gravity.

2. Look at the diagram on page 23. The water is labelled, but it is not drawn in. In the box below draw and label a similar diagram; then draw in the water.
3. Read the activity described on page 24. What do you think would happen if you turned the spoons so that the water flowed between the insides of the spoons instead of over the backs of the spoons? Tell why.

____________________________________________________

____________________________________________________

____________________________________________________

____________________________________________________

4. Read the activity described on page 25.

Benjamin tried the activity, but when he did it, the candle stayed lit. It would not go out. See if you can come up with three possible reasons why Benjamin could not get the candle to go out.

a. ___________________________________________________

b. ___________________________________________________

c. ___________________________________________________
Directions: Use *Mini Textbook*, pages 22 – 25 to help you with the questions.

1. Write O if the sentence tells about an observation and I if it tells about an inference.
   - [ ] Air presses equally on an object from all directions.
   - [ ] If you inhale deeply, you cannot smell air if it is pure.
   - [ ] Air is made up of tiny particles called molecules.
   - [ ] If you blow air between two Christmas balls that are close together, they will move toward each other.
   - [ ] Air takes up space.
   - [ ] Moving air has less air pressure than still air.
   - [ ] The atmosphere is pulled to Earth by Earth’s gravity.

2. Look at the diagram on page 23. The water is labelled, but it is not drawn in. In the box below draw and label a similar diagram; then draw in the water.
3. Read the activity described on page 24. What do you think would happen if you turned the spoons so that the water flowed between the insides of the spoons instead of over the backs of the spoons? Tell why.

Answers will vary.

Probably the spoons would not move together. The water flowing between the insides of the spoons would not do so at a great enough speed to cause an air pressure differential.

4. Read the activity described on page 25.

Benjamin tried the activity, but when he did it, the candle stayed lit. It would not go out. See if you can come up with three possible reasons why Benjamin could not get the candle to go out. Answers may vary.

   a. Person not blowing hard enough

   b. Air stream not aimed accurately enough

   c. Can is too big in diameter

   d. Person did not blow steadily
Lesson Sixteen

Concept: Air and Aerodynamics – Part I Review

Resources/Materials: Air and Aerodynamics – Part I Review Sheets (student copies)

Introduction: Explain that the first half of the unit on Air and Aerodynamics is now almost complete and it is time to prepare for a test.

Procedure:

1. If you have the time, briefly go over the concepts and skills covered to date.
2. 
Lesson Sixteen

Concept: Air and Aerodynamics – Part I Review

Resources/Materials: Air and Aerodynamics – Part I Review Sheets (student copies)

Introduction: Explain that the first half of the unit on Air and Aerodynamics is now almost complete and it is time to prepare for a test.

Procedure:

1. If you have the time, briefly go over the concepts and skills covered to date.
   - Air is matter.
   - We use our senses to observe many of air’s properties.
   - We must use inference to determine many of air’s properties.
   - The air around Earth is called atmosphere.
   - Air is composed of many different gases.
   - Oxygen and carbon dioxide are two gases that greatly impact living things.
   - Convection currents are moving air caused by uneven heating.
   - Air occupies space.
   - Air has mass
   - Air presses on objects from all sides
   - Air pressure decreases with altitude.

2. Distribute the Air and Aerodynamics – Part I Review Sheets. Have students work on them independently. If you have the time, check them in class as a group.

Assignment:

Do the Air and Aerodynamics – Part I Review Sheets.
1. Define each of the following terms.
   a. atmosphere
   b. aerodynamics

2. Which gas is most common in the air?

3. The gas is most important to humans is

4. What are ten properties of air?
   a. 
   b. 
   c. 
   d. 
   e. 
   f. 
   g. 
   h. 
   i. 
   j. 

5. Below is a chart that shows the percentage of some different gases that are found in the air. Use this information to complete the bar graph.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>78.09%</td>
</tr>
<tr>
<td>oxygen</td>
<td>20.9%</td>
</tr>
<tr>
<td>argon</td>
<td>0.93%</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>0.04%</td>
</tr>
<tr>
<td>neon</td>
<td>0.0018%</td>
</tr>
<tr>
<td>helium</td>
<td>0.0005%</td>
</tr>
<tr>
<td>krypton</td>
<td>0.0001%</td>
</tr>
<tr>
<td>hydrogen</td>
<td>0.00005%</td>
</tr>
<tr>
<td>xenon</td>
<td>0.000008%</td>
</tr>
</tbody>
</table>

Title: ___________________________________
6. Examine the diagram.

The lighted candle will eventually go out because

a. carbon dioxide is used in combustion.
b. the oxygen in the jar is used up during combustion.
c. fresh air is allowed into the jar.
d. the string will break off.

7. If you drop a piece of fruit on the floor, the fruit’s skin breaks a little. Explain why the fruit starts to turn brown where the skin is broken.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

8. Explain why a fire extinguisher filled with carbon dioxide is effective in putting out fires.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
9. Examine the diagram. The glass will **not** fill because

- a. water is heavier than air.
- b. air is lighter than water.
- c. air takes up space.
- d. gravity pulls down on the water.

10. Describe an activity you could do to demonstrate that air has mass.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

11. Where would air pressure be greatest?

- a. at sea level
- b. on the Moon
- c. at the top of a high mountain
- d. in an airplane
12. Define air pressure.

13. Which of the following correctly tells about the relationship between air's density and air pressure?
   a. Air pressure is greatest when air is least dense.
   b. As air increases in density, it decreases in pressure.
   c. Denser air has greater air pressure than less dense air.
   d. As air pressure increases, air density decreases.

*Use the information in the box to answer question 14.*

Peter filled up a glass with water until it overflowed slightly. Then he placed an index card on the top of the glass. He placed his hand on the index card and quickly, but carefully, turned the glass upside down. To his amazement he found that the index card stayed in place.

14. Which statement best tells why the index card did not fall off?
   a. Water is lighter than air.
   b. Air pressure pushed up on the index card, holding it in place.
   c. The index card was glued to the glass.
   d. The water is heavier than air.
Use the information below to answer questions 15 and 16.

The boy is blowing air through the paper tent.

15. Which statement correctly tells what will happen?

   a. Both sides will bend inward.
   b. Both sides will bend outward.
   c. Neither side will bend.
   d. One side will bend inward and the other will bend outward.

16. Which statement tells why the above will occur?

   a. Moving air has greater air pressure than still air.
   b. Moving air has lower air pressure than still air.
   c. The sides of the tent are not held in place strongly enough.
   d. The tent is too stiff.

17. Look at the illustration. Why is it that the paper does not get wet?
18. Fill in the blanks with the words in the box.

<table>
<thead>
<tr>
<th>occupies</th>
<th>reduced</th>
<th>composed</th>
<th>similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>exerts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Air _________________ space.

b. There are many ___________________ between air movement and water movement.

c. Air _________________ pressure on all sides of objects.

d. Air is _________________ of several different gases.

e. When air is moving, air pressure is _________________.

19. Number the layers of Earth’s atmosphere starting with the layer closes to Earth.

_____ exosphere  
_____ troposphere  
_____ mesosphere  
_____ thermosphere  
_____ stratosphere
1. Define each of the following terms.
   a. atmosphere the mixture of gases that surrounds the earth
   b. aerodynamics the study of moving air

2. Which gas is most common in the air?
   nitrogen

3. The gas is most important to humans is oxygen

4. What are ten properties of air?
   a. invisible
   b. tasteless
   c. odourless
   d. makes no sound
   e. cannot feel still air
   f. occupies space / has mass
   g. exerts pressure down
   h. exerts pressure up
   i. exerts pressure sideways
   j. density changes with temperature / altitude
5. Below is a chart that shows the percentage of some different gases that are found in the air. Use this information to complete the bar graph.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>78.09%</td>
</tr>
<tr>
<td>oxygen</td>
<td>20.9%</td>
</tr>
<tr>
<td>argon</td>
<td>0.93%</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>0.04%</td>
</tr>
<tr>
<td>neon</td>
<td>0.0018%</td>
</tr>
<tr>
<td>helium</td>
<td>0.0005%</td>
</tr>
<tr>
<td>krypton</td>
<td>0.0001%</td>
</tr>
<tr>
<td>hydrogen</td>
<td>0.00005%</td>
</tr>
<tr>
<td>xenon</td>
<td>0.000008%</td>
</tr>
</tbody>
</table>

Title: ____________________________

![Bar graph diagram]

Nitrogen   Oxygen   Argon   Other Gases

Percent: 0, 10, 20, 30, 40, 50, 60, 70, 80
6. Examine the diagram.

The lighted candle will eventually go out because

a. carbon dioxide is used in combustion.
   b. the oxygen in the jar is used up during combustion.
   c. fresh air is allowed into the jar.
   d. the string will break off.

7. If you drop a piece of fruit on the floor, the fruit’s skin breaks a little. Explain why the fruit starts to turn brown where the skin is broken.

   broken skin allows oxygen from air to permeate fruit’s skin
   oxygen combines with phenols in fruit to form brownish substance

8. Explain why a fire extinguisher filled with carbon dioxide is effective in putting out fires.

   carbon dioxide does not support burning
9. Examine the diagram. The glass will **not** fill because

- a. water is heavier than air.
- b. air is lighter than water.
- c. air takes up space.
- d. gravity pulls down on the water.

10. Describe an activity you could do to demonstrate that air has mass.  
**Answers will vary**

- put empty balloon on a scale; note weight
- inflate balloon
- weigh inflated balloon.

11. Where would air pressure be greatest?

- a. at sea level
- b. on the Moon
- c. at the top of a high mountain
- d. in an airplane
12. Define air pressure.

force per unit of area

13. Which of the following correctly tells about the relationship between air's density and air pressure?

a. Air pressure is greatest when air is least dense.
b. As air increases in density, it decreases in pressure.
c. Denser air has greater air pressure than less dense air.
d. As air pressure increases, air density decreases.

*Use the information in the box to answer question 14.*

Peter filled up a glass with water until it overflowed slightly. Then he placed an index card on the top of the glass. He placed his hand on the index card and quickly, but carefully, turned the glass upside down. To his amazement he found that the index card stayed in place.

14. Which statement best tells why the index card did not fall off?

a. Water is lighter than air.
b. Air pressure pushed up on the index card, holding it in place.
c. The index card was glued to the glass.
d. The water is heavier than air.
Use the information below to answer questions 15 and 16.

The boy is blowing air through the paper tent.

15. Which statement correctly tells what will happen?

   a. Both sides will bend inward.
   b. Both sides will bend outward.
   c. Neither side will bend.
   d. One side will bend inward and the other will bend outward.

16. Which statement tells why the above will occur?

   a. Moving air has greater air pressure than still air.
   b. Moving air has lower air pressure than still air.
   c. The sides of the tent are not held in place strongly enough.
   d. The tent is too stiff.

17. Look at the illustration. Why is it that the paper does not get wet?

   "Air occupies space in the glass, preventing water from going up into glass; thus paper stays dry."
18. Fill in the blanks with the words in the box.

<table>
<thead>
<tr>
<th>occupies</th>
<th>reduced</th>
<th>similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>exerts</td>
<td>composed</td>
<td></td>
</tr>
</tbody>
</table>

a. Air _______ occupies _______ space.

b. There are many _______ similarities _______ between air movement and water movement.

c. Air _______ exerts _______ pressure on all sides of objects.

d. Air is _______ composed _______ of several different gases.

e. When air is moving, air pressure is _______ reduced _______.

19. Number the layers of Earth’s atmosphere starting with the layer closes to Earth.

5. exosphere

1. troposphere

3. mesosphere

4. thermosphere

2. stratosphere
Lesson Seventeen

Concept: Air and Aerodynamics – Part I Test

Resources/Materials: Air and Aerodynamics – Part I Test (student copies)

Procedure:

Distribute the tests. Have students complete them independently.
1. What are five properties of air?
   a. 
   b. 
   c. 
   d. 
   e. 

2. Define atmosphere.
   
   
   

3. Define aerodynamics.
   
   
   

4. Most of the air is made up of which gas? 

5. The gas that is most important to humans is 

6. Read each sentence. Write O if it tells about oxygen, C if it tells about carbon dioxide, and B if it tells about both.
   
   _____ It is found in Earth's atmosphere.
   
   _____ Our bodies need it to survive.
   
   _____ It is heavier than air.
   
   _____ If makes up about one-fifth of air.
   
   _____ Green plants need it.
1. Green plants need it to make food.

2. It supports burning.

3. It combined with iron to form rust.

4. It does not support burning.

5. It combines with phenols in fruits and vegetables to make them brown.

6. It is given off when a horse exhales.

7. Look at the diagram. What will happen to the liquid that is being poured into the funnel?

   Explain why this happens.
8. Below is a chart that shows the percentage of some different gases that are found in air. Use this information to label the pie chart correctly.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>78.09%</td>
</tr>
<tr>
<td>oxygen</td>
<td>20.9%</td>
</tr>
<tr>
<td>argon</td>
<td>0.93%</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>0.04%</td>
</tr>
<tr>
<td>neon</td>
<td>0.0018%</td>
</tr>
<tr>
<td>helium</td>
<td>0.0005%</td>
</tr>
<tr>
<td>krypton</td>
<td>0.0001%</td>
</tr>
<tr>
<td>hydrogen</td>
<td>0.00005%</td>
</tr>
<tr>
<td>xenon</td>
<td>0.000008%</td>
</tr>
</tbody>
</table>

Title: ____________________________

Words to use:
- Nitrogen
- Oxygen
- Argon
- Other Gases
9. Examine the diagram. Tell what will happen if you pop one of the balloons.

What does this tell you about air?

10. Define air pressure.
Use the following information to answer question 11.

Susan placed a crumpled up sheet of paper in the bottom of a jar. She then turned the jar upside down and held it in a large container of water. Susan found that the paper did not get wet.

11. Which of the following statements best explains why the paper did not get wet?

a. Water is lighter than air.
b. The air in the jar exerts pressure on the water.
c. Paper cannot absorb water.
d. Water cannot go through glass.
Jack filled a jar full of water until it overflowed. He then placed a square of paper on the top of the jar. He then quickly turned the jar upside down. He noticed that the square of paper did not come off.

12. Which statement best tells why the square of paper stayed in place?

a. The paper was glued to the jar.
b. Water is heavier than air.
c. Air pressure pushed up on the paper.
d. None of the above.
Use the following information to answer question 13.

Linda held a strip of paper to her mouth. When she did this, the end of the paper strip drooped down. However, when blew steadily over the top of the strip, to her surprise the end of the paper strip raised up.

13. Which statement best explains why the end of the paper strip raised up?
   
   a. Air pressed downward on the strips.
   b. Moving air has less air pressure than still air.
   c. The air between the strips was not moving at all.
   d. Air pressed down from above.

Use the information below to answer question 14.

Bob placed two spoons on either side of a tap of running water so that the water ran over the backs of the spoons. He then moved the spoon handles away from each other so that the water ran over just the very bottom tips of the spoons.

14. Which statement tells what will most likely happen next?
   
   a. The spoons did not move.
   b. The distance between the spoons increased.
   c. The spoons turned.
   d. The distance between the spoons decreased.
15. Answer T for true and F for false.

____ Air does not occupy space.
____ Air exerts pressure on all sides of an object.
____ Air is heavier than water.
____ Air is composed of only five different gases.
____ Moving air reduces air pressure.
____ There are similarities between air movement and water movement.

*Use the information below to answer question 16.*

If the boy blows through the straw, the candle will go out.

16. Which statement best tells why the candle goes out?

a. The higher pressured still air pushes against the lower pressured moving air.
b. The lower pressured still air pushes out on the higher pressured moving air.
c. The higher pressured still air pushes out on the lower pressured moving air.
d. The lower pressured still air pushes in on the higher pressured moving air.
1. What are five properties of air? \textit{Any 5.}

\begin{itemize}
  \item [a.] invisible \hspace{2cm} f. cannot feel if still \hspace{2cm}
  \item [b.] occupies space \hspace{2cm} g. changes density with increase/decrease in temperature \hspace{2cm}
  \item [c.] takes shape of container \hspace{2cm} h. has mass \hspace{2cm}
  \item [d.] tasteless \hspace{2cm} i. presses against objects on all sides \hspace{2cm}
  \item [e.] odourless \hspace{2cm} j. no sound if still \hspace{2cm}
\end{itemize}

2. Define atmosphere.

\textit{mixture of gases that surrounds Earth}

3. Define aerodynamics.

\textit{study of moving air}

4. Most of the air is made up of which gas? \textit{nitrogen}

5. The gas that is most important to humans is \textit{oxygen}

6. Read each sentence. Write \textbf{O} if it tell about oxygen, \textbf{C} if it tells about carbon dioxide, and \textbf{B} if it tells about both.

\begin{itemize}
  \item \textbf{B} It is found in Earth’s atmosphere.
  \item \textbf{O} Our bodies need it to survive.
  \item \textbf{C} It is heavier than air.
  \item \textbf{O} If makes up about one-fifth of air.
  \item \textbf{B} Green plants need it.
\end{itemize}
0. Green plants need it to make food.
0. It supports burning.
0. It combines with iron to form rust.
C. It does not support burning.
0. It combines with phenols in fruits and vegetables to make them brown.
C. It is given off when a horse exhales.

7. Look at the diagram. What will happen to the liquid that is being poured into the funnel?

Liquid will stay in funnel

Explain why this happens.

Liquid cannot enter jar because air occupies the space in jar.
8. Below is a chart that shows the percentage of some different gases that are found in air. Use this information to label the pie chart correctly.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>78.09%</td>
</tr>
<tr>
<td>oxygen</td>
<td>20.9%</td>
</tr>
<tr>
<td>argon</td>
<td>0.93%</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>0.04%</td>
</tr>
<tr>
<td>neon</td>
<td>0.0018%</td>
</tr>
<tr>
<td>helium</td>
<td>0.0005%</td>
</tr>
<tr>
<td>krypton</td>
<td>0.0001%</td>
</tr>
<tr>
<td>hydrogen</td>
<td>0.00005%</td>
</tr>
<tr>
<td>xenon</td>
<td>0.000008%</td>
</tr>
</tbody>
</table>

Title: ________________________________________

Words to use:
Nitrogen
Oxygen
Argon
Other Gases

---

oxygen
argon
other gases
nitrogen
9. Examine the diagram. Tell what will happen if you pop one of the balloons.

- Side with inflated balloon goes down

What does this tell you about air?

Air has mass; therefore, inflated balloon has greater mass than uninflated balloon

10. Define air pressure.

Force per unit of area the air exerts on objects/surfaces
Use the following information to answer question 11.

Susan placed a crumpled up sheet of paper in the bottom of a jar. She then turned the jar upside down and held it in a large container of water. Susan found that the paper did not get wet.

11. Which of the following statements best explains why the paper did not get wet?

a. Water is lighter than air.
b. The air in the jar exerts pressure on the water.
c. Paper cannot absorb water.
d. Water cannot go through glass.
Jack filled a jar full of water until it overflowed. He then placed a square of paper on the top of the jar. He then quickly turned the jar upside down. He noticed that the square of paper did not come off.

12. Which statement best tells why the square of paper stayed in place?

a. The paper was glued to the jar.
b. Water is heavier than air.
c. Air pressure pushed up on the paper.
d. None of the above.
Use the following information to answer question 13.

Linda held a strip of paper to her mouth. When she did this, the end of the paper strip drooped down. However, when blew steadily over the top of the strip, to her surprise the end of the paper strip raised up.

13. Which statement best explains why the end of the paper strip raised up?

   a. Air pressed downward on the strips.
   b. Moving air has less air pressure than still air.
   c. The air between the strips was not moving at all.
   d. Air pressed down from above.

Use the information below to answer question 14.

Bob placed two spoons on either side of a tap of running water so that the water ran over the backs of the spoons. He then moved the spoon handles away from each other so that the water ran over just the very bottom tips of the spoons.

14. Which statement tells what will most likely happen next?

   a. The spoons did not move.
   b. The distance between the spoons increased.
   c. The spoons turned.
   d. The distance between the spoons decreased.
15. Answer T for true and F for false.

F  Air does not occupy space.
T  Air exerts pressure on all sides of an object.
F  Air is heavier than water.
F  Air is composed of only five different gases.
T  Moving air reduces air pressure.
T  There are similarities between air movement and water movement.

*Use the information below to answer question 16.*

If the boy blows through the straw, the candle will go out.

16. Which statement best tells why the candle goes out?

a. The higher pressured still air pushes against the lower pressured moving air.
b. The lower pressured still air pushes out on the higher pressured moving air.
c. The higher pressured still air pushes out on the lower pressured moving air.
d. The lower pressured still air pushes in on the higher pressured moving air.
About Part II

Part II of Air and Aerodynamics focuses on aerodynamics. Students learn about the properties of air when it is compressed and when it is moving. Part II consists of a mixture of hands-on and non-hands-on activities. For those lessons where the teacher opts not to have students participate in hands-on activities, a non-hands-on alternative is provided, where possible.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On?</th>
<th>Non Hands On Option?</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Air Can Be Compressed</td>
<td>26, 27</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>Air and Compressibility</td>
<td>28</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Compressed Air Tries to Escape</td>
<td>29, 30</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Compressed Air Tries to Equalize</td>
<td>31, 32</td>
<td>Partly</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>How a Tire Pump Works</td>
<td>33, 34</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>The Bernoulli Principle</td>
<td>35, 36</td>
<td>Partly</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>Demonstrating the Bernoulli Principle</td>
<td>37</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25</td>
<td>Creating Lift: The Airfoil</td>
<td>38, 39</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>26</td>
<td>More About the Airfoil</td>
<td>40</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>27</td>
<td>Thrust and Drag</td>
<td>41, 42</td>
<td>Partly</td>
<td>Yes</td>
</tr>
<tr>
<td>28</td>
<td>Streamlining</td>
<td>43 – 45</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>29</td>
<td>Surface Area Affects Drag (Optional)</td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>30</td>
<td>Review of Thrust, Drag, Lift, and Weight</td>
<td>46, 47</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>31</td>
<td>Adaptations That Enable Birds to Fly</td>
<td>48</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>32</td>
<td>Adaptations That Enable Insects to Fly</td>
<td>49</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>33</td>
<td>Air and Aerodynamics – Part II Review</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Air and Aerodynamics – Part II Test</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson Eighteen

Concept: Air Can Be Compressed

Resources/Materials: Mini Textbook, pages 26 and 27
large balloons (hands on option, 1 per student)
Worksheet #6A.18a (transparency)
Worksheet #6A.18b (student copies, hands on option)
Worksheet #6A.18c (student copies, non-hands on option)

Introduction: Have students inhale deeply and discuss how air fills their lungs. Then have them exhale to expel as much air from their lungs as possible. Explain that lungs are somewhat pliable and a bit stretchy. Discuss how this characteristic of lungs is necessary for breathing.

Pose the question: “If you were to measure the volume of air that you breathed in and compared it with the volume of your lungs, how do you think they would compare?” Discuss that you breathe in more air than your lungs can actually hold. **Discuss how this is possible.** Conclude that when air fills your lungs, it compresses.

Procedure:

1. Explain that air compresses when it is forced into a cavity or container if the volume of air forced in is greater than the volume of the container. The molecules of air are forced to move closer together.

2. Each of our lungs is like a balloon. A balloon is stretchy. When air is forced into a balloon, the molecules of air move closer together. Eventually, the balloon reaches a point where the molecules are so close together that they push out on the inside of the balloon and cause the rubber to expand.

3. Our lungs expand for the same reason.

4. Have students copy the notes from the transparency of Worksheet #6A.18a.

5. HANDS ON. Explain that students will be doing an activity where they will be compressing air. Distribute Worksheet #6A.18b along with the balloons. Go over the directions, if necessary.


Assignments:

1. Copy the notes from the transparency of Worksheet #6A.18a.
2. HANDS ON. Do Worksheet #6A.18b.
3. NON HANDS ON. Read *Mini Textbook*, pages 26 and 27. Then do Worksheet #6A.18c.
Compression

Air can be compressed. This means that molecules of air can be pushed together into a small space. When you blow air into a balloon, you are compressing it. As air flows into a balloon, the air molecules are pushed together or compressed.

When air molecules are forced too closely together, they begin to push outward. A balloon stretches because of this outward force.


Question: What happens when air is forced into a balloon?

Materials: large round-type balloon       ruler

Procedure:

With deep breaths blow into the neck of the balloon. Stop blowing after six breaths. Keep track of

• the number of breaths it took for the balloon to take its roundish shape but not stretch.
• the diameter of the balloon after six breaths.

Observations:

<table>
<thead>
<tr>
<th>Number of breaths it took for balloon to take its roundish shape, but not stretch</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of balloon after six breaths</td>
<td></td>
</tr>
</tbody>
</table>

1. Draw each of the following, using tiny circles to represent air molecules.

| air in uninflated balloon | air when balloon takes roundish shape, but does not stretch | air in balloon after six breaths |

2. Define compressed. 


3. At what point did the air in the balloon begin to become compressed? 


Worksheet #6A.18b
Directions: Use *Mini Textbook*, pages 26 and 27 to help you with the questions.

1. What happens when air is compressed?

2. In Box 1 draw diagram of the air molecules that are not compressed and in Box 2 draw a diagram of air molecules that are compressed.

   ![Diagram](image)

3. Why do you think that gases can be compressed but liquids and solids cannot?

   ____________________________________________________________________________

   ____________________________________________________________________________

4. When we force air into a closed container of some kind, we are compressing it. Think of three instances where we compress air.

   a. __________________________________________________________________________

   b. __________________________________________________________________________

   c. __________________________________________________________________________
Compressing Air

Question: What happens when air is forced into a balloon?

Materials: large round-type balloon ruler

Procedure:

With deep breaths blow into the neck of the balloon. Stop blowing after six breaths. Keep track of

- the number of breaths it took for the balloon to take its roundish shape but not stretch.
- the diameter of the balloon after six breaths.

Observations: Answers will vary

<table>
<thead>
<tr>
<th>Number of breaths it took for balloon to take its roundish shape, but not stretch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Diameter of balloon after six breaths</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

1. Draw each of the following, using tiny circles to represent air molecules.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>air in uninflated balloon</td>
<td>air when balloon takes roundish shape, but does not stretch</td>
<td>air in balloon after six breaths</td>
</tr>
</tbody>
</table>

2. Define compressed: squeezed together so that it takes up less space

3. At what point did the air in the balloon begin to become compressed? probably as soon as the air forced into balloon to start to fill out and take shape
Directions: Use *Mini Textbook*, pages 26 and 27 to help you with the questions.

1. What happens when air is compressed?
   
   *molecules are closer together*

2. In Box 1 draw diagram of the air molecules that are not compressed and in Box 2 draw a diagram of air molecules that are compressed.

   ![Diagram A](image)
   ![Diagram B](image)

3. Why do you think that gases can be compressed but liquids and solids cannot?
   
   *molecules in gases are relatively far apart. Molecules in liquids/solids are already so close together that they cannot easily be pressed even closer.*

4. When we force air into a closed container of some kind, we are compressing it. Think of three instances where we compress air. *Answers will vary.*
   a. balloon
   b. inflatable tires
   c. playground balls
Lesson Nineteen

Concept: Air Pressure and Compressibility

Resources/Materials: Mini Textbook, page 28
    inflated soccer ball (or other inflated ball)
    Worksheets #6A.19a and #6A.19b (student copies)

Introduction: Recall that when a certain volume of air is forced into a container that is of a lesser volume, the air compresses. The air in the container becomes denser. Recall also that air pressure is the force per unit of area with which air presses on surfaces. Explain that the air pressure within a container is directly related to the amount the air in the container has been compressed.

Procedure:

1. Show the soccer ball. Explain that you pumped air into the uninflated ball. Explain also that you did not simply want the ball to round out, but that you wanted to force enough air into it so that the air inside compressed to a particular point.

2. Explain that when the air inside the ball is compressed, the air pushes out on the inside of the ball. Its air pressure is greater than the air pressure pushing in on the ball from the outside.

3. Explain that if you do not pump enough air into the ball, it will not travel far when you kick it. If you pump too much air into the ball, it will actually hurt your toes when you kick it. Pumping just the right amount of air into the ball means that when your strike it with the toe of your shoe, it will travel quite a distance without hurting your toes.

4. Explain that the more air is compressed, the greater the pressure it has.


6. Distribute Worksheets #6A.19a and #6A.19b. Go over the directions, if necessary.

Assignments:


2. Do Worksheets #6A.19a and #6A.19b.
Directions: Use Mini Textbook, page 28 to help you with the questions.

1. What is the connection between air pressure and air compression?

2. Why is it that the more air is compressed, the greater its pressure?

3. Examine the picture at the bottom of page 28. Why does the inflated balloon lift the book? In your explanation you must use the terms air pressure, compressed, and weight.

In the space below, draw a diagram of the balloon raising the book. Inside the balloon draw the molecules moving and pushing against the inside of the balloon.
Red River Carts were used by the Métis in the 1800s. They were very rough to ride in. The beach wheelbarrow gives a much smoother ride and can pushed along sandy areas.

Why do you think the beach wheelbarrow is less bumpy to ride in than a Red River cart?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5. The use of inflatable tires on automobiles was considered a big improvement. Why?

________________________________________________________________________

________________________________________________________________________

6. In each pair, circle the one that most likely has the greater air pressure.

   a. inflated lung          uninfated lung
   b. regular mattress      air mattress
   c. baseball              soccer ball
   d. automobile tire       push lawn mower tire
Directions: Use Mini Textbook, page 28 to help you with the questions.

1. What is the connection between air pressure and air compression?

   - the more air is compressed, the greater the air pressure

2. Why is it that the more air is compressed, the greater its pressure?

   When air is compressed, the air molecules collide and push against the container’s sides more frequently.

3. Examine the picture at the bottom of page 28. Why does the inflated balloon lift the book? In your explanation you must use the terms air pressure, compressed, and weight.

   - balloon is filled with compressed air
   - balloon can lift book when it has reached the point where the air pressure inside exerts enough force that it is greater than weight of the book

In the space below, draw a diagram of the balloon raising the book. Inside the balloon draw the molecules moving and pushing against the inside of the balloon.
Red River Carts were used by the Métis in the 1800s. They were very rough to ride in. The beach wheelbarrow gives a much smoother ride and can pushed along sandy areas.

Why do you think the beach wheelbarrow is less bumpy to ride in than a Red River cart?

Red River car has solid wheels. The wood from which they are made will not easily compress. Wheelbarrow has inflatable tires. Air in tires will compress as the wheelbarrow hits bumps in the road.

5. The use of inflatable tires on automobiles was considered a big improvement. Why?

Air in inflatable tires compresses as the automobile runs over bumps.

6. In each pair, circle the one that most likely has the greater air pressure.

a. inflated lung  [ ] uninflated lung
b. regular mattress  [ ] air mattress
c. baseball  [ ] soccer ball
d. automobile tire  [ ] push lawn mower tire
Lesson Twenty

Concept: Compressed Air Tries to Escape

Resources/Materials: Mini Textbook, pages 29 and 30
  - balloon (any kind)
  - long piece of string (5 m+)
  - long-shaped balloon (if possible)
  - jumbo drinking straw (not the flexible type)
  - bulldog style clip
  - Worksheets #6A.20a and #6A.20b (student copies, hands on)
  - Worksheets #6A.20c and #6A.20d (student copies, non hands on)

Introduction: Hold up the balloon and ask students what will happen if you blow up the balloon and then let it go. Then have a student blow up the balloon and release it. Explain that the compressed air inside the balloon tries to escape, forcing itself out of the tiny opening in the balloon’s neck. The balloon travels in the general direction that is opposite the direction of the escaping air. This property of air is what scientists use when making jet airplanes go forward and rockets take off from Earth into space.

Procedure:

A. Hands On

1. Distribute Worksheet #6A.20a. With students go over the activity.
2. Have students write up the activity in their notebooks or on Worksheet #6A.20b.
3. Discuss:
   - **What makes the balloon go?** (Compressed air has greater air pressure than non-compressed air. The compressed air is trying to escape through the balloon’s neck. This force pushes the balloon in the opposite direction from the escaping balloon.)
   - **How could we use this air power in everyday life?** (This same is what makes tire pumps, air tools, jack hammers, rockets, and jet engines work.)
   - **How could we make a rocket go faster and/or farther?** (Increase the amount of compression.)

Assignment:
Write up the activity in your notebooks or use Worksheet #6A.20b.

B. Non Hands On

2. Distribute Worksheets #6A.20c and #6A20d.

Assignments:
1. Read Mini Textbook, pages 29 and 30.
2. Do Worksheets #6A.20c and #6A.20d.
Question: What happens to compressed air if it is allowed to escape?

Materials: 5 m long piece of string  
         large drinking straw  
         bulldog clip  
         large balloon  
         tape

Procedure:

1. Cut the drinking straw in half.
2. Thread the straw pieces onto the string.
3. Tie the string to two places about 5 m apart. Try to make the heights of the two places approximately the same height off the floor.
4. Inflate the balloon. Hold the neck closed with a bulldog clip.
5. Attach the straw sliders to the balloon and to the string. (See picture below.)
6. Move the balloon to one end of the string. Take off the clip and watch it go.
7. Write up this activity in your notebook or on Worksheet #6A.20b. Use these headings:

   Question:

   What We Did:

   What We Observed (include a diagram):

   What We Can Infer:
Question: What happens to compressed air if it is allowed to escape?

What We Did:


What We Observed:


What We Can Infer:


Directions: Use *Mini Textbook*, pages 29 and 30 to help you with the questions.

1. Put an X beside those things that contain or use compressed air.
   - [ ] an automobile tire
   - [ ] a solid rubber tire
   - [ ] a tire pump
   - [ ] a jet engine
   - [ ] a bag filled with garbage
   - [ ] a nail gun
   - [ ] an inflated balloon
   - [ ] a bicycle tire

2. Briefly explain what Isaac Newton discovered about forces.

   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

3. Examine the diagram of the balloon-powered boat.

   [Diagram of a balloon-powered boat]

   a. Draw arrows to show the direction of the escaping air and the direction the boat will move.

   b. What would happen if the free end of the straw was pointing toward the front end of the boat?
4. Examine the diagram of an air powered car. At what point will the car stop moving?

5. Answer **true** or **false**.

- Compressed air is denser than uncompressed air.
- The more air is compressed, the greater is its pressure.
- In a jet engine, the compressed air must shoot out the front of the jet so that the airplane will move forward.
- To increase the force with which a nail comes out of a nail gun, you must pull harder on the trigger of the nail gun.
- To make a rocket launch, you must force air upward toward the sky.

6. What is a compressor?
Question: What happens to compressed air if it is allowed to escape?

What We Did:

We blew up a balloon and secured the neck with a bulldog clip.

We threaded a straw onto a long string that was pulled tight.

We tape the straw onto the balloon.

We removed the bulldog clip.

What We Observed:

When the clip was removed, the balloon moved along the string, and the air emptied out of the balloon very quickly.

The balloon travelled in the opposite direction of the escaping air.

What We Can Infer:

The compressed air inside the balloon escaped until the air pressure inside the balloon equaled the air pressure outside the balloon. A balloon will travel in the direction opposite the air escaping from it.
Directions: Use Mini Textbook, pages 29 and 30 to help you with the questions.

1. Put an X beside those things that contain or use compressed air.
   - X an automobile tire
   - X a tire pump
   - ___ a bag filled with garbage
   - X an inflated balloon
   - ___ a solid rubber tire
   - X a jet engine
   - X a nail gun
   - X a bicycle tire

2. Briefly explain what Isaac Newton discovered about forces.
   If a force is exerted in one direction, another force of equal power will be exerted in the opposite direction.

3. Examine the diagram of the balloon-powered boat.
   a. Draw arrows to show the direction of the escaping air and the direction the boat will move.
   b. What would happen if the free end of the straw was pointing toward the front end of the boat?
      Boat would move backward
4. Examine the diagram of an air powered car. At what point will the car stop moving?

When enough air has escaped from the balloon such that
air pressure inside the balloon is equal to air pressure outside the
balloon. (That is, when air stops trying to escape from balloon.)

5. Answer true or false.

true  Compressed air is denser than uncompressed air.
true  The more air is compressed, the greater is its pressure.
false In a jet engine, the compressed air must shoot out the front of the jet so
that the airplane will move forward.
false  To increase the force with which a nail comes out of a nail gun, you must
pull harder on the trigger of the nail gun.
false  To make a rocket launch, you must force air upward toward the sky.

6. What is a compressor?
Lesson Twenty-One

**Concept:** Compressed Air Tries to Equalize

**Resources/Materials:** Mini Textbook, pages 31 and 32

<table>
<thead>
<tr>
<th>One set of materials per group</th>
</tr>
</thead>
<tbody>
<tr>
<td>plastic bag (like a grocery store produce bag)</td>
</tr>
<tr>
<td>balloon</td>
</tr>
<tr>
<td>bulldog clip</td>
</tr>
</tbody>
</table>

Worksheet #6A.21 (optional, student copies)

**Introduction:** Recall that compressed air always tries to escape from its container. Then ask, “At what point will the air stop escaping?” Explain that in today’s lesson, they will find out.

