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# ***Narrative STEM Lessons: Suggested Grade Level K-2***

## *Counting Crocodiles* – Building Bridges

**Grade Level:** K

**Disciplinary Area:** STEM

**Unit:** Counting

**Literacy:** *Counting Crocodiles*, by Judy Sierra

**Content Standards:**

### **Science**

- *Next Generation Science Standards:* K-2-ETS.1-1: Engineering Design, Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new and improved object or tool.

### **Technology**

- *Standards for Technological Literacy:* Standard 11. Students will develop the abilities to apply the design process.
  - B. Build or construct an object using the design process.

### **Engineering**

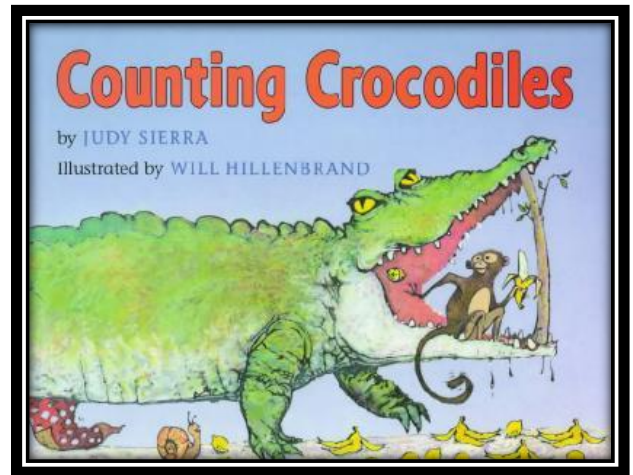
- *Standards for Technological Literacy:* Standard 1. Students will develop an understanding of the characteristics and scope of technology.
  - B. All people use tools and techniques to help them do things.

### **Math**

- *Common Core Mathematics* (Geometry): CCSS.Math.Content.K.G.B.5 Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes.
- *Common Core Mathematics* (Counting and Cardinality): CCSS.Math.Content.K.CC.A.1 Count to 100 by ones and by tens.

### **English Language Arts**

- *Common Core ELA Standards* (Speaking and Listening): CCSS.ELA-Literacy.SL.K.1 Participate in collaborative conversations with diverse partners about *kindergarten topics and texts* with peers and adults in small and larger groups.



**Big Ideas:**

- Proper use of the Design Loop
- Counting from 1-10
- Writing numbers 1-10
- Identifying shapes in the real world

**Essential Question:** How could you design a bridge to help your monkey friend get his bananas?

**Scenario:** The monkey sees some more bananas growing on the other island. Remembering how good they tasted, he wants them. Today the crocodiles are nowhere to be found, so he has to think of a different way to get across the water. He decides to build a bridge out of branches (toothpicks) and lemons (marshmallows).

**Challenge:** Using the materials provided, follow the design loop to design and build a bridge to help the monkey get the bananas.

**Materials:**

- Teacher:
  - Literacy: Sierra, Judy (2001). *Counting Crocodiles*. New York: Gulliver Books
- Students (to be divided amongst groups):
  - 2 packs of toothpicks
  - 3 bags of mini- marshmallows
  - 1 bag large marshmallows
  - Number Practice worksheet (one for each student)

**Content Information:**

- Lesson Context: Students have been learning to count, recognize, and write the numbers 1-10. The literacy component of this lesson will reinforce this information, while the design/engineering problem will introduce students to the design loop and basic geometry. After the lesson, the students will be able to recall the lesson as an example of building shapes in the real world using common materials.
- Read *Counting Crocodiles* aloud to the class
- Divide students into groups of 4-5 students
- Have students follow the Design Loop to brainstorm (Technology) (Science), build (Engineering), and test their bridges (Math)
- Students will receive a worksheet to practice writing their numbers, which will tie in with the book.
- Closure: Have student groups take turns showing their design and discussing how/ why they built what they did. Discuss what they might do differently next time.
- Deliverables: Number Practice Worksheet

Name : \_\_\_\_\_

Score : \_\_\_\_\_

Teacher : \_\_\_\_\_

Date : \_\_\_\_\_

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9

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**Evaluation:**

**Grading Rubric**

Demonstrates knowledge of Design Loop (0-25pts): \_\_\_\_\_  
Student is able to follow the Design Loop to brainstorm ideas, build, and complete project.

Effective collaborator (0-25pts): \_\_\_\_\_  
Student is able to work cooperatively with group members, displaying effective conflict resolution if necessary.

Demonstrates understanding of components of shapes (0-25pts): \_\_\_\_\_  
Student is able to demonstrate knowledge that shapes are made of components, and that multiple shapes can make other shapes when put together.

