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### Lesson Focus

This lesson focuses on parachute design. Teams of students construct parachutes from everyday materials. They then test their parachutes to determine whether they can transport a metal washer to a target on the ground with the slowest possible rate of descent.

### Lesson Synopsis

The "Playing with Parachutes" lesson explores how parachutes are used to slow moving objects. Students work in teams of "engineers" to design and build their own parachutes out of everyday items. They test their parachutes, evaluate their results, and present to the class.

### Age Levels

8-18



### Objectives

During this lesson students will:

- ◆ Design and construct a parachute
- ◆ Test and refine their designs
- ◆ Communicate their design process and results

### Anticipated Learner Outcomes

As a result of this lesson, students will have:

- ◆ Designed and constructed a parachute
- ◆ Tested and refined their designs
- ◆ Communicated their design process and results

### Lesson Activities

Students work in teams to design and build parachutes out of everyday items. The parachutes need to be able to transport a payload of one metal washer to a target on the ground with the slowest rate of descent. Student teams review their own designs, the designs of other teams, and present their findings to the class.

### Resources/Materials

- ◆ Teacher Resource Documents (attached)
- ◆ Student Worksheets (attached)
- ◆ Student Resource Sheets (attached)

### Playing with Parachutes

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## **Alignment to Curriculum Frameworks**

See attached curriculum alignment sheet.

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## **Internet Connections**

- ◆ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- ◆ NOVA – Design a Parachute (<http://www.pbs.org/wgbh/nova/mars/parachute.html>)
- ◆ History of the Parachute (<https://www.thoughtco.com/history-of-the-parachute-1992334>)

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## **Recommended Reading**

- ◆ The Silken Canopy: History of the Parachute (ISBN: 978-1853108556)
- ◆ Sky People : A History of Parachuting (ISBN: 978-1853108693)

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## **Optional Writing Activity**

- ◆ Research Leonardo DaVinci’s conical parachute and compare and contrast it with modern parachute designs.

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## For Teachers: Teacher Resource

### ◆ Lesson Goal

The goal of this lesson is for students to develop a parachute that can carry a metal washer to a 10 cm diameter target on the ground with the slowest rate of descent. Student teams design their parachutes out of everyday materials and then test their designs. Students then evaluate the effectiveness of their parachutes and those of other teams, and present their findings to the class.

### ◆ Lesson Objectives

During this lesson, students will:

- ◆ Design and construct a parachute
- ◆ Test and refine their designs
- ◆ Communicate their design process and results

### ◆ Materials

- ◆ Student Resource Sheets
- ◆ Student Worksheets
- ◆ Meterstick
- ◆ Small ladder (for teacher use only)
- ◆ One set of materials for each group of students:
  - roll of string
  - plastic trash bag
  - plastic shopping bag
  - several sheets of copy paper
  - coffee filters
  - newspaper
  - aluminum foil
  - scissors
  - masking tape
  - metal washer (3cm diameter)
  - ruler

### ◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must develop their own working parachute from everyday items that can carry one metal washer to the ground from a height of 2 M. The parachute has to hit a target 10 cm in diameter with the slowest rate of descent. The parachute that can hit the target with the slowest descent rate is the winner.
4. Students meet and develop a plan for their parachute. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
5. Student teams may trade unlimited materials with other teams to develop their ideal parts list.
6. Student groups next execute their plans. They may need to rethink their plan, request other materials, trade with other teams, or start over.
7. Next....teams will test their parachutes. **Drop height should be measured from the bottom edge of the washer.** The teacher should serve as the dropper. The target can be made on the ground with tape or string, or a paper plate can be used.
8. Teams complete evaluation/reflection worksheet, and present findings to class.