**Procedure:**


2. Then tell the students they are to try out the activity described on page 31.

3. Once the students know what to do and each student is assigned a responsibility, allow students to proceed with the activity.

4. Then have students write the activity up in their notebooks (Use the heading below.) OR on Worksheet #6A.21.

**Question:** At what point does compressed air stop escaping?

**What We Did:**

**What We Observed:**

**What We Can Infer:** (Compressed air will try to equalize with the air surrounding it.)

**Assignments:**


2. Do and write up the activity described on *Mini Textbook*, page 30. (Do in notebook or on Worksheet #6A.21.)
Compressed Air Tries to Equalize

Question: ____________________________________________________________

What We Did: ________________________________________________________

What We Observed: ____________________________________________________

What We Can Infer: ___________________________________________________
Question: What happens to compressed air?

What We Did:

We taped the opening of a small plastic bag to a straw.
We blew up a balloon and fastened the neck with a clip so that no air could escape.
We taped the other end of the straw to the neck of the balloon.
We removed the clip.

What We Observed:

When we removed the clip, the escaping air from the balloon began to inflate the bag. The balloon decreased in size, but did not totally deflate.

What We Can Infer:

The bag inflated and the balloon partially deflated because the compressed air inside the balloon equalized with the non-compressed air inside the bag. Air movement stopped when air pressure inside the balloon and bag were the same.
Lesson Twenty-two

Concept: How a Tire Pump Works

Resources/Materials: Mini Textbook, pages 33 and 34
bicycle tire pump

Introduction: Show students the tire pump, if you have one. If possible, inflate a balloon or a playground ball with it. Ask them to speculate how it works. Tell them it has to do with creating and releasing compressed air.

Procedure:

1. Have students turn to Mini Textbook, page 33. Allow them to preview pages 33 and 34 for a few moments.

2. Tell students they will be doing some research to find out how a tire pump works.

3. On the board write these points:
   
   • The design
   • Labelled diagrams
   • How it works

4. Tell students they are to read the article about the tire pump. Then they are to write a report telling what they found. They must include the points written on the board. (Clarify, if necessary.)

Assignments:

1. Read Mini Textbook, pages 33 and 34.

2. Research and write a report on the tire pump.
Lesson Twenty-three

Concept: The Bernoulli Principle (Low pressure is created by rapidly moving air.)

Resources/Materials: Mini Textbook, pages 35 and 36
- strips of paper 3 cm X 15 cm (one per student)
- Worksheet #6A.23a (transparency)
- Worksheet #6A.23b (optional, student copies)

Introduction: Ask students if they have ever wondered how airplanes stay in the air or how insects and birds fly. Tell them that it was the work of a Swiss scientist, Daniel Bernoulli, that gave scientists the information to actually invent devices such as the airplane. **He discovered that faster moving air has less air pressure than slower moving air.**

Procedure:

1. Give each student a strip of paper. Direct students to hold the strip so that the narrow end of the strip is just touching the place immediately below their bottom lip.

2. Then tell them to blow out gently and steadily. (The end of the strip should rise up.)

3. Have students speculate as to why this happens. **(The strip rises up because the air above it is moving faster than the air below it. Faster moving air has less air pressure than slower moving air. The air pressure below the strip is greater than the air pressure above it. Therefore, there is more upward force exerted on the strip than there is downward force.)**

4. If you like, have students read the information on Mini Textbook, pages 35 and 36.

5. Put up the transparency of Worksheet #6A.23a. Read and discuss with students. Then have them copy the information into their notebooks.

6. If you like, have students write up the activity done above in their notebooks OR on Worksheet #6A.23b.

Assignments:

1. OPTIONAL. Read Mini Textbook, pages 35 and 36.

2. Copy the notes from Worksheet #6A.23a into notebooks.

3. OPTIONAL. Write up the activity in notebooks OR on Worksheet #6A.23b.
The Bernoulli Principle

Airplanes are able to fly by producing forces that overcome the downward pull of gravity and support them in the air. The forces are **thrust** (provided by the engines) and **lift**. Daniel Bernoulli, a Swiss scientist, discovered that faster-moving air has lower air pressure than slower-moving air. This effect (known as the Bernoulli Principle) allows an airplane to LIFT off the ground to fly.

An airplane’s wings are designed so that the air moving over it will move more rapidly than the air going under it. This means that the air pressure under the wings is greater than the air pressure on top of the wings. It is this design that gives an airplane its lift.

Worksheet #6A.23a
Science Grade 6 Topic A Air and Aerodynamics – Part II
Worksheets

**The Bernoulli Principle**

**Question:** Does moving air have less air pressure than still air?

**What We Did:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**What We Observed:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**What We Can Infer:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Worksheet #6A.23b
Science Grade 6 Topic A Air and Aerodynamics – Part II

Worksheets

The Bernoulli Principle

Question: Does moving air have less air pressure than still air?

What We Did:

I held a strip of paper just below my bottom lip.

Then I steadily blew down the length of the strip.

What We Observed:

When I blew on the strip, it went from a drooping position to one where it was parallel to the floor.

What We Can Infer:

When I blew along the top of the strip, the air moved faster over the top than underneath the strip. Thus, the air pressure under the strip was greater than the air pressure over the strip, causing the strip to rise up.
Lesson Twenty-four

Concept: Demonstrating the Bernoulli Principle

Resources/Materials: Mini Textbook, page 37
- ping pong balls
glue
lire index cards
Worksheets #6A.24a (student copies)
OR Worksheet #6A.24b (optional, student copies)
Worksheet #6A.24c (optional, student copies)

Introduction: Review the Bernoulli Principle. Explain that today students will have the opportunity to investigate just how the Bernoulli Principle works.

Procedure:


2. Have students do either Activity A or Activity B or both.

Activity A
a. Distribute Worksheet #6A.24a. With students go over the directions.
b. Distribute Worksheet #6A.24b. Have students make the funnel as directed on the worksheet.
c. Predict what will happen if you blow into the stem.
d. Blow up into the funnel from the bottom.
e. What do you observe? What can you infer?

_for the Teacher:_ The ping pong ball will hover just below the bottom of the funnel, but will not rise up. The moving air caused by blowing air into the funnel means that the air pressure under the ball is less than in the air above it. The relatively greater force of the air above keeps the ping pong ball from rising.

Activity B
a. Distribute Worksheet #6A.24a. With students go over the directions.
b. Bend a large index card in half across its width to form a V or tent shape.
c. Set it up on a table, pointed side up. Secure it with tape on either side.
d. Bend over and blow hard, straight through the upside down V shape.
e. What do you observe? What can you infer?

_for the Teacher:_ Blowing through the tent lowers the air pressure inside the tent since the air is moving faster. The outside air has greater air pressure and pushes the sides of the card, causing them to cave in.

Assignments:
1. Read Mini Textbook, page 37.
2. Do Activity A and/or Activity B and write the activity(s) up in notebooks or on Worksheet #6A.24c.
Activity A

Materials: Worksheet #6A.24b    ping pong ball    tape or glue

Procedure:

1. Make a funnel using the directions on Worksheet #6A.24b.
2. Place a ping pong ball into the funnel and hold the funnel upright.
3. Blow up through the funnel from the bottom.
4. What do you observe? What can you infer?
5. Write up this activity up in your notebook OR on Worksheet #6A.24c.

Activity B

Materials: large index card    tape

Procedure:

1. Bend the index card in half across its width to form a V or tent shape.
2. Set it up on a table, pointed side up. Secure it with tape on either side.
3. Bend over and blow hard, straight through the upside down V shape.
4. What do you observe? What can you infer?
5. Write this activity up in your notebook OR on Worksheet #6A.24c.
Directions:
- Cut out the shape below.
- Pull A and B together to form a cone shape and tape or glue in place.
- Cut the point from the cone.
- Put a ping pong ball in the cone. Hold the cone above your head and try to blow the ball out of the cone.
Demonstrating the Bernoulli Principle

Question: ________________________________________________

What We Did: ______________________________________________

What We Observed: _________________________________________

What We Can Infer: _________________________________________
Activity A

Question: Does moving air have less air pressure than still air?

What We Did:

I made a cone of paper and cut off the tip.
I placed a ping pong ball in the cone.
I then blew up at the ping pong ball from the bottom of the cone and through the hole.

What We Observed:

When I blew up into the cone, the ping pong ball moved a little, but it did not rise up.

What We Can Infer:

Blowing up through the hole made the air pressure under the ball less than the air pressure over the ball. The higher pressure above the ball prevented the ball from rising.
Activity B

Question: Does moving air have less air pressure than still air?

What We Did:
- We folded a large index card in half to form a V-shape.
- We set it on a table, pointed side up and secured it with tape.
- We blew steadily into the inside of the "tent".

What We Observed:
- When we blew into the tent, the sides of the tent caved in a little.

What We Can Infer:
- Blowing into the tent caused the air pressure inside the tent to lower. The air pressure outside the tent was now greater than inside, causing the sides of the tent to cave in.
Lesson Twenty-five

Concept: Creating Lift: The Airfoil

Resources/Materials: Mini Textbook, page 38 and 39
- half sheets of paper (one per student)
- tape
- ruler
Worksheets #6A.25a (student copies)
Worksheets #6A.25b, and #6A.25c (optional, student copies)

Introduction: Explain that airplane wings are designed to create lift. They use Bernoulli’s Principle. Tell students that today they will learn why airplane wings look the way they do and now they help planes fly.

Procedure:

1. Distribute Worksheet #6A.25a. Go over the directions with students. (These directions are summarized below):
   - Take a half sheet of paper and fold it in half. Tape the edges.
   - Next, tape the paper so that the long edges don’t line up by about 4 cm.
   - Put a ruler inside the “wing” like in the picture, so that the edge of the ruler is along the curved part of the wing and the widest part of the wing is on top.
   - Hold the rule and paper and blow hard on the fold.
   - What did you observe?
   - What can you infer? Explain why it happened.

   For the Teacher
   When an airplane takes off, the movement creates wind around the wings, just like the wind you feel when riding a bike.

   Airplane wings are curved like the paper in the activity. When the plane moves forward, the wind moves around the wing in a special way, creating a force called LIFT. This is what made the back of the paper wing lift up. LIFT is what makes the airplane go up as it goes forward, and keep the plane in the air while it moves.
   The design of the wing is such that wind moving over the wing moves faster than the wind going under the wing. This causes the air pressure under the wing to be greater than the air pressure over the wing. This makes the amount of force pushing up on the wing to be greater than the force pushing down on the wing. This airplane wing design is called an airfoil.

2. OPTIONAL but RECOMMENDED. Have students turn to Mini Textbook, page 38. Guide the reading of pages 38 and 39.

3. In notebooks, have students write an explanation that tells why the “wing” (in the above activity) lifted up as they blew across it.

4. OPTIONAL. Distribute Worksheets #6A.25b and #6A.25c. Go over the directions, if necessary.

Assignments:

1. OPTIONAL/RECOMMENDED. Read Mini Textbook, pages 38 and 39.
2. In notebook, write an explanation as to why the wing lifted as you blew across it.
3. OPTIONAL. Do Worksheets #6a.25b and #6A.25c.
Science Grade 6 Topic A Air and Aerodynamics – Part II
Worksheets

How Does an Airplane Wing Create Lift?

Do this activity to find out.

**Materials:** half sheet of paper (cut a full sheet of paper in half lengthwise) tape ruler

**Procedure:**

1. Take a half sheet of paper and fold it in half. Tape the edges.

2. Next, tape the paper so that the long edges don’t line up by about 4 cm.

3. Put a ruler inside the “wing” like in the picture, so that the edge of the ruler is along the curved part of the wing and the widest part of the wing is on top.

4. Hold the rule and paper and blow hard on the fold.

5. **What did you observe?**

6. **What can you infer?** Explain why it happened.
Directions: Use Mini Textbook, pages 38 and 39 to help you with the questions.

1. Describe each of the forces that are involved when an airplane flies.

<table>
<thead>
<tr>
<th>Force</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Complete the sentences with words from the box.

- airfoil
- bottom
- thrust
- jet engine
- top
- lift
- weight
- propeller
- wings

a. The parts of an airplane that create lift are the ____________________.

b. The shape of a cross-section cut of an airplane wing is an ____________________.

c. In an airplane, thrust is created by a ____________________ or a ____________________.

d. An airplane’s ____________________ is the amount of force that gravity exerts on the airplane.

e. As an airplane moves through the air, it encounters ____________________. This force is called drag.

f. In order for an airplane to fly ____________________, must be greater than drag and ____________________ must be greater than gravity.

g. An airfoil is designed so that air will move quickly over its ____________________ compared to under its ____________________.
3. On the diagram below label **lift, gravity, thrust, and drag**. Then draw arrows to show which direction the airplane would be moving.

![Diagram](image)

4. On the diagram below label the **leading edge** and the **trailing edge**.

![Diagram](image)

5. Ben drew a diagram of a cross-section cut of an airplane wing. His teacher told him that a wing of this shape would not produce enough lift to keep an airplane in the air. Explain why.

![Diagram](image)
Science Grade 6 Topic A Air and Aerodynamics – Part II
Worksheets
Creating Lift

Directions: Use Mini Textbook, pages 38 and 39 to help you with the questions.

1. Describe each of the forces that are involved when an airplane flies.

<table>
<thead>
<tr>
<th>Force</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lift</td>
<td>upward force</td>
</tr>
<tr>
<td>weight</td>
<td>force of gravity</td>
</tr>
<tr>
<td>thrust</td>
<td>forward force</td>
</tr>
<tr>
<td>drag</td>
<td>force that resists thrust</td>
</tr>
</tbody>
</table>

2. Complete the sentences with words from the box.

<table>
<thead>
<tr>
<th>airfoil</th>
<th>bottom</th>
<th>jet engine</th>
<th>lift</th>
<th>propeller</th>
<th>wings</th>
</tr>
</thead>
<tbody>
<tr>
<td>resistance</td>
<td>thrust</td>
<td>top</td>
<td>weight</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. The parts of an airplane that create lift are the **wings**

b. The shape of a cross-section cut of an airplane wing is an **airfoil**

c. In an airplane, thrust is created by a **propeller** or a **jet engine**

d. An airplane’s **weight** is the amount of force that gravity exerts on the airplane.

e. As an airplane moves through the air, it encounters **resistance**. This force is called drag.

f. In order for an airplane to fly, **thrust** must be greater than drag and **lift** must be greater than gravity.

g. An airfoil is designed so that air will move quickly over its **top** compared to under its **bottom**.
3. On the diagram below label **lift, gravity, thrust, and drag.** Then draw arrows to show which direction the airplane would be moving.

4. On the diagram below label the **leading edge** and the **trailing edge.**

5. Ben drew a diagram of a cross-section cut of an airplane wing. His teacher told him that a wing of this shape would not produce enough lift to keep an airplane in the air. Explain why.

The air would flow faster under the wing because it has more of a curve compared to the upperside. This would result in greater air pressure over the wing compared to under, making lift very difficult.
Lesson Twenty-six

Concept: More About the Airfoil

Resources/Materials: Mini Textbook, page 40
Worksheets #6A.26a and #6A.26b (student copies)

Introduction: Recall last day’s activity. Explain that the shape created by folding and taping the paper is called an airfoil. In simplest terms, an airfoil is curved on top and flat on the bottom.

For the Teacher

The cross-section of an airplane wing has a shape called an airfoil. As the wing moves through the air, the air divides to pass around the wing. The airfoil is curved so that the air passing above the wing moves faster than air passing beneath. Fast-moving air has a lower pressure than slow-moving air. The pressure of the air is therefore greater beneath the wing than above it. This difference in air pressure forces the wing upward. The force is called lift.

![Airfoil Diagram]

The principle used to design airplane wings is also used to design such things as helicopter blades, propellers, spoilers (on race cars), ship’s stabilizers, and hydrofoils.

Procedure:

1. Draw a diagram of a cross-section cut of an airfoil on the board (See above.). Explain that the curved top of the wing takes up more space than the flat bottom. When the air gets to the wing, it is forced to move up and is squeezed between the wing and the other air in the sky. This causes the air on top of the wing to be forced over the curve and move more quickly when compared to the air under the wing.

2. Explain that since faster moving air has less air pressure than slower moving air. The force pressing up on the wing is greater than the force pressing down, causing the wing to want to raise up. This upward force for an airplane is called lift.


4. Distribute Worksheets #6A.26a and #6A.26b. Go over the directions. You may want to do the first couple with students to give them the idea.

Assignment:

Do Worksheets #6A.26a and #6A.26b
What Holds an Airplane Up?

Directions: Read the paragraphs that explain how lift is created in an airplane. Then draw and label diagrams that illustrate the paragraphs.

What holds an airplane up?

1. An airplane’s wings are shaped to make the air flow faster on the upper side than on the lower side. The upper side is curved upward, but the lower side if quite flat.

Show with diagrams and labels.
(Use arrows to show direction of air flow.)

2. As the airplane moves, air flows past it. Air slows down when it hits the front of the wing. Some of the air flows along the top part of the wing. Some of it flows along the bottoms part of the wing.
3. The curved top of the wing takes up more space than the bottom of the wing. When the air gets to the wing, it is forced to move up and is squeezed between the wing and the other air in the sky. That makes air on top of the wing move more quickly than air under the wing.

4. Whenever air moves faster, air pressure is lower. The wings are pushed toward the place with the lowest air pressure, that place is up!

5. The faster an airplane moves, the faster the air moves over the top of the wing. That means a big difference in air pressure between the top and the bottom of the wing. That big difference in air pressure is what keeps the plane up.
Directions: Read the paragraphs that explain how lift is created in an airplane. Then draw and label diagrams that illustrate the paragraphs.

What holds an airplane up?

1. An airplane’s wings are shaped to make the air flow faster on the upper side than on the lower side. The upper side is curved upward, but the lower side is quite flat.

Show with diagrams and labels.
(Use arrows to show direction of air flow.)

2. As the airplane moves, air flows past it. Air slows down when it hits the front of the wing. Some of the air flows along the top part of the wing. Some of it flows along the bottom part of the wing.
3. The curved top of the wing takes up more space than the bottom of the wing. When the air gets to the wing, it is forced to move up and is squeezed between the wing and the other air in the sky. That makes air on top of the wing move more quickly than air under the wing.

4. Whenever air moves faster, air pressure is lower. The wings are pushed toward the place with the lowest air pressure, that place is up!

5. The faster an airplane moves, the faster the air moves over the top of the wing. That means a big difference in air pressure between the top and the bottom of the wing. That big difference in air pressure is what keeps the plane up.
Lesson Twenty-seventy

Concept: Thrust and Drag

Resources/Materials: Mini Textbook, pages 41 and 42
sheets of paper
Worksheets #6A.27a and #6A.27b (transparencies)

Introduction: Recall that it is a force called lift that raises an airplane up. If necessary, review that weight (the force of gravity) is the force that wants to pull it down. Lift and gravity are opposing forces. Just like lift and gravity are opposing forces, there are opposing forces that make the airplane want to go forward or not. These forces are thrust and drag. (If necessary, refer back to Mini Textbook, page 40.)

Procedure:

1. Explain that in a car or airplane, thrust is provided by some kind of engine. Recall the balloon-on-the-string activity – It was the air trying to escape from the balloon that provided the thrust.

2. Give each student a sheet of paper to make a paper airplane. Give them a few moments to make them and try them out. Ask them what is providing the thrust (their muscles).

3. Discuss that a motor boat gets its thrust from a propeller as do some airplanes. Insects and birds get thrust by flapping their wings. Wind-up toys get thrust from the uncoiling action of a spring.

4. Ask “Why doesn’t your paper airplane just keep going?” Tell students that when an object pushes against air, it slows it down. This for is called air resistance or drag. For a boat, water resistance produces most of the drag.

5. Have students turn to Mini Textbook, page 41. Have them read pages 41 and 42.

6. Put up the transparencies of Worksheets #6A.27a and #6A.27b. Go over them. Direct students to copy the notes into their notebooks.

Assignments:

1. Read Mini Textbook, pages 41 and 42.

2. Copy the notes from Worksheets #6A.27a and #6A.27b.

\[ \text{lift} \]

\[ \text{drag} \]

\[ \text{thrust} \]

\[ \text{gravity (weight)} \]
Lifting Up

**lift** – force that raises an object
**gravity** – force that pulls an object down

In order for something to fly, lift must be greater than gravity.

**What Provides Lift?**

The airplane wings provide lift to an airplane. The airplane design is called an airfoil.
Moving Forward

thrust – force that pushes an object forward
drag – resistance to thrust

In order for something to move forward, thrust must be greater than drag.

What provides thrust?

a. **propellered aircraft** – propeller turned by an engine.
b. **jet aircraft** – jet engine
c. **birds and flying insects** – as wings beat up and down, they push air backwards which propels them forward.
Lesson Twenty-eight

Concept: Streamlining

Resources/Materials: Mini Textbook, page 43 – 45
Worksheet #6A.28 (student copies)

Introduction: Ask students to think about a time when they were riding in a van and the van was driving into the wind. When this happens the driver must step on the accelerator more to produce more thrust in order to overcome the air resistance or drag that the wind is producing. This is undesirable, because it uses more fuel. Similarly, you get more tired walking into the wind than when the wind is at your back.

Review that the force that pushes an object like a car or airplane ahead is called thrust. Also review that the force that reduces thrust is called drag. When going through the air, it is air resistance that produces the most drag.

Procedure:

1. Explain that people who design motor vehicles, airplanes, and other devices try to shape things so that the amount of air resistance or drag is low. When this is done, the vehicle or airplane uses less fuel in order the produce thrust.

2. Draw two simple line drawings like the ones below. Explain that the spherical object has produces more drag than the other one.

   Non-Streamline Shape
   Streamlines
   LOW

   Streamline Shape
   Streamlines


4. Distribute Worksheet #6A.28. Go over the directions, if time.

For the Teacher

Streamlining is the shaping of an object, such as an aircraft body or wing, to reduce the amount of drag or resistance to motion through a stream of air. A curved shape allows air to flow smoothly around it. A flat shape fights air flow and causes more drag or resistance. Streamlining reduces the amount of resistance and increases thrust.

To produce less resistance, the front of the object should be well-rounded and the body should gradually curve back from the midsection to tapered rear section.

Assignments:

1. Read Mini Textbook, pages 43 – 45.
2. Do Worksheet #6A.28.
Directions: For each pair of boxes create two designs. Make one more streamlined than the other. Once you finish, trade with a partner. See if he or she can tell which is the more streamlined.

Cars

Airplanes

Trucks

Worksheet #6A.28
Lesson Twenty-nine (Optional)

Concept: Surface Area Affects Drag

Resources/Materials: sheets of paper, metre stick

Introduction: Stand on the teacher’s desk and drop two sheets of paper onto the floor at the same time. Notice that both take about the same amount of time. Then crumble one up into a ball. Drop the crumpled and uncrumpled papers simultaneously. This time note that the crumpled paper drops faster. Ask students to explain why this is so. (Although mass is the same, the crumpled paper has less surface area, and is rounder in shape; thus, there is less drag.)

Procedure:

1. Explain that airplane designers design aircraft so that they resemble the bodies of birds – rounded heads and smaller tapered tails. The idea is to create less wind resistance or drag; that is, streamlining.

2. Tell students they will be making two paper airplanes, one more streamlined than the other. They will be throwing each five times, and calculating the average distances. **Have students make a table like the one below in their notebooks before you give them the sheets for the airplanes.**

Distances Travelled by Paper Airplanes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Airplane One</th>
<th>Airplane Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Give students each a sheet of paper. Tell them their task is to design and make a paper airplane that flies as far as possible when thrown by hand.

4. Record the distance the plane flies for five throws. Calculate the average distance.

5. Next, give the students another sheet of paper. They are to design and make an airplane that will fly, but is less streamlined. Throw it five times and calculate the average distance.

Assignment:

Have students write up the activity in their notebooks. OR Have students write a sentence that explains the relationship between streamlining and the amount of drag.
Lesson Thirty

Concept: Review of Thrust, Drag, Lift, and Weight (Gravity)

Resources/Materials: Mini Textbook, pages 46 and 47
Worksheets #6A.30a and #6A.30b (student copies)

Introduction: Review the meanings of the terms thrust, drag, lift, and weight and their relationships to flying.

Procedure:


2. Distribute Worksheets #6A.30a and #6A.30b, if necessary.

3. OPTIONAL. Write these notes on the board for students to copy into their notebooks.

The Forces of Lift, Weight, Thrust, and Drag

If lift becomes greater than mass, the plane *ascends.*
If thrust becomes greater than drag, the plane *accelerates.*
If lift, mass, thrust, and drag become equal, the plane would *hover.*
If thrust becomes less than drag, the plane would *decelerate.*
If lift becomes less than mass, the plane *descends.*

Assignments:


2. Do Worksheets #6A.30a and #6A.30b.

3. OPTIONAL. Copy notes (above) into notebooks.
1. Label the four forces of flight for the bird and the airplane

2. Draw and label the forces of flight for the following:

<table>
<thead>
<tr>
<th>bird</th>
<th>helicopter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>hovercraft</th>
<th>paper airplane</th>
</tr>
</thead>
</table>
3. Imagine an airplane flying through the air. Use what you know about lift, drag, weight, and thrust to tell you what will happen to this airplane. Use the vocabulary in the box.

Vocabulary

**accelerate** – speed up
**decelerate** – slow down
**ascend** – go up
**descend** – go down
**hover** – stay suspended in one place

a. If lift becomes greater than weight, the plane ____________________________.

b. If thrust becomes greater than drag, the plane ____________________________.

c. If thrust becomes less than drag, the plane ____________________________.

d. If lift becomes less than weight, the plane ____________________________.

e. If lift, mass, thrust, and drag become equal, the plane ____________________________.
1. Label the four forces of flight for the bird and the airplane.

2. Draw and label the forces of flight for the following:

   - Bird
   - Helicopter
   - Hovercraft
   - Paper airplane
3. Imagine an airplane flying through the air. Use what you know about lift, drag, weight, and thrust to tell you what will happen to this airplane. Use the vocabulary in the box.

Vocabulary

accelerate – speed up
decelerate – slow down
ascend – go up
descend – go down
hover – stay suspended in one place

a. If lift becomes greater than weight, the plane **ascends**

b. If thrust becomes greater than drag, the plane **accelerates**

c. If thrust becomes less than drag, the plane **decelerates**

d. If lift becomes less than weight, the plane **descends**

e. If lift, mass, thrust, and drag become equal, the plane **hovers**
Lesson Thirty-one

Concept: Adaptations That Enable Birds to Fly

Resources/Materials: Mini Textbook, page 48
Worksheets #6A.30a, #6A.30b, and #6A.30c (student copies)

Introduction: Discuss that airplanes are modelled after birds. That is, scientists and engineers have examined what it is that enables birds to fly. Then they tried to design aircraft so that they could do some of the same things.

The characteristics of a bird or a flying insect that enable it to fly are referred to as adaptations. Today you will examine the adaptations that enable birds to fly.

Procedure:


2. Distribute copies of Worksheets #6A.30a, #6A.30b, and #6A.30c. The first three sheets tell about the design of an airplane and how it enables it to fly.

3. Explain that each box on Worksheet #6A.30c gives the main idea of one of the parts on the other two sheets.

4. Have students cut apart the boxes from Worksheet #6A.30c. (Have them put their initials or names on the backs of each box, in case they drop on the floor.)

5. Students are to find the boxes from Worksheet #6a.30c that go with those on Worksheets #6a.30a and #6A.30b. They are to paste them in the appropriate boxes.

Assignment:

Paste the main ideas in the boxes from Worksheet #6A.30c next to the appropriate boxes on Worksheets #6A.30a and #6A.30b.
### Facts About How a Bird Flies

<table>
<thead>
<tr>
<th>A bird has a smooth, streamlined shape.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A bird’s wings, and each of its feathers, are shaped much like an aircraft’s wing – curved on top and flatter underneath.</td>
<td></td>
</tr>
<tr>
<td>Its flight is powered by large muscles inside its body. Powerful chest muscles flap the wings up and down.</td>
<td></td>
</tr>
<tr>
<td>A bird’s collar bone is fused in a “wishbone” shape that forms a rigid frame so its body is not squashed when the powerful wing muscles contract</td>
<td></td>
</tr>
<tr>
<td>The tail is used for steering</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6A.31a
<table>
<thead>
<tr>
<th>Facts About How a Bird Flies</th>
<th>Matching Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wings are covered with tightly fitting feathers that trap the air.</td>
<td></td>
</tr>
<tr>
<td>A bird’s wing can change shape. As the wings beat down, they push the air backwards. Special feathers at the tip of the wings come together to help push the air back. This makes the bird move forward.</td>
<td></td>
</tr>
<tr>
<td>When the wings are pulled up, the tips of the wing feathers move apart to let air flow through. This reduces air resistance and means the bird uses less energy pushing against the air.</td>
<td></td>
</tr>
<tr>
<td>To take off, a bird has to beat its wings very hard to force air quickly over the upper surfaces and produce lift. Once it has climbed high enough, the rate of beating can be reduced.</td>
<td></td>
</tr>
<tr>
<td>The bones of a bird contain many hollow spaces, making the bird lightweight but strong.</td>
<td></td>
</tr>
</tbody>
</table>
**Directions:** Read each of the adaptations that birds have that enable them to fly. Then cut apart the boxes. Paste them beside the corresponding explanations.

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Explanation</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>A bird uses its tail for steering.</td>
<td>Like an aircraft’s wing, a bird’s wings and each of its feathers is curved on top and flat on the bottom.</td>
<td>Birds have to beat their wings very hard to produce enough lift so they can take off.</td>
</tr>
<tr>
<td>The body is streamlined. The body is smooth.</td>
<td>Birds have hollow bones, which makes them lighter.</td>
<td>The wing feathers fit together tightly so that they can trap air.</td>
</tr>
<tr>
<td>A bird can beat its wings to push air back. Then it can make special feathers on the wings tips come together to provide thrust.</td>
<td>Birds can move their wing feathers apart to reduce drag.</td>
<td>The bird’s wishbone is so strong that it cannot be squashed when the wing muscles work.</td>
</tr>
<tr>
<td>Thrust is provided by large chest muscles that flap the wings up and down.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6A.31c
### Facts About How a Bird Flies

<table>
<thead>
<tr>
<th>Fact</th>
<th>Matching Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>A bird has a smooth, streamlined shape.</td>
<td>The body is streamlined. The body is smooth.</td>
</tr>
<tr>
<td>A bird's wings, and each of its feathers, are shaped much like an aircraft's wing – curved on top and flatter underneath.</td>
<td>Like an aircraft's wing, a bird's wings and each of its feathers is curved on top and flat on the bottom.</td>
</tr>
<tr>
<td>Its flight is powered by large muscles inside its body. Powerful chest muscles flap the wings up and down.</td>
<td>Thrust is provided by large chest muscles that flap the wings up and down.</td>
</tr>
<tr>
<td>A bird's collar bone is fused in a “wishbone” shape that forms a rigid frame so its body is not squashed when the powerful wing muscles contract.</td>
<td>The bird's wishbone is so strong that it cannot be squashed when the wing muscles work.</td>
</tr>
<tr>
<td>The tail is used for steering.</td>
<td>A bird uses its tail for steering.</td>
</tr>
</tbody>
</table>
## Facts About How a Bird Flies

<table>
<thead>
<tr>
<th>Wings are covered with tightly fitting feathers that trap the air.</th>
<th>The wing feathers fit together tightly so that they can trap air.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A bird’s wing can change shape. As the wings beat down, they push the air backwards. Special feathers at the tip of the wings come together to help push the air back. This makes the bird move forward.</td>
<td>A bird can beat its wings to push air back. Then it can make special feathers on the wings tips come together to provide thrust.</td>
</tr>
<tr>
<td>When the wings are pulled up, the tips of the wing feathers move apart to let air flow through. This reduces air resistance and means the bird uses less energy pushing against the air.</td>
<td>Birds can move their wing feathers apart to reduce drag.</td>
</tr>
<tr>
<td>To take off, a bird has to beat its wings very hard to force air quickly over the upper surfaces and produce lift. Once it has climbed high enough, the rate of beating can be reduced.</td>
<td>Birds have to beat their wings very hard to produce enough lift so they can take off</td>
</tr>
<tr>
<td>The bones of a bird contain many hollow spaces, making the bird lightweight but strong.</td>
<td>Birds have hollow bones, which makes them lighter.</td>
</tr>
</tbody>
</table>
Lesson Thirty-two

Concept: Adaptations That Enable Insects to Fly

Resources/Materials: Mini Textbook, page 49
Worksheets #6A.31a, #6A.31b, and #6A.31c (student copies)

Introduction: Review that when birds flap their wings, that effort with their muscle combined with how they shaped their wings helps them to control lift and thrust.

Explain that insects perform in pretty well the same fashion.

Procedure:

1. Explain to students that they are going to do a similar activity for the adaptations that enable insects to fly as they did for adaptations that enable birds to fly.

2. Have students turn to *Mini Textbook*, page 49. Guide the reading. As you go through the table on page 49, have students look for similarities between insect adaptation and bird adaptations.

3. Students are to cut out the boxes from Worksheet #6A.31c and **put their names or initials on the backs of each**.

4. The sentences in these boxes give the main ideas for the explanations on Worksheets #6A.31a and #6A.31b. Students are to paste the cut out boxes next to the matching explanations.

Assignment:

Paste the boxes from Worksheet #6A.31c next to the matching boxes from Worksheets #6A.31a and #6A.31b.
<table>
<thead>
<tr>
<th>How Insects Fly</th>
<th>Matching Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generally, insects are small and lightweight.</td>
<td></td>
</tr>
<tr>
<td>Insect wings are much thinner and flatter than bird wings. They are often flat</td>
<td></td>
</tr>
<tr>
<td>when at rest.</td>
<td></td>
</tr>
<tr>
<td>The wings take on the curved shape of an airfoil once they beat against the</td>
<td></td>
</tr>
<tr>
<td>air.</td>
<td></td>
</tr>
<tr>
<td>As an insect flaps its wings down, they push against the air. This pushing</td>
<td></td>
</tr>
<tr>
<td>moves the insect upwards and forwards.</td>
<td></td>
</tr>
<tr>
<td>How Insects Fly</td>
<td>Matching Idea</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Some insects that single wings and some have double wings.</td>
<td></td>
</tr>
<tr>
<td>Insect wings are attached to the middle body sections called the thorax.</td>
<td></td>
</tr>
<tr>
<td>Some insects with two pairs of wings join the front and back wings together.</td>
<td></td>
</tr>
<tr>
<td>This makes a bigger surface to push against the air.</td>
<td></td>
</tr>
<tr>
<td>Insects have specialized flight muscles to power their wings.</td>
<td></td>
</tr>
<tr>
<td>Insect flight muscles have to be warm before they will work.</td>
<td></td>
</tr>
<tr>
<td>Their body temperature varies with the temperature of the immediate environment, so when it is cold outside, their body temperature is too low to fly.</td>
<td></td>
</tr>
</tbody>
</table>
**Adaptations of Insects**

**Directions:** Read each of the adaptations that insects have that enable them to fly. Then cut apart the boxes. Paste them beside the corresponding explanations.

<table>
<thead>
<tr>
<th>There are some insects that have double wings; others have single wings.</th>
<th>Insect wings can become curved on top and flat on the bottom, just like an airplane.</th>
<th>Insects can only fly when the muscles on their bodies are warm enough.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like birds, insects have specialized muscles to move their wings.</td>
<td>Insects' wings are attached to the thorax. The thorax is the middle section of an insect's body.</td>
<td>Insects get thrust and lift by flapping their wings up and down.</td>
</tr>
<tr>
<td>Compared to birds, insect wings are flatter and thinner.</td>
<td>They are small and lightweight.</td>
<td>Insects with two pairs of wings can create more thrust and lift because they have a larger surface to push against the air.</td>
</tr>
</tbody>
</table>
## Fly Like an Insect

### How Insects Fly

<table>
<thead>
<tr>
<th>Generally, insects are small and lightweight.</th>
<th>They are small and lightweight.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insect wings are much thinner and flatter than bird wings. They are often flat when at rest.</td>
<td>Compared to birds, insect wings are flatter and thinner.</td>
</tr>
<tr>
<td>The wings take on the curved shape of an airfoil once they beat against the air.</td>
<td>Insect wings can become curved on top and flat on the bottom, just like an airplane.</td>
</tr>
<tr>
<td>As an insect flaps its wings down, they push against the air. This pushing moves the insect upwards and forwards.</td>
<td>Insects get thrust and lift by flapping their wings up and down.</td>
</tr>
</tbody>
</table>
## How Insects Fly

<table>
<thead>
<tr>
<th>How Insects Fly</th>
<th>Matching Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some insects that single wings and some have double wings.</td>
<td>There are some insects that have double wings; others have single wings.</td>
</tr>
<tr>
<td>Insect wings are attached to the middle body sections called the thorax.</td>
<td>Insects’ wings are attached to the thorax. The thorax is the middle section of an insect’s body.</td>
</tr>
<tr>
<td>Some insects with two pairs of wings join the front and back wings together. This makes a bigger surface to push against the air.</td>
<td>Insects with two pairs of wings can create more thrust and lift because they have a larger surface to push against the air.</td>
</tr>
<tr>
<td>Insects have specialized flight muscles to power their wings.</td>
<td>Like birds, insects have specialized muscles to move their wings.</td>
</tr>
<tr>
<td>Insect flight muscles have to be warm before they will work. Their body temperature varies with the temperature of the immediate environment, so when it is cold outside, their body temperature is too low to fly.</td>
<td>Insects can only fly when the muscles on their bodies are warm enough.</td>
</tr>
</tbody>
</table>
Lesson Thirty-two

Concept: Air and Aerodynamics – Part II Review

Resources/Materials: Air and Aerodynamics – Part II Review Sheets (student copies)

Introduction: Review that in the unit *Air and Aerodynamics* students learned about some of the many properties of air in Part I. In Part II they learned about aerodynamics – how air behaves when it is moving. Explain that the unit is now almost complete and it is time for review.