Completion of provided handouts for evaluation (0-25pts): \_\_\_\_\_  
Student completed all included handouts to reinforce writing of numbers.

**Total Points:** \_\_\_\_\_/100

## *Jangles* – Big Fish Tournament

**Suggested Grade Level:** 2<sup>nd</sup> Grade

**Literacy Connection:** *Jangles a Big Fish Story*

By: David Shannon

### **STEM Content Standards:**

#### **Next Generation Science Standards**

PS3.C Relationship between energy and forces

Bigger pushes and pulls cause bigger changes in an object's motion or shape.

PS2.A Forces and motion

The effect of unbalanced forces on an object results in a change of motion.

#### **Standards for Technological Literacy**

Standard 8 - Students will develop an understanding of the attributes of design.

C. The design process is a purposeful method of planning solutions to problems.

Standard 9 - Students will develop an understanding of engineering design.

C. The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.

#### **Common Core State Math Standards**

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.3.MD.A.2

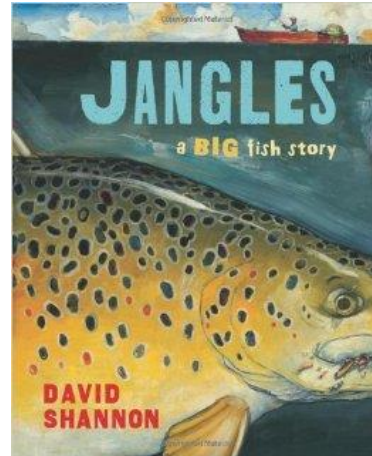
Measure and estimate masses of objects using standard units of grams (g), kilograms (kg)

#### **Big Ideas:**

- Using the design loop properly
- Using creativity for problem solving
- Understanding of forces (weight)

**Essential Question:** How can you design a laminated fishing pole that can hold a great amount of weight to be prepared to catch a big fish?

**Scenario:** There is an annual fishing tournament, the person that catches the heaviest fish will receive a trophy. You are interested in signing up for the tournament and you know *Jangles* lives in the lake. *Jangles* has broken



many fishing poles so it is up to you to create a new, unique fishing pole that can catch *Jangles* and win the tournament.

**Challenge:** Working as a member of a STEM team, design a fishing pole that will hold the most weight and not break. Before starting the design, complete the design loop worksheet. Use the tools and materials available to create a fishing pole that will resist the forces exerted by a heavy fish. When your design is ready to be tested, begin adding weight to the hook until the fishing pole fails and complete the “test for results” worksheet.

**Tools, Materials, and Resources:**

Tools	Materials	Resources
<ul style="list-style-type: none"><li>• Scale</li><li>• Wire cutter</li><li>• Scissors</li></ul>	<ul style="list-style-type: none"><li>• Spaghetti Noodles (8)</li><li>• Tape (10 inches)</li><li>• Woven string (fishing line)</li><li>• Metal clothes hanger (hook)</li><li>• Metal washers</li></ul>	<ul style="list-style-type: none"><li>• <i>Jangles a Big Fish Story</i></li><li>• Design loop worksheet</li><li>• Test for Results worksheet</li></ul>

**Content information:**

Prior to the challenge the students need to read or listen to the story *Jangles a Big Fish Story*.

What is force?

- Strength of a physical action or movement

What is weight?

- Quantity of matter providing downward gravitational force

How beams are made stronger?

- What are interlocking patterns
- What is structural integrity?
- What is lamination?
- How tension and compression can be used to our favor?

**Deliverables:**

- Completion of the design loop worksheet
- Completion of the test for results worksheet
- Presentation of their final design and results

**Parameters or constraints:**

- Use only tools and materials provided
- The washers (weight) may only be added to the hook one at a time
- The fishing pole must be a minimum of 16” long with a 2 inch handle
- The fishing pole handle must be capable of being inserted into the test stand

**Turn in:**

- Final design (the fishing pole)
- Engineering Design Loop



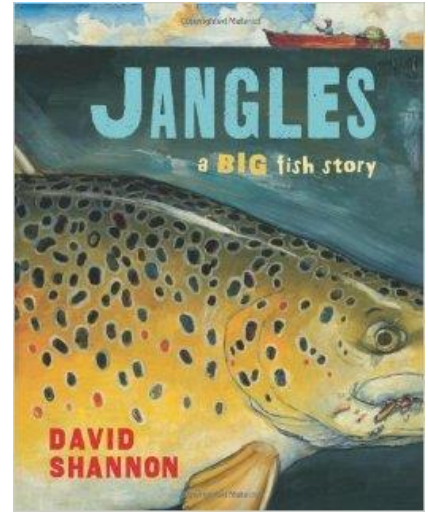
- Test for Results Worksheet

## STUDENT COPY

**Essential Question:** How can you design a laminated fishing pole that can hold a great amount of weight to be prepared to catch a big fish?