### ◆ Time Needed

- ◆ Two to three 45 minute class periods

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## **Student Resource:**

### ◆ **History of Parachutes**

Parachutes are devices used to slow the movement of objects. Parachutes are typically used to slow the movement of falling objects but they can also be used to slow down horizontally moving objects such as racecars. The word parachute is believed to be of French origin combining the words para, (a French word with Greek roots) chute meaning to shield against falling. The modern parachute has evolved over several centuries. It is believed that Chinese acrobats used parachutes in their acts as early as the 1300's. Leonardo DaVinci sketched designs for a pyramid shaped parachute in the mid 15<sup>th</sup> century. The first time a parachute was actually attempted by a human was in the mid 16<sup>th</sup> century by Faust Vrancic, a Croatian Inventor. He called his invention Homo Volans or the Flying man. He actually tested out his parachute in 1617 by jumping off a tower in Venice. Andrew Garnerin was the first person on record to use a parachute that did not possess a rigid frame. He used his parachute to jump out of hot air balloons from a height of 8000 feet! He was also the first person to include a vent in the canopy to reduce instability. The parachutes we are more familiar with today didn't begin to take shape until the 18<sup>th</sup> century.

### ◆ **Parts of a parachute**

The upper portion of the parachute is known as the canopy. Historically, canopies were made of silk but now they are usually made out of nylon fabric. Sometimes the canopy has a hole or vent in the center to release pressure. When a parachute is housed in a container such as a backpack, it may consist of main canopy and another smaller canopy known as a pilot chute. The pilot chute comes out of the container first and serves to pull open the main canopy. A set of lines connects the canopy to the backpack. The lines are gathered through metal or canvas links attached to thick straps known as risers. The risers are then connected to a harness if the parachute is going to be used by a person.



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## Student Resource (continued):

### ◆ Types of Parachutes

There are many different types of parachutes. Here are some of the more common parachute designs.

- ◆ *Round parachute:* The parachute most people are familiar with is the round parachute. The round parachute is characterized by a circular canopy.
- ◆ *Square parachute:* The square or cruciform parachute possesses a squarish shaped canopy. Square parachutes are beneficial because they reduce jostling of the user and have a slower rate of descent; reducing injuries.
- ◆ *Ram-air parachute:* Most of the parachutes which are intended for use by people that we see today are ram-air parachutes. The canopy in a ram type parachute is made up of 2 layers of material which are sewn together to form air filled cells.
- ◆ *Ribbon and ring parachute:* Used at supersonic speeds.

### ◆ Law of Falling Bodies

Galileo Galilei (1564-1642) was an Italian astronomer and physicist. Galileo conducted much research on motion and developed what is known as the Law of Falling Bodies. This law states that all objects regardless of their mass fall at the same speed, and that their speed increases uniformly as they fall. Galileo's calculations however, did not take into consideration air resistance. Drag, or the force that opposes the motion of an object plays a significant role in the motion of a falling parachute.

### ◆ Newton's Laws of Motion

Sir Isaac Newton (1642-1727) was a brilliant mathematician, astronomer and physicist who is considered to be one of the most influential figures in human history. Newton studied a wide variety of phenomena during his lifetime, one of which included the motion of objects and systems. Based on his observations he formulated Three Laws of Motion which were presented as *Philosophiæ Naturalis Principia Mathematica* in 1686.

- ◆ *Newton's First Law* – An object at rest will remain at rest and an object in motion will remain in motion at a constant speed unless acted on by an unbalanced force (such as friction or gravity). This is also known as the law of inertia.
- ◆ *Newton's Second Law* – An object's acceleration is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the applied net force. Newton's Second Law can be expressed as:  $F = ma$
- ◆ *Newton's Third Law* – For every action there is an equal and opposite reaction.

### ◆ Gravity

Newton's work on developing the Laws of motion led him to formulate the Law of Universal Gravitation. The law states that two bodies attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. We can use the following equation to calculate the force of gravity with which an object is attracted to the Earth:  $F_G = mg$

$m$  = mass of the object     $g$  = the acceleration of gravity

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**Student Worksheet (continued):**

◆ Construction Phase

Build your parachute. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ Testing Phase

Each team will test their parachute. You'll need to time your test to make sure you can support the washer and achieve the slowest rate of descent.

<b>Parachute Testing Data</b>				
	<b>Drop Height (m)</b>	<b>Drop Time (s)</b>	<b>Velocity (m/s)</b>	<b>Distance Landed from Target</b>
<b>Test 1</b>				
<b>Test 2</b>				
<b>Test 3</b>				
<b>Test 4</b>				
<b>Average</b>				

◆ Evaluation Phase

Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the Playing with Parachutes Lesson:

1. Did you succeed in creating a parachute that could hit the target? If so, what was your slowest rate of descent? If not, why did it fail?
  