Procedure:

1. If possible, as a class orally review the main concepts covered in this half of the unit:
   - Air can be compressed.
   - The more air is compressed, the greater is its pressure.
   - Compressed air tries to equalize.
   - Devices such as tire pumps and automatic nailers use compressed air.
   - The Bernoulli Principle
   - How the airfoil shape of an airplane’s wings give it lift.
   - Lift and gravity (weight); thrust and drag.
   - Streamlining helps to reduce drag.

2. Distribute the *Air and Aerodynamics – Part II* review sheets. Have students work on them independently. If possible, check them together as a class.

Assignment:

Do the *Air and Aerodynamics – Part II* Review Sheets.
1. What happens when air is compressed?

2. Why does an inflated balloon dart off through the air when you let go of the neck?

Use the information below to answer question 3.

Jose performed a demonstration related to air pressure. He inserted an inflation needle into a soccer ball and let the air move into an empty plastic bag, as shown in the diagram.

3. Which statement is true?

As the air moves into the bag, the volume of the air in the bag will

a. keep increasing due to low air pressure in the ball.
b. start decreasing due to the high pressure in the ball.
c. stay the same because the air pressure in the ball and bag are equal.
d. increase until the air pressure in the ball and in the bag are equal.
4. When the handle on the tire pump is pressed down,

   a. the air in the cylinder compresses and forces the outlet check valve closed.
   b. the air in the cylinder compresses and forces the outlet check valve open.
   c. the inlet check valve opens and the outlet check valve closes.
   d. both the inlet check valve and the outlet check valve open.

5. What is the Bernoulli Principle?
6. Examine the diagram below. Describe what will happen if you blow steadily across the top of the curved paper. Use the Bernoulli Principle to explain why this happens.

7. Examine the illustration of a cross-section cut of an airplane wing. Write a paragraph that explains how the shape of the wing enables the airplane to get enough lift to rise up.
8. Define each of these terms.

a. lift

b. thrust

c. drag

d. altitude

e. ascend

f. descend

9. Fill the blanks with these words: accelerate, decelerate, ascend, descend, hover.

a. When thrust is greater than drag, an airplane will ________________.

b. When lift if greater than weight, an airplane will ________________.

c. When drag is greater than thrust, an airplane will ________________.

d. When weight is greater than lift, an airplane will ________________.

e. If weight and lift are equal, and thrust and drag are equal, an airplane will ________________.
10. Label the diagrams with these words: drag, lift, thrust, weight.

11. A pilot is flying a plane at a high speed. He wants to slow down and descend because he is getting close to the airport. In order to do this, what two things must happen?

   a. 
   b. 

12. A bird on the ground wants to take off and fly. What does it do to create lift?

   

13. A typical airplane wing is straight on the bottom and curved on the top. The airflow around a wing produces the force that holds the airplane up. Where on the wing is the airflow the fastest?
14. Look at the chart below. It describes the speed of a small airplane. This plane can land on water as well as on a runway. Use the information to answer the questions.

**AIR SPEEDS—Muskrat 131**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td>5</td>
</tr>
<tr>
<td>Take off</td>
<td>70</td>
</tr>
<tr>
<td>Cruise Flight—with floats</td>
<td>110</td>
</tr>
<tr>
<td>Cruise Flight—with wheels</td>
<td>130</td>
</tr>
</tbody>
</table>

a. When does the airplane have the greatest amount of thrust?

b. When does the airplane have the least amount of thrust?

c. Tell why the airplane would fly more slowly with floats than with wheels.

15. What does a bird do to produce thrust?

16. Name two ways that different types of airplanes produce thrust.
   a. 
   b. 
17. Examine the picture of the model airplane below.

How do you increase the amount of thrust on this airplane?

18. Birds and airplanes have bodies that are streamlined. How does this help them to fly?
19. There are many features of a bird that are similar to the features of an airplane. For each bird feature, tell about an similar airplane feature.

<table>
<thead>
<tr>
<th>Bird Feature</th>
<th>Airplane Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legs that fold up to reduce drag</td>
<td></td>
</tr>
<tr>
<td>Tail feathers</td>
<td></td>
</tr>
<tr>
<td>Two feathered wings that are curved on top</td>
<td></td>
</tr>
<tr>
<td>Streamlined design</td>
<td></td>
</tr>
<tr>
<td>Skeleton with bones that are hollow</td>
<td></td>
</tr>
</tbody>
</table>
20. Examine the diagram in the box.

Circle the box that correctly identifies the forces acting on the airplane.

a.  
   Force 1 – Thrust  
   Force 2 – Gravity  
   Force 3 – Lift  
   Force 4 – Drag

b.  
   Force 1 – Lift  
   Force 2 – Thrust  
   Force 3 – Gravity  
   Force 4 – Drag

c.  
   Force 1 – Drag  
   Force 2 – Lift  
   Force 3 – Thrust  
   Force 4 – Gravity

d.  
   Force 1 – Lift  
   Force 2 – Drag  
   Force 3 – Gravity  
   Force 4 - Thrust
1. What happens when air is compressed?
   - molecules become closer together
   - air pressure increases

2. Why does an inflated balloon dart off through the air when you let go of the neck?
   - air pressure inside balloon tries to equalize with air pressure in the room

Use the information below to answer question 3.

Jose performed a demonstration related to air pressure. He inserted an inflation needle into a soccer ball and let the air move into an empty plastic bag, as shown in the diagram.

3. Which statement is true?
   As the air moves into the bag, the volume of the air in the bag will
   a. keep increasing due to low air pressure in the ball.
   b. start decreasing due to the high pressure in the ball.
   c. stay the same because the air pressure in the ball and bag are equal.
   d. increase until the air pressure in the ball and in the bag are equal.
4. When the handle on the tire pump is pressed down,

a. the air in the cylinder compresses and forces the outlet check valve closed.

b. the air in the cylinder compresses and forces the outlet check valve open.

c. the inlet check valve opens and the outlet check valve closes.

d. both the inlet check valve and the outlet check valve open.

5. What is the Bernoulli Principle?

_Faster moving air has lower air pressure than slower moving air_
6. Examine the diagram below. Describe what will happen if you blow steadily across the top of the curved paper. Use the Bernoulli Principle to explain why this happens.

If you blow steadily across the top of the curved surface, the paper will flip up. This is because the moving air on the top of the paper will have lower air pressure than the air beneath. The air below will exert more force than the air above the paper.

7. Examine the illustration of a cross-section cut of an airplane wing. Write a paragraph that explains how the shape of the wing enables the airplane to get enough lift to rise up.

The curved leading edge splits the airstream. The air going over and along the curved surface will move faster than the air going under. The faster moving air will have lower air pressure. The slower, higher pressure air under the wing exerts more force on the wing than the faster, lower pressure air, causing lift.
8. Define each of these terms.

a. lift  ____________

b. thrust  ____________

c. drag  ____________

d. altitude  ____________

e. ascend  ____________

f. descend  ____________

9. Fill the blanks with these words: accelerate, decelerate, ascend, descend, hover.

a. When thrust is greater than drag, an airplane will  _____________.

b. When lift if greater than weight, an airplane will  _____________.

c. When drag is greater than thrust, an airplane will  _____________.

d. When weight is greater than lift, an airplane will  _____________.

e. If weight and lift are equal, and thrust and drag are equal, an airplane will  _____________.

hover  _____________.

10. Label the diagrams with these words: **drag, lift, thrust, weight.**

11. A pilot is flying a plane at a high speed. He wants to slow down and descend because he is getting close to the airport. In order to do this, what **two** things must happen?

   a. decrease thrust
   
   b. decrease lift

12. A bird on the ground wants to take off and fly. What does it do to create lift?

   flap wings

13. A typical airplane wing is straight on the bottom and curved on the top. The airflow around a wing produces the force that holds the airplane up. Where on the wing is the airflow the fastest?

   over the top
14. Look at the chart below. It describes the speed of a small airplane. This plane can land on water as well as on a runway. Use the information to answer the questions.

<table>
<thead>
<tr>
<th>AIR SPEEDS—Muskrat 131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
</tr>
<tr>
<td>Take off</td>
</tr>
<tr>
<td>Cruise Flight—with floats</td>
</tr>
<tr>
<td>Cruise Flight—with wheels</td>
</tr>
</tbody>
</table>

a. When does the airplane have the greatest amount of thrust?
   **cruising with wheels**

b. When does the airplane have the least amount of thrust?
   **taxiing**

c. Tell why the airplane would fly more slowly with floats than with wheels.
   **floats increase drag**

15. What does a bird do to produce thrust?

   **flap its wings**

16. Name two ways that different types of airplanes produce thrust.

   a. **jets**
   b. **propellers**
      **twisted elastics**
17. Examine the picture of the model airplane below.

How do you increase the amount of thrust on this airplane?

- increase number of twists on elastic

18. Birds and airplanes have bodies that are streamlined. How does this help them to fly?

- decrease resistance (drag)
19. There are many features of a bird that are similar to the features of an airplane. For each bird feature, tell about an similar airplane feature.

<table>
<thead>
<tr>
<th>Bird Feature</th>
<th>Airplane Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legs that fold up to reduce drag</td>
<td>wheels that fold up into fuselage</td>
</tr>
<tr>
<td>Tail feathers</td>
<td>tail</td>
</tr>
<tr>
<td>Two feathered wings that are curved on top</td>
<td>wings that are curved on top</td>
</tr>
<tr>
<td>Streamlined design</td>
<td>streamlined design</td>
</tr>
<tr>
<td>Skeleton with bones that are hollow</td>
<td>fuselage that is hollow</td>
</tr>
</tbody>
</table>
20. Examine the diagram in the box.

Circle the box that correctly identifies the forces acting on the airplane.

a. Force 1 – Thrust  
   Force 2 – Gravity  
   Force 3 – Lift  
   Force 4 – Drag

b. Force 1 – Lift  
   Force 2 – Thrust  
   Force 3 – Gravity  
   Force 4 – Drag

c. Force 1 – Drag  
   Force 2 – Lift  
   Force 3 – Thrust  
   Force 4 – Gravity

d. Force 1 – Lift  
   Force 2 – Drag  
   Force 3 – Gravity  
   Force 4 – Thrust
Lesson Thirty-three

Concept: Air and Aerodynamics – Part II Test

Resources/Materials: Air and Aerodynamics – Part II Test (student copies)
1. Air can be compressed. Explain what this means.

2. What is the relationship between how much air has been compressed and air pressure?

Use the information below to answer question 3.

Examine the diagram of the inflated balloon. It is taped to a straw that has been threaded onto a long string.

3. Which statement best tells why the balloon will move along the string when you let go of the neck?
   
   a. The air pressure inside the balloon is less than the air pressure outside the balloon.
   b. The compressed air inside the balloon is trying to escape through the neck of the balloon and pushes the balloon along the string.
   c. The compressed air outside the balloon is trying to get inside the balloon.
   d. The air pressure inside the balloon will try to compress further.
Mr. Brown blew up a balloon. He then placed a clip over the neck of the balloon so that no air could not escape. Then Mr. Brown attached the neck of an uninflated balloon over the neck of the inflated balloon and taped the necks. When he took off the clip, he noticed that some of the air from the balloon he blew up went into the uninflated balloon.

4. Which statement best tells why the some of the air from the inflated balloon flowed into the uninflated balloon?

   a. Compressed air will try to equalize with non-compressed air.
   b. The air in the inflated balloon has lower pressure than the air in the uninflated balloon.
   c. The air in the inflated balloon has the same pressure as the air in the uninflated balloon.
   d. The air in the uninflated balloon has a higher air pressure than the air in the inflated balloon.

5. When you blow up a balloon too much, it will burst. Which statement best tells why this happens?

   a. The air pressure in the balloon is lower than the air pressure outside the balloon.
   b. The compressed air inside the balloon has less air pressure than the air outside the balloon.
   c. The compressed air inside the balloon has too much air pressure for the size and strength of the balloon.
   d. The compressed air inside the balloon is colder than the outside air.
Use the following information to answer question 6.

Examine the diagram of the hand-held pump.

6. The pump is designed to

a. pump air only into bicycle tires.
b. compress air and then allow it to flow out through the valve.
c. heat air and then allow it to expand.
d. reduce the volume of air in a tire so that the air will fill the tire.

7. What is the Bernoulli Principle?

8. Examine the diagram. Describe what will happen if you blow steadily up into the funnel. Use the Bernoulli Principle to explain why this happens.
Science Grade 6 Topic A Air and Aerodynamics – Part II
Test

7. Look at the picture. What will happen when the girl blows air across the top of the strip of paper?
   a. The paper will remain in the same position.
   b. The paper will bend down further.
   c. The paper will lift up.
   d. The paper will bend in half.

8. Look at the illustration. The boy is blowing air through the paper tent. Which statement correctly tells what will happen?
   a. Both sides of the tent will bend outward.
   b. Both sides of the tent will bend inward.
   c. One side will bend outward and the other inward.
   d. Both sides of the tent will not move.

9. Below is an illustration of air passing over and under an airplane wing. Write a paragraph to explain how the design of the airplane wing helps the airplane to stay up in the air. You must use these words in your explanation: airfoil, lift, air pressure, faster, slower.
10. Define each of these terms.

a. lift

b. weight

c. thrust

d. drag

11. Label this diagram with the forces acting on an airplane as it flies through the air.
12. Complete these sentences with words from the box.

| hover | descend | accelerate | decelerate | ascend |

a. If lift becomes greater than weight, an airplane will ________________.
b. If weight becomes greater than lift, an airplane will ________________.
c. If thrust becomes greater than drag, an airplane will ________________.
d. If drag becomes greater than thrust, an airplane will ________________.
e. If lift and weight are equal and thrust and drag are equal, the airplane will ________________.

13. A pilot is flying an airplane. After takeoff he steadily increases the airplane's speed and altitude. For these increases to occur

a. thrust must be equal to drag and lift must equal gravity.
b. thrust must be greater than drag and lift must be greater than gravity.
c. thrust must equal drag and lift must be greater than gravity.
d. thrust must be greater than drag and lift must equal gravity.

14. The airflow around a wing produces the force that holds the airplane up. This airflow is fastest

a. behind the wing.
b. in front of the wing.
c. over top of the wing.
d. underneath the wing.
AIR SPEEDS – Muskrat 131

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td>5</td>
</tr>
<tr>
<td>Take off</td>
<td>70</td>
</tr>
<tr>
<td>Cruise Flight – with floats</td>
<td>110</td>
</tr>
<tr>
<td>Cruise Flight – with wheels</td>
<td>130</td>
</tr>
</tbody>
</table>

15. From the chart, you can infer that the airplane has the greatest amount of thrust when

a. it is taxiing.
b. it is taking off.
c. it is cruising with floats.
d. it is cruising with wheels.

16. From the chart, you can infer that the airplane flies more slowly with floats than with wheels because the floats

a. increase thrust.
b. decrease thrust.
c. increase drag.
d. decrease drag.

17. How do airplanes produce thrust?

________________________________________________________________________________

________________________________________________________________________________

18. What do birds do to produce thrust?

________________________________________________________________________________

________________________________________________________________________________
Use the information below to answer question 19.

19. The force affected by the number of turns of the elastic is
   a. thrust.
   b. gravity.
   c. drag.
   d. lift.

20. An airplane is like a bird in that both are streamlined in order to reduce
   a. lift.
   b. weight.
   c. drag.
   d. thrust.
21. Examine this illustration of two cars coming down a ramp. Tell which car will come down faster and tell why.

Use the information to answer question 22.

### Features of Birds

I. Streamlined design  
II. Tail feathers  
III. Long claws  
IV. Legs that fold up

22. The features of birds listed above that is similar to features in airplane designs are

a. I, II, and III.  
b. I, II, and IV.  
c. I, III, and IV.  
d. II, III, and IV.
23. A bird is flying in the air. To rise up it must
   a. beat its wings very hard to force air quickly over the upper surfaces and produce lift.
   b. run fast.
   c. beat its wings slowly so that the air can come under its body.
   d. wait for an air current to lift it.

24. What is the shape of a bird’s wings when they are spread out?
   a. flat on top and curved on the bottom
   b. curved on the top and on the bottom
   c. flat on top and flat on the bottom
   d. flat on the bottom and curved on the top.
1. Air can be compressed. Explain what this means.

   molecules can be squeezed closer together

2. What is the relationship between how much air has been compressed and air pressure?

   The more air is compressed, the greater the air pressure

*Use the information below to answer question 3.*

Examine the diagram of the inflated balloon. It is taped to a straw that has been threaded onto a long string.

3. Which statement best tells why the balloon will move along the string when you let go of the neck?

   a. The air pressure inside the balloon is less than the air pressure outside the balloon.
   b. The compressed air inside the balloon is trying to escape through the neck of the balloon and pushes the balloon along the string.
   c. The compressed air outside the balloon is trying to get inside the balloon.
   d. The air pressure inside the balloon will try to compress further.
Use the information below to answer question 4.

Mr. Brown blew up a balloon. He then placed a clip over the neck of the balloon so that no air could not escape. Then Mr. Brown attached the neck of an uninflated balloon over the neck of the inflated balloon and taped the necks. When he took off the clip, he noticed that some of the air from the balloon he blew up went into the uninflated balloon.

4. Which statement best tells why the some of the air from the inflated balloon flowed into the uninflated balloon?
   a. Compressed air will try to equalize with non-compressed air.
   b. The air in the inflated balloon has lower pressure than the air in the uninflated balloon.
   c. The air in the inflated balloon has the same pressure as the air in the uninflated balloon.
   d. The air in the uninflated balloon has a higher air pressure than the air in the inflated balloon.

5. When you blow up a balloon too much, it will burst. Which statement best tells why this happens?
   a. The air pressure in the balloon is lower than the air pressure outside the balloon.
   b. The compressed air inside the balloon has less air pressure than the air outside the balloon.
   c. The compressed air inside the balloon has too much air pressure for the size and strength of the balloon.
   d. The compressed air inside the balloon is colder than the outside air.
6. The pump is designed to
   a. pump air only into bicycle tires.
   b. compress air and then allow it to flow out through the valve.
   c. heat air and then allow it to expand.
   d. reduce the volume of air in a tire so that the air will fill the tire.

7. What is the Bernoulli Principle?
   Faster moving air has lower air pressure than slower moving air.

8. Examine the diagram. Describe what will happen if you blow steadily up into the funnel. Use the Bernoulli Principle to explain why this happens.
   The ball will not rise up. Blowing up from the bottom decreases air pressure under the ball. The air pressure above the ball is now greater. This pushes the ball down.
7. Look at the picture. What will happen when the girl blows air across the top of the strip of paper?

   a. The paper will remain in the same position.
   b. The paper will bend down further.
   c. The paper will lift up.
   d. The paper will bend in half.

8. Look at the illustration. The boy is blowing air through the paper tent. Which statement correctly tells what will happen?

   a. Both sides of the tent will bend outward.
   b. Both sides of the tent will bend inward.
   c. One side will bend outward and the other inward.
   d. Both sides of the tent will not move.

9. Below is an illustration of air passing over and under an airplane wing. Write a paragraph to explain how the design of the airplane wing helps the airplane to stay up in the air. You must use these words in your explanation: **airfoil, lift, air pressure, faster, slower**.

   An airplane wing has an **airfoil** shape. As the airplane glides through the air, it splits the air. The air that goes over along the curved part flows faster and thus has lower **air pressure** than the air flowing along the bottom, which flows more slowly. This creates **lift**.
10. Define each of these terms.

a. lift \underline{upward force}\ng

b. weight \underline{downward force (gravity)}
g

c. thrust \underline{forward force}\ng

d. drag \underline{force of resistance}\ng

11. Label this diagram with the forces acting on an airplane as it flies through the air.
12. Complete these sentences with words from the box.

<table>
<thead>
<tr>
<th>hover</th>
<th>descend</th>
<th>accelerate</th>
<th>decelerate</th>
<th>ascend</th>
</tr>
</thead>
</table>

a. If lift becomes greater than weight, an airplane will **ascend**.

b. If weight becomes greater than lift, an airplane will **descend**.

c. If thrust becomes greater than drag, an airplane will **accelerate**.

d. If drag becomes greater than thrust, an airplane will **decelerate**.

e. If lift and weight are equal and thrust and drag are equal, the airplane will **hover**.

13. A pilot is flying an airplane. After takeoff he steadily increases the airplane’s speed and altitude. For these increases to occur

   a. thrust must be equal to drag and lift must equal gravity.
   b. thrust must be greater than drag and lift must be greater than gravity.
   c. thrust must equal drag and lift must be greater than gravity.
   d. thrust must be greater than drag and lift must equal gravity.

14. The airflow around a wing produces the force that holds the airplane up. This airflow is fastest

   a. behind the wing.
   b. in front of the wing.
   c. over top of the wing.
   d. underneath the wing.
Use the information below to answer questions 15 and 16.

**AIR SPEEDS – Muskrat 131**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td>5</td>
</tr>
<tr>
<td>Take off</td>
<td>70</td>
</tr>
<tr>
<td>Cruise Flight – with floats</td>
<td>110</td>
</tr>
<tr>
<td>Cruise Flight – with wheels</td>
<td>130</td>
</tr>
</tbody>
</table>

15. From the chart, you can infer that the airplane has the greatest amount of thrust when
   a. it is taxiing.
   b. it is taking off.
   c. it is cruising with floats.
   d. it is cruising with wheels.

16. From the chart, you can infer that the airplane flies more slowly with floats than with wheels because the floats
   a. increase thrust.
   b. decrease thrust.
   c. increase drag.
   d. decrease drag.

17. How do airplanes produce thrust?
   - propellers or jets

18. What do birds do to produce thrust?
   - flap wings
19. The force affected by the number of turns of the elastic is

   a. thrust.
   b. gravity.
   c. drag.
   d. lift.

20. An airplane is like a bird in that both are streamlined in order to reduce

   a. lift.
   b. weight.
   c. drag.
   d. thrust.
21. Examine this illustration of two cars coming down a ramp. Tell which car will come down faster and tell why.

The rounded car will come down faster. It is more streamlined so it will have reduced drag.

Use the information to answer question 22.

<table>
<thead>
<tr>
<th>Features of Birds</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Streamlined design</td>
</tr>
<tr>
<td>II Tail feathers</td>
</tr>
<tr>
<td>III Long claws</td>
</tr>
<tr>
<td>IV Legs that fold up</td>
</tr>
</tbody>
</table>

22. The features of birds listed above that is similar to features in airplane designs are

a. I, II, and III.
b. I, II, and IV.
c. I, III, and IV.
d. II, III, and IV.
23. A bird is flying in the air. To rise up it must
   a. beat its wings very hard to force air quickly over the upper surfaces and produce lift
   b. run fast.
   c. beat its wings slowly so that the air can come under its body.
   d. wait for an air current to lift it.

24. What is the shape of a bird’s wings when they are spread out?
   a. flat on top and curved on the bottom
   b. curved on the top and on the bottom
   c. flat on top and flat on the bottom
   d. flat on the bottom and curved on the top.
Topic B

Flight
## Materials List By Lesson
Optional items are in brackets [ ].

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Materials Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>paper, tape</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30 cm X 30 cm square of plastic (grocery bag), cork, thread, tape, paper clips, step ladder</td>
</tr>
<tr>
<td>5</td>
<td>different fabrics (five kinds), washers, thread</td>
</tr>
<tr>
<td>6</td>
<td>4 sheets plastic (30 cm X 30 cm), thread, washers, step ladder</td>
</tr>
<tr>
<td>7</td>
<td>[photos of hot air balloons]</td>
</tr>
<tr>
<td>8</td>
<td>empty 2 L plastic pop bottle, large bowl or sink, large balloon, hot tap water</td>
</tr>
<tr>
<td>9</td>
<td>inexpensive thin garbage bag, 4 twist ties, hair dryer</td>
</tr>
<tr>
<td>10</td>
<td>2 inexpensive thin garbage bags, 8 twist ties, hair dryer</td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>paper</td>
</tr>
<tr>
<td>16</td>
<td>[model airplane]</td>
</tr>
<tr>
<td>17</td>
<td>[model airplane]</td>
</tr>
<tr>
<td>18</td>
<td>paper, tape, paper clips</td>
</tr>
<tr>
<td>19</td>
<td>paper, paper clips</td>
</tr>
<tr>
<td>20</td>
<td>paper, paper clips</td>
</tr>
<tr>
<td>21</td>
<td>paper</td>
</tr>
<tr>
<td>22</td>
<td>paper of various weights, paper clips, tape, Plasticine</td>
</tr>
<tr>
<td>23</td>
<td>paper of various weights, paper clips, Plasticine, foil</td>
</tr>
<tr>
<td>24</td>
<td>one-hole punch, 2 cm X 21 cm strip of Manila tag, drinking straw, masking tape</td>
</tr>
<tr>
<td>25</td>
<td>empty bottle with cork, unsharpened round pencils, vinegar, baking soda, tissue paper, clean, empty drink box with straw, Plasticine</td>
</tr>
<tr>
<td>26</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>
Comprehensive Materials List
(optional materials are in square brackets)

baking soda
bowl (large or access to a sink)
cork
drink box (clean, empty with straw)
fabrics (various kinds)
garbage bags (lightweight, thin)
hair dryer
ladder (step)

Manila tag

paper (plain white bond)
paper (various weights)
pencils (several round, unsharpened)
[photos of hot air balloons]
Plasticine
pop bottle (empty, plastic, 2 L)
punch (one-hole)
straws (drinking)
tape (masking)
tape (Magic Mending)
thread
tissue paper
twist ties

vinegar

washers (to act as payloads for parachutes)
Grade Six
Topic B
Flight
Mini Textbook
Revised Edition
Science Grade Six
Topic B: Flight

Contents

Part I: Floaters and Gliders

Introduction 4

Types of Flight 5
  Floaters 6
  Gliders 7
  Flyers 9

Floaters 12
  The Effect of Air Resistance on Floaters 13
  Parachute: Information Article 15

Gliders 20
  Hot Air Balloon: Information Article 21

Conducting a Fair Test 26
  Parts of a Fair Test 27
# Part II: Flyers

**Introduction**  
A Review of Aerodynamics  
28  
The Airfoil  
29

**A Review of the Forces Acting on an Airplane in Flight**  
Paper Airplane: Glider or Flyer?  
30  
31

**The Basic Movements of an Airplane**  
The Three Axes  
32  
33

**The Controlling Surfaces of an Airplane**  
The Parts of an Airplane  
34  
Controlling the Airplane  
35

**Basic Airplane Movements: A Closer Look**  
The Role of Air Resistance  
36  
Controlling Pitch  
37  
Controlling Roll  
38  
Controlling Yaw  
39  
Banking  
40

**Producing and Controlling Thrust**  
Introduction  
41  
Propellers  
42  
Jet Engines  
45  
Rockets  
47
Flight

Introduction

For thousands of years, humans have been fascinated with air travel. They observed objects drifting through the air and birds flying around them. They wondered if they too could take flight and see the earth from far above.

Leonardo da Vinci, an Italian who lived in the 15th and 16th centuries, analyzed how birds fly. He also made drawings of how he thought people could use parachutes to descend from high places and wrote down ideas of how humans might be able to fly. He did centuries before humans actually used parachutes and flew in airplanes.
Part I

Floaters and Gliders

Types of Flight

We can divide things that take flight into three basic categories: floaters, gliders, and flyers. These are not distinct groupings; that is, not all devices fit nicely into just one group. Some floaters have a few characteristics of gliders; some gliders have one or two characteristics of flyers; and so on.

Floaters: *The wind controls the speed and direction of flight.*

Gliders: *Wings interact with the air currents. The direction of travel and the rate of descent can be controlled somewhat.*

Flyers: *Use an engine or body muscles to create lift and thrust. Direction of travel and rate of descent can be controlled.*

A bicycle with wings attached to its frame was an early attempt at a flying machine in the early 1900s. As the cyclist pedalled, he would make the wings flap, hoping that with enough speed, he would lift off into the air and fly! This winged bicycle was not successful.

An ancient Greek myth tells the story of a god named Icarus who could fly by attaching feathers to his body with wax. When he got too close to the sun, the wax melted and the feathers fell off. He then plunged into the sea.
Floaters

Floaters are devices that start off in the air and are pulled to the earth's surface by gravity. The wind affects a floater's speed and direction of flight. In general, floaters have relatively large surface areas for their weight. In nature, floaters keep more or less the same shape. Humans have designed their own floaters, but have included some ways to control descent. Following are some examples of floaters.

Many seeds are dispersed because of the float from one place to another using the power of the wind to carry them. (1. milkweed  2. dandelion  3. cottonwood tree  4. maple tree)

Falling leaves drift back and forth in the air and eventually settle on the ground. (Right)

Parachutes are also floaters. Canopy shapes and designs can vary. (Below)
Gliders

Gliders are different than floaters. They have wings or membranes that interact with the air currents. This enables the animal or person gliding to have some control over the direction and rate of descent; something that most floaters do not have. Gliders cannot create thrust or lift.

Nature’s Gliders

There are many examples of gliders in nature. The ability to glide enables many different species to travel from place to place.

The flying squirrel cannot really fly. It can glide, however. It has a fur-covered membrane that joins each of its front legs to the back legs. It glides through the air from tree to tree.

The paradise flying snake is found in southeast Asia. It prefers to live in trees. It travels from one tree to another by using springing action. While in the air, it flattens its body and curves it into an arc. This helps to catch the air and enables it to get to the next tree.

Flying fish are found in some oceans, usually in warmer seas. They have extra long fins, which they can spread. When they are trying to escape from enemies, they leap out of the water, spread their fins and glide long distances.
Devices That Enable Humans to Glide

The human body is not designed for gliding. Humans have designed devices that enable them to glide. These devices have controls of some kind that enable the operator to control the rate and direction of descent. Most human-designed gliders are used for recreational purposes.

A kite is a glider, although some classify it as a floater. The person operating the kite can control its descent by pulling on a string attached to the kite.

A glider looks like an airplane. It has no engine. Gliders are towed up into the air with a propellered aircraft. Once in the air, the tow rope is detached. The glider’s pilot uses controls that can adjust the shape of the wings. In this way, the pilot can travel through the sky and land safely.

A hang glider “hangs” onto a large sail. In order to get airborne, the hang glider must start off near the top of a cliff. He or she runs and then jumps off the cliff. The hang glider can adjust the sails to control his or her descent.

A parasail canopy resembles the canopy of a parachute. The parasailor is harnessed to the canopy, which is also attached to a motorboat. The parasailor starts off standing on the beach. The motorboat gradually picks up speed. A helper gives the parasailor a boost up. As the parasail catches the wind, it ascends. He or she can stay up in the air as long as the motorboat is travelling at a good speed. When the motorboat slows down, the parasail descends.
A hot air balloon is also a type of glider. It is similar to a flyer in that the balloonist has some control over lift and the rate of descent. What he or she cannot do is create thrust. This means that the balloonist has little or no control of the speed and direction of flight.

The Space Shuttle looks like an airplane, but it is a glider. This is one glider that is not designed to be used for recreation. It has been extremely useful in helping scientists find out more about outer space. The Shuttle is launched into the air using a rocket, that falls away once the Shuttle is travelling fast enough. Space Shuttles have made many trips into outer space. The crew of a space shuttle must be highly trained. When it is time to return to Earth, the crew uses controls to guide the aircraft safely from outer space, into Earth’s atmosphere, and back to a landing strip.

Flyers

Flyers, whether natural or human-made are the most sophisticated air travellers. Nature’s flyers use muscle tissue to create lift and thrust. Human-made flyers burn fuel to perform these functions. Flyers can also control the rate of travel, the direction of travel, and the rates of ascent and descent.

Approximately 300 000 000 Monarch butterflies migrate from their summer homes in central and northern North America to their winter homes in Mexico. These flyers travel at about 50 km/h. It takes them 8 – 10 weeks to make the 5000 km journey.
Bats live in colonies. These mammals are also flyers. They do not have wings like birds. Instead, they have membranes that join their front limbs to their bodies. The membranes perform the same basic function as wings.

Most birds, like these Canada geese, are flyers. They use a flapping motion to create lift and thrust. However, as flapping requires a great deal of energy, they spend much of their time in the air gliding.

Unlike most birds, hummingbirds can hover in one spot by flapping their wings rapidly. This enables them to remain suspended in the air while sucking the nectar from flower blossoms. Hovering requires a great deal of energy. Hummingbirds have a high body temperature and need a great deal of nutrition to keep up their energy level.

Like hummingbirds, helicopters can hover. This is a particularly useful feature as they are regularly used to rescue people who have become stranded or hurt on the sides of mountains or out at sea.
Airplanes are classified as flyers. A propellered airplane (left) gets its thrust when a propeller attached to an engine rotates. A jet airplane (right) gets its thrust from air coming out the back of one or more jet engines. In order to create lift, airplanes must be travelling forward at a certain speed. This is the reason that airplanes must accelerate down a runway before taking off.

The Snowbirds are the precision flying team of the Canadian Forces. They use small two-person jets to do their manoeuvres. When flying in formation, the jets can be as close as four metres apart. For this reason the jet aircraft used are very quick and agile.
Floaters and Gliders

Introduction

Floaters and gliders have one thing in common: they do not have their own way to produce thrust. Some can have very long flights, but eventually gravity brings them all back to earth. The flights that floaters and gliders take depend largely on air currents. Some floaters and all gliders can be adjusted so that catch air currents to shorten or extend their flying time and direction.

Floaters

Of all the objects that travel through the air, the flight of floaters is most affected by the forces of nature. On a windy day floaters are whisked to faraway places. No matter how far they travel and at what speed they move, sooner or later the force of gravity brings them back to earth.

Falling leaves and dandelions seeds are examples of floaters. Unlike natural floaters, human-made floaters, such as parachutes, sometimes have ways of controlling the rate of descent.
The Effect of Air Resistance on Floaters

Objects in the air fall toward the earth because of the force of gravity. As they fall, they collide with any air molecules that are in their way. In order to continue falling, the objects must push these molecules out of the way. This force that prevents objects from falling faster is called \textit{air resistance}. Air resistance is the force that is opposite or opposes gravity. Air resistance is also referred to as \textit{drag}.

Usually, gravity is greater than air resistance, so objects fall toward the earth.

A falling object collides with air molecules as it descends to earth. It has to push the molecules out of the way so that it can continue to fall. This force which acts against a falling object is referred to as air resistance or drag.
What determines how quickly an object will fall?

There are two main factors that determine how quickly an object will fall.

1. **Distance.** The farther an object falls, the faster it falls. Objects pick up speed as they fall.

2. **Surface Area.** Generally, the greater the surface area of an object, the more slowly it falls. This is because an object with a greater surface area meets with more air resistance than one with a smaller surface area.

An object with a large surface area will usually fall more slowly than one with a smaller surface area. However, this is not necessarily always the case. If you drop a sheet of plywood so that it is exactly vertical, it will fall much faster than a sheet of plywood that is horizontal. This is because the area of the surface that actually collides with air molecules is much smaller if it falls vertically compared to if it falls horizontally.

A sheet of paper will drift down to the floor, while a crumpled up sheet of paper will fall much more quickly. This is because when you crumple up a sheet of paper the surface area of the paper is reduced. When this happens it meets with less air resistance.
Introduction

A parachute is a device used to slow the fall of a person or object from an aircraft or any other great height. It is a type of floater. The operation of a parachute is based on simple principles. There are two forces that act on any falling object – gravity and air resistance. Gravity pulls the object toward the earth. But air resists the object’s movement. Because the pull of gravity is much stronger than the resistance of the air, the air can only slow the speed of the falling object. Larger surfaces offer the greatest resistance to the air. Thus, the larger the parachute’s surface area, the more air resistance it meets and the slower it falls.

Uses of Parachutes

Parachutes have been used for several different purposes over the years. One of the early uses was to allow people to descend from gas-filled balloons called blimps. However, blimps never became really popular, so this use of parachutes was very limited.

Since the development of airplanes, parachutes have been used for emergency jumps from damaged aircraft. If the pilot of an aircraft thinks that he or she has no chance of safely landing the airplane, the pilot can eject from the plane. A parachute slows down the rate of descent so that he or she can get to Earth without harm.

Parachutes are also used to deliver cargo. Airplanes drop food and medicine by parachute to places that cannot be reached easily by other means. This is especially
important when there have been natural disasters like floods, earthquakes, and tornadoes. In these instances, roads, railway tracks, and nearby airports may have been destroyed, and there may be no way to reach people who live in remote towns and villages. Airplanes fly past the affected regions, dropping packages of necessary emergency supplies. Because parachutes slow the rate of descent, the packages containing these supplies are attached to parachutes. This way the supplies have a better chance of reaching the ground without being damaged.

During World War II, troops dropped from airplanes to particular locations. This was helpful when roads were blocked or bridges destroyed. It also enabled soldiers to actually get behind enemy lines.

Today parachutes are used to help some racing cars, called funny cars, and the Space Shuttle come to a quicker stop. This is particularly helpful because it helps these vehicles come to rest in a much shorter distance.

The most common use of parachutes today is for skydiving. Skydiving is done for sport or recreation. For many, jumping out of an airplane at high altitudes and falling to the ground using a parachute provides excitement and exhilaration. Skydivers also hold competitions where people try to land on a small target on the ground. Other skydivers work in teams. They jump out of the aircraft together and make patterns in the air before finally releasing their parachutes and drifting to the ground.
Parts of a Parachute

The part of the parachute that catches the air is called the *canopy*. For many years, parachutes had a round canopy that looked somewhat like an umbrella. Today, many canopies have a rectangular shape, somewhat like the wings of an airplane. The front part of a rectangular canopy is cut off, allowing air to enter. The air inflates the canopy and makes it fairly rigid like an air mattress.

Skydivers generally use a Rectangular parachute that is twice as wide as it is deep. Round parachutes are used mainly for cargo drops.

A sport parachute brings a skydiver down very slowly. When the skydiver pulls the *ripcord*, the *pilot chute* opens and pulls out the main canopy. The canopy is packed in a container of heavy nylon cloth. This container is attached to the parachutist’s body by a *harness* that fits around the shoulder and legs. Straps called *risers* connect the harness to the *suspension lines* or *shrouds*, which are attached to the canopy. *Steering lines* are attached to either side of the canopy. By pulling on handles attached to the Steering lines, the parachutist can have some control over how the parachute descents. The load attached to the canopy by the shrouds is called the *payload*. The payload can be cargo or a person.
How Parachutes Work

Skydivers generally open their parachutes when they are about 750 metres above the ground. The parachutist reaches into a pouch on the leg strap and pulls out a pilot parachute that measures about a metre across. This parachute quickly inflates, releases the ripcord pin on the canopy container, and pulls out the main canopy. After the canopy opens, the ride to the ground takes about three minutes. The parachute moves at about 32 kilometres per hour. The parachutist can pull on the right steering line to turn right and on the left steering line to turn left.

Rectangular parachutes have a greater forward speed than round parachutes, and so are not easily blown backward when they encounter wind. Rectangular parachutes also descend more slowly than round parachutes. In landing, the parachutists can pull down the back edge of the rectangular canopy with the steering lines. This slows the parachute’s motion and permits a gradual, soft landing.

A small hole in the centre of the canopy prevents the parachute from wobbling. The hole lets some air escape out the top rather than spilling out one side or the other.

Materials

A parachute must be light enough in weight for a person to carry yet strong enough to perform its function. The appropriate materials are necessary not only to make it perform correctly, but also to ensure the safety of the parachutist. Parachute designers have found that best material for making parachute parts is nylon. Nylon can be used to make harnesses, suspension lines, steering lines, and canopies. Nylon has been found to be particularly good for making parachute canopies. It can be made into a thin, strong fabric that is lightweight and can be folded into a small bundle. Nylon holds dyes well. Because of its strength, nylon is able to withstand any air resistance the canopy might encounter.
History of Parachutes

It is believed that the Chinese were the inventors of the parachute. As early as the 1100s, they experimented with parachutes by jumping from high structures with umbrella-like devices. Since then many inventors and scientists have experimented with and thought about different ways to use air resistance to slow down the speed at which a person falls to the ground. The first known parachute jump was made from a tower in 1783 by a French scientist named Sebastian Lenormand. The first parachute jump from a gas-filled balloon was made in 1797. The first parachute jump from a damaged airplane was made in 1922.

![Leonardo da Vinci, and Italian artist and inventor, drew a sketch of a parachute he designed in 1497. He called it a “tent roof”.

An early parachute was made in 1595 to accompany an article by an Italian experimenter named Veranzio.

Conclusion

The idea of slowing the rate of descent from a higher altitude to a lower altitude has been around for hundreds of years. The design of parachutes has changed over the years. They have become more stable and easier to control. Parachutes are mainly used today for recreation and sport. They are still used if a pilot needs to eject from a damaged aircraft. With the human fascination with flight and the need for excitement and thrills, it is likely that this floater will continue to be in use for generations to come.
Gliders are air travellers that are somewhere between floaters and flyers as far as control over thrust, drag, and lift are concerned. Whereas floaters have little or no control over these forces, flyers have control over all of them. Gliders are devices that can manipulate one or two of these forces, but not all three.

A hot air balloon is classified as a glider. Unlike most gliders that have wings or membranes that help them to control their flight, a hot air balloon has neither of these. A hot air balloonist can control the balloon’s ascent and descent by heating or cooling the air inside the balloon itself. It works on the principle that warmer air is less dense than cooler air.Warmer, less dense air rises; cooler, denser air falls.

Like floaters, a hot air balloon cannot control the speed or direction of flight. For this reason, you seldom see hot air balloons in the sky on windy days. Some hot air balloonists do try to travel from one place to another by catching air currents. This can be dangerous, however, as strong winds can cause a balloon to collapse.
Hot Air Balloon: Information Article

Introduction

A hot air balloon is a balloon-shaped aircraft whose bag is inflated with hot air. Its passengers stand in a basket suspended below this large bag of heated air. Hot air balloons use the idea that a bag filled with less dense air will float because it is lighter than the denser air surrounding it. Early balloons were filled with hydrogen gas, which is very light, but because hydrogen gas could easily catch fire, it is not used today.

Heat makes air molecules become more active and farther apart

Hot air rises because it is less dense and therefore, lighter than air.
How Hot Air Balloons Work

Hot air balloons work because the air inside the bag is warmer — and therefore — lighter than the surrounding air. Air expands when heated, which makes it lighter than an equal volume of cool air. The heat for a hot air balloon comes from a burner that uses propane, a safe and inexpensive gas. The burner produces a flame that reaches up into the bag.

If the pilot of the balloon wants to create more lift, he or she turns up the burner. This causes the air inside the bag to become less dense compared to the air outside the balloon. The air molecules become more active and move farther apart from each other. If the pilot wants to descend, he opens up a hole in the top of the bag and turns the burner down. This releases the hot air. Denser cool air from outside the bag starts to replace the hot air. The molecules in the cool air are less active and closer together. As the air inside the balloon becomes heavier, it is able to descend and land.
HOW HOT-AIR BALLOONS WORK

Air that has been heated by the hot flames of a gas burner rises and collects in the balloon.

1. When the air inside the balloon is hot, it gives enough lift to overcome the balloon’s weight. The balloon rises from the ground and soars into the sky.

2. As it rises, the hot air in the balloon begins to cool and the lift gets weaker. When the lift equals the balloon’s weight, the balloon stops rising and floats at the same height in the air.

3. As the hot air cools further, the lift becomes less than the balloon’s weight. The balloon begins to sink.

4. To keep the balloon flying, the pilot turns the burner on again. Short bursts of flame keep the air inside hot. The lift stays strong enough to keep the balloon from sinking.

5. To descend, a valve at the top of the balloon opens to release the hot air. Cold air replaces the hot air. The balloon becomes heavier and is able to descend and land.
Parts of a Hot Air Balloon

The bag of a hot air balloon is called the *envelope*. It made of tough, but light weight nylon. The bigger the envelope, the more weight it can lift into the air. The propane burner and the flying instruments are located in the *basket*. The basket also holds the crew. It is made of light, flexible wicker. *Rigging wires* hold the basket to the balloon envelope. A *propane gas burner* is used to keep the envelope hot. The *skirt* channels the hot air into the balloon’s envelope.

A hole in the top of the envelope is covered with the *rip panel*. If the balloon’s pilot wants to descend, he or she pulls the *rip cord*. This uncovers the hole and allows the hot air to escape. The pilot can also control the altitude by opening and closing a vent on the side of the envelope called the *cooling vent*. 
How Hot Air Balloons Are Used

Almost all hot air balloons are used for recreation or sport ballooning. Recreational users of hot air balloons most often pick good calm days and use their balloons to ascend into the sky and drift peacefully along. From that viewpoint, they can see the countryside and enjoy the scenery.

Hot air balloons come in many different shapes and sizes. The envelopes of these hot air balloons are shaped like cartoon characters.

Many people enjoy the sport of hot air balloon racing. World championships for hot air balloons are held in alternate years in various countries. Sport balloons are easy to operate, but a pilot must pay close attention to weather conditions.

Racing hot air balloons can be thrilling, but they can also be dangerous if a balloon crashes in an unfriendly environment.

Conclusion

For the most part, hot air balloons do not have many practical uses. They do help us to understand how differences in the density of air can create lift. The first hot air balloons were invented in France, using paper bags. Today’s balloons have taken advantage of new materials and new technology to make them easier to operate and control and to make them safer.
Conducting a Fair Test

Scientists, inventors, and engineers are always looking for ways to improve the quality of our lives. To do this, they often conduct fair tests. The purpose of a fair test is to try to identify how a particular factor affects how a product performs or how well a process proceeds.

Conducting a fair test is one of the most important ingredients of doing good, scientifically valuable experiments. In a fair test, you must change only one factor at a time while keeping all other conditions the same. Scientists called the changing factors in an experiment, variables. Changing only one factor at a time is important because it helps you determine what effects that factor has on the outcome of the test. If you change two factors, you will not know which of the two factors actually affected the outcome.
Parts of a Fair Test

**Question:** It asks what you want to find out. It must contain certain information: the factor you are changing, the outcome you are focusing on, and how you will be measuring the outcome. (Example: Does a larger vent hole cause a hot air balloon to descend more quickly than a smaller vent hole?)

**Hypothesis:** This states your best guess and gives a reason why. (I think a larger vent will cause a hot air balloon to descend more quickly than a smaller one because a larger vent hole will allow hot air to escape more quickly.)

**Materials:** This is a list of everything you will need to conduct the fair test. (two identical hot air balloons, stop watch, balloon pilot)

**Manipulated Variable:** This is the one factor you will change. (size of vent hole)

**Constant Variables:** These are the factors that will be the same. (size, shape, and colour of hot air balloon, with the exception of the vent hole size, balloon pilot, air conditions)

**Responding Variable:** This is the outcome you will be measuring. (rate of descent)

**Procedure:** This is a step-by-step detailing of how you will go about conducting the trials.

**Observations:** This details the results of measuring the responding variable in each trial. It always includes written observations and may include diagrams, charts, and graphs to support the written observations. (The hot air balloon with the large vent hole descended at a rate of 2.5 m/s. The hot air balloon with the small vent hole descended at a rate of 1 m/s.)

**Conclusion:** This is a statement that answers the **Question** based on the observations. (A hot air balloon with a larger vent hole will descend more quickly than a hot air balloon with a smaller vent hole.)
Part II: Flyers

Introduction

In Part I: Floaters and Gliders, you learned that devices that take flight can be divided into three basic categories: floaters, gliders, and flyers. You also learned that floaters have little or no control over the speed and direction of flight; gliders have some control, and flyers have complete control. It is important to remember that these categories are not distinct; that is, not every airborne device fits neatly into any particular category. For example, a parachute has almost all the characteristics of a floater. However, the parachutist does have some control over direction of flight and speed of descent.

In Part II: Airplanes you will learn more about the airplane, which is an example of a flyer. Flyers can control speed and direction. They can also create lift and thrust. An airplane creates thrust with its engines. It creates lift by using wings that are of a certain shape.

A Review of Aerodynamics

If you have already studied Air and Aerodynamics, you will know that aerodynamics is the study of moving air. Knowledge of aerodynamics is essential for understanding how airplanes fly. Here are some important aspects of aerodynamics:

- Air exerts force on objects from all sides (up, down, and sideways)
- Air pressure refers to the force per unit of area that air exerts.
- Slower moving air has less air pressure than faster moving air. (The Bernoulli Principle)
- Air can be compressed.
- Compressed air has greater air pressure than non-compressed air.
- Areas of high air pressure will always try to equalize with areas of low air pressure.
- When an object moves through air, the air resists the object’s movement.

Engineers have made some important discoveries when it comes to giving flying objects lift (the ability to ascend).

- If air meets an object, some of the air will go over top of the object and some will go underneath.
- If the object has a curved surface and a flat surface, the air going along the curved surface will travel faster than the air going along the flat surface.
- The air pressure moving next to the curved surface is less than the air pressure moving along the flat surface.
The Airfoil

Using their knowledge of aerodynamics, engineers have found that an appropriate shape for an airplane wing is the airfoil. It is curved along the top and flatter on the bottom. When airplane wings travel through the air, the air flowing over top of the wings travels faster than the air flowing under the wing. The result is that the air pressure above the wings is less than the air pressure below the wings. (Remember Bernoulli’s Principle.) This means that the force pushing up on the wings is greater than the force pushing down on the wings. This is what causes an airplane to rise or lift up.

This diagram of a cross-section cut of an airplane wing shows that it is in the shape of an airfoil.

When an airplane is sitting on the ground, it does not lift up because the air pressure below and above are the same; that is, lift is equal to gravity.

The airplane picks up speed as it travels down the runway. The faster the airplane goes, the greater the difference in air pressure above and below the wings becomes.

When the airplane is going fast enough, the airplane can take off. This is the point at which there is enough difference in the air pressure above and below the wing. The force of lift is then greater than the force of gravity.
A Review of the Forces Acting on an Airplane in Flight

There are four basic forces acting on an airplane when it is in the air.

<table>
<thead>
<tr>
<th>Force</th>
<th>What It Is</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>thrust</td>
<td>force that moves airplane forward</td>
<td>airplane engines</td>
</tr>
<tr>
<td>drag</td>
<td>force that holds the airplane back</td>
<td>air resistance</td>
</tr>
<tr>
<td>lift</td>
<td>upward force that holds an airplane in the air</td>
<td>difference in air pressure above and below wings</td>
</tr>
<tr>
<td>weight</td>
<td>force that pulls airplane down</td>
<td>gravity</td>
</tr>
</tbody>
</table>

In order to understand how an airplane moves through the air, you must be familiar with some basic terms.

- **altitude** – height above sea level
- **accelerate** – speed up
- **decelerate** – slow down
- **ascend** – rise up
- **descend** – go down
- **hover** – stay in one place

The following statements show how the relationship between the forces acting on an airplane affects the airplane’s movements.

- When lift is greater than weight, the airplane will ascend.
- When weight is greater than lift, the airplane will descend.
- When thrust is greater than drag, the airplane will accelerate.
- When drag is greater than thrust, the airplane will decelerate.
- When lift and weight are equal, and thrust and drag are equal, the airplane will hover.
Paper Airplane: Glider or Flyer?

Making and launching a paper airplane is fun and inexpensive. The materials needed are readily available. Is a paper airplane really an airplane; that is, is it a flyer like other airplanes? The answer is no.Flyers can control lift and thrust while they are in flight. This is not the case with paper airplanes.

The thrust from a paper airplane comes from the person launching it. Even the amount of lift a paper airplane gets when first thrown depends on the angle and speed of the launch. Since the thrust and lift of a paper airplane cannot be controlled once it is in flight, we cannot classify it as a flyer. A paper airplane is really a paper glider.

Paper airplanes come in all sizes, shapes, and designs.

Paper Glider Movement

The design of a paper glider has a direct effect on its flight. But design is not the only factor that affects its movements. How well the glider is balanced, how sharply the folds are creased, the type of material used, and the speed and direction of the launch all determine flight patterns.

Once you launch a paper glider, observe its flight pattern. Then make adjustments to how you throw it and/or to the glider itself to improve its flight.

- Let it go sooner (or later).
- Sharpen the creases.
- Adjust the wings to make the glider more symmetrical.
- Adjust the angle of the wings.
- Fold the outer part of the wing to make winglets.

This commercial jet has winglets.
The Basic Movements of an Airplane

People involved in aviation use a specific language to describe airplane movements. An airplane makes three basic movements. They are pitch, roll, and yaw.

1. **Pitch.** Pitch has to do with raising an airplane’s nose up or down. When an airplane is cruising, it has a level pitch. When it is ascending, it has an upward pitch. When it is descending, it has a downward pitch.

   ![downward pitch](image1) ![level pitch](image2) ![upward pitch](image3)

2. **Roll.** Roll has to do with dipping the wings up or down. If you are sitting in the pilot’s seat, and you dip the left wing down, this is called a left roll. If you dip the right wing down, this is called a right roll. If the wings are level with each other, you have level flight. The illustrations below show each type of roll as you look at the nose of the airplane.

   ![right roll](image4) ![level flight](image5) ![left roll](image6)

3. **Yaw.** Yaw has to do with turning the airplane’s nose to the left or to the right. If you are sitting in the pilot’s seat and you turn the nose to the left, you have made a left yaw. If you turn the nose to the right, you have made a right yaw. If you fly straight ahead, you are at level flight.

   ![left yaw](image7) ![level flight](image8) ![right yaw](image9)
**The Three Axes**

The pilot of an airplane makes the three basic movements of pitch, roll, and yaw around three axes. These axes are imaginary straight lines that go through the airplane longitudinally, vertically, and horizontally.

**Lateral Axis.** The lateral axis runs from wing tip to wing tip. When the airplane’s nose goes up, the tail goes down. When the airplane’s nose goes down, the tail goes up. These movements take place around the lateral axis. When a plane pitches, it moves around the lateral axis.

**Longitudinal Axis.** The longitudinal axis runs from the nose to the tail of the airplane. If you put your arms out and put one up and the other down, then the other way around, you are moving your arms around the longitudinal axis. The same goes for the wings of the airplane. When the airplane rolls, it moves around the longitudinal axis.

**Vertical Axis.** The vertical axis runs from the top to the bottom of the airplane’s fuselage. When the airplane’s nose is turned to the left, the tail goes to the right. When its nose is turned to the right, its tail goes to the left. Yawing takes place around the vertical axis.
The Controlling Surfaces of an Airplane

A pilot controls the pitch, roll, and yaw of an airplane by adjusting certain parts. By making these adjustments, he or she makes changes to the shape of some of the airplane’s surfaces. This change in shape affects how exerts force on the airplane.

The Parts of an Airplane

The diagram below shows the main parts of a fixed-wing aircraft. Each of these parts plays a role in helping the pilot control the aircraft.

Here is a description of the main control surfaces on a fixed-wing aircraft.

1. **Fuselage.** The fuselage is the aircraft’s body. It functions as a place for the pilot, passengers, and cargo. It also anchors the wings at a certain angle to ensure lift. The other control surfaces, the horizontal stabilizers and the vertical stabilizers, are also attached to the fuselage.

2. **Horizontal Stabilizers.** They are a set of miniature wings located on the aircraft’s tail. They keep the airplane flying on an even flight path.

3. **Elevators.** The elevators are flaps located on the horizontal stabilizers. The pilot uses the elevators to control the pitch of the airplane. When the elevators are raised, it increases the drag above the tail. This slows down the air moving over the tail, resulting in higher pressure above the tail. This pushes the tail down, and causes the nose to go up. To lower the nose, the pilot would lower the elevators. The elevators can also be used to lower air speed because they cause drag to increase.

4. **Vertical Stabilizer.** The vertical stabilizer is the upright fin located at the tail of the airplane. It keeps the plane from rolling (banking left or right).
5. **Rudder.** The rudder is a flap found in the vertical stabilizer. The rudder allows the pilot to change direction from left to right or right to left. If the rudder is turned to the left, the nose of the plane *yaws* left. If the rudder is turned to the right, the nose yaws right. The nose turns right because air pushes against the rudder, swinging it to the left. This causes the nose to turn to the right.

6. **Ailerons.** The ailerons are flaps located on the back edge of the wings. They are used to *control roll*, which helps the plane to turn. To turn, an airplane must *bank*, or tip, a little on its side, much the same way a cyclist leans when turning a corner.

When an aileron is raised, drag is created and this slows the air moving over the upper surface of the wing, thereby increasing pressure. The result is less lift on the wing. If the aileron is lowered, the air speed over the top of the wing is faster, compared to the speed under the wing. The pressure on top of the wing decreases, which makes lift greater.

What happens if the right aileron is raised and the left one is lowered? The right wing drops because it loses lift and the left one rises because it gains lift and the plane, as a whole, banks to the right. When the aileron positions are reversed, the plane banks to the left. Pilots use the ailerons and the rudder together to turn the aircraft.

### Controlling the Airplane

The chart below shows how an airplane pilot controls the airplane.

<table>
<thead>
<tr>
<th>What Pilot Wants to Do</th>
<th>How the Pilot Does It</th>
</tr>
</thead>
<tbody>
<tr>
<td>pitch up</td>
<td>raise the elevators</td>
</tr>
<tr>
<td>pitch down</td>
<td>lower the elevators</td>
</tr>
<tr>
<td>yaw right</td>
<td>turn the rudder to the right</td>
</tr>
<tr>
<td>yaw left</td>
<td>turn the rudder to the left</td>
</tr>
<tr>
<td>roll right</td>
<td>raise the right aileron and lower the left aileron</td>
</tr>
<tr>
<td>roll left</td>
<td>raise the left aileron and lower the right aileron</td>
</tr>
<tr>
<td>bank right</td>
<td>To do this the pilot must yaw right and roll right at the same time. He must turn the rudder to the right; raise the right aileron; lower the left aileron.</td>
</tr>
<tr>
<td>bank left</td>
<td>To do this the pilot must yaw left and roll left at the same time. He must turn the rudder to the right; raise the left aileron; lower the right aileron.</td>
</tr>
</tbody>
</table>
Basic Airplane Movements: A Closer Look

The Role of Air Resistance

If you examine the fuselage, the wings, and the tail of an airplane, you will notice that they are streamlined. The idea of streamlining is to try to decrease drag by minimizing the effect of air resistance on the airplane as it travels through the air. The engines on an airplane provide the power to create thrust. When drag is minimized, the thrust created by the engines increases. This is important because it helps to improve fuel efficiency.

The part of the airplane that first meets the air and forces it to go over and under that part is called the leading edge. The leading edge is really the front part. It is rounded. The rear part is called the trailing edge. The overall shape is an elongated teardrop. The devices that control airplane movement are all parts of the trailing edges of airplane parts:

- The elevators are at the trailing edge of the horizontal stabilizers.
- The rudder is at the trailing edge of the vertical stabilizer.
- The ailerons are at the trailing edges of the wings.

You will notice that the thickest parts are in the area just behind the leading edge. You might think that the thinnest parts should be at the leading edge. However, engineers have found that having the thickest parts near the leading edge helps the airplane or airplane part cut through the air more effectively. The air resistance near the front edge might be relatively high, but streamlined shape also creates very little air resistance closer to the trailing edge.

For airplane movement, the effects of air resistance are not all negative. In fact, air resistance is essential for airplane movement. When a pilot adjusts the elevators, rudder, and ailerons, he or she wants to increase or decrease air resistance to that particular part or parts of the airplane. It is this change in air resistance that causes the airplane to change how it is moving. This is because a change in air resistance can cause a change in the speed with which air passes a particular airplane part, which in turn, causes a change in the air pressure directly next to that part.
Controlling Pitch

Pitch has to do with whether the airplane’s nose is horizontal, pointing up, or pointing down. When a pilot is changing an airplane’s pitch, the airplane rotates around the lateral axis.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Part(s) Involved</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch up</td>
<td>Elevators</td>
<td>Raise the elevators</td>
</tr>
<tr>
<td>Pitch down</td>
<td>Elevators</td>
<td>Lower the elevators</td>
</tr>
</tbody>
</table>

How the Elevators Work

Pretend a pilot wants to increase the altitude at which the airplane is flying. He wants to pitch up. To do this, he or she must raise the elevators. When they are up, the air going over the horizontal stabilizers hits the elevators. Because they are up, the air encounters more resistance and slows down. This causes an increase in air pressure above the horizontal stabilizers (Remember the Bernoulli Principle.). Now the air pressure above the horizontal stabilizers is greater than the air pressure below them. This causes the horizontal stabilizers to push the tail section down, and this makes the nose of the airplane pitch up.

When the pilot wants to descend, he wants to pitch down. In order to do this, he or she lowers the elevators. Now the air passing below the horizontal stabilizers meets more air resistance, causing it to slow down. In turn, this causes a drop in air pressure. Because the air pressure below the horizontal stabilizers is now less than that above them, the horizontal stabilizers push the tail section up, causing the airplane’s nose to point down.

Airplane acrobats use the elevators when they make loops.
Controlling Roll

Roll occurs when the airplane’s wings dip up and down. During roll, the airplane rotates around the longitudinal axis. When the left wing dips down, the right wing moves up, and vice versa. The pilot uses the ailerons to control roll. The ailerons are located at the trailing edge of the wings.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Part(s) Involved</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll right</td>
<td>Ailerons</td>
<td>Right aileron up; left aileron down</td>
</tr>
<tr>
<td>Roll left</td>
<td>Ailerons</td>
<td>Left aileron up; right aileron down</td>
</tr>
</tbody>
</table>

How the Ailerons Work

The ailerons on an airplane are controlled so that when the aileron of one wing is put up, the one on the other wing is automatically goes down, and vice versa.

When the pilot wants the airplane to roll right, he or she wants the right wing to dip down and the left wing to tip up. To do this the pilot puts the right aileron up and the left one down. When this is done, the air flowing under the right wing speeds up, resulting in a decrease in air pressure under the right wing. The right wing dips down. Meanwhile, the air flowing over the left wing picks up speed, resulting in a decrease in air pressure over the left wing. The left wing tips up.

During a right roll, the pilot wants to create greater air pressure over the right wing and under the left wing so that the right wing will dip down and the left up will tip up.

During a left roll, the pilot wants to create greater air pressure over the left wing and under the right wing.

Manoeuvres like these require that pilots know how to roll.
Controlling Yaw

Yaw has to do with turning the airplane’s nose right or left. Controlling yaw is necessary if the pilot wants to change the direction of flight. When changing yaw, the airplane rotates around its vertical axis.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Part(s) Involved</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yaw right</td>
<td>Rudder</td>
<td>Turn rudder right</td>
</tr>
<tr>
<td>Yaw left</td>
<td>Rudder</td>
<td>Turn rudder left</td>
</tr>
</tbody>
</table>

How the Rudder Works

The rudder is located at the trailing edge of the vertical stabilizer. If the pilot wants the airplane to yaw right, that is, turn to the right, he or she adjusts the rudder so that it is positioned right. When the air passing the right side of the vertical stabilizer pushes up against the rudder, it slows down. This causes the air pressure on the right side of the vertical stabilizer to increase so that now the air pressure on the right side is greater than the air pressure on the left side. This pushes the tail section left, and so the airplane’s nose moves toward the right.

When the rudder is turned right, it pushes the tail section to the left. This makes the nose pointed further to the right.

When the pilot wants to yaw left, he or she adjusts the rudder so that it is turned to the left. When air passing along the left side of the vertical stabilizer encounters the rudder, it slows down causing an increase in air pressure. The air pressure on the left side of the vertical stabilizer is now greater than that on the right side. This pushes the tail section right, and so the airplane’s nose moves toward the left.

When the pilot yaws left, he turns the rudder left. Air resistance increases on the left side of vertical stabilizer, pushing the tail section to the right, causing the nose to point more to the left.
Banking

When an airplane pilot wants to turn an airplane, he or she must do a combination of yawing and rolling. Have you ever noticed that on a highway, where automobiles can travel at high speeds, that the road is banked at the curves? This is necessary so that the motor vehicles will stay on the road. Without the banking, there is a great risk that they will skid off into the ditch. Similarly, when turning an airplane, it is not enough simply to yaw left or right, the pilot must also bank the airplane appropriately so that it stays on course. When discussing aircraft, banking and turning are often used to mean the same thing. *Yawing should not be used as a synonym for banking and turning*, however.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Part(s) Involved</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank right (turn right)</td>
<td>Rudder; ailerons</td>
<td>Yaw right; roll right</td>
</tr>
<tr>
<td>Bank left (turn left)</td>
<td>Rudder; ailerons</td>
<td>Yaw left; roll left</td>
</tr>
</tbody>
</table>

How Banking Occurs

Changing the direction an airplane flies might seem like a simple procedure, but it is actually one that requires a lot of skill and coordination. The reason is that it involves carrying out two procedures at the same time. First, the pilot must adjust the position of the rudder; then he or she must adjust the ailerons. It is important that if the pilot wants to bank left that he or she turn the rudder to the left, put the left aileron up, and put the right aileron down. If the pilot mistakenly adjusts the controls for a left yaw and a right roll, it could mean disaster.

Pilots of very large aircraft like the one above like to make gradually turns. This means that they need only make small adjustments to the positions of the rudder and ailerons. Even though the changes in positions of these parts might seem hardly noticeable, they alter the overall shapes of the wings and vertical stabilizer enough to cause the airplane to bank.
Producing and Controlling Thrust

Introduction

Thrust is the force that propels or pushes an aircraft forward. In order for a flyer to move forward, thrust must be greater than drag. The larger the flyer, the greater the amount of thrust it must produce. Insects, birds, and flying mammals produce thrust by using particular muscles in their bodies to flap their wings.

Human made aircraft use several different types of devices to produce thrust. These devices have two things in common.

- *They are based on the principle that when possible, air pressure tries to equalize.* That is, air will try to flow from an area of high pressure to an area of low pressure. This flow will continue until the pressure in both areas is the same.
- *They are based on the principle that if there is a force that is directed in one direction, there will be an equal force directed in the opposite direction.* You may recall that this principle is referred to as *Newton’s Third Law of Motion.*

This section will deal with two of the main ways that aircraft produce thrust:

- Propellers
- Jet engines and rocket launchers
Propellers

A propeller is a device consisting of a set of blades mounted to a shaft that is spun so that it provides a stream of flowing air. **The purpose of a propeller is to create thrust. It does this by accelerating a large mass of air to a higher speed.**

A propeller must have at least two blades, but can have three, four, five, or even six. Most have somewhere between two and four, however. A small light aircraft may need only one propeller to provide the necessary thrust, but larger, more massive aircraft may have more.

An airplane like this one needs only one propeller. It is designed to carry only a few passenger and a bit of cargo. A single-propellered airplane typically has its propeller attached to the nose of the fuselage.

Larger aircraft are heavier and are designed to carry greater loads. They need several propellers to provide the necessary thrust. With airplanes that have more than one propeller, the engines and propeller are mounted to the wings.

Engineers have found that the most efficient way for propellers to produce thrust is if the blades are
- shaped like an airfoil
- slightly twisted
- taper off at the ends

Look carefully at the photo of the propeller. The photo itself is not of very good quality, but you can notice that it has typical propeller characteristics.
How a Propeller Produces Thrust

A propeller might look like a very simple device, but the technology behind it is actually quite complex. In fact, not all scientists and engineers agree on exactly how a propeller produces thrust. There are two main theories. The first theory asks us to remember that an airplane wing is an airfoil. So is a propeller blade. Think of a propeller blade as a rotating wing. The most important thing to consider is that because each blade is an airfoil, there is a difference in air pressure on one side of the blade compared to the other side. This is an application of the Bernoulli Principle.

The blades are shaped and attached to the shaft in such a way that the air pressure in front of the propeller is less than air pressure directly behind the propeller. This creates a type of “lift”, similar to that created at the wings. Where the lift created by the wings pushes the aircraft up, the “lift” created by the propeller pushes the aircraft forward. This is simply because airplane wings are more or less horizontal whereas propeller blades are vertical to the ground. In the case of an airplane, thrust is really lift that is directed in a forward motion.

Both airplane wings and propeller blades are airfoils. The wings are horizontal to the ground and lift the aircraft up. The propeller blades are vertical to the ground and provide a forward lift.

The second theory states that as the propeller turns, it takes in large masses of air. The shape of the blades and the speed at which they are turning cause the air to shoot out the back of the propeller at high velocity (speed) and force. That is, the propeller blades accelerate the air speed. The air shooting out from the propeller toward the rear of the airplane causes the airplane to move in the opposite direction; that is, forward. The stronger the force of the air behind the propeller, the greater the forward thrust. This explanation of how a propeller produces thrust is a good example of Newton’s Third Law of Motion (See page 34.).

The moving air behind the propeller is called an airstream. The airplane moves in the direction opposite that of the air in the airstream.
If all of this seems rather complicated and difficult to understand, it is because it is very complex. Which is more important when it comes to a propeller creating thrust, the Bernoulli Principle or Newton’s Third Law of Motion? Scientists do not agree. For now, the main thing to remember is that a propeller produces thrust.

The large propellers on a helicopter are called rotors. The rotor mounted on the top of the helicopter’s body gives it lift.

This airboat is not an aircraft, but it does use a propeller to create thrust. Unlike most watercraft that have a submerged propeller, the airboat has one that sits above the water. It can travel easily on shallow water where there is a lot of vegetation because there is little danger that the propeller will hit ground or get caught in the vegetation.
Jet Engines

Jet engines (also called gas turbines) provide the thrust for many airplanes. They can go much faster than propeller driven aircraft, and they are much quieter. Although the way jet engines create thrust is different from how it is produced by propellers, there are some similarities.

This balloon-powered car gets its thrust because of three different principles:

- Compressed air has higher pressure than non-compressed air.
- If there is a difference in air pressure in two different but neighbouring areas, the air pressure tries to equalize if there is a way for air to travel between the areas.
- If air pushes in one direction, there will be an equal force in the opposite direction. (Newton’s Third Law of Motion)

When the balloon is inflated, the air inside is compressed. This means that the air trapped inside the balloon has greater air pressure than the air surrounding the balloon. When the air is allowed to pass out of the balloon, it travels through in the straw and out. It will continue to escape from the balloon until the air pressure inside the balloon is equal to the pressure in the surrounding air. Finally, the car will move in the opposite direction from the escaping air. The principles that make the car move are the same principles that make a jet engine provide thrust to a jet aircraft.

1. The Concorde was a passenger jet that could travel faster than the speed of sound.
2. The A380 is the largest passenger jet in use today. It can carry over 800 passengers.
3. The Antonov An-255 is the world’s largest cargo jet. It can carry as much as 250 000 kg.
4. Wealthy and powerful people might own their own luxury jets
How does a jet engine work?

1. **Air is taken in.** The engine sucks air in at the front with a fan.

2. **The air is compressed.** A set of blades attached to a shaft rotates. This compresses the air, thus raising the pressure of the air.

3. **The compressed air is mixed with fuel and ignited.** The compressed air is then sprayed with fuel and an electric spark lights the mixture.

4. **The gas mixture expands very quickly as it burns.** As the gas mixture burns, it expands further. This raises the pressure in the combustion chamber even more.

5. **The gases escape through nozzles.** The pressurized gases try to equalize with air surrounding the jet engine. It is allowed to escape through tiny holes called nozzles, which are located at the rear of the engine.

6. **The escaping vapours provide thrust.** The gases exit the engine with a great deal of force. As the jets of gas shoot backward, the engine and the aircraft are thrust forward.

You can tell how many jet engines an aircraft has by examining the vapour trail it leaves as it travels through the sky.
Rockets

Throughout history humans have demonstrated a fascination with space. Part of satisfying this curiosity has been launching rockets that could help them learn more about outer space. Today, thanks to rocket science, we know much more about the Moon, our planet Earth, the solar system, and the universe.

People who study history believe that simple rockets have been around for thousands of years. Most feel that the ancient Chinese invented the first rocket. They used a solid fuel that burned quickly to send a small object into the air.