2. Did you decide to revise your original design or request additional materials while in the construction phase? Why?



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***Student Worksheet (continued):***

◆ Evaluation Phase (continued)

3. Did you negotiate any material trades with other teams? How did that process work for you?
  
4. If you could have had access to materials that were different than those provided, what would your team have requested? Why?
  
5. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?
  
6. If you had to do it all over again, how would your planned design change? Why?
  
7. What designs or methods did you see other teams try that you thought worked well?
  
8. Do you think you would have been able to complete this project easier if you were working alone? Explain...
  
9. What kind of changes do you think you would need to make to your design if you needed to transport a heavier payload? Try it!

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## For Teachers:

### Alignment to Curriculum Frameworks

**Note:** Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards ([http://www.nap.edu/catalog.php?record\\_id=4962](http://www.nap.edu/catalog.php?record_id=4962))
- U.S. Next Generation Science Standards (<http://www.nextgenscience.org/>)
- International Technology Education Association's Standards for Technological Literacy (<http://www.iteea.org/TAA/PDFs/xstnd.pdf>)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (<http://www.nctm.org/standards/content.aspx?id=16909>)
- U.S. Common Core State Standards for Mathematics (<http://www.corestandards.org/Math>)
- Computer Science Teachers Association K-12 Computer Science Standards (<http://csta.acm.org/Curriculum/sub/K12Standards.html>)

#### ◆ National Science Education Standards Grades K-4 (ages 4 - 9)

##### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

##### **CONTENT STANDARD B: Physical Science**

As a result of the activities, all students should develop an understanding of

- ◆ Properties of objects and materials
- ◆ Position and motion of objects

##### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ◆ Science as a human endeavor

#### ◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

##### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

##### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop an understanding of

- ◆ Motions and forces

##### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ◆ Science and technology in society

##### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ◆ History of science

#### ◆ National Science Education Standards Grades 9-12 (ages 14-18)

##### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

##### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop understanding of

- ◆ Motions and forces

##### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ◆ Science and technology in local, national, and global challenges

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## For Teachers:

### Alignment to Curriculum Frameworks

#### ◆ National Science Education Standards Grades 9-12 (ages 14-18)

##### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of Historical perspectives

- ◆ History of science



#### ◆ Next Generation Science Standards Grades 2-5 (Ages 7-11)

##### **Matter and its Interactions**

Students who demonstrate understanding can:

- ◆ 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

##### **Energy**

Students who demonstrate understanding can:

- ◆ 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

##### **Engineering Design**

Students who demonstrate understanding can:

- ◆ 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials/time/cost.
- ◆ 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet criteria/constraints of the problem.
- ◆ 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

#### ◆ Next Generation Science Standards Grades 6-8 (Ages 11-14)

##### **Engineering Design**

Students who demonstrate understanding can:

- ◆ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ◆ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

#### ◆ Principles and Standards for School Mathematics (ages 11 - 14)

##### **Measurement Standard**

-Apply appropriate techniques, tools, and formulas to determine measurements.

- ◆ solve simple problems involving rates and derived measurements for such attributes as velocity and density.

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**For Teachers:****Alignment to Curriculum Frameworks****◆ Principles and Standards for School Mathematics (ages 14 - 18)****Measurement Standard**

- Apply appropriate techniques, tools, and formulas to determine measurements.
  - ◆ analyze precision, accuracy, and approximate error in measurement situations.

**◆ Common Core State Standards for School Mathematics Grades 2-8 (ages 7-14)****Measurement and data**

- Measure and estimate lengths in standard units.
  - ◆ CCSS.Math.Content.2.MD.A.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
  - ◆ CCSS.Math.Content.2.MD.A.3 Estimate lengths using units of inches, feet, centimeters, and meters.

**◆ Standards for Technological Literacy - All Ages****Design**

- ◆ Standard 8: Students will develop an understanding of the attributes of design.
- ◆ Standard 9: Students will develop an understanding of engineering design.
- ◆ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

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