The science used to design, launch, and get rockets safely back to early is extremely complex. Engineers, rocket scientists, and astronauts must train for many years to gain the knowledge and skills they need to be part of these types of activities. Yet, the actual principles on which rocket science is based are quite simple:

- When fuels burn, they form heat and gases.
- Gases take up more room than liquids or solids.
- Gases can be compressed. Compressed gases have higher pressure than non-compressed gases.
- When possible, areas of gases with different pressures will try to equalize.
- If a force is produced in one direction, another force of equal strength is produced in the opposite direction. (Newton’s Third Law of Motion)

Today’s rockets cost anywhere from several hundred million to well over a billion dollars to build and launch. The purpose of the rocket determines how much this cost will be. A rocket designed to launch a satellite into an orbit around Earth would not cost as much as one that has people on board. Some rockets are really space probes that are designed to explore the outer reaches of the solar system. They are basically on a one-way mission. Other rockets are designed to go to places like the Moon and return to Earth.
How do rockets launch?

When a rocket launches, it is sent off from Earth’s surface into space. In order to do this, it must produce thrust. Rockets create thrust by burning either a liquid or a solid fuel. As you might imagine, it takes a great deal of fuel to provide the energy to launch a massive object like a rocket into space. One of the tricky parts of rocket launching is to burn fuel without causing an explosion, which could result in destroying the rocket.

Many rockets do not use oxygen from the air to burn fuel. Instead they use a substance called an oxidizer, which contains the oxygen needed by the fuel so it can burn. Oxidizers can be liquids or solids. The advantage of using an oxidizer is that it can be used to burn fuel in environments where there is no air, such as on the Moon.

Launching a rocket is a complex process, which is difficult for even the most experienced and knowledgeable scientists to understand. The process is slightly different, depending on whether liquid or solid fuel is used. But basically, rocket launching follows these steps:

1. Fuel is mixed with oxygen.
2. The fuel-oxygen mixture is ignited in a combustion chamber. This produces large amounts of heat and gases.
3. The hot gases become compressed as they fill the combustion chamber. The pressure inside the combustion chamber is very high compared to the surrounding air pressure.
4. The compressed gases are allowed to escape through a jet nozzle.
5. The gases rush out through the jet nozzle toward the ground with a tremendous amount of force.
6. The rocket lifts off the launch pad in the opposite direction as the escaping gases. The force of the escaping gases is enough to launch the rocket.

Solid fuel rockets burn a solid that is made up of this fuel and the oxidizer. This solid is packed into a cylinder with a tunnel through the middle. The mixture is then ignited. It burns from the centre out.

Liquid rocket engines use a liquid oxidizer and a liquid fuel. They are sprayed together and burned in the engine’s combustion chamber to produce heat and gases.
Science Grade 6 Topic B Flight – Part I
Lesson Plans

Topic B

Flight
Revised Edition
Science
Grade Six

Topic B: Flight

Contents

Part I: Floaters and Gliders

Lesson One     Floaters, Gliders, and Flyers  5
Lesson Two     Floaters  6
Lesson Three  The Parachute: A Floater  7
Lesson Four    Floaters: Parachutes – Constructing a Basic Parachute  8
Lesson Five    Parachutes: Does the fabric used for the canopy make a difference?  9
Lesson Six     Parachutes: Does the hole in the canopy make a difference?  10
Lesson Seven   Gliders: Hot Air Balloon (Research)  11
Lesson Eight   Hot Air is Less Dense Than Cool Air  12
Lesson Nine    Constructing a Hot Air Balloon  13
Lesson Ten     Hot Air Balloon: Fair Test  14
Lesson Eleven  Flight – Part I Review  15
Lesson Twelve  Flight – Part I Test
Part II: Flyers

Lesson Thirteen  Aerodynamics: Review (Optional)  18
Lesson Fourteen  Forces Acting on an Airplane (Optional)  19
Lesson Fifteen  Making a Glider  20
Lesson Sixteen  The Basic Movements of an Airplane  21
Lesson Seventeen  The Controlling Surfaces of an Airplane  22
Lesson Eighteen  Overcoming Air Resistance  23
Lesson Nineteen  Controlling Pitch  24
Lesson Twenty  Controlling Roll  25
Lesson Twenty-one  Controlling Yaw and Banking  26
Lesson Twenty-two  Constructing a Glider or Flyer: Making Adjustments to Control It  27
Lesson Twenty-three  Propellers: Constructing a Roto-copter  28
Lesson Twenty-four  Propellers: Constructing a Heliostraw (Optional)  29
Lesson Twenty-five  Thrust in Jets and Rockets  30
Lesson Twenty-six  Flight – Part II Review  31
Lesson Twenty-seven  Flight – Part II Test  32
About Part I

Part I of Flight focuses on the air travel of objects and devices that rely on external forces to provide them with thrust. They are divided into two broad categories, floaters and gliders. Air resistance or drag is introduced as the force that opposed gravity and how manipulating surface area can affect the effects of drag. Another important concept is the relationship between temperature and density and how this relationship is used to control the flight of some gliders, such as hot air balloon.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On</th>
<th>Non Hands On Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Floaters, Gliders, and Flyers</td>
<td>4 – 1</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Floaters</td>
<td>12 – 14</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>The Parachute: A Floater</td>
<td>15 – 19</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Floaters: Parachutes: Constructing a Basic Parachute</td>
<td>--------</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Parachutes: Does the fabric used for the canopy make a difference</td>
<td>--------</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Parachutes: Does the hole in the canopy make a difference</td>
<td>--------</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Gliders: Hot Air Balloons (Research)</td>
<td>20 – 25</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Hot Air is Less Dense Than Cool Air</td>
<td>--------</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Constructing a Hot Air Balloon</td>
<td>--------</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Hot Air Balloons: Fair Test</td>
<td>--------</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Flight – Part I Review</td>
<td>--------</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Flight – Part II Test</td>
<td>--------</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson One

Concept: Floaters, Gliders, and Flyers

Resources/Materials: Mini Textbook, pages 4 – 11
Worksheet #6B.1a (transparency or written on chart paper)
Worksheet #6B.1a (student copies)

Introduction: Ask “What do a jet airplane, a rocket, and a dandelion seed have in common?” (All have to do with flight.) Explain that the next unit of study will be on “flight”. We will study three kinds of things that fly: floaters, gliders, and flyers. Nature has all three. People have created inventions that copy nature. Explain that by the end of the unit, students will have learned the forces that make each of them work.

Procedure:

1. Ask students to name all the things they can think of that float, glide, or fly through the air. Write them on the board.

Examples: dandelion seed, flying squirrel, milkweed seed, jet airplane, helicopter, glider, parachute, birds, propellered airplane, hang glider, parasail, hot-air balloon, poplar fluff, cottonwood fluff, flying insects, bubbles

2. Put up the chart or transparency of Worksheet #6B.1a. With students read the notes. Explain that gliders and powered flyers are different from floaters in that the wind controls the wind and direction of flight. With gliders and flyers, the bird, insect, or pilot has control. Tell students to copy the notes from the transparency.

3. If you like, have students read Mini Textbook, pages 4 – 11 to get more information on floaters, gliders, and flyers.

4. Then distribute Worksheet #6B.1b. Tell students to complete the chart by classifying those things that fly.

Assignments:

1. Copy notes from Worksheet #6A.1a.
2. OPTIONAL. Read Mini Textbook, pages 4 – 11.
3. Do Worksheet #6B.1b.
4. OPTIONAL. Make a title page.
Things that fly can be classified into three main categories:

**Floaters** – wind controls the speed and direction of flight

**Gliders** – wings interact with the air currents; rate of descent can be controlled somewhat

**Flyers** – use an engine or body energy to fly
**Science Grade 6 Topic B Flight**

**Worksheets**

**Things That Fly**

**Directions:** Classify the things that fly from the box. If you can, add more to each category.

<table>
<thead>
<tr>
<th>Floaters</th>
<th>Gliders</th>
<th>Flyers</th>
</tr>
</thead>
<tbody>
<tr>
<td>dandelion seed</td>
<td>flying squirrel</td>
<td>milkweed seed</td>
</tr>
<tr>
<td>helicopter</td>
<td>glider</td>
<td>jet airplane</td>
</tr>
<tr>
<td>propellered airplane</td>
<td>hang glider</td>
<td>birds</td>
</tr>
<tr>
<td>poplar fluff</td>
<td>cottonwood fluff</td>
<td>hot-air balloon</td>
</tr>
<tr>
<td>rockets</td>
<td>Frisbee</td>
<td>bubbles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>falling leaf</td>
</tr>
</tbody>
</table>
**Directions:** Classify the things that fly from the box. If you can, add more to each category.

```
dandelion seed  flying squirrel  milkweed seed  jet airplane
helicopter    glider            parasail            birds
propellered airplane hang glider    parachute   hot-air balloon
poplar fluff    cottonwood fluff flying insects   bubbles
Frisbee          
```

<table>
<thead>
<tr>
<th>Floaters</th>
<th>Gliders</th>
<th>Flyers</th>
</tr>
</thead>
<tbody>
<tr>
<td>dandelion seed</td>
<td>flying squirrel</td>
<td>jet airplane</td>
</tr>
<tr>
<td>milkweed seed</td>
<td>glider</td>
<td>helicopter</td>
</tr>
<tr>
<td>falling leaf</td>
<td>hang glider</td>
<td>birds</td>
</tr>
<tr>
<td>parachute</td>
<td>hot air balloon</td>
<td>propellered airplane</td>
</tr>
<tr>
<td>poplar fluff</td>
<td>Frisbee</td>
<td>flying insects</td>
</tr>
<tr>
<td>cottonwood fluff</td>
<td>paper airplane</td>
<td>rockets</td>
</tr>
<tr>
<td>bubbles</td>
<td>parasail</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6B.1b
Lesson Two

Concept: Floaters

Resources/Materials: Mini Textbook, pages 12 – 14
Hands On: sheets of paper, tape
Worksheets #6B.2a and #6B.2b (student copies)
Non Hands On: Worksheets #6B.2c and #6B.2d (optional, student copies)

Introduction: Explain that the first category of things we will be studying are the floaters. Remind students that floaters always end up at a lower altitude compared to where they started because of the force of gravity. Explain that a parachutist jumps out of an airplane at very high altitudes. He or she uses a large sheet, usually made of nylon to help him or her get to Earth safely. This large nylon sheet is fold up and carried on the parachutist’s back. When the parachutist is safely out of the airplane, the nylon sheet unfolds and the person drifts to earth.

Procedure:

1. Discuss the difference between a person floating down to earth with and without the aid of the parachute. Discuss that it is air resistance or drag that slows the rate of descent. A parachute is a floater used to slow down the rate of descent.

2. Explain that today, we will be exploring the whole idea of drag and its effect on rate of descent.

3. HANDS ON. Distribute Worksheets #6B.2a and #6B.2b. With students examine the sheets to get an idea of what they will be doing. Discuss that they will be given several sheets of paper. They will be conducting 5 trials. For each trial, they will stand on a high spot (like a chair) and drop an uncrumpled sheet of paper at the same time as they drop a crumpled sheet. The crumpled sheet can be crumpled tightly or loosely; in a spherical shape, egg-shaped, square-shape etc. Once the trials have been completed, discuss that an uncrumpled sheet takes longer to descend than a crumpled sheet because it has more surface area. When an object falls, it has to push air molecules out of its way. The larger the surface area, the more molecules it encounters. The force of gravity is what makes the object fall. Air resistance is the force that opposes gravity and slows down descent. Emphasize the distance and surface area affect rate of descent. In a vacuum, where there are not air molecules, weight does not affect speed of falling; but heavier objects are able to punch through air more easily than light ones.

4. HANDS ON. Have students turn to Mini Textbook, page 12. Guide the reading of pages 12 – 14. Have students make notes on what they read OR have them do Worksheets #6B.2c and #6B.2d.

Assignments:

1. HANDS ON. Do Worksheets #6B.2a and #6B.2b.

2. NON HANDS ON. Read Mini Textbook, pages 12 – 14. Make notes on what was read OR do Worksheets #6B.2c and #6B.2d.
Question: ________________________________

Prediction: ________________________________

Observations: Which fell faster? Record the results of your test by checking the appropriate box.

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Crumpled</th>
<th>Flat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: ________________________________

The crumpled paper that seemed to fall most quickly:
It fell most quickly because

Jonathan wanted to know which took longer to fall to the floor, a crumpled paper or a flat one. He did the activity and recorded his observations in the chart below.

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Crumpled</th>
<th>Flat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Unfortunately, Jonathan forgot about the rules for conducting fair test. Give as many reasons as you can as to why the flat sheets of paper might have fallen more quickly in Trials #2, #3, and #6.

a. 

b. 

c. 

d. 

e. 

Worksheet #6B.2b
Directions: Use *Mini Textbook*, pages 12 – 14 to help you with the questions.

1. Complete the sentences with words that make sense.

   Both floaters and gliders cannot produce their own __________________________.
   ___________________________ is the force that brings all floaters and gliders to Earth.
   The flights that both floaters and gliders take depends a lot on __________________________.
   Of all the objects that travel through the air, the flight of ___________________________ is most
   affected by the forces of ___________________________.
   When it comes to falling objects, the force that opposes gravity is ___________________________
   ___________________________.

2. Explain why floaters encounter drag when falling to Earth.

   ___________________________.
   ___________________________.
   ___________________________.

3. Put an X in front of the factors that affect how quickly an object will fall.

   _____ how far the object has fallen
   _____ how heavy the object is
   _____ the surface area of the object
   _____ whether or not the object is filled with air
   _____ the amount of air resistance
   _____ the colour of the object
   _____ the material the object is made of
   _____ whether the object is falling flat side down or thin side down.
4. In each pair circle the object you think will fall more quickly. If you think they will fall at the same rate, circle both.

<table>
<thead>
<tr>
<th></th>
<th>small sheet of paper</th>
<th>large sheet of paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>feather dropped from a high ladder</td>
<td>feather dropped from a chair seat</td>
</tr>
<tr>
<td>b</td>
<td>sheet of plywood</td>
<td>2 X 4 piece of lumber</td>
</tr>
<tr>
<td>c</td>
<td>flat sheet of paper</td>
<td>crumpled sheet of paper</td>
</tr>
<tr>
<td>d</td>
<td>nickel</td>
<td>dime</td>
</tr>
<tr>
<td>e</td>
<td>textbook falling the flat way down</td>
<td>textbook falling the skinny way down</td>
</tr>
<tr>
<td>f</td>
<td>bag of marbles where the marbles are glued together</td>
<td>bag of marbles where the marbles are not glued together</td>
</tr>
<tr>
<td>g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. A block made of cement will most likely fall more quickly than a block of the same size and shape made of Styrofoam. Why do you suppose this is?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Answers will vary.

Question: Which will fall more slowly, a crumpled or a flat sheet of paper?

Prediction: I think that a flat sheet of paper will fall more slowly because it has more surface area.

Observations: Which fell faster? Record the results of your test by checking the appropriate box.

Conclusion: A flat sheet will fall more slowly than a crumpled sheet.

The crumpled paper that seemed to fall most quickly:
It fell most quickly because it was crumpled up more tightly and so had the smallest surface area.

Jonathan wanted to know which took longer to fall to the floor, a crumpled paper or a flat one. He did the activity and recorded his observations in the chart below.

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Crumpled</th>
<th>Flat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Unfortunately, Jonathan forgot about the rules for conducting fair test. Give as many reasons as you can as to why the flat sheets of paper might have fallen more quickly in Trials #2, #3, and #6.

Answers may vary.

a. dropped flat sheet from a lesser height

b. used a sheet of paper that was much smaller in size

c. dropped the flat sheet edge down

d. put a fold in the flat sheet

e. used a much heavier weight of paper for the flat sheet

f. affixed a weight to the flat sheet

g. might have dropped some of the sheets where it was windy and some where it was not.
Directions: Use *Mini Textbook*, pages 12 – 14 to help you with the questions.

1. Complete the sentences with words that make sense.

   Both floaters and gliders cannot produce their own **thrust**.  
   **Gravity** is the force that brings all floaters and gliders to Earth.  
   The flights that both floaters and gliders take depends a lot on **air** currents.  
   Of all the objects that travel through the air, the flight of **floaters** is most affected by the forces of **nature**.  
   When it comes to falling objects, the force that opposes gravity is **air** resistance.

2. Explain why floaters encounter drag when falling to Earth.

   **as they fall, they must push air molecules out of the way. This** slows descent.

3. Put an **X** in front of the factors that affect how quickly an object will fall.

   - **X** how far the object has fallen
   - **X** how heavy the object is
   - **X** the surface area of the object
   - **X** whether or not the object is filled with air
   - **X** the amount of air resistance
   - **** the colour of the object
   - **X** the material the object is made of
   - **X** whether the object is falling flat side down or thin side down.
4. In each pair circle the object you think will fall more quickly. If you think they will fall at the same rate, circle both.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>small sheet of paper</td>
</tr>
<tr>
<td>b</td>
<td>feather dropped from a high ladder</td>
</tr>
<tr>
<td>c</td>
<td>sheet of plywood</td>
</tr>
<tr>
<td>d</td>
<td>flat sheet of paper</td>
</tr>
<tr>
<td>e</td>
<td>nickel</td>
</tr>
<tr>
<td>f</td>
<td>textbook falling the flat way down</td>
</tr>
<tr>
<td>g</td>
<td>bag of marbles where the marbles are glued together</td>
</tr>
</tbody>
</table>

5. A block made of cement will most likely fall more quickly than a block of the same size and shape made of Styrofoam. Why do you suppose this is?

A cement block’s greater weight enables it to push air molecules out of the way more easily than a light Styrofoam block.

NOTE: In a vacuum, where there is no air resistance, objects fall at the same rate, regardless of mass.
Lesson Three

Concept: The Parachute: A Floater

Resources/Materials: Mini Textbook, pages 15 - 19

Note: If you have a set of encyclopedias, consider having students use them as resource materials instead of the mini textbook.

Introduction: Explain that in a few days, students will have a chance to try to make a parachute. Before that, they must do some research on how parachutes work.

Tell students that although parachutes are gliders, they are really complex machines. Because safety is such an important factor, the design must be very precise. Today students will begin to research and write a report on parachutes.

Procedure:

1. Brainstorm with students questions they could answer in their reports, such as
   - What are parachutes used for?
   - What are the parts of a parachute?
   - How does a parachute work?
   - What is the design of a parachute? (What does it look like?)
   - What are the different types of parachutes?

2. Categorize and organize the questions to make an outline.

3. If necessary, go over the steps involved in researching. (Example: Write each question at the top of a sheet of paper. As you read the article, take point-form notes, writing the information under the appropriate question.

4. If necessary, go over the parts of a research report, such as:

   - **Introduction:** Tells what the report will be about and why the topic is important
   - **Body:** Give the details – answers the research questions.
     Several paragraphs in length; includes diagrams that support the ideas in the main text.
   - **Conclusion:** Restates the importance of the topic and its implications for the present and/or the future.

5. Have students turn to *Mini Textbook*, page 15 and direct them to read pages 15 – 19 (or encyclopedia articles). If necessary, show students how to skim and then read for information, take notes, and so on.

Assignment:

Research and write a report on parachutes.
Lesson Four

Concept: Floaters: Parachutes – Constructing a Basic Parachute

Resources/Materials:

HANDS ON: Worksheet #6B.4a (one copy per group)
           Worksheet #6B.4b (student copies)
           For each group:
           cork or something similar    thread (1.2 m)
           medium weight plastic (30 cm X 30 cm), like a grocery bag
           tape    two small paper clips
           step ladder

NON HANDS ON:  Worksheets #6B.4c and #6B.4d (student copies)

Introduction: Tell students they will have the opportunity to examine the construction of a simple parachute.

Procedure:

HANDS ON
1. Distribute Worksheets #6B.4a and #6B.4b. Go over the directions with students.
2. Distribute the materials and have students construct the parachute.
3. When students have completed their parachutes, have them stand on the step ladder to test them.
4. Encourage students to make changes to their parachutes to make them more successful
5. Discuss possible reasons for relative degrees of success.
6. Have students complete Worksheet #6B.4b.

NON HANDS ON

1. Distribute Worksheets #6B.4c and #6B.4d. Go over the directions, if necessary.
2.

Assignment:

HANDS ON
1. Make a parachute using the directions Worksheet #6B.4a.
2. Record findings on Worksheet #6B.4b.

NON HANDS ON
1. Do Worksheets #6B.4c and #6B.4d.
Constructing a Parachute

**Materials:**
- 1.2m thread
- 2 small paper clips
- scissors
- 30 cm X 30 cm square of plastic
tape
- cork or something of similar size and mass

**Procedure:**

1. Cut the thread into four equal lengths. They should be about 30 cm each. (An easy way to do this is to fold the long thread in half and cut it. Then fold each of the halves in half and cut them.)

2. Tie one end of each thread securely to each corner of the plastic square.

![Diagram of a parachute]

3. Prepare the basket (payload) by taping a paper clip to either side of the cork.

4. Gather four threads together. Slip them through the paper clips, adjusting the lengths so they are all the same. Tie a reef know (see diagram). To prevent slippage, tie another knot over the reef knot.

5. To launch your parachute, grasp the middle of the plastic with the cork hanging freely below. Stand on a chair or ladder and drop it.

![Diagram of launching the parachute]

6. Observe how your parachute drops. Try to make improvements and drop it again.

Worksheet #68.4a
Directions: Complete this page to record how you made your parachute, how it descended, and what you did to try to improve it.

1. In the space below, draw a diagram of your parachute. Label these parts: canopy, shroud lines, payload.

2. Describe in detail how your parachute descended.

3. Describe any changes you made to make your parachute operate more smoothly. Then tell what differences, if any, the changes made to how well your parachute performed.
**Directions:** Read the information in the box. Then illustrate each of the steps described in construction a parachute.

**Make a simple toy parachute out of a plastic shopping bag.** It is an easy, inexpensive way to use up those plastic bags piling up around the house. You can make a mini-person to sit in the parachute, or you can use a plastic model person instead.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cut out an octagon shape from a plastic bag.</td>
<td></td>
</tr>
<tr>
<td>2. Make a small hole at each corner of the octagon.</td>
<td></td>
</tr>
<tr>
<td>3. Tie/tape string of the same length to each one of the holes.</td>
<td></td>
</tr>
<tr>
<td>4. Tie all the free ends of the strings to a large paper clip.</td>
<td></td>
</tr>
</tbody>
</table>
5. Make a toy person out of modelling clay.

6. Fasten the person onto the paper clip.

7. Cut a small hole about 1 cm in diameter in the centre of the parachute canopy.

8. Take hold of the middle of the canopy. Hold it up as high as you can (or climb onto a chair or step ladder).

9. Let the parachute go and watch it glide to the ground.
Lesson Five

Concept: Parachutes: Does the fabric used for the canopy make a difference?

Resources/Materials:

HANDS ON: Worksheets #6B.5a, #6B.5b, and #6B.5c (student copies)
4 – 30 cm X 30 cm squares of five different types of fabrics
thread
washers (to act as the payloads)

NON HANDS ON: Worksheets #6B.5d (student copies) and #6B.5e (optional, student copies)

Introduction: Recall how the parachute was made from last day’s class. Discuss what types of factors made the parachutes perform better. Explain that today students will try to determine if the type of fabric used to make the canopy makes a difference in how well the parachute performs.

Procedure:

HANDS ON

1. Explain that students will be conducting a fair test to determine if the fabric used to make a canopy affects how quickly a parachute descends
2. If you feel students need a review on how to conduct a fair test, you may want to go over Mini Textbook, pages 26 and 27.
3. Distribute the materials and Worksheet #6B.5a. Go over the directions, if necessary.
4. Distribute Worksheet #6B.5b and #6B.5c. If necessary, help students fill in the sections up to observations. Remind students that a fair test question should be worded in such a way that the results are observable measurable. For example: Which type of parachute canopy will make the parachute descend most slowly, one make of plastic, nylon, denim, cotton, or polyester?
5. Have students construct a bar graph of the results.
6. Once finished have students write sentences to record their observations. If necessary, help students make their conclusions based on their observations.
7. If necessary, help students make their conclusion based on their observations.

NON HANDS ON

1. Explain to students that they read some information about the importance of fabric type of how well a parachute performs. Distribute Worksheet #6B.5d. Have them read the article.
2. Then have students make a table in their notebooks showing the qualities that the fabric used for parachute canopies must have OR have them complete Worksheet #6B.5e.

Assignments:

1. HANDS ON. Make parachutes using various canopy materials, using Worksheet #6B.5a. Test them out. Write up the activity as a fair test on Worksheets #6B.5b and #6A.5c.

2. NON HANDS ON. Read the information on Worksheet #6B.5d. Then make a table summarizing the desirable quality of the fabric used for parachute canopies OR do Worksheet #6B.5e.
Question: What type of canopy material makes a parachute descend most slowly?

Materials: 30 cm X 30 cm squares of five different types of materials
washers (to act as the payloads)  thread
step ladder  stop watch

Procedure:

1. Make five parachutes, each using a different type of material. Be sure that you are holding these variables constant:
   • Size of material
   • Length of the shroud lines
   • The size of the payload (in this case it will be the number of washers)
   • Height of the drop
   • Place where you hold the canopy

2. Once you have made all five parachutes, make a table to record your results. Do this on the Fair Test sheet.

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Trial #1 Time (s)</th>
<th>Trial #2 Time (s)</th>
<th>Trial #3 Time (s)</th>
<th>Trial #4 Time (s)</th>
<th>Trial #5 Time (s)</th>
<th>Average Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Drop each parachute five times. Be careful to drop each parachute from exactly the same height and in exactly the same way. Determine how much time it takes for each drop. Record your observations in the table. **The drop time is the responding variable** since it is going to be what changes because the type of canopy materials changes.

4. Calculate the average drop time for each fabric.

5. Make a bar graph of the results you recorded in the table.

6. Write sentences that tell what you observed. For example: The parachute with the plastic canopy had an average descending time of _____ seconds. The parachute with the nylon canopy had an average descending time of _____ seconds. (and so on)

7. Write your conclusion. (Example: A parachute with a canopy made of ________ descends most slowly, followed by ____________, ____________, ____________, and ________, in that order.)
Question: ____________________________________________________________

Hypothesis: ____________________________________________________________

Materials: ____________________________________________________________

Manipulated Variable: _________________________________________________

Constant Variables: _________________________________________________

Responding Variable: _______________________________________________

Procedure: __________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

Observations:

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

Conclusion:
Directions: Read the following information about parachute fabric. Then make point-form notes about the article OR do Worksheet #6B.5e. Your teacher will tell which of these two options to do.

How Parachutes Work

A parachute is a type of equipment which decelerates the fall of an object from mid-air by creating drag. It works on the basic principle that air resistance opposes gravity. The descent of a parachute largely depends on the material, and therefore it is important that the material chosen is windproof, light, flexible, and has a fine texture.

When a parachute is deployed, air gets trapped inside the canopy, thus making the parachute fabric stretch outwards and resist the fall. This reduces the speed at which the parachute descends.

The Qualities of Parachute Fabric

Parachute material must have certain qualities. It has to be resistant to wind. This is especially true when a parachute is used at high altitudes where strong winds are common. The fabric’s density must also be taken into consideration, as it has a direct relationship with the time it takes for a parachute to descend. The denser the material of the canopy, the faster will be the speed at which the chute comes down.

Like density, rigidity or stiffness plays an important role in determining the time taken to complete a fall. The more rigid the material, the more stable the canopy will be. The more stable the parachute, the more slowly it will descend. If it is not stable and swings, the canopy will lose air and come down at a greater speed. The texture of the parachute also affects drag, but in a very small way.

Parachute Fabric Over the Years

The first parachute canopies were made of canvas. Canvas was quite strong and could withstand air resistance. This was eventually replaced by silk. Silk was thinner, lighter, and stronger than canvas. It was also fire resistant and easier to fold. In the late 1930s and early 1940s, silk was replaced with nylon. Nylon is a human-made material. It had many of the same qualities as silk, but it was much less expensive. Unlike silk, nylon did not rot. The nylon used in parachutes today is woven in a special way with extra thick thread, to create a pattern of small squares. This helps prevent any tears in the canopy from spreading.

Even though nylon continues to be the first choice for parachute canopies, another human-made fabric called Kevlar is gaining in popularity. Kevlar has many of the same qualities as nylon, but in addition, it is stronger and heat resistant.

The canopy of a parachute has come a long way from plain canvas material to Kevlar. It would not be surprising if we have better fabrics in the future. Right now, nylon continues to be the most widely used, as it fulfills all the requirements of a good parachute canopy fabric.
Directions: Use the article about parachute fabric to answer the following questions.

1. How a Parachute Works. Explain how a parachute canopy slows down the rate of descent.

2. The Qualities of Parachute Fabric. Complete the table by listing and describing four parachute fabrics and the effects they have on how a parachute performs.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Effect on Parachute Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Parachute Fabric Over the Years. Tell about the desirable qualities of each of these parachute canopy fabrics that have been used over the years.

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Qualities</th>
</tr>
</thead>
<tbody>
<tr>
<td>canvas</td>
<td></td>
</tr>
<tr>
<td>silk</td>
<td></td>
</tr>
<tr>
<td>nylon</td>
<td></td>
</tr>
<tr>
<td>Kevlar</td>
<td></td>
</tr>
</tbody>
</table>
Answers will vary.

Question: What type of canopy material makes a parachute descend most slowly: plastic, denim, nylon, cotton, or polyester?

Hypothesis: I think a canopy made of plastic will make a parachute descend most slowly.

Materials: 30 cm x 30 cm squares of plastic, denim, nylon, cotton, polyester

washers

thread

step ladder

step watch

Manipulated Variable: type of canopy material

Constant Variables: size of canopy shape of canopy

number of washers (mass of payload) drop height

length of shroud lines (suspension lines)

Responding Variable: descending time

Procedure: Make five identical parachutes, each with a canopy made of a different material

Drop each parachute 5 times from the same height. Record the times.

Find the average times for the 5 drops for each parachute

Observations:

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

<table>
<thead>
<tr>
<th>Drop Time Average (sec)</th>
<th>Type of Canopy Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Make a labelled diagram.

The average drop time for the _____ canopy parachute was _____ sec.

[Blank lines for observations]

Conclusion: A parachute with a canopy made of _____ will fall most slowly, followed by canopies made of _____, _____, and _____, in that order.
Directions: Use the article about parachute fabric to answer the following questions.

1. **How a Parachute Works.** Explain how a parachute canopy slows down the rate of descent.

   *When parachute is released, the canopy unfolds as it catches air. This makes the fabric stretch out and resist the fall.*

2. **The Qualities of Parachute Fabric.** Complete the table by listing and describing four parachute fabrics and the effects they have on how a parachute performs.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Effect on Parachute Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>wind resistant</td>
<td>must not tear when exposed to high winds</td>
</tr>
<tr>
<td>density</td>
<td>The denser the fabric, the faster will be the descent rate</td>
</tr>
<tr>
<td>rigidity</td>
<td>The more rigid the material, the more stable the descent</td>
</tr>
<tr>
<td>texture</td>
<td>affects drag</td>
</tr>
</tbody>
</table>

3. **Parachute Fabric Over the Years.** Tell about the desirable qualities of each of these parachute canopy fabrics that have been used over the years.

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Qualities</th>
</tr>
</thead>
<tbody>
<tr>
<td>canvas</td>
<td>strong; could withstand air resistance</td>
</tr>
<tr>
<td>silk</td>
<td>thinner, lighter, stronger than canvas; fire resistance, ease of folding</td>
</tr>
<tr>
<td>nylon</td>
<td>less expensive than silk; with many of same qualities</td>
</tr>
<tr>
<td>Kevlar</td>
<td>stronger than nylon and heat resistant</td>
</tr>
</tbody>
</table>
Lesson Six

Concept: Parachutes: Does a hole in the canopy make a difference?

Resources/Materials:
HANDS ON: Worksheet #6B.6a (one per group)
         Worksheets #6B.6b and #6B.6c (student copies)
         4 sheets plastic (30 cm X 30 cm) thread
         washers (to act as payload) step ladder
NON HANDS ON: Worksheets #6B.6d #6B.6e, and #6B.6f (student copies)

Introduction: Recall last day’s fair test where students determined which type of canopy material resulted in the slowest descent time. Explain that today students will be doing another fair test, this time to determine if having a hold in the canopy will affect rate of descent.

Procedure:
1. If you feel it is necessary, review the “fair test” vocabulary: question, hypothesis, materials, manipulated variable, constant variables, responding variable, procedure, observations, conclusion.
   HANDS ON
2. Distribute the materials and Worksheet #6B.6a. Go over the directions, if you feel it is necessary. Some students may need help in deciding what the various variables are.
   • Manipulated variable: size of the hole in the canopy
   • Constant variables: size of canopy, shape of canopy, length of shroud lines, size and mass of payload, drop height.
   • Responding variable: descent time
3. Distribute Worksheets #6B.6b and #6B.6c. Have students fill in the sections they are able.
4. Have them makes the parachutes and time their descents.
5. Have students finished writing up the fair test. If necessary, help them with the conclusion.
   NON HANDS ON
1. Explain that making hole in the canopy of a parachute lessens its tendency to oscillate (wobble back and forth) as it descends. Students will read and about an activity a student in another school did about how the vent hole affects the rate of descent of a parachute. They will write the activity up as a fair test.
2. Distribute Worksheets #6B.6d, #6B.6e, and #6B.6f. Go over the directions, if necessary.

Assignment:
HANDS ON
1. Do a fair test to determine the effects of a canopy hole on descent time using Worksheet #6B.6a.
2. Write up the fair test in notebooks or on Worksheets #6B.6b and #6B.6c.
NON HANDS ON: Do Worksheets #6B.6d, #6B.6e, and #6B.6f.

For the Teacher
A small hole in the centre of the canopy prevents the parachute from wobbling. The hole lets air escape out the top rather than spilling out one side, and then the other. As a hole in the canopy reduces the amount of drag; the larger the hole, the less the descent time.
Does a Hole in the Canopy Make a Difference?

**Question:** Which type of parachute will descend most slowly, one with no hole in the canopy, one with a small hole in the canopy, or one with a large hole in the canopy?

**Materials:** 4 squares of plastic (30 cm X 30 cm) thread washers step ladder

**Procedure:**

1. Make three identical parachutes.

2. Leave one alone. Make a hole about one centimetre in diameter in the canopy of another one, and a hole about three centimetres in diameter in another.

3. Drop each one from the same height, using a step ladder.

4. Record your results in a table such as the one below.

<table>
<thead>
<tr>
<th>Hole Size</th>
<th>Trial #1 Time (s)</th>
<th>Trial #2 Time (s)</th>
<th>Trial #3 Time (s)</th>
<th>Trial #4 Time (s)</th>
<th>Trial #5 Time (s)</th>
<th>Trial #6 Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Make a graph of what your table shows.

6. Write sentence to tell what you observed.

7. Write your conclusion.

Worksheet #6B.6a
Fair Test: Canopy Hole

Question: ________________________________________________________________

Hypothesis: ______________________________________________________________

Materials: ________________________________________________________________

Manipulated Variable: _____________________________________________________

Constant Variables: _______________________________________________________

Responding Variable: ______________________________________________________

Procedure: ______________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Observations:

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

Conclusion: 
**Directions:** In school Bart was studying about parachutes. Read about an activity Bart did. Then write up Bart’s activity as a fair test.

While studying about parachutes, Bart learned that there is usually a hole in the top of a round parachute canopy. It is called a vent hole. Without a vent hole, air trapped under the canopy can only escape out from the edges. This causes the parachute to oscillate or wobble back and forth because first air spills out one edge and then the other, tilting and throwing the parachutist from one direction to another. When there is a vent hole, most of the air trapped inside the canopy can escape through the hole instead of out of the edges. The presence of a vent hole causes the rate of descent to be faster, but more comfortable since the parachute does not swing back and forth so much.

Bart was curious to know if the number of vent holes in the canopy affected the rate of descent. Before doing the activity, Bart guessed that a parachute with one vent hole who descend faster than one with several smaller vent holes. He took two identical parachutes. Both had canopies made from the same materials and were the same shape. Both canopies were the same size and the shroud lines were exactly the same size and made of the same materials. Bart also ensured that the payload was identical for both parachutes.

In one canopy, Bart made a vent hole that was 1000 cm\(^2\) in area. He called this parachute Parachute A. In the other canopy he made six holes of identical size in a circular pattern at the top. Their total area of the six holes was 1000 cm\(^2\). He called this parachute Parachute B. Bart performed three trials. In each trial he dropped each parachute from a height of 25 m and measured the time it took for each parachute to reach the ground.

Here is what Bart observed. The times for Parachute A were: trial #1 – 23 sec; trial #2 – 26 sec; trial #3 – 25 sec. The times for Parachute B were: trial #1 – 19 sec; trial #2 – 24 sec; trial #3 – 22 sec.
Question: ____________________________________________________________

Hypothesis: _________________________________________________________

Materials: ___________________________________________________________

Manipulated Variable: _________________________________________________

Controls: ___________________________________________________________

Responding Variable: _________________________________________________

Procedure:

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

Worksheet #6B.6e
Observations:

<table>
<thead>
<tr>
<th></th>
<th>Trial #1</th>
<th>Trial #2</th>
<th>Trial #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parachute A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parachute B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: ___________________________
Answers will vary

Question: Which type of parachute will descend most slowly, one with no hole in the canopy, one with a small hole, or one with a large hole?

Hypothesis: I think a parachute with no hole in the canopy will descend most slowly.

Materials: 3 sheets of plastic (30 cm x 30 cm)
thread
step ladder
washers
stop watch

Manipulated Variable: size of hole in canopy

Constant Variables: size of canopy, length of shroud lines, number of washers, drop height

Responding Variable: descending time

Procedure: Make 3 identical parachutes
Cut a 1 cm hole in the centre of one parachute and a 3 cm hole in another. Leave the third one without a hole.

Drop each parachute from the same height 6 times. Record the descending time.
Find the average descending time for each parachute.

Observations:

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

The average descending time for the parachute with no hole in the canopy was _____ seconds, etc.

Conclusion: The _____ parachute had the longest descending time, followed by the _____ and then the _____.
Answers may vary.

Question: Which type of parachute will descend more quickly, one with a single larger hole in its canopy or one with several smaller holes in its canopy?

Hypothesis: I think...

Materials: two identical parachutes; one with a single 1000 cm² hole in the canopy, the other with six holes in the canopy, with a total area of 1000 cm²

Manipulated Variable: number of holes in the canopy

Controls: size of canopy, shape of canopy, canopy fabric, payload, size/material of shroud lines, drop height

Responding Variable: descent time

Procedure:

Drop each parachute from a height of 25 m.

Repeat 3 times
Observations:

<table>
<thead>
<tr>
<th></th>
<th>Trial #1</th>
<th>Trial #2</th>
<th>Trial #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parachute A</td>
<td>23 sec</td>
<td>26 sec</td>
<td>25 sec</td>
</tr>
<tr>
<td>Parachute B</td>
<td>19 sec</td>
<td>24 sec</td>
<td>22 sec</td>
</tr>
</tbody>
</table>

The descent times for Parachute A were 23 sec, 26 sec, and 25 sec.

The descent times for Parachute B were 19 sec, 24 sec, and 22 sec.

Conclusion: A parachute with several smaller holes will descend more quickly than a parachute with one larger hole.
Lesson Seven

Concept: Gliders: Hot Air Balloon (Research)

Resources/Materials: Mini Textbook, pages 20 – 25
(alternately, photocopy encyclopedia and reference book articles)
Photos of hot air balloons

Introduction: Relate to students the accomplishment of a man named Steve Fawcett. He travelled around the world in a device called a hot air balloon. A hot air balloon has some characteristics of a floater and some of a glider. It is not like a party balloon made of rubber. It is build a little more like a parachute, but with some significant differences. First it is much much larger. Second, the operator of the hot air balloon can control the ascent and descent. That is how it is like a glider. Finally, like a parachute, the operator cannot control the direction or the speed. This part of it is like a floater. During the next week or so, we will be investigating hot air balloons.

Procedure:

1. Compliment students on their first report on parachutes. (Yes...butter them up!)

2. Go over the steps in researching and writing a report
   - Think about questions about hot air balloons.
   - Read and make notes.
   - Organize your notes according to topic.
   - Use your notes to make paragraphs. Add illustrations.
   - Edit and revise to make a good copy.

3. With students think of questions or headings they could use to guide the research. Examples:
   - What is a hot air balloon?
   - What are the parts of a hot air balloon?
   - How does a hot air balloon work?
   - How are hot air balloons used?

4. Have students turn to Mini Textbook, page 20. Guide the reading of page 20. Then refer students to pages 21 – 25. If necessary, go over how the article is organized.

Assignment:

Research and write a report on hot air balloons.
Lesson Eight

Concept: Hot Air is Less Dense Than Cool Air

Resources/Materials: Worksheet #6B.8a (optional, one copy per group)

Note: This activity can be done as a demonstration. In that case students do not need a copy of worksheet #6B.8a

Worksheet #6B.8b (optional, student copies)

Per Group
Empty plastic 2-L pop bottle
large bowl or sink
large balloon

Introduction: Review that students learned from their research that hot air balloons work on the principle that hot air is less dense than cooler air. When the air inside a balloon’s envelope is warmer than the surrounding air, it will rise. Explain that today, students will do an activity that demonstrates that warm air expands and becomes less dense.

Procedure:

1. Explain that today students will be able to inflate a balloon without even blowing into it.

2. If students are doing this activity independently, distribute Worksheet #6B.8a and the materials; otherwise, do the activity as a demonstration, explaining what you are doing as you go along.

3. Basically, students will be securing an uninflated balloon to the mouth of an empty plastic 2-L pop bottle. Then they will fill the sink or large bowl with hot water. They will then hold the pop bottle in the water. The balloon should inflate.

For the teacher
Holding the empty pop bottle in the hot water causes the air inside the bottle to heat up. Heat makes the molecules inside the pop bottle become more active and want to move farther apart. When this happens the air expands and becomes less dense. The “expanded” air takes up more space. It goes up into the balloon and begins to fill it up.

Assignment:

Have student write up the activity in their notebooks, using these headings:

Question:
What We Did:
What We Observed:
What We Can Infer:

OR use Worksheet #6B.8b.

ALTERNATELY. If you like, have students write the activity up in paragraph form.
Question: What happens when air is heated?

Do this activity to find out.

**Materials:**  large bowl or a sink  
large balloon  
2-L plastic empty pop bottle

**Procedure:**

1. Stretch the balloon over the opening of the pop bottle. Be sure the balloon is not inflated.

2. Fill the sink or bowl with about 12 – 15 cm of hot water. (Be careful.)

3. Hold the bottle in the water. Wait for a few seconds.

4. What do observe?

5. What can you infer?
Expanding Air

Question:

What We Did:

What We Observed:

Diagram

What We Can Infer:
Question: What happens when air is heated?

What We Did:

- We placed an uninflated balloon over the opening of a 2-L pop bottle.
- We filled a large bowl with hot tap water.
- We held the pop bottle in the hot water in the bowl.

What We Observed:

- After a few seconds the balloon began to inflate.

What We Can Infer:

- The hot water heated the air in the pop bottle. The heated air expanded and began to inflate the balloon.
Lesson Nine

Concept: Constructing a Hot Air Balloon

Resources/Materials: Worksheet #6B.9a (optional, one copy per group)
Note: This activity can be done as a demonstration. In this case students will not need Worksheet #6B.9a
Worksheet #6B.9b (optional, student copies)
Per Group  Inexpensive garbage bag – the thinner the better
4 twist ties
hair dryer

Introduction: Review that the hot air is less dense than cooler air. Filling a balloon with hot air will make it rise.

Procedure:

1. If students will be doing the activity independently, distribute Worksheet #6B.9a. Also distribute the materials. Go over the directions for the activity, if necessary.

2. If you are doing the activity as a demonstration, follow these steps.

   Prepare the Bag: Use the twist ties to make the opening of the garbage bag smaller by tying the opening at four evenly-spaced points.

   Heat the Bag: Hold the garbage bag up the edges or the twist ties. Place the hair dryer near the mouth of bag so that its air will inflate the bag. Turn the hair dryer on high heat.
   WARNING: Do NOT put the hair dryer inside the bag to inflate it. This will cause the hair dryer to overheat and burn out the motor.

   Test the Balloon: Release the balloon and see if it floats.

3. Have student observe. Have them make suggestions to try to improve the balloons performance. Try out the improvements, if it is feasible

4. Have students decide why it is that the “balloon” rose up and eventually why it descended again.

Assignment:

1. Write up the activity in your notebooks using these headings:
   Question:
   What We Did:
   What We Observed:
   What We Can Infer:
2. OR use Worksheet #6B.9b.
3. OR write a paragraph to tell what you did and what you found out.
Question: Why does a hot air balloon create lift?

Do the following activity to find out.

Materials: large thin garbage bag
           hair dryer
           4 twist ties

Procedure:

1. Use the twist ties to make the opening of the garbage bag smaller. To do this use the twist ties to tie parts of the neck of the garbage bag, so that the tied parts are equally spaced.

2. Hold the garbage bag by the edges or by the twist ties in such a way that the hair dryer can blow air into the opening of the bag.

3. Turn the hair dryer on high heat and the hair dryer fan on high.

NOTE: Do not put the hair dryer inside the bag. This will cause it to overheat and the motor to burn out.

4. Once the bag is filled with hot air, release the bag.

5. What do you observe? Does the bag rise up? What happens after a few seconds?

6. What can you infer?
Constructing a Hot Air Balloon

Question:

What We Did:

What We Observed:

Diagram

What We Can Infer:
Question: How does a hot air balloon create lift?

What We Did:

We used four twist ties to tie parts of the opening edges of a lightweight garbage bag so that the opening became smaller.
We held a hair dryer, turned on high, to the opening until the garbage bag was filled with hot air.
We released the garbage bag.

What We Observed:

The garbage bag ascended ___ m into the air.
After a few seconds, it descended.

What We Can Infer:

The garbage filled with hot air ascended because hot air is less dense than the cooler outside air. The balloon descended when the air inside the bag began to cool.
Lesson Ten

Concept: Hot Air Balloon: Fair Test

NOTE: You and your students can choose to manipulate any variable you like, such as the size of the bag, the mass of the payload, the temperature of the air, and so on.

Resources/Materials: Worksheet #6B.10b and #6B.10c (student copies)
Worksheet #6B.10a (optional, one copy per group)

Note: If this activity is done as a demonstration, students will not need Worksheet #6B.10a.

Per Group: inexpensive lightweight garbage bags
8 twist ties hair dryer

Introduction: Review why the hot air balloon made last class ascended and eventually descended. Explain that today, students will do a fair test to see if the temperature of the air in a hot air balloon really does make a difference.

Procedure:

HANDS ON

1. If students are doing this activity independently, distribute Worksheets #6B.10a, #6B.10b, and #6B.10c, and the materials.
2. Go over the procedure and have them prepare first sections of Worksheet #6B.10a.

Note: Students will not have to make a table or graph for this activity.

3. If students are doing the activity independently, direct them to follow the directions on Worksheet #6B.10a and then write up the activity on Worksheets #6B.10b and #6B.10c.
4. If necessary, establish the following:
   Manipulated Variable: temperature of the air in the bag
   Constant Variables: size of the bags, mass of the bags, shape of the bags, size of bag openings, number of twist ties used
   Responding Variable: amount of ascent

5. If you are doing the activity as a demonstration, follow these directions:
   - Make two identical parachutes using the garbage bags and twist ties, as you did in the previous class.
   - Fill one parachute using the hair dryer, just turning on the fan, but not the heat. Observe.
   - Fill the other parachute with hot air. Observe.

NON HANDS ON: Instead of actually doing the activity described on Worksheet #6B.10a, have students pretend they did it. They are to make up their own observations and then write up the fair test on Worksheets #6B.10b and #6B.10c.

Assignment:

1. HANDS ON. Finish writing up the fair test on Worksheets #6B.10b and #6B.10c.
2. NON HANDS ON. Read about the fair test described on Worksheet #6B.10a. Then make up your own observation data, using this information to write up the fair test on Worksheets #6B.10b and #6B.10c.
Question: Does the temperature of the air in a hot air balloon make a difference in its ability to rise?

Do the following to find out.

Materials: 2 lightweight garbage bags of equal size, shape, and mass
8 twist ties
hair dryer

Procedure:

1. Make two identical parachutes, using the twist ties to make the openings of the garbage bags smaller.

2. Hold the first bag by the edges of the opening or by the twist ties. Fill it with cold air, using the hair dryer. Once the bag is filled with the cold air, release the bag. Observe.

3. Do the same with the second parachute, but this time, fill the bag with hot air from the hair dryer. Once the bag is filled with hot air, release the bag. Observe.

4. What did you observe?

5. What can you infer?
Science Grade 6 Topic B Flight
Worksheets

Fair Test: Temperature and Hot Air Balloons

Question: ____________________________________________________________
____________________________________________________________________

Hypothesis: __________________________________________________________
____________________________________________________________________

Materials: ___________________________________________________________
____________________________________________________________________
____________________________________________________________________

Manipulated Variable: ________________________________________________

Constant Variables: _________________________________________________
____________________________________________________________________
____________________________________________________________________

Responding Variable: ________________________________________________

Procedure: __________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

Observations:

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

Conclusion: ____________________________________________

_____________________________________________________

_____________________________________________________

_____________________________________________________

_____________________________________________________

_____________________________________________________

Worksheet #6B.10b
Answers will vary. **Fair Test: Temperature and Hot Air Balloons**  

**Question:** Which will rise higher, a hot air balloon filled with cool air or one filled with hot air. 

**Hypothesis:** I think... 

**Materials:**  
- 2 lightweight garbage bags of equal size, shape, mass  
- 8 twist ties  
- hair dryer  

**Manipulated Variable:** temperature of air in garbage bag. 

**Constant Variables:** size, shape, and mass of garbage bag  
- number of twist ties used  
- size of garbage bag opening  

**Responding Variable:** how high the hot air balloon rises. 

**Procedure:** Use the twist ties to make two identical hot air balloons  
- Fill one with cold air, using the hair dryer (cool setting). Release it.  
  - Measure the height it ascends.  
- Fill one with hot air, using the hair dryer (hot setting). Release it.  
  - Measure the height it ascends. 

**Observations:** 

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

The garbage bag filled with cool air rose ___.
The garbage bag filled with hot air rose ___.

Conclusion: A hot air balloon filled with hot air will rise higher than one filled with cold air.
Lesson Eleven

Concept: Flight, Part I Review

Resources/Materials: Flight, Part I Review Sheets (student copies)

Introduction: Explain that the first half of the unit on Flight is now over and it is time to review some of the major concepts covered.

Procedure:

1. Briefly go over the major concept covered:
   - We can divide aircraft into three major categories: floaters in which air currents and gravity control the direction and rate of descent; gliders in which there is some control over rate of descent; and flyers, in which a pilot can control thrust, and lift.
   - Drag or air resistance plays a major role in the descent of floaters.
   - Parachutes are floaters. The size and shape of its canopy affect how and how quickly it descends.
   - Parachutes are gliders.
   - Pilots of parachutes control the ascent and descent of parachutes by controlling the temperature of the air inside the parachutes envelope.
   - Hotter air is less dense than cooler air. If you fill the envelope of a balloon with hot air, it will make the balloon rise. If you cooler the air down, it will descend.


3. Have students complete the Review Sheets. Check them in class, if possible.

Assignment:

Do the Flight, Part I Review Sheets.
Review

1. Examine each of the things below that can fly. Write F for floater, G for glider, and P for powered flyer.

   _____ jet       _____ dandelion seed       _____ dragonfly
   _____ thistle seed       _____ parachute       _____ helicopter
   _____ paper airplane       _____ glider airplane       _____ falling leaf
   _____ hot air balloon       _____ propellered airplane       _____ robin

2. What is the purpose of a parachute?

   __________________________________________
   __________________________________________

3. Explain how a parachute works. Use these words in your explanation: air resistance, canopy, inflate, descend

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

4. Write true or false about these statements about parachutes.

   a. _____ The size of the canopy does not affect the rate of descent.
   b. _____ The colour of the canopy will affect the rate of descent.
   c. _____ The presence of a cooling vent will make a parachute more stable.
   d. _____ The shape of a canopy will affect the stability and rate of descent.
   e. _____ The type of material used for the canopy can affect the rate of descent.
   f. _____ The length of the shroud lines can affect the rate of descent.
5. Explain why modern-day parachutes usually have rectangular-shaped canopies instead of round ones.

6. Label the parts of the parachute in the diagram below.
7. Examine the display showing some of the different parachute designs. From the information in the display you can infer that

a. all parachutes have the same rate of descent.
b. the Hawk will be more stable than the Swallow.
c. the Falcon will fall more slowly to the ground than the Hawk.
d. the Eagle will be more stable than the Hawk.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Name</th>
<th>Drop Speed (metres per second)</th>
<th>Hole diameter (centimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Swallow</td>
<td>100 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Hawk</td>
<td>40 m/s</td>
<td>20 cm</td>
</tr>
<tr>
<td></td>
<td>Eagle</td>
<td>50 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Falcon</td>
<td>45 m/s</td>
<td>40 cm</td>
</tr>
</tbody>
</table>
8. Jim, Heather, and Mary want to conduct a fair test. They want to see if the length of the shroud lines will affect the rate of descent of a parachute. Write up the fair test. The information below will help you.

**Materials:**
2 squares of plastic, 40 cm X 40 cm  
2 corks of equal size, shape, and mass  
4 paper clip  
4 – 50 cm lengths of thread  
4 – 100 cm lengths of thread  
tape  
step ladder

**Question:**


**Hypothesis:**


**Manipulated Variable:**


**Constant Variables:**


**Responding Variable:**


**Procedure:**


**Observations:**


<table>
<thead>
<tr>
<th>50 cm shroud lines</th>
<th>100 cm shroud lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descent time in seconds</td>
<td>5</td>
</tr>
</tbody>
</table>
Observations (continued)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Conclusion: ____________________________________________________________

________________________________________________________________________

9. Explain how a hot air balloon works. In your explanation, you must use these words: ascend, descend, air, density, burner, pilot, and bag.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

For questions 10 – 17, choose the best answer.

10. Once in the air a hot air balloon pilot can only control one thing. What is it?
   a. the direction of the wind
   b. the size of the canopy
   c. the length of the shroud lines
   d. the rate of descent
11. In order for a hot air balloon to descend, the pilot would

   a. turn up the propane burners.
   b. open up the rip panel.
   c. pull on the basket handle.
   d. close the vent hole.

12. In order for a hot air balloon to ascend, the pilot would

   a. turn up the propane burners.
   b. open up the rip panel.
   c. pull on the basket handle.
   d. close the vent hole.

13. In a hot air balloon, the purpose of the basket is

   a. to hold the burners and the crew.
   b. to decrease the mass of the payload.
   c. to decrease the effects of the wind.
   d. to make the hot air balloon more colourful.

14. A hot air is a type of glider because

   a. it cannot be controlled in any way.
   b. the pilot can make it ascend or descend.
   c. it is used mostly for recreation.
   d. it looks like an airplane.

15. Hot air balloonists always check with the weather department before launching their balloons because

   a. the envelope of a hot air balloon is not waterproof.
   b. hot air balloons cannot fly without sun.
   c. bad weather, like strong winds, can make ballooning dangerous.
   d. hot air balloonists prefer windy days to help them travel faster.

16. Hot air balloonists usually have a chase vehicle on the ground following them as they travel through the air. From this, you can infer that

   a. balloonists are friendly people and like to have company.
   b. balloonists prefer to have someone on the ground following them in case they run into problems.
   c. it is against the law to operate a hot air balloon.
   d. balloonists are not brave people.
17. Hot air balloons rise because the
   a. air outside the balloon is lighter than the air inside the balloon.
   b. air inside the balloon takes up space and can be compressed.
   c. lift on the balloon is greater than the force of gravity.
   d. air inside the balloon is denser than the air outside the balloon.

18. Label the parts of a hot air balloon. Use these words: **mouth, skirt, basket, rip cord, vent cord, cooling vent, panel.**
1. Examine each of the things below that can fly. Write F for floater, G for glider, and P for powered flyer.

   |   |   |
---|---|---|
P | F | P |
   | F |   |
   | G |   |
   | G |   |

2. What is the purpose of a parachute?

   slow rate of descent

3. Explain how a parachute works. Use these words in your explanation: air resistance, canopy, inflate, descend. Answers will vary.

When the parachute begins to descend, the canopy inflates.

The parachute descends slowly because of air resistance on the underside of the canopy.

4. Write true or false about these statements about parachutes.

   a. F  The size of the canopy does not affect the rate of descent.
   b. F  The colour of the canopy will affect the rate of descent.
   c. T  The presence of a cooling vent will make a parachute more stable.
   d. T  The shape of a canopy will affect the stability and rate of descent.
   e. T  The type of material used for the canopy can affect the rate of descent.
   f. T  The length of the shroud lines can affect the rate of descent.
5. Explain why modern-day parachutes usually have rectangular-shaped canopies instead of round ones.

6. Label the parts of the parachute in the diagram below.

- Canopy
- Shroud lines (suspension lines)
- Payload
- Pilot chute
7. Examine the display showing some of the different parachute designs. From the information in the display you can infer that

a. all parachutes have the same rate of descent.
b. the Hawk will be more stable than the Swallow.
c. the Falcon will fall more slowly to the ground than the Hawk.
d. the Eagle will be more stable than the Hawk.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Name</th>
<th>Drop Speed (metres per second)</th>
<th>Hole diameter (centimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Swallow</td>
<td>100 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Hawk</td>
<td>40 m/s</td>
<td>20 cm</td>
</tr>
<tr>
<td></td>
<td>Eagle</td>
<td>50 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Falcon</td>
<td>45 m/s</td>
<td>40 cm</td>
</tr>
</tbody>
</table>
8. Jim, Heather, and Mary want to conduct a fair test. They want to see if the length of the shroud lines will affect the rate of descent of a parachute. Write up the fair test. The information below will help you.

**Materials:**
- 2 squares of plastic, 40 cm X 40 cm
- 2 corks of equal size, shape, and mass
- 4 paper clip
- 4 – 50 cm lengths of thread
- 4 – 100 cm lengths of thread
- tape
- step ladder

*Answers will vary.*

**Question:** Which parachute will descend more slowly, one with longer shroud lines or one with shorter shroud lines.

**Hypothesis:** I think . . .

**Manipulated Variable:** length of shroud lines

**Constant Variables:** size and shape of canopy; canopy fabric; size, shape, and mass of payload; drop height

**Responding Variable:** descent time

**Procedure:** Make two parachutes that are identical, except put 50 cm shroud lines on one and 100 cm shroud lines on the other.

Drop each parachute from the same height. Time the descents.

**Observations:**

<table>
<thead>
<tr>
<th></th>
<th>50 cm shroud lines</th>
<th>100 cm shroud lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descent time in seconds</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
Observations (continued)

The parachute with the 50 cm shroud lines descended in 5 sec.

The parachute with the 100 cm shroud lines descended in 3 sec.

Conclusion: The longer a parachutes shroud lines, the more slowly it will descend.

9. Explain how a hot air balloon works. In your explanation, you must use these words: ascend, descend, air, density, burner, pilot, and bag.

When the pilot wants the hot air balloon to rise, he/she turns on the burner. This heats the air in the bag. It becomes less dense, causing the balloon to rise. When the pilot wants the balloon to descend, he/she turns off the burner and opens the rip panel (vent hole) so that hot air in the bag escapes and the bag fills with cooler, more dense air.

For questions 10 – 17, choose the best answer.

10. Once in the air a hot air balloon pilot can only control one thing. What is it?
   a. the direction of the wind
   b. the size of the canopy
   c. the length of the shroud lines
   d. the rate of descent
11. In order for a hot air balloon to descend, the pilot would
   a. turn up the propane burners.
   b. open up the rip panel.
   c. pull on the basket handle.
   d. close the vent hole.

12. In order for a hot air balloon to ascend, the pilot would
   a. turn up the propane burners.
   b. open up the rip panel.
   c. pull on the basket handle.
   d. close the vent hole.

13. In a hot air balloon, the purpose of the basket is
   a. to hold the burners and the crew.
   b. to decrease the mass of the payload.
   c. to decrease the effects of the wind.
   d. to make the hot air balloon more colourful.

14. A hot air is a type of glider because
   a. it cannot be controlled in any way.
   b. the pilot can make it ascend or descend.
   c. it is used mostly for recreation.
   d. it looks like an airplane.

15. Hot air balloonists always check with the weather department before launching their balloons because
   a. the envelope of a hot air balloon is not waterproof.
   b. hot air balloons cannot fly without sun.
   c. bad weather, like strong winds, can make ballooning dangerous.
   d. hot air balloonists prefer windy days to help them travel faster.

16. Hot air balloonists usually have a chase vehicle on the ground following them as they travel through the air. From this, you can infer that
   a. balloonists are friendly people and like to have company.
   b. balloonists prefer to have someone on the ground following them in case they run into problems.
   c. it is against the law to operate a hot air balloon.
   d. balloonists are not brave people.
17. Hot air balloons rise because the
   a. air outside the balloon is lighter than the air inside the balloon.
   b. air inside the balloon takes up space and can be compressed.
   c. lift on the balloon is greater than the force of gravity.
   d. air inside the balloon is denser than the air outside the balloon.

18. Label the parts of a hot air balloon. Use these words: **mouth, skirt, basket, rip cord, vent cord, cooling vent, panel.**
Lesson Twelve

Concept: Flight, Part I Test

Resources/Materials: Flight, Part I Test (student copies)
1. Classify each of the following as floaters, gliders, or powered flyers.

<table>
<thead>
<tr>
<th>floaters</th>
<th>gliders</th>
<th>powered flyers</th>
</tr>
</thead>
<tbody>
<tr>
<td>parachute</td>
<td>jet</td>
<td>propellered airplane</td>
</tr>
<tr>
<td>hot air balloon</td>
<td>dandelion seed</td>
<td>paper airplane</td>
</tr>
<tr>
<td>glider airplane</td>
<td>bird</td>
<td>thistle seed</td>
</tr>
<tr>
<td>leaf</td>
<td>helicopter</td>
<td>mosquito</td>
</tr>
</tbody>
</table>

2. Explain why a sheet of wadded up paper will fall more quickly than a flat sheet of paper.
3. The main purpose of a parachute is
   a. to decrease the rate of descent.
   b. to increase the rate of descent.
   c. to get a better view of the scenery.
   d. to provide fun and entertainment.

4. Which of the following will **NOT** affect the rate of descent of a parachute?
   a. the mass of the payload
   b. the size of the canopy
   c. the shape of the canopy
   d. the colour of the canopy

5. Which of the following is most likely to affect the stability of a parachute?
   a. the type of shroud lines used
   b. the presence of a vent hole
   c. the colour of the canopy
   d. the amount of sunshine

6. When parachutes were first used, the canopies were round. Today, most parachutes have rectangular-shaped canopies. This is because
   a. rectangular-shaped canopies cost less.
   b. rectangular-shaped canopies use less material.
   c. it is easier to control the descent with rectangular-shaped canopies.
   d. rectangular-shaped canopies are more stable.

7. Explain how a parachute works. You must use these words: **canopy**, **rate of descent**, and **drag**.
8. Label the following parts of a parachute: **payload, canopy, shroud lines, pilot chute.**
9. Examine the display below. It shows different types of parachutes.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Name</th>
<th>Drop Speed (metres per second)</th>
<th>Hole diameter (centimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Swallow</td>
<td>100 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Hawk</td>
<td>40 m/s</td>
<td>20 cm</td>
</tr>
<tr>
<td></td>
<td>Eagle</td>
<td>50 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Falcon</td>
<td>45 m/s</td>
<td>40 cm</td>
</tr>
</tbody>
</table>

The best parachute for a slow, controlled descent is the

a. Swallow.
b. Hawk.
c. Eagle.
d. Falcon.
10. Billy and Jane wanted to conduct a fair test. They wanted to see if the shape of the canopy of a parachute affected the rate of descent. Write up a fair test to show what they did, their observations, and their conclusion.

**Materials:**
two pieces of plastic of equal area, one rectangular and one round
8 – 40 cm pieces of thread
2 corks of equal size
4 paper clips of equal size
step ladder
tape

Here is a table showing what they observed:

<table>
<thead>
<tr>
<th></th>
<th>rectangular-shaped canopy</th>
<th>round canopy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time (s)</strong></td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Question:**

**Hypothesis:**

**Materials:**

**Manipulated Variable:**

**Constant Variables:**

**Responding Variable:**
Procedure: ________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Observations: ____________________________________________________________

________________________________________________________________________

________________________________________________________________________

Conclusion: ______________________________________________________________

________________________________________________________________________

11. Explain how a hot air balloon works. Use must use these words: envelope, vent hole, propane burner, descend, ascend, and dense.
For questions 12 – 19 choose the best answer.

12. The pilot of a hot air balloon is able to control
   a. the direction of the wind.
   b. the shape of the envelope.
   c. the rates of ascent and descent.
   d. the course of the balloon.

13. A hot air balloon rises because
   a. the air inside the envelope is more dense than the air outside the bag.
   b. the air inside the envelope is more moist than the air outside the bag.
   c. the envelope is rounder in shape.
   d. the air inside the envelope is less dense than the air outside the bag.

14. If the pilot of a hot air balloon wants the parachute to ascend more quickly, he will
   a. pull on the suspension lines.
   b. turn up the burner.
   c. turn down the burner.
   d. increase the mass of the basket.

15. All hot air balloons are required to have a “chaser”. A chaser is someone on the ground who follows the hot air balloon in a vehicle. The most likely reason for this is because
   a. hot air balloon pilots want company.
   b. hot air balloon pilots cannot control their ascent and descent.
   c. hot air balloon pilots cannot control the direction in which they travel.
   d. hot air balloon pilots are usually not experienced in flying hot air balloons.

16. Think about the envelope of a hot-air balloon. Which of the following shapes will give the pilot the most control over the rate of ascent and descent?
   a. cube
   b. egg
   c. rectangular prism
   d. sphere

17. The main purpose of the basket is
   a. to hold any groceries the pilot may want to bring on the trip.
   b. to hold the burner, pilot and any passengers.
   c. to stabilize the hot air balloon.
   d. to increase the rate of ascent and descent.
18. When the sun is shining brightly on a summer day, the warmed air over a field will rise because

a. it is less dense than the surrounding air.
b. it is more dense than the surrounding air.
c. the high-altitude cold air is more stable than the lower air.
d. the high-altitude warm air is less stable than the lower air.

19. A hot air balloon moves toward the ground when the

a. air inside the balloon is being heated.
b. weight of the balloon is greater than its lift.
c. air outside the balloon is heated by the sun’s rays.
d. weight of the balloon is greater than its drag.

20. Label the diagram of a hot air balloon using the following words: basket, rip panel, cooling vent, skirt, mouth, rip cord, vent cord.
1. Classify each of the following as **floaters**, **gliders**, or **powered flyers**.

<table>
<thead>
<tr>
<th>floaters</th>
<th>gliders</th>
<th>powered flyers</th>
</tr>
</thead>
<tbody>
<tr>
<td>parachute</td>
<td>hot air balloon</td>
<td>jet</td>
</tr>
<tr>
<td>hot air balloon</td>
<td>dandelion seed</td>
<td>propellered airplane</td>
</tr>
<tr>
<td>glider airplane</td>
<td>bird</td>
<td>paper airplane</td>
</tr>
<tr>
<td>leaf</td>
<td>helicopter</td>
<td>thistle seed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mosquito</td>
</tr>
</tbody>
</table>

2. Explain why a sheet of wadded up paper will fall more quickly than a flat sheet of paper.

```
less surface area means less air resistance and quicker fall
```

---

1
3. The main purpose of a parachute is
   a. to decrease the rate of descent.
   b. to increase the rate of descent.
   c. to get a better view of the scenery.
   d. to provide fun and entertainment.

4. Which of the following will NOT affect the rate of descent of a parachute?
   a. the mass of the payload
   b. the size of the canopy
   c. the shape of the canopy
   d. the colour of the canopy

5. Which of the following is most likely to affect the stability of a parachute?
   a. the type of shroud lines used
   b. the presence of a vent hole
   c. the colour of the canopy
   d. the amount of sunshine

6. When parachutes were first used, the canopies were round. Today, most parachutes have rectangular-shaped canopies. This is because
   a. rectangular-shaped canopies cost less.
   b. rectangular-shaped canopies use less material.
   c. it is easier to control the descent with rectangular-shaped canopies.
   d. rectangular-shaped canopies are more stable.

7. Explain how a parachute works. You must use these words: canopy, rate of descent, and drag.

   When the parachute drops, the canopy inflates. The drag created by the inflated canopy decreases the rate of descent.
8. Label the following parts of a parachute: payload, canopy, shroud lines, pilot chute.
9. Examine the display below. It shows different types of parachutes.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Name</th>
<th>Drop Speed (metres per second)</th>
<th>Hole diameter (centimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Swallow</td>
<td>100 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Hawk</td>
<td>40 m/s</td>
<td>20 cm</td>
</tr>
<tr>
<td></td>
<td>Eagle</td>
<td>50 m/s</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Falcon</td>
<td>45 m/s</td>
<td>40 cm</td>
</tr>
</tbody>
</table>

The best parachute for a slow, controlled descent is the

a. Swallow.
b. Hawk.
c. Eagle.
d. Falcon.
10. Billy and Jane wanted to conduct a fair test. They wanted to see if the shape of the canopy of a parachute affected the rate of descent. Write up a fair test to show what they did, their observations, and their conclusion.

**Materials:**
two pieces of plastic of equal area, one rectangular and one round
8 – 40 cm pieces of thread
2 corks of equal size
4 paper clips of equal size
step ladder
tape

**NOTE:** The results of the particular fair test may not be indicative of what typically happens. But students must draw conclusions based on the data provided.

Here is a table showing what they observed:

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Rectangular-shaped canopy</th>
<th>Round canopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Answers may vary.

**Question:** Which parachute will fall more quickly, one with a rectangular-shaped canopy or one with a round canopy?

**Hypothesis:** I think...

---

**Materials:**
two pieces of plastic of equal area, one rectangular; the other round
8 – 40 cm pieces of thread
4 paper clips of equal size
2 corks of equal size
tape
step ladder

**Manipulated Variable:** shape of canopy

**Constant Variables:**
canopy size and material
size of shroud lines
drop height
size and mass of payload

**Responding Variable:** descent time
Procedure: Make two identical parachutes, except make one with a rectangular canopy and one with a round canopy. Drop each parachute from the same height. Time each descent.

Observations: The parachute with the rectangular canopy took 4 sec to descend. The parachute with the round canopy took 4 sec to descend.

Conclusion: The shape of a parachute's canopy does not affect its descent time.

11. Explain how a hot air balloon works. Use must use these words: envelope, vent hole, propane burner, descend, ascend, and dense.

When the pilot wants to ascend, he/she turns on the propane burner. This heat the air in the envelope, causing the air inside the envelope to expand and become less dense. This causes the balloon to rise. When the pilot wants to descend, he/she opens the vent hole and turns off the burner. This allows the hot air inside the envelope to escape. It is replaced with cooler air, which is more dense. This causes the balloon to descend.
For questions 12 – 19 choose the best answer.

12. The pilot of a hot air balloon is able to control
   a. the direction of the wind.
   b. the shape of the envelope.
   c. the rates of ascent and descent.
   d. the course of the balloon.

13. A hot air balloon rises because
   a. the air inside the envelope is more dense than the air outside the bag.
   b. the air inside the envelope is more moist than the air outside the bag.
   c. the envelope is rounder in shape.
   d. the air inside the envelope is less dense than the air outside the bag.

14. If the pilot of a hot air balloon wants the parachute to ascend more quickly, he will
   a. pull on the suspension lines.
   b. turn up the burner.
   c. turn down the burner.
   d. increase the mass of the basket.

15. All hot air balloons are required to have a “chaser”. A chaser is someone on the ground who follows the hot air balloon in a vehicle. The most likely reason for this is because
   a. hot air balloon pilots want company.
   b. hot air balloon pilots cannot control their ascent and descent.
   c. hot air balloon pilots cannot control the direction in which they travel.
   d. hot air balloon pilots are usually not experienced in flying hot air balloons.

16. Think about the envelope of a hot-air balloon. Which of the following shapes will give the pilot the most control over the rate of ascent and descent?
   a. cube
   b. egg
   c. rectangular prism
   d. sphere

17. The main purpose of the basket is
   a. to hold any groceries the pilot may want to bring on the trip.
   b. to hold the burner, pilot and any passengers.
   c. to stabilize the hot air balloon.
   d. to increase the rate of ascent and descent.
18. When the sun is shining brightly on a summer day, the warmed air over a field will rise because

a. it is less dense than the surrounding air.
b. it is more dense than the surrounding air.
c. the high-altitude cold air is more stable than the lower air.
d. the high-altitude warm air is less stable than the lower air.

19. A hot air balloon moves toward the ground when the

a. air inside the balloon is being heated.
b. weight of the balloon is greater than its lift.
c. air outside the balloon is heated by the sun’s rays.
d. weight of the balloon is greater than its drag.

20. Label the diagram of a hot air balloon using the following words: basket, rip panel, cooling vent, skirt, mouth, rip cord, vent cord.
About Part II

In Part II of Flight students continue their study of devices that travel through the air. Whereas Part I focused on floaters and gliders, Part II focuses entirely on flyers. Flyers are different from floaters and gliders because they have their own sources of power that enable them to control thrust and lift. This not only gives them more control to overcome the forces of drag and gravity, it affords them greater manoeuvrability in the air.

For many of the lessons students will rely on the Mini Textbook to get information. However, hands on activities are suggested to help them understand the concepts involved when flyers travel through the air. The materials and equipment, for the most part, are those found in any colony school.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On</th>
<th>Non Hands On Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Aerodynamics: Review</td>
<td>28 and 29</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Forces Acting on an Airplane</td>
<td>30</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Making a Glider</td>
<td>31</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>The Basic Movements of an Airplane</td>
<td>32 and 33</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>The Controlling Surfaces of an Airplane</td>
<td>34 and 35</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Overcoming Air Resistance</td>
<td>36</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>19</td>
<td>Controlling Pitch</td>
<td>37</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Controlling Roll</td>
<td>38</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Controlling Yaw and Banking</td>
<td>39 and 40</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>Constructing a Glider or Flyer: Making Adjustments to Control It</td>
<td>---------</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>23</td>
<td>Propellers: Constructing a Roto-copter</td>
<td>41 – 44</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>Propellers: Constructing a Heliostraw</td>
<td>---------</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25</td>
<td>Thrust in Jets and Rockets</td>
<td>45 – 48</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>26</td>
<td>Flight – Part II Review</td>
<td>---------</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>27</td>
<td>Flight – Part II Test</td>
<td>---------</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson Thirteen (Optional)

If students have just previously taken the unit on Air and Aerodynamics, you may want to consider omitting Lesson Thirteen and Lesson Fourteen.

Concept: Aerodynamics: Review

Resources/Materials: Mini Textbook, pages 28 and 29
Worksheet #6B.13a and #6B.13b (student copies)

Introduction: Review that the term aerodynamics refers to the study of moving air. By examining some of the principles of aerodynamics, we can better understand how airplanes fly. Write a definition of aerodynamics on the board.

Aerodynamics – the study of moving air

Procedure:

1. Explain that one of the most important ideas in aerodynamics is that air exerts a force on all surfaces. This force is called air pressure. Air presses up, down, and sideways. Write down a definition of air pressure on the board for students to copy into their notebooks.

Air Pressure – the force that air exerts

2. Explain that another important idea in aerodynamics is called Bernoulli’s Principle. It is named after a Swiss scientist who first discovered that moving air has less air pressure than still air. Write Bernoulli’s Principle on the board.

Bernoulli’s Principle – moving air has less air pressure than still air.

3. Explain that inventors and scientists use these and other ideas from aerodynamics when designing aircraft. An aircraft wing is shaped in a certain shape. This shape is called an airfoil.

4. Draw a cross-section cut of an airfoil. Explain that the air going over the curved top surface of the wing travels at a faster rate than the air passing under the straight bottom surface. This means that the pressure pushing up on the wing is greater than the air pushing down on the wing. This is what causes an airplane to lift up. If necessary, go over how an airfoil creates lift, several times.


6. Distribute Worksheets #6B.13a and #6B.13b.

Assignment:

1. Copy the notes from the board.
2. Read Mini Textbook, pages 28 and 29.
3. Do Worksheet #6B.13a and #6B.13b.
1. Define each of these terms:

   a. aerodynamics ____________________________________________

   ________________________________________

   b. air pressure ____________________________________________

   ________________________________________

2. What is Bernoulli’s Principle?

   ________________________________________

   ________________________________________

3. Examine the cross-section cut of an airfoil. Explain why the airfoil shape of an airplane wing helps to make an airplane ascend.

   ________________________________________

   ________________________________________

   ________________________________________

   ________________________________________

   ________________________________________

   ________________________________________

   ________________________________________

   ________________________________________
4. Examine the picture below. Explain what will happen as the girl blows across the top of the paper strip. Tell why it happens.

5. In the picture below the boy is blowing a steady stream of air through the paper tent. Tell what will happen. Explain why it will happen.
1. Define each of these terms:
   a. aerodynamics _study of moving air_
   b. air pressure _force that air exerts_

2. What is Bernoulli's Principle?
   Faster moving air has less air pressure than slower moving air

3. Examine the cross-section cut of an airfoil. Explain why the airfoil shape of an airplane wing helps to make an airplane ascend.

   Air goes over and under the wing. The curve of the upper surface makes the air pressure above the wing less than the air pressure under the wing. Thus more force is exerted upward than downward causing the aircraft to ascend.
4. Examine the picture below. Explain what will happen as the girl blows across the top of the paper strip. Tell why it happens.

The end of the strip will stick straight out or maybe even rise past horizontal. This is because the moving air over the top of the strip has less air pressure than the still air under the strip.

5. In the picture below the boy is blowing a steady stream of air through the paper tent. Tell what will happen. Explain why it will happen.

The sides of the tent will cave in somewhat. The moving air inside the tent has less air pressure than the still air outside the tent.
Lesson Fourteen (Optional)

Concept: Forces Acting on an Airplane

Resources/Materials: Mini Textbook, pages 30  
Worksheet #6B.14 (student copies)

Introduction: Explain again that it is Bernoulli’s Principle that enables airplanes, birds, and insects to fly. Explain that today we will discuss the forces that act on an airplane.

Procedure:

1. Have students turn to Mini Textbook, page 30. Guide the reading of the page. Emphasize that thrust and drag are opposing forces as are lift and weight (gravity).

2. Let students know that an airplane cannot hover like a helicopter or hummingbird can. (See the final point on Mini Textbook, page 30.) The mini textbook page statement is really a theoretical construct.

3. OPTIONAL. Using the information on Mini Textbook, page 30 make notes using the following headings:

   The Forces Acting on an Airplane

   Basic Aviation Terms

   Relationships Between Forces

4. Distribute Worksheet #6B.14. Go over the directions, if necessary.

Assignment:

1. OPTIONAL. Make notes on Mini Textbook, page 30.

2. Do Worksheet #6B.14.
1. Explain the meanings of these forces that act on a moving aircraft.
   a. lift
   b. weight
   c. thrust
   d. drag

2. Tell what each of the following mean.
   a. accelerate
   b. decelerate
   c. ascend
   d. descend
   e. hover

3. Fill in the spaces with the appropriate word.
   a. When drag is greater than thrust, an aircraft will _________________.
   b. When thrust is greater than drag, an aircraft will _________________.
   c. When lift is greater than weight, an aircraft will _________________.
   d. When weight is greater than lift, an aircraft will _________________.
   e. When lift is equal to weight, and thrust is equal to drag, an aircraft will __________.
Science Grade 6 Topic B Flight – Part II
Worksheets

The Forces Acting on a Moving Airplane

1. Explain the meanings of these forces that act on a moving aircraft.
   a. lift  up\textit{ward force} that holds aircraft in the air
   b. weight \textit{force} that pulls aircraft down
   c. thrust \textit{force} that moves aircraft forward
   d. drag \textit{air resistance} that holds aircraft back

2. Tell what each of the following mean.
   a. accelerate \textit{speed up}
   b. decelerate \textit{slow down}
   c. ascend \textit{go up}
   d. descend \textit{go down}
   e. hover \textit{stay in one place in the air}

3. Fill in the spaces with the appropriate word.
   a. When drag is greater than thrust, an aircraft will \textit{decelerate}.
   b. When thrust is greater than drag, an aircraft will \textit{accelerate}.
   c. When lift is greater than weight, an aircraft will \textit{ascend}.
   d. When weight is greater than lift, an aircraft will \textit{descend}.
   e. When lift is equal to weight, and thrust is equal to drag, an aircraft will \textit{hover}.
Lesson Fifteen

Concept: Making a Glider

Resources/Materials: Mini Textbook, page 31
- Worksheets #6B.15a (student copies)
- Worksheets #6B.15b, #6B.15c, #6B.15d, and #6B.15e (optional, student copies)
- Few sheets of paper per student

Introduction: Explain that gliders are different from floaters in that glider pilots have some control over how the aircraft flies. Gliders are not powered flyers because gliders do not have the power to create thrust and lift on their own. The next few lessons will be about making and testing out gliders.

Procedure:

1. Explain that students will have a chance to make paper airplanes and test them out. **Paper airplanes are considered to be a type of glider because they do not have their own source of thrust.**

2. With paper airplanes, you cannot control the flight pattern once it has left the throwers hands. With real glider airplanes, the pilot does have some mid-flight control over how the glider flies.

3. Explain that today students are to make paper airplanes, throw them, and then record the flight patterns of their and their classmates’ airplanes.
   Examples: Took a nose dive
   - Flew toward the left
   - Glided in a straight line before landing
   - Spiralled
   - Spun nose over tail

4. **Have students prepare their notebooks to record the flight patterns:**
   - Flight Patterns

5. Distribute Worksheet #6B.15a. This provides students with directions for making a basic paper glider.

6. **OPTIONAL.** Distribute Worksheets #6B.15b, #6B.15c, #6B.15d, and/or #6B.15e. Explain that these are also paper airplane patterns students can use to make their gliders.

7. Distribute three or four sheets of paper to each student. Have them make paper airplanes of their own design choice. Give minimal directions. Allow students a few practice shots. If you like, you can have students try to adjust their gliders to improve flight. Mini Textbook, page 31 has some pointers.

   **This can get a little wild, and the other students will probably be very distracted. But that’s okay once in a while, right?!**

Assignment:

Take turns throwing your airplanes. After each throw record the type of flight pattern. Keep throwing and recording until time is up or you just can’t stand it anymore.
THE POINT-NOSED GLIDER

To make a point-nosed glider:

1. Fold a 8 1/2 by 11 piece of paper in half lengthwise.
2. Open up the paper. Fold both top corners into the center fold.
3. Fold both sides into the center fold, matching the edges of the paper to the center fold.
4. Turn the paper over. Fold the edges once again into the center crease line.
5. Open this last fold and pinch the center crease. You are now grasping the underside of the plane.
6. Turn over and tape the body of the plane together.

---

Worksheet #6B.15a
1. Fold paper in half lengthwise, then open it to create center line.

2. Fold corners in to center line.

3. Fold point up.

4. Fold corners in.

5. Fold point down.

6. Fold in half along center line.

7. Fold wings down.

8. Fold wing tips up.

9. Cut wing flaps and fold up.

staple
First, fold a piece of paper in half the long way, like this.

Next, open it and fold the top corners in and down like this.

Then fold the top down like this.

Then fold the top corners down again like before.

Now fold it in half the lengthwise again.

Fold the wings down like this.

Then fold the tips of the wings up like this. Next, place a paperclip under the plane, about an inch from the front. Now you're ready to soar!
Throw this plane outside in an open space and it will soar far.

**Step 1**
Fold the paper in half the long way.

**Step 2**
Unfold it and fold the top corners in like this.

**Step 3**
Turn the paper over and fold the top down like this.

**Step 4**
Now fold the top corners in again like this.

**Step 5**
Turn it over again and fold it in half, bringing the left side up to meet the right.

**Step 6**
Put a small piece of tape along the bottom as shown and fold the wings down where the dotted lines are in the picture.

**Step 7**
Put a paperclip under the nose of the plane and you're ready to fly!
This plane is a trick plane. If you fold it carefully, it should “roll” as it flies.

Start with a SQUARE piece of paper with sides 21.5 cm.

**Step 1**
Fold the paper in half.

**Step 2**
Fold the top corners in like this.

**Step 3**
Fold the top down where the corners meet like this.

**Step 4**
Then fold the top over again like this.

**Step 5**
Fold the top corners in again like this.

**Step 6**
Turn the paper over and fold it in half along the center like this.
Place a small piece of tape at the bottom.

**Step 7**
Fold the wings down along the lines shown in this picture.

**Step 8**
Put a paper clip along the bottom and hit the skies!
Lesson Sixteen

Concept: The Basic Movements of an Airplane

Resources/Materials: Mini Textbook, pages 32 and 33
Worksheets #6B.16a and #6B.16b (student copies)
model airplane (optional)

Introduction: With students recall the different types of flight patterns their aircraft had. Explain that in order to improve the flight patterns, students need to know the basic movements of an airplane and how they might be controlled.

Procedure:

1. Explain that an airplane has three basic types of movements: pitch, roll, and yaw. Pitch has to do with the nose going up or down. Roll has to do with the wings dipping up or down. Yaw has to do with the nose turning left or right.

2. Have students turn to Mini Textbook, pages 32 and 33. Guide the reading of the pages. The concepts on these pages can be quite challenging. Most will need your help to understand them. If you have a model airplane, use it to demonstrate the various manoeuvres and axes.

3. Distribute Worksheets #6B.16a and #6B.16a. Have students complete them.

Assignment:

1. Read Mini Textbook, pages 32 and 33.
2. Do Worksheet #6B.16a and #6B.16b.
1. Match the airplane movements with their descriptions.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pitch</td>
<td>a. the nose turning left or right</td>
</tr>
<tr>
<td>roll</td>
<td>b. the wings tipping up or down</td>
</tr>
<tr>
<td>yaw</td>
<td>c. the nose raising up or dipping down</td>
</tr>
</tbody>
</table>

2. Examine the pictures on this page. On the line, write one of the following: **downward pitch, level pitch, upward pitch, right bank, level flight, left bank, left yaw, right yaw.**
3. Fill the blanks with these words: **pitch, roll, yaw**.
   a. An airplane pilot wants to fly straight, but instead he notices that the plane is banking left. He must try to control the ________________.
   
b. Now the pilot wants to descend. To do this he will have to put the aircraft in a downward ________________.
   
c. The pilot notices that the aircraft’s nose is turning to the left, but he wants to go straight ahead. To correct this, he must adjust the ________________.

4. An airplane moves around three axes: **lateral**, **longitudinal**, and **vertical**. Fill in the blanks to make the sentence correct. Use these words and phrases: **nose, wing, top of the fuselage, yaw, roll, pitch, bottom of the fuselage, tail**.
   a. The lateral axis runs from ________________ to ________________. When the airplane rotates around the lateral axis, you would see it ________________.
   
b. The vertical axis runs from the ________________ to the ________________. When the airplane rotates around the vertical axis, you would see it ________________.
   
c. The longitudinal axis runs from the ________________ to the ________________. When the airplane rotates around the longitudinal axis, you would see it ________________.

5. On the diagram below, label the lateral axis, vertical axis, longitudinal axis, pitch, roll, and yaw.

![Diagram of an airplane with axes labeled](image)
The Basic Movements of an Airplane

1. Match the airplane movements with their descriptions.

<table>
<thead>
<tr>
<th>pitch</th>
<th>roll</th>
<th>yaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>b</td>
<td>a</td>
</tr>
</tbody>
</table>

- a. the nose turning left or right
- b. the wings tipping up or down
- c. the nose raising up or dipping down

2. Examine the pictures on this page. On the line, write one of the following: downward pitch, level pitch, upward pitch, right bank, level flight, left bank, left yaw, right yaw.

- left yaw
- right bank
- downward pitch
- level pitch
- right yaw
- left bank
- upward pitch
- level flight
- level flight (yaw)
3. Fill the blanks with these words: *pitch, roll, yaw.*

   a. An airplane pilot wants to fly straight, but instead he notices that the plane is banking left. He must try to control the **roll**.

   b. Now the pilot wants to descend. To do this he will have to put the aircraft in a downward **pitch**.

   c. The pilot notices that the aircraft’s nose is turning to the left, but he wants to go straight ahead. To correct this, he must adjust the **yaw**.

4. An airplane moves around three axes: *lateral, longitudinal,* and *vertical.* Fill in the blanks to make the sentence correct. Use these words and phrases: *nose, wing, top of the fuselage, yaw, roll, pitch, bottom of the fuselage, tail.*

   a. The lateral axis runs from **wing tip** to **wing tip**. When the airplane rotates around the lateral axis, you would see it **pitch**.

   b. The vertical axis runs from the **top of the fuselage** to the **bottom of the fuselage**. When the airplane rotates around the vertical axis, you would see it **yaw**.

   c. The longitudinal axis runs from the **nose** to the **tail**. When the airplane rotates around the longitudinal axis, you would see it **roll**.

5. On the diagram below, label the lateral axis, vertical axis, longitudinal axis, pitch, roll, and yaw.
Lesson Seventeen

Concept: The Controlling Surfaces of an Airplane

Resources/Materials: Mini Textbook, pages 34 and 35  
Worksheets #6B.17a, #6B.17b, and #6B.17c (student copies)  
model airplane (optional)

Introduction: Review the basic movements of an airplane and the axes around which they rotate.

Explain that today students will learn about the parts of an airplane and the functions of the parts.

Procedure:

1. Have students turn to Mini Textbook, pages 34 and 35. Guide the reading. If you have a model airplane, use it to point out the various controlling surfaces.

2. Distribute Worksheets #6B.17a, #6B.17b, and #6B.17c. Tell students to use the information from the mini textbook pages to complete the worksheets.

Assignment:

1. Read Mini Textbook, pages 34 and 35.

2. Do Worksheets #6B.17a, #6B.17b, and #6B.17c.
1. Label the controlling surfaces of the fixed-wing airplane on the diagram below.

![Diagram of an airplane with labeled parts]

2. Complete the chart to show the locations and functions of the control surfaces of a fixed-wing aircraft.

<table>
<thead>
<tr>
<th>Part</th>
<th>Location</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>fuselage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>horizontal stabilizers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertical stabilizers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>elevators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rudder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ailerons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Controlling the Airplane

Directions: Tell what a pilot would do if he wanted to do the following.

1. Yaw right: ________________________________________________________________

2. Climb to a higher altitude: ________________________________________________

3. Roll left: __________________________________________________________________

4. Descend: __________________________________________________________________

5. Yaw left: __________________________________________________________________

6. Roll right: __________________________________________________________________

7. Turn right: __________________________________________________________________

8. Turn left: __________________________________________________________________
The Controlling Surfaces of an Airplane

Directions: The answer to each riddle is one of the controlling surfaces of an airplane.

1. The wings and tail are attached to me. I hold the pilot, passengers, and any cargo. What am I?

2. We keep the airplane flying forward on an even flight path. We look like a set of miniature wings on the aircraft’s tail.

3. I am a flap in the vertical stabilizer. By turning me, the pilot can turn yaw left or right.

4. We are part of the tail. I keep the aircraft flying upright.

5. We are flaps located in the horizontal stabilizers. By flipping us up or down, the pilot can make the airplane ascend or descend.

6. We are located on the back edge of the wings. We are used to control roll.

7. We are two different types of controlling surfaces. A pilot needs both of us to make a turn.
1. Label the controlling surfaces of the fixed-wing airplane on the diagram below.

![Diagram of an airplane with labeled parts: vertical stabilizer, rudder, elevator, horizontal stabilizer, aileron, fuselage.]

2. Complete the chart to show the locations and functions of the control surfaces of a fixed-wing aircraft.

<table>
<thead>
<tr>
<th>Part</th>
<th>Location</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>fuselage</td>
<td>central part of aircraft</td>
<td>hold wings, tail in place, hold cumo/pilot</td>
</tr>
<tr>
<td>horizontal stabilizers</td>
<td>tail</td>
<td>keep aircraft flying level</td>
</tr>
<tr>
<td>vertical stabilizers</td>
<td>tail</td>
<td>keep aircraft flying level</td>
</tr>
<tr>
<td>elevators</td>
<td>on horizontal stabilizers</td>
<td>control pitch</td>
</tr>
<tr>
<td>rudder</td>
<td>on vertical stabilizer</td>
<td>control yaw</td>
</tr>
<tr>
<td>ailerons</td>
<td>on wings</td>
<td>control roll</td>
</tr>
</tbody>
</table>
Directions: Tell what a pilot would do if he wanted to do the following.

1. Yaw right: turn rudder to right

2. Climb to a higher altitude: put elevators up

3. Roll left: left aileron up; right aileron down

4. Descend: put elevators down

5. Yaw left: turn rudder to left

6. Roll right: left aileron down; right aileron up

7. Turn right: right aileron up; left aileron down; rudder right

8. Turn left: left aileron up; right aileron down; rudder left
Directions: The answer to each riddle is one of the controlling surfaces of an airplane.

1. The wings and tail are attached to me. I hold the pilot, passengers, and any cargo. What am I?
   
   fuselage

2. We keep the airplane flying forward on an even flight path. We look like a set of miniature wings on the aircraft’s tail.
   
   horizontal stabilizers

3. I am a flap in the vertical stabilizer. By turning me, the pilot can turn yaw left or right.
   
   rudder

4. We are part of the tail. I keep the aircraft flying upright.
   
   vertical stabilizer

5. We are flaps located in the horizontal stabilizers. By flipping us up or down, the pilot can make the airplane ascend or descend.
   
   elevators

6. We are located on the back edge of the wings. We are used to control roll.
   
   ailerons

7. We are two different types of controlling surfaces. A pilot needs both of us to make a turn.
   
   rudder, ailerons
Lesson Eighteen

Concept: Overcoming Air Resistance

Resources/Materials: Mini Textbook, page 36
- Worksheet #6B.18a (transparency or copied onto chart)
- Worksheet #6B.18b (student copies)
- paper
- tape
- paper clips

Introduction: Review the different ways that pilots control aircraft:
- Horizontal and vertical stabilizers: keep aircraft flying level and upright
- Elevators: control pitch
- Rudder: controls yaw
- Ailerons: control roll

Recall with students that parachutes used air resistance to slow down the rate of descent. Airplanes are designed so that the controlling surfaces can be moved to increase air resistance in certain places to make the airplane move in certain ways.

Procedure:

1. Give each student a piece of paper. Have them raise it over his/her head and let it float down. (Observe how it falls from side to side. This is because of air resistance. The air is going out one side, then other.)

2. Now have students make three or four accordion pleats along one side and tape the pleats to the paper. Again have them hold the papers over their heads and let them drop. Observe that the folded side reaches the floor first. The folded part makes what is called a leading edge. It cuts through the air, helping to reduce air resistance. A paper folded with a leading edge is more stable than a flat piece of paper. The other end of the paper is called the trailing edge. NOTE: PAPER AIRPLANES CAN BE VERY FINICKY. TELL STUDENTS NOT TO GET DISCOURAGED IF THEIR FLYERS DO NOT ALWAYS PERFORM AS EXPECTED.

3. Relate this to the design of an airplane. Usually the airplane has a long narrow body, streamlined fuselage, and flat wings. This helps the airplane “cut through” the air, helping it to overcome air resistance.

4. Put up on the overhead or display the chart of Worksheet #6B.18a. With students read the notes. Then have them copy the notes into their notebooks.

5. Distribute Worksheet #6B.18b. Go over the directions, if necessary.

Assignments:
1. Copy notes from Worksheet #6B.18a.
2. Do Worksheet #6B.18b.
Overcoming Air Resistance

In order for an airplane to go forward, it needs to overcome air resistance. Airplanes are designed so that they have leading edges. Leading edges cut through the air, helping to reduce air resistance. Rounded noses, streamlined fuselages, and flat wings are all leading edges that help reduce air resistance.
**The Role of Air Resistance**

**Directions:** Use *Mini Textbook*, page 36 to help you with the questions.

1. Each of the sentences below is not correct. Cross out the wrong word or words and write the correct word or words.

   The fuselage, wings, and tail of an airplane are all underlined.

   The idea of streamlining is to try to increase drag by maximizing the effect of air resistance.

   The engines of an airplane give it lift.

   When drag is increased, thrust decreases.

   The part of an airplane that first meets the air and forces it to go over or under the part is called the trailing edge.

2. Where would you find each of these airplane parts?

   a. rudder

   b. elevators

   c. ailerons

3. In each drawing, put an X where air resistance will be greatest.

   a. [Diagram with airflow indicated]

   b. [Diagram with airflow indicated]

---

Worksheet 6B.18b
Directions: Use Mini Textbook, page 36 to help you with the questions.

1. Each of the sentences below is not correct. Cross out the wrong word or words and write the correct word or words.

   The fuselage, wings, and tail of an airplane are all streamlined.
   The idea of streamlining is to try to increase drag by maximimizing the effect of air resistance.
   The engines of an airplane give it thrust.
   When drag is decreased, thrust decreases.
   The part of an airplane that first meets the air and forces it to go over or under the part is called the leading edge.

2. Where would you find each of these airplane parts?
   a. rudder trailing edge of vertical stabilizer
   b. elevators trailing edges of horizontal stabilizers
   c. ailerons trailing edges of wings

3. In each drawing, put an X where air resistance will be greatest.

   a. 
   [Diagram of airflow with an X at the angle]
   b. 
   [Diagram with airflow perpendicular to a surface with an X at the point of contact]
Lesson Nineteen

Concept: Controlling Pitch

Resources/Materials: Mini Textbook, page 37
Worksheet #6B.19a (transparency of copied onto chart)
Worksheet #6B.19b (one copy for every five students)

Introduction: Review that pitch is the pointing up or down of the airplane’s nose. Ask “How can a pilot control pitch?” (Students should recall that the pilot flips the elevators of the horizontal stabilizers to do this.)

Procedure:

2. **Have students take out the paper accordion flyers they made earlier.** Have them add a paper clip to each side of the leading edge. Have them launch their papers by holding the trailing edge between the thumb and the index finger, with the pleats up, and **pushing** the paper **forward** in front of them. Observe the flight path. (should go fairly straight for a short distance and then fall to the ground.) Tell students that it is the initial part of the flight we are most interested in for now.

3. Explain that the trailing edge of their paper acts like a horizontal stabilizer. Now have the students make an **elevator** for their horizontal stabilizer by giving the trailing edge an upward curve. Do this by putting the thumb under the paper and pulling the index fingernail toward the trailing edge, curling the paper slightly.

4. Launch the flyer by holding them high and pushing with a slight forward motion. Observe that initially, the flyer went up. Then it came down. Discuss that this occurs because of Bernoulli’s Principle. (fast moving air has less air pressure than slow moving air).

For the Teacher
The upward position of the elevator creates air resistance, slowing the moving air. The air pressure above the tail is now greater than the air pressure below it. This causes the tail section to go down, raising the nose. **When the elevators are up, the tail section lowers and the nose points up.** **When the elevators are down, the tail section lifts, lowering the nose.** This is because the air below the tail section is now moving more slowly than that above it. The air pressure below the tail is now greater, causing the tail to lift and the nose to point downward. **Airplane acrobats use the elevators when they make loops.**

5. Put up the transparency or chart of the notes on Worksheet #6B.19a. Have students copy the notes. Give each student two copies of the tail section of an airplane (Worksheet #6B.19b). Have them draw in the elevators in the up position on one picture and in the down position on the other. (Mini Textbook, page 37 will help.) Then have them label the pictures.

Assignment:
1. Copy the notes from Worksheet #6B.19a.
2. Draw in the up and down elevator positions on the tail sections pictures and paste in the appropriate boxes. Label the diagrams.
Controlling Pitch

On an airplane elevators are used to control pitch. The elevators are located at the back of the horizontal stabilizers. When the elevators are up, the tail section lowers and the nose pitches up. When the elevators are down, the tail section lifts and the nose pitches down.

<table>
<thead>
<tr>
<th>Elevators Up, Nose Pitches Up</th>
<th>Elevators Down, Nose Pitches Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste and label tail section pictures here.</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6B.19a
Science Grade 6 Topic B Flight – Part II
Worksheets

Tail Section Pictures

(To be used with the notes from Worksheet #6B.19a)
Lesson Twenty

Concept: Controlling Roll

Resources/Materials: Mini Textbook, pages 38
- Worksheets #6B.20a (transparency or on charts)
- Worksheet #6B.20b (one copy per five students)

Introduction: Review again how airplane design tries to overcome resistance by creating streamlined leading edges. Airplane design also uses air resistance to control pitch by manipulating the elevators. Explain that today we will be investigating how to control yaw and roll. Review, if necessary, that roll is the dipping and raising of the wings along the longitudinal axis. Also review the terms thrust, drag, lift, gravity.

Procedure:

1. **Controlling Roll.** Have students turn to *Mini Textbook*, page 38. Guide the reading.

2. Give each student a sheet of paper. Have them fold it in half, lengthwise. With the centre fold facing upward, make a leading edge (accordion pleats) and secure it with tape and paper clips. Refold the centre crease, accentuating the crease. This gives the flyer wings. Make sure the wings are the same on both sides.

3. Give the trailing edge ailerons. Tear the paper on the crease one or two centimetres, beginning at the trailing edge side. Launch the flyer several times with the ailerons in different positions (both up, both down, the right one up and the left one down, the right one down and the left one up).

   NOTE: PAPER AIRPLANE CONSTRUCTION IS QUITE TRICKY AND FLIGHT IS SENSITIVE TO THE SLIGHTEST IRREGULARITIES. IF THE FLYER DOES NOT PERFORM EXACTLY AS EXPECTED, TELL STUDENTS NOT TO GET DISCOURAGED.

4. Put up the transparency or chart of Worksheet #6B.20a and distribute copies of Worksheet #6B.20b. Have student copy the notes, using the drawings from Worksheet #6B.20b.

5. Distribute Worksheet #6B.20c. Go over the directions, if necessary.

Assignments:

2. Copy notes from transparency of Worksheet #6B.20a.
3. Do Worksheet #6B.20c.
Controlling Roll

Pilots control roll by using the ailerons. They are the flaps located on the trailing edge of the wings. To bank left, the pilot raises the left aileron. This causes the air above the wing to move more slowly than the air below it. This air pressure above the wing is greater than below the wing. This causes the left wing to dip or bank. To bank right, raise the right aileron.

When a pilot wants to turn the airplane, he or she must lower one aileron and raise the other. So, if he wants to turn left, he raises the left aileron and lowers the right aileron.

<table>
<thead>
<tr>
<th>Turning Left</th>
<th>Turning Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste pictures here.</td>
<td></td>
</tr>
</tbody>
</table>
Controlling Roll

(To be used with the notes from Worksheet #6B.20a.)
Directions: Use *Mini Textbook*, page 38 to help you with the questions.

1. Complete the sentences with words that make sense.
   
a. Roll occurs when an airplane's wings ____________________________.

b. During a roll, an airplane rotates around its ____________________________.

c. A pilot uses the ____________________________ to control roll.

d. During a roll when the left wing is up, the right wing ____________________________.

e. The ailerons are located ____________________________.

2. Explain what action an airplane pilot should take if he or she wants to
   
a. roll left ____________________________

b. roll right ____________________________

3. a. During a right roll, air pressure is greater ____________________________ the right wing than under it.

   During a right roll, air pressure is greater ____________________________ the left wing than over it.

   b. During a left roll, air pressure is greater ____________________________ the left wing than under it.

   During a left roll, air pressure is greater ____________________________ the right wing than over it.
Directions: Use Mini Textbook, page 38 to help you with the questions.

1. Complete the sentences with words that make sense.
   a. Roll occurs when an airplane’s wings ____________.
   b. During a roll, an airplane rotates around its ____________.
   c. A pilot uses the ____________ to control roll.
   d. During a roll when the left wing is up, the right wing ____________.
   e. The ailerons are located ____________.

2. Explain what action an airplane pilot should take if he or she wants to
   a. roll left ____________
   b. roll right ____________

3. a. During a right roll, air pressure is greater ____________ the right wing than under it.
   b. During a left roll, air pressure is greater ____________ the left wing than over it.

   During a right roll, air pressure is greater ____________ the left wing than over it.
   b. During a left roll, air pressure is greater ____________ the right wing than under it.

   During a left roll, air pressure is greater ____________ the left wing than
   over it.
Lesson Twenty-one

Concept: Controlling Yaw and Banking

Resources/Materials: Mini Textbook, pages 39 and 40
Worksheet #6B.21a (transparency or on charts)
Worksheet #6B.21b (one copy per five students)
Worksheet #6B.21c (student copies)

Introduction: Recall that in order to control pitch and roll, an airplane pilot makes adjustments to particular surfaces in order increase or decrease air resistance. The same goes for controlling yaw – the pointing of the airplane’s nose to the left, to the right, or straight ahead.

Discuss that highways are constructed so that when there is a sharper turn, the road is slanted. This helps an automobile turn relatively sharply without flipping over. Similarly, when an pilot wants to make a turn, he must tilt the aircraft as well as point the nose in the desired direction. This is called banking. In order to bank, the pilot must roll and yaw the airplane.

Procedure:


   **Controlling Yaw.** Yaw is the pointing of the airplane nose to the left or to the right. It is the rudder that controls yaw. The rudder is the flap located on the trailing edge of the vertical stabilizer.

   Take the glider used to demonstrate controlling roll. Fold the end of the flyer’s wings about one cm upward. Launch the flyer, noting the path. (Check to make sure both sides are the same.) Try different positions. Observe what happens.

   To turn or yaw the plane to the left, you must turn the rudder to the left. This causes the air on the left side to slow down because of air resistance. This results in the air pressure on the left side being greater than that on the right side. This pushes the tail to the right and the nose yaws to the left.

2. Put up the transparency or charts of Worksheet #6B.21a. Have student copy the notes. They are to use the small airplane drawings from Worksheet #6B.21b.

3. Distribute Worksheet #6B.21c. Go over the directions, if necessary.

Assignments:

1. Copy notes from transparency or charts of Worksheet #6B.21a. (Use drawings from Worksheet #6B.21b.)
2. Do Worksheet #6B.21c.
Controlling Yaw

The rudder is used to control yaw, or turns to the left or right. The rudder is located at the trailing edge of the vertical stabilizer. To yaw the airplane left, turn the rudder to the left. To yaw it right, turn the rudder to the right.

Pilots use the rudder to assist the airplane to turn right or left.

<table>
<thead>
<tr>
<th>Yaw Left</th>
<th>Yaw Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste pictures here.</td>
<td></td>
</tr>
</tbody>
</table>
Controlling Yaw

(To be used with the notes from Worksheet #6B.21a.)
Directions: Use Mini Textbook, page 40 to help you with the questions.

1. What two aircraft movements are involved in banking?
   a. ____________________________  
   b. ____________________________

2. Complete the table.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Controlling Surfaces the Pilot Adjusts</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>bank left</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bank right</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Tell what aircraft movement each of the following describes.
   a. rudder turned to the right ________________________________
   b. elevators up ________________________________
   c. left aileron up; right aileron down ________________________________
   d. right aileron up; left aileron down ________________________________
   e. rudder turned to the right; left aileron down; right aileron up ________________________________
   f. elevators down ________________________________
   g. right aileron down; rudder turned to the left; left aileron up ________________________________
   h. rudder turned to the left ________________________________
Directions: Use Mini Textbook, page 40 to help you with the questions.

1. What two aircraft movements are involved in banking?
   a. roll ____________________________  
   b. yaw ____________________________

2. Complete the table.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Controlling Surfaces the Pilot Adjusts</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>bank left</td>
<td>rudder; ailerons</td>
<td>yaw left</td>
</tr>
</tbody>
</table>
<pre><code>                    |                                        | roll left        |
</code></pre>
<p>| bank right    | rudder, ailerons                       | yaw right        |
|                                        | roll right       |</p>

3. Tell what aircraft movement each of the following describes.
   a. rudder turned to the right ________ right yaw ____________________________
   b. elevators up ________ pitch up ________________________________________
   c. left aileron up; right aileron down ________ roll left __________________
   d. right aileron up; left aileron down ________ roll right ________________
   e. rudder turned to the right; left aileron down; right aileron up ________ bank right ________________
   f. elevators down ________ pitch down _____________________________________
   g. right aileron down; rudder turned to the left; left aileron up ________ bank left __________________
   h. rudder turned to the left ________ left yaw ____________________________

Worksheet #6B.21c
Lesson Twenty-two

Concept: Constructing a Glider or Flyer; Making Adjustments to Control It

Resources/Materials:  Worksheet #6B.22a (student copies)
                                               Worksheet #6B.22b (optional, student copies)
                                               paper of various weights  paper clips  tape
                                               scissors  other found materials

Introduction: Review the various movements that airplane pilots must try to control and the parts of the plane that help him/her to do them. Tell students that today they will construct paper airplanes, and that they must try to manoeuvre them to meet certain challenges.

Procedures:

1. Distribute Worksheet #6B.22a, which has the instructions and challenges on it. Suggest that students treat this like a checklist; that is, check them off as you can do them. This worksheet also has hints for students to try to improve their flyers’ performances.

2. Clarify that they can make a pointed flyer or any other type they want.

3. If you like, you can have students try the flyer on Worksheet #6B.22b.

Assignment:

Do Worksheet #6B.22a.
Directions: Make a paper flyer. Then try to do each of the following:

- Fly in a straight path
- Turn to the right
- Turn to the left
- Ascend
- Descend
- Ascend and turn to the right
- Ascend and turn to the left
- Descend and turn to the right
- Descend and turn to the left

Some Hints

1. A flyer should not be launched upwards. It should be pushed gently forward. Aim horizontally or even slightly downward.

2. If the flyer turns to the right, try bending the right aileron lower; or, bending the rudder slightly more to the left; or, bending the left aileron slightly upward.

3. If the flyer turns to the left, try lowering the left aileron downward some more; or, bending the rudder slightly to the right; or, raising the right aileron upward some more.

4. If the plane noses upwards, try bending the elevators down slightly. The plane will fly faster and the nose should remain down.

5. If the plane noses downward, try bending the elevators up slightly. The nose will point upward better, resisting diving.

6. Ensure that edges are aligned and folds are crisp. Don't use too much glue.

7. To control roll, make sure the wing tips are slightly higher than the place where they attach to the fuselage. Make sure both wings are equally angled.

8. To control pitch, try adjusting the centre of gravity by weighting either the tail or the nose, as well as adjusting the elevators.

9. It is important to get the centre of gravity in the right spot. A small dab of Plasticine, tape, or a small pin may be added to the nose.

10. Always make small corrections; a small adjustment has a big effect.
Science Grade 6 Topic B Flight – Part II
Worksheets

**Paper Glider**

1. Fold a piece of paper in half, then open it and turn in two corners. Close the paper again and cut wings and a tail into it.
2. Fold the wings and tail. Add mass to your glider’s nose with a paper clip and tape the wings together. Glue a fin and rudder into the tail.
3. Now fold the rudder, elevators and ailerons and test fly your glider. Try flying it with its control surfaces bent in different positions.
Lesson Twenty-three

Concept: Propellers: Constructing a Roto-copter

Resources/Materials: Mini Textbook, page 41
    HANDS ON: Worksheet #6B.23a (student copies)
    Worksheets #6B.23b, #6B.23c, and #6B.23d (optional, student copies)
    Optional: assorted papers (varying weights) tape
    paper clips Plasticine foil
    NON HANDS ON: Mini Textbook, pages 41 – 44
    Worksheets #6B.23e and #6B.23f (student copies)

Introduction: Explain that it is now time to learn more about how powered flyers produce thrust. For living things like birds, thrust comes from using muscles. When it comes to human-made devices, thrust is produced in two main ways: propellers and jets and rocket launchers.

Procedure:


HANDS ON

2. Explain that today, students will make and test out a type of propeller called a roto-copter. Instead of an engine turning the propellers, the force of gravity will provide the power to turn the propellers.
3. Distribute Worksheet #6B.23a. Have students follow the directions to make their roto-copters. They can stand on a chair and test them out.

For the Teacher: Gravity pulls the copter to the ground. As it falls, the “rabbit” ears create an imbalance in the pressure – lower pressure above and higher pressure beneath. This gives the copter lift. The moving air alternately is caught and slips past the ears, setting up a rotation. Increasing mass and shortening the wings are two means of increasing rotational speed.

4. OPTIONAL. Have student conduct a fair test involving roto-copters. Discuss the different manipulated variables they could choose: size, mass, colour, length of blades, etc. (Worksheet #6B.23 b has patterns for making extra roto-copters. Students can write up their fair tests on Worksheets #6B.23e and #6B.23d

NON HANDS ON

6. Distribute Worksheets #6B.23e and #6B.23f. Go over the directions, if necessary.

Assignments:

1. Read Mini Textbook, page 41.
2. HANDS ON. Make a roto-copter using Worksheet #6B.23a. Optional. Conduct a fair test using the roto-copters patterns on Worksheet 6B.23b and write up the test on Worksheets #6B.23c and #6B.23d.
3. NON HANDS ON. Read Mini Textbook pages 42 – 44. Do Worksheets #6B.23e and 6B.23f.
Directions:

1. Cut out the figure along the solid lines.

2. Fold in the bottom two flaps along the dotted lines.

3. Clip the folded flaps together using a paper clip.

4. Fold the A and B in opposite directions along the dotted lines.

5. Stand on your chair and drop the Roto-copter to the ground.
_____ = cut  
---- = fold
Science Grade 6 Topic B Flight – Part II
Worksheets

**Fair Test: Roto-copters**

**Question:**

**Hypothesis:**

**Materials:**

**Manipulated Variable:**

**Constant Variables:**

**Responding Variable:**

**Procedure:**

**Observations:**

If appropriate, in the space below make a table or chart to record your observations.
If appropriate, make a graph to show your observations.

Make a labelled diagram.

Conclusion:
Directions: Use Mini Textbook, pages 41 – 44 to help you with the questions.

1. Define thrust. 

2. What do insects, birds, and flying mammals use to produce thrust?

3. What are the two main ways that human-made flyers produce thrust?

4. What does a propeller do that enables it to create thrust?

5. Why is it that larger, heavier aircraft need larger propellers and more than one propeller?

6. What are three characteristics of propeller blades?
   a. 
   b. 
   c. 

Worksheet #6B.23e
7. There are two theories that try to explain how propellers actually provide thrust. Fill in the spaces in these sentences about the two theories, with words that make sense. Use the words in the box.

**Theory Using the Bernoulli Principle**
A propeller blade is like an ______________. When it moves through the air, there is a ______________ between the air pressure on one side of the ______________ compared to the other side. The air in front of the blades moves ______________ than the air behind the blades. According to the Bernoulli Principle this means that there is ______________ air pressure behind the blades than in ______________. This greater pressure behind the propeller pushes it ______________. Because the propeller is firmly ______________ to the rest of the aircraft, the whole aircraft moves forward.

**Theory Using Newton’s Third Law of Motion**
The propeller blades are slightly ______________. This shape enables them to take in large ______________ of air. The twisted shape of the blades also causes the propeller to ______________ the air speed as it leaves the propeller. The air shooting out the back of the ______________ is moving much faster than the air going into the propeller. According to Newton’s Third Law of Motion, the airplane’s forward ______________ will be equal to the force of the air shooting out the ______________ of the propeller.

<table>
<thead>
<tr>
<th>accelerate</th>
<th>airfoil</th>
<th>attached</th>
</tr>
</thead>
<tbody>
<tr>
<td>back</td>
<td>blades</td>
<td>difference</td>
</tr>
<tr>
<td>faster</td>
<td>forward</td>
<td>front</td>
</tr>
<tr>
<td>greater</td>
<td>masses</td>
<td>propeller</td>
</tr>
<tr>
<td>thrust</td>
<td>twisted</td>
<td></td>
</tr>
</tbody>
</table>
Directions: Use Mini Textbook, pages 41 – 44 to help you with the questions.

1. Define thrust. force that pushes aircraft forward

2. What do insects, birds, and flying mammals use to produce thrust? own muscles

3. What are the two main ways that human-made flyers produce thrust? propellers
   jet engines and rockets

4. What does a propeller do that enables it to create thrust? accelerates large masses of air to a higher speed.

5. Why is it that larger, heavier aircraft need larger propellers and more than one propeller? takes more thrust to move a larger aircraft forward

6. What are three characteristics of propeller blades?
   a. shaped like an airfoil
   b. slight twisted
   c. taper off at ends
7. There are two theories that try to explain how propellers actually provide thrust. Fill in the spaces in these sentences about the two theories, with words that make sense. Use the words in the box.

Theory Using the Bernoulli Principle

A propeller blade is like an airfoil. When it moves through the air, there is a difference between the air pressure on one side of the blades compared to the other side. The air in front of the blades moves faster than the air behind the blades. According to the Bernoulli Principle this means that there is greater air pressure behind the blades than in front. This greater pressure behind the propeller pushes it forward. Because the propeller is firmly attached to the rest of the aircraft, the whole aircraft moves forward.

Theory Using Newton’s Third Law of Motion

The propeller blades are slightly twisted. This shape enables them to take in large masses of air. The twisted shape of the blades also causes the propeller to accelerate the air speed as it leaves the propeller. The air shooting out the back of the propeller is moving much faster than the air going into the propeller. According to Newton’s Third Law of Motion, the airplane’s forward thrust will be equal to the force of the air shooting out the back of the propeller.

<table>
<thead>
<tr>
<th>accelerate</th>
<th>airfoil</th>
<th>attached</th>
</tr>
</thead>
<tbody>
<tr>
<td>back</td>
<td>blades</td>
<td>difference</td>
</tr>
<tr>
<td>faster</td>
<td>forward</td>
<td>front</td>
</tr>
<tr>
<td>greater</td>
<td>masses</td>
<td>propeller</td>
</tr>
<tr>
<td>thrust</td>
<td>twisted</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Twenty-four (Optional)

Concept: Propellers: Constructing a Heliostraw

Resources/Materials:  Worksheets #6B.24a and #6B.24b (student copies)
                        one-hole punch   Plasticine
For each student:  2 cm X 21 cm strip of Manila tag   drinking straw   masking-tape

Introduction: Remind students that the roto-copter worked using the force of gravity. Today they will make another kind of propeller powered by the student’s hand movements.

Procedure:

1. Remind students that precision is important.

2. Distribute the Manila tag strips and Worksheet #6B.24a. With students make the heliostraw.

3. Have students make several test flights.

4. Give each student a small dab of Plasticine, and have them push it up into the straw to a height of about 1 cm. Have them try it again and note any difference.

5. Discuss

For the Teacher
The heliostraw flies like a helicopter. When the helicopter’s blades are tilted, it flies in the direction of the tilt. Turning the wings sideways produces a propeller. However, if you try to fly the heliostraw like a propeller, it will crash to the ground. A propeller needs to be attached to something that has lift, such as wings. The wings provide the lift and the propeller gives it thrust or forward motion.

6. Distribute Worksheet #6B.24b. Have students try some of the manoeuvres and then record what they observed.

Assignments:

1. Make a heliostraw using Worksheet #6B.24a.

2. Do Worksheet #6B.24b.
**Materials:** 2 cm X 21 cm strip of Manila tag
drinking straw
One-hole punch
small dab of Plasticine
tape

1. Locate the centre of the piece of Manila tag by drawing a diagonal like form each of the corners. (See diagram.)

2. Punch a hole exactly where the diagonal lines intersect.

3. Make a 1 cm long cut on either side of the hole. (See diagram.)

4. Wrap tape around one end of the straw, so that the wrapped end is a snug fit when you put it into the hole in the wing. If the wing wobbles, tape the straw to the wing to hold it firm.

5. Fold under the last 1 cm of the wing tips. Tape these folds down. This will add weight to the wing tips and increase the amount of momentum as the wings spin.

6. From the cuts outward, bend the wings down slightly along the fold line. Do not bend the wings down too far. There should be a gentle curve. Make sure both wings are bent down the same amount.
Directions: Following are some things you can do with your heliostraw. Try each one. Then describe what you observed. For #4 and #5, try two other changes. Tell what you did and what you observed.

1. The Glide
   Spin the heliostraw gently backwards and let it go. Spin clockwise.

2. The Hover
   Hold the straw straight up and down and fly the heliostraw.

3. Fast Forward
   Launch the straw by tilting it away from you.

4. 

5. 

Worksheet #6B.24b
Lesson Twenty-five

Concept: Thrust in Jets and Rockets

Resources/Materials:

HANDS ON: Worksheets #6B.25a and #6B.25b (student copies)
clean, empty drink box (one per student) Plasticine
empty bottle with cork several long round pencils
water vinegar
baking soda Vaseline
tissue paper

NON HANDS ON: Mini Textbook, pages 45 – 48
Worksheets #6B.25c and #6B.25d (student copies)

Introduction: Explain that propellers create lift and sometimes thrust by taking advantages of differences in air pressure and air speed. Rockets and jet engines use the power of compressed air to create thrust.

Procedure:

HANDS ON

1. Explain that today the class will be examining two activities that demonstrate the principles by which devices such as rockets and jet engines, get their thrust.
2. Distribute Worksheet #6B.25a. With students, go over the directions for the first activity. then do it as a demonstration or have the students do it independently.
3. Then give the students the materials needed to the second activity. Tell them they are to do the activity.

For the Teacher:
The combination of vinegar and baking soda causes a chemical reaction, which releases a large amount of gas. As more gas is produced, it becomes compressed in the bottle, building up pressure. When the pressure in the bottle is greater than that which holds the cork in place, it pushes the cork out. The gas inside the bottle escapes, gushing out through the bottle’s neck. The bottle rolls on the pencils in the opposite direction. Jets and rockets operate on the same principle. For rockets, air is compressed and then released. It pushes quickly toward the ground, which results in the rocket launching skyward. For jet engine, air is compressed and then released so that it pushes back, causing the airplane to go forward.

NON HANDS ON

6. Distribute Worksheets #6B.25c and #6B.25d. Go over the directions, if necessary.

Assignments:

1. HAND ON. Do the activities on Worksheet #6B.25a. Write up one of the two activities on Worksheet #6B.25b.
To make a mini rocket:

1. Wash out a drink box and a straw.
2. Seal the straw at one end, using either plastic tape or a small ball of Plasticine. This weighted end will serve as the nose of the rocket.
3. Insert the open end of the straw into the drink box. Using a sharp squeeze, launch your straw rocket.
4. To re-launch, you will have to inflate the box by blowing in the straw hole and repeating Step 3. Do several tests.
5. You may be directed to add fins or cardboard tabs and observe the effects these have on the flight of your rocket.

Blast Off!

A. Read the instructions below and predict what will happen.

___________________________________________________________________________

___________________________________________________________________________

B. To make a model rocket:

1. Put Vaseline in the neck of the bottle where the cork will be inserted.
2. Place several pencils in a parallel line several centimetres apart
3. Half fill the bottle with a mixture of water and vinegar. (This is the fuel.)
4. Put baking soda (the oxidizer) in a piece of tissue paper and twist the ends.
5. Then slip the baking soda into the bottle; and before the paper can come loose and release the baking soda, cork the bottle and place is across the pencils.
6. Observe the movement of both the cork and the bottle.
Science Grade 6 Topic B Flight – Part II
Worksheets
Jet and Rocket Engines

Question: ____________________________________________________________
______________________________________________________________

What We Did:
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

What We Observed:
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Diagram

What We Can Infer:
________________________________________________________________
________________________________________________________________
________________________________________________________________

Worksheet #6B.25b
Directions: Use *Mini Textbook*, pages 45 – 48 to help you with the questions.

1. Put a check mark (✓) in front of the principles that help to explain how jet engines work.
   
   _____ Air can be compressed.
   
   _____ Compressed air tries to equalize.
   
   _____ Compressed air has higher pressure than non-compressed air.
   
   _____ Faster moving air has lower air pressure than slower moving air.
   
   _____ If air pushes out of a jet engine in one direction, the aircraft will move in the opposite direction.
   
   _____ Cool air is denser than warm air.

2. Generally, larger aircraft need more jet engines than smaller aircraft. Why do you suppose this is?

   __________________________________________________________
   
   __________________________________________________________
   
   __________________________________________________________

3. Following are the steps that explain how a jet engine works. Number them in the correct order.

   _____ As it burns the air-fuel mixture expands very quickly.
   
   _____ Once in the engine, the air is compressed.
   
   _____ The escaping vapours gush out the back of the engine, pushing the aircraft forward
   
   _____ The compressed air is mixed with a jet fuel and then ignited.
   
   _____ The gases, which are now under high pressure, are allowed to escape through nozzles.
   
   _____ Air enters the engine.

4. How can you tell how many jet engines an aircraft has by examining the vapour trails?

   __________________________________________________________
5. Following are the principles on which rockets work. Put a check mark (√) beside the principles that are similar to those on which jet engines work.

____ When fuels burn, they form heat and gases.
____ Gases take up more room than liquids or solids.
____ Gases can be compressed.
____ Compressed gases have higher pressure than non-compressed gases.
____ When possible, areas of gases with different pressures will try to equalize.
____ If a force is produced in one direction, another force of equal strength is produce in the opposite direction.

6. Explain why rockets used to explore outer space use an oxidizer instead of oxygen from the air to burn rocket fuel, once they are out of Earth’s atmosphere.

________________________________________________________________________
________________________________________________________________________

7. Following are the steps involved in launching a rocket. Number them in the correct order.

____ Rocket fuel is mixed with oxygen.
____ The rocket lifts off toward the heavens.
____ The hot gases are compressed as they fill the combustion chamber.
____ The escaping gases gush out through the nozzles toward the ground.
____ The compressed gases are allowed to escape through tiny jet nozzles
____ Heat and gases are produced when the fuel-oxygen mixture is ignited.
Jet Engines and Rockets

Directions: Use *Mini Textbook*, pages 45 – 48 to help you with the questions.

1. Put a check mark (√) in front of the principles that help to explain how jet engines work.
   - √ Air can be compressed.
   - √ Compressed air tries to equalize.
   - √ Compressed air has higher pressure than non-compressed air.
   - ̅̅ Faster moving air has lower air pressure than slower moving air.
   - √ If air pushes out of a jet engine in one direction, the aircraft will move in the opposite direction.
   - √ Cool air is denser than warm air.

2. Generally, larger aircraft need more jet engines than smaller aircraft. Why do you suppose this is?
   - Takes more thrust to move large aircraft forward

3. Following are the steps that explain how a jet engine works. Number them in the correct order.
   - 4 As it burns the air-fuel mixture expands very quickly.
   - 2 Once in the engine, the air is compressed.
   - 6 The escaping vapours gush out the back of the engine, pushing the aircraft forward.
   - 3 The compressed air is mixed with a jet fuel and then ignited.
   - 5 The gases, which are now under high pressure, are allowed to escape through nozzles.
   - 1 Air enters the engine.

4. How can you tell how many jet engines an aircraft has by examining the vapour trails?
   - Number of vapour trails equals number of jet engines
5. Following are the principles on which rockets works. Put a check mark (✓) beside the principles that are similar to those on which jet engines work.

✓ When fuels burn, they form heat and gases.
✓ Gases take up more room than liquids or solids.
✓ Gases can be compressed.
✓ Compressed gases have higher pressure than non-compressed gases.
✓ When possible, areas of gases with different pressures will try to equalize.
✓ If a force is produced in one direction, another force of equal strength is produce in the opposite direction.

6. Explain why rockets used to explore outer space use an oxidizer instead of oxygen from the air to burn rocket fuel, once they are out of Earth’s atmosphere.

no oxygen in outer space

7. Following are the steps involved in launching a rocket. Number them in the correct order.

1  Rocket fuel is mixed with oxygen.
6  The rocket lifts off toward the heavens.
3  The hot gases are compressed as they fill the combustion chamber.
5  The escaping gases gush out through the nozzles toward the ground.
4  The compressed gases are allowed to escape through tiny jet nozzles
2  Heat and gases are produced when the fuel-oxygen mixture is ignited.
Lesson Twenty-six

Concept: Flight, Part II Review

Resources/Materials: Flight, Part II Review Sheets (student copies)

Introduction: Explain that the unit on Flight is now at an end and it is time to prepare for a test.

Procedure:

1. Briefly go over the main ideas covered in the chapter.
   - Forces acting on an aircraft
   - Bernoulli’s Principle
   - Basic Movements of an Airplane: roll, pitch, yaw
   - Controlling Surfaces of an Airplane
   - Maneuvering Airplanes
   - Propellers
   - Powering Rockets and Jet Engines

2. Distribute the Flight, Part II Review Sheets. Have students complete them. Check them as a class, if possible.

Assignment:

Do the Flight, Part II Review Sheets
1. Examine the diagram of the airplane. Then on the spaces below, write the names of the parts of the airplane beside the correct number. You may use the same word twice.

1 ___________________ 6 ___________________
2 ___________________ 7 ___________________
3 ___________________ 8 ___________________
4 ___________________ 9 ___________________
5 ___________________

2. Tell what a pilot would do to perform the following movements:
   a. Make the airplane ascend __________________________
   b. Make the airplane yaw right _______________________
   c. Make the airplane roll left ________________________
   d. Make the airplane descend _________________________
   e. Make the airplane bank to make a left turn ______________________
3. Which part of a bird corresponds to the rudder of an airplane?
   a. breast
   b. beak
   c. wing
   d. tail

4. Birds have thrust because they
   a. have feathers.
   b. flap their wings.
   c. ride wind currents.
   d. have hollow bones.

5. Examine the picture of the helicopter.

   ![Helicopter Image]

   One reason that a helicopter is able to hover is because
   a. lift is equal to gravity.
   b. drag is equal to lift.
   c. thrust is equal to lift.
   d. drag is equal to gravity.

6. Pretend you built a paper glider. When you launched it, it immediately dived, nose first to the ground. This is probably because
   a. there is too much mass on the tail.
   b. there is too little mass on the wings.
   c. there is too much mass on the nose.
   d. there is too little mass on the nose.

7. If an airplane pilot wants the aircraft to make loops, he would adjust the
   a. ailerons.
   b. rudder.
   c. propeller.
   d. elevators.
8. Look at the airfoil on the racing car. Draw an arrow on the diagram to show the direction of the force it creates. Explain why.

9. Which of these vehicles shows the best example of a streamlined vehicle?
   a. 
   b. 
   c. 
   d. 

10. Look at the rear views of these airplanes. The control surfaces are set to perform certain movements. What are they?
    a. 
    b. 
    c. 

11. Examine the model airplane below. What is it that is providing the thrust?

a. the wheels  
b. the wound up elastic  
c. the elevators  
d. the wings

12. If you wanted the glider below to lift off the ground, which part must be changed?

Write the number. ____________

13. What are the purposes of the airplane’s fuselage?
18. Complete each of these sentences.
   a. The function of the vertical stabilizer is ____________________________
   b. The function of the rudder is ____________________________
   c. The function of the elevators is ____________________________
   d. The function of the horizontal stabilizers is ____________________________
   e. The functions of the ailerons is to control ____________________________

11. What must an airplane pilot do to turn an airplane to the right?
    ___________________________________________________________________
    ___________________________________________________________________
    ___________________________________________________________________

12. Read the following information. Then answer the questions.

Susan built a launch pad for a glider. The launch pad has a rubber band slingshot on a track. Susan hooked the glider to the rubber band and pulled the glider back 2 cm. She then released the glider and measured how far it travelled. Susan performed three more trials, stretching the same rubber band back 3 cm 4 cm, and finally 5 cm. She was careful to keep the surface of the track, the slant of the track, and the rubber band the same for all the trials.
For Susan’s experiment, what was the

a. manipulated variable?______________________________

b. constant variables?_________________________________

______________________________

c. responding variable?_______________________________

d. What do you think Susan observed?____________________

______________________________

13. Ben wanted to do a fair test on a whirlybird that he made. He wound the string around the empty spool 10 times. He launched the whirlybird by quickly pulling the thread off by the loose end. He used a stop watch to determine the amount of time the whirlybird stayed in the air. Then he launched the whirlybird a second time. This time he wound the string around the spool 20 times. Again he determined how long the whirlybird stayed in the air.

![Diagram of a hand holding a whirlybird]

Which of the following would be the best question for Ben’s fair test?

a. Are whirlybirds more fun than heliostraws?
b. Will a whirlybird with large rotors stay in the air longer than one with small rotors?
c. Does the height at which you launch a whirlybird affect how long it stays in the air?
d. Does the number of winds of string around the spool affect how long a whirlybird will stay in the air?
1. Examine the diagram of the airplane. Then on the spaces below, write the names of the parts of the airplane beside the correct number. You may use the same word twice.

1. fuselage
2. propeller
3. aileron
4. elevator
5. rudder
6. vertical stabilizer
7. wing
8. aileron (flap)
9. horizontal stabilizers

2. Tell what a pilot would do to perform the following movements:
   a. Make the airplane ascend __elevators up__
   b. Make the airplane yaw right __rudder right__
   c. Make the airplane roll left __left aileron up; right aileron down__
   d. Make the airplane descend __elevators down__
   e. Make the airplane bank to make a left turn __left aileron up; right aileron down; rudder left__
3. Which part of a bird corresponds to the rudder of an airplane?
   a. breast
   b. beak
   c. wing
   d. tail

4. Birds have thrust because they
   a. have feathers.
   b. flap their wings.
   c. ride wind currents.
   d. have hollow bones.

5. Examine the picture of the helicopter.

![Helicopter Image]

One reason that a helicopter is able to hover is because
   a. lift is equal to gravity.
   b. drag is equal to lift.
   c. thrust is equal to lift.
   d. drag is equal to gravity.

6. Pretend you built a paper glider. When you launched it, it immediately dived, nose first to the ground. This is probably because
   a. there is too much mass on the tail.
   b. there is too little mass on the wings.
   c. there is too much mass on the nose.
   d. there is too little mass on the nose.

7. If an airplane pilot wants the aircraft to make loops, he would adjust the
   a. ailerons.
   b. rudder.
   c. propeller.
   d. elevators.
8. Look at the airfoil on the racing car. Draw an arrow on the diagram to show the direction of the force it creates. Explain why.

Air flowing over the airfoil will move more slowly than air moving under the airfoil's curved surface. The air pressure under the airfoil will be less than the air pressure above it.

9. Which of these vehicles shows the **best** example of a streamlined vehicle?

a. ![Car Image]

b. ![Suv Image]

c. ![Truck Image]

d. ![Van Image]

10. Look at the rear views of these airplanes. The control surfaces are set to perform certain movements. What are they?

a. ![Plane Image]

   **pitch up**

b. ![Plane Image]

   **roll left**

c. ![Plane Image]

   **roll right**
11. Examine the model airplane below. What is it that is providing the thrust?

   a. the wheels  
   b. the wound up elastic  
   c. the elevators  
   d. the wings

12. If you wanted the glider below to lift off the ground, which part must be changed?

   Write the number. 3

13. What are the purposes of the airplane’s fuselage?

   hold wings and tail in place

   hold cargo, passengers, pilot
18. Complete each of these sentences.
   a. The function of the vertical stabilizer is \underline{\textit{keep aircraft up right}}
   b. The function of the rudder is \underline{\textit{control yaw}}
   c. The function of the elevators is \underline{\textit{control pitch}}
   d. The function of the horizontal stabilizers is \underline{\textit{keep aircraft level}}
   e. The functions of the ailerons is to control \underline{\textit{roll}}

11. What must an airplane pilot do to turn an airplane to the right?
   \underline{\textit{right aileron up}}
   \underline{\textit{left aileron down}}
   \underline{\textit{rudder right}}

12. Read the following information. Then answer the questions.

Susan built a launch pad for a glider. The launch pad has a rubber band slingshot on a track. Susan hooked the glider to the rubber band and pulled the glider back 2 cm. She then released the glider and measured how far it travelled. Susan performed three more trials, stretching the same rubber band back 3 cm 4 cm, and finally 5 cm. She was careful to keep the surface of the track, the slant of the track, and the rubber band the same for all the trials.
For Susan’s experiment, what was the

a. manipulated variable? distance rubber band is pulled back

b. constant variables? surface of track, slant of track, rubber band, glider

c. responding variable? distance glider travels

d. What do you think Susan observed? The more the rubber band was pulled back, the farther the glider travelled.

13. Ben wanted to do a fair test on a whirlybird that he made. He wound the string around the empty spool 10 times. He launched the whirlybird by quickly pulling the thread off by the loose end. He used a stop watch to determine the amount of time the whirlybird stayed in the air. Then he launched the whirlybird a second time. This time he wound the string around the spool 20 times. Again he determined how long the whirlybird stayed in the air.

Which of the following would be the best question for Ben’s fair test?

a. Are whirlybirds more fun than heliostraws?
b. Will a whirlybird with large rotors stay in the air longer than one with small rotors?
c. Does the height at which you launch a whirlybird affect how long it stays in the air?
d. Does the number of winds of string around the spool affect how long a whirlybird will stay in the air?
Lesson Twenty-seven

Concept: Flight, Part II Test

Resources/Materials: Flight, Part II Test (student copies)
1. What are the purposes of the fuselage on an airplane?

__________________________________________________________________________

__________________________________________________________________________

2. What must a pilot do if he wants to roll his airplane from side to side?

__________________________________________________________________________

__________________________________________________________________________

3. Complete the sentences by using the words in the box.

| pitch ailerons | yaw rudder | roll elevators |

a. Rotation around longitudinal axis is called _____________________. It is controlled by the _____________________.

b. Rotation around the lateral axis is called _____________________. It is controlled by the _____________________.

c. Rotation around the vertical axis is called _____________________. It is controlled by the _______________________.

1
Mrs. James' class has been learning about flight. They have been making and testing many different types of aircraft.

4. Jack has learned that aircraft wings must be designed so that air moves
   a. faster across the bottom of the wing.
   b. more slowly across the top of the wing.
   c. more quickly across the top of the wing.
   d. at the same speed across the top and the bottom of the wing.

5. To make the nose of her glider rise, Samantha would have to bend the
   a. rudder up.
   b. elevators up.
   c. rudder down.
   d. elevators down.

6. If her glider flies a short distance and then falls tail up, it probably
   a. needs to be thrown harder.
   b. has different length wings.
   c. has too much mass on the tail.
   d. has too much mass on the nose.

7. What must a pilot do if she wants her airplane to yaw left?
   a. turn the rudder left
   b. turn the rudder right
   c. lift the right aileron
   d. lower the elevators.

8. What must a pilot do if he wants to make his airplane ascend?
   a. raise the elevators
   b. lower the elevators
   c. raise the ailerons
   d. lower the ailerons
9. What must a pilot do if she wants her airplane to bank left?

10. Examine the diagram of the airplane. Write the names of the parts beside the correct numbers.
11. Examine the following diagram. Then answer the question.

Predict what will happen once the fan is turned on. The device

a. will not move.
b. will roll forward.
c. will roll backward.
d. will roll slightly backward and then forward.

12. In which of the following diagrams of the rear view of an airplane are the control surfaces set in a position that would allow the plane to roll to the left?

a. 

b. 

c. 

d. 

13. Jeremy made a paper glider. When he released it, it dove immediately to the ground. He most likely needs to make adjustments to the

a. wings.
b. rudder.
c. ailerons.
d. elevators.
Bev designed four different paper gliders to see which one would stay in the air the longest. After testing them, she recorded the following results.

<table>
<thead>
<tr>
<th>Glider</th>
<th>Distance Flown (metres)</th>
<th>Flight Path</th>
<th>Time in Air (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Flying Acer</td>
<td>5</td>
<td>Straight</td>
<td>4</td>
</tr>
<tr>
<td>The Dart</td>
<td>4</td>
<td>Straight</td>
<td>4</td>
</tr>
<tr>
<td>Airtime Glider</td>
<td>3</td>
<td>Lofts up</td>
<td>6</td>
</tr>
<tr>
<td>Barnaby Flyer</td>
<td>3</td>
<td>Loops</td>
<td>2</td>
</tr>
</tbody>
</table>

14. Which of the following variable could Bev *not* control?

a. type of paper used  
b. size of paper used  
c. weight of paper used  
d. time glider was in the air.

15. The structure of a bird that has the same function as the rudder on an airplane is

a. curved wings.  
b. pointed beaks.  
c. strong muscles.  
d. tail feathers.

In Allison’s project, she experimented to see if adding mass to a paper airplane will affect how far a paper airplane will fly. A graph of her results is shown below.

16. An inference that can be made from Allison’s graph is that

a. an airplane requires at least one paper clip to fly.  
b. an airplane that flies 8 m has only 4 paper clips.  
c. an increase in mass affects the distance an airplane flies.  
d. after 5 paper clips are added, an airplane will fly 12 m.
A designer working for an aircraft company made a glider and recorded the distance it flew three times. Examine the results on the graph below.

He wanted to make his fly further so he modified it and tested it three more times. This is the graph of those trials.

17. From examining the graphs, was the modification successful? ________________

Tell how you know. ________________

______________________________

______________________________
18. Use the following information to answer the questions.

Jane wanted to know more about balloon jets. She made two different balloon jets, one using a round balloon and the other using a long thin balloon. For both balloon jets, she kept the length of the string, the size of the balloons, the amount of air in the balloons, the size of the straw, and the angle of the string the same. She launched both balloons to see which travelled farther. She recorded the results in the table below.

<table>
<thead>
<tr>
<th>Shape of Balloon</th>
<th>Distance Travelled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round Balloon</td>
<td>346 cm</td>
</tr>
<tr>
<td>Long Thin Balloon</td>
<td>298 cm</td>
</tr>
</tbody>
</table>

a. What is the manipulated variable? ____________________________

b. What is the responding variable? ____________________________

c. What are the constant variables? ____________________________

                   ____________________________
                   ____________________________
                   ____________________________

d. From the information in the table, what can Jane conclude?

                   ____________________________
1. What are the purposes of the fuselage on an airplane?
   - hold wings and tail in place
   - carry pilot, passengers, cargo

2. What must a pilot do if he wants to roll his airplane from side to side?
   - adjust ailerons

3. Complete the sentences by using the words in the box.

   pitch  ailerons  yaw  rudder  roll  elevators

   a. Rotation around longitudinal axis is called roll__________. It is controlled by the ailerons__________.
   b. Rotation around the lateral axis is called pitch__________. It is controlled by the elevators__________.
   c. Rotation around the vertical axis is called yaw__________. It is controlled by the rudder__________.
Mrs. James’ class has been learning about flight. They have been making and testing many different types of aircraft.

4. Jack has learned that aircraft wings must be designed so that air moves
   a. faster across the bottom of the wing.
   b. more slowly across the top of the wing.
   c. more quickly across the top of the wing.
   d. at the same speed across the top and the bottom of the wing.

5. To make the nose of her glider rise, Samantha would have to bend the
   a. rudder up.
   b. elevators up.
   c. rudder down.
   d. elevators down.

6. If her glider flies a short distance and then falls tail up, it probably
   a. needs to be thrown harder.
   b. has different length wings.
   c. has too much mass on the tail.
   d. has too much mass on the nose.

7. What must a pilot do if she wants her airplane to yaw left?
   a. turn the rudder left
   b. turn the rudder right
   c. lift the right aileron
   d. lower the elevators.

8. What must a pilot do if he wants to make his airplane ascend?
   a. raise the elevators
   b. lower the elevators
   c. raise the ailerons
   d. lower the ailerons
9. What must a pilot do if she wants her airplane to bank left?

- left aileron up
- right aileron down
- rudder left

10. Examine the diagram of the airplane. Write the names of the parts beside the correct numbers.

1. fuselage
2. propeller
3. aileron
4. elevator
5. rudder
6. vertical stabilizer
7. wing
8. aileron (flap)
9. horizontal stabilizers
11. Examine the following diagram. Then answer the question.

Predict what will happen once the fan is turned on. The device

a. will not move.
b. will roll forward.
c. will roll backward.
d. will roll slightly backward and then forward.

12. In which of the following diagrams of the rear view of an airplane are the control surfaces set in a position that would allow the plane to roll to the left?

a.  

b.  

c.  

d.  

13. Jeremy made a paper glider. When he released it, it dove immediately to the ground. He most likely needs to make adjustments to the

a. wings.
b. rudder.
c. ailerons.
d. elevators.
Bev designed four different paper gliders to see which one would stay in the air the longest. After testing them, she recorded the following results.

<table>
<thead>
<tr>
<th>Glider</th>
<th>Distance Flown (metres)</th>
<th>Flight Path</th>
<th>Time in Air (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Flying Acer</td>
<td>5</td>
<td>Straight</td>
<td>4</td>
</tr>
<tr>
<td>The Dart</td>
<td>4</td>
<td>Straight</td>
<td>4</td>
</tr>
<tr>
<td>Airtime Glider</td>
<td>3</td>
<td>Lofts up</td>
<td>6</td>
</tr>
<tr>
<td>Barnaby Flyer</td>
<td>3</td>
<td>Loops</td>
<td>2</td>
</tr>
</tbody>
</table>

14. Which of the following variable could Bev not control?
   a. type of paper used
   b. size of paper used
   c. weight of paper used
   d. time glider was in the air.

15. The structure of a bird that has the same function as the rudder on an airplane is
   a. curved wings.
   b. pointed beaks.
   c. strong muscles.
   d. tail feathers.

In Allison’s project, she experimented to see if adding mass to a paper airplane will affect how far a paper airplane will fly. A graph of her results is shown below.

16. An inference that can be made from Allison’s graph is that
   a. an airplane requires at least one paper clip to fly.
   b. an airplane that flies 8 m has only 4 paper clips.
   c. an increase in mass affects the distance an airplane flies.
   d. after 5 paper clips are added, an airplane will fly 12 m.
A designer working for an aircraft company made a glider and recorded the distance it flew three times. Examine the results on the graph below.

He wanted to make his fly further so he modified it and tested it three more times. This is the graph of those trials.

17. From examining the graphs, was the modification successful? **no**

Tell how you know. **On the whole, the glider flew farther before the modification.**
18. Use the following information to answer the questions.

Jane wanted to know more about balloon jets. She made two different balloon jets, one using a round balloon and the other using a long thin balloon. For both balloon jets, she kept the length of the string, the size of the balloons, the amount of air in the balloons, the size of the straw, and the angle of the string the same. She launched both balloons to see which travelled farther. She recorded the results in the table below.

<table>
<thead>
<tr>
<th>Shape of Balloon</th>
<th>Distance Travelled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round Balloon</td>
<td>346 cm</td>
</tr>
<tr>
<td>Long Thin Balloon</td>
<td>298 cm</td>
</tr>
</tbody>
</table>

a. What is the manipulated variable?  **shape of balloon**

b. What is the responding variable?  **distance balloon travelled**

c. What are the constant variables?  **length of string, size of balloon, amount of air in balloon, size of straw, angle of string**

d. From the information in the table, what can Jane conclude?

**Round balloon travels farther than long balloon.**