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### Tools, Materials, and Resources:

Tools	Materials	Resources
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### Turn in:

- Final design (the fishing pole)
- Engineering Design Loop
- Test for Results Worksheet

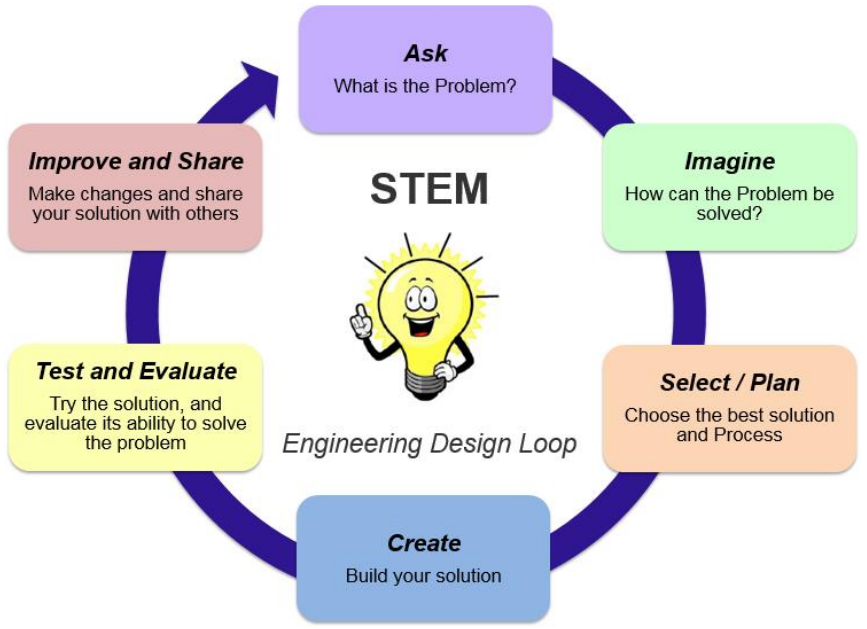


Sketch the final design or attach photo on backside of design loop!

What is the question asking? What are the parameters?

Idea Sketch

What can be improved and shared?



Idea Sketch

How did the design work?

Describe the best idea.

Idea Sketch

Team Member Names:

### ***Test for Results Worksheet***

You should record your answers to nearest hundredths place. All measurements should be in grams (g).

#### **Test #1**

How many washers did your fishing pole hold?

How much do you think your washers will weigh? Estimate to the nearest whole number.

How much did the washers weigh?

#### **Test #2**

How many washers did your fishing pole hold?

How much do you think your washers will weigh? Estimate to the nearest whole number.

How much did the washers weigh?

#### **Final Test**

How many washers did your fishing pole hold?

How much do you think your washers will weigh? Estimate to the nearest whole number.

How much did the washers weigh?

#### **Class Performance**

How many washers did the most successful fishing pole in class hold?

What ideas could you borrow from other teams?

Team Member Names: \_\_\_\_\_

Assessment Sheet

1. Quality and strength of the completed fishing pole and presentation	_____/25
2. Design included creativity and proper use of tools and materials	_____/25
3. The Fishing Pole is able to hold some weight successfully	_____/25
4. Accurate measurements and demonstration of learning in presentation and results worksheet.	_____/25
5. Team members worked as a collaborative and successful team	_____/25
Total _____/100	

Comments:

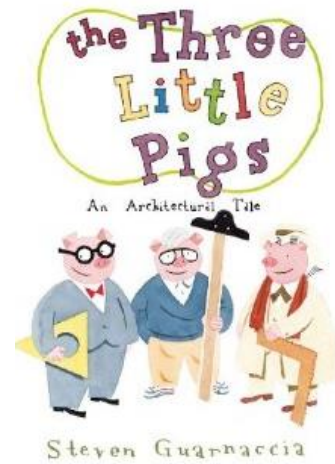
## *The Three Little Pigs - Building Like an Architect*

**Grade Level:** 2<sup>nd</sup> Grade

**Unit:** Structures, Force, Motion

**Literacy:** *The Three Little Pigs – An Architectural Tale*

By Steven Guarnaccia



### **STEM Content Standards**

#### **Science:**

*Next Generation Science Standards: 3-ESS3-1*

Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

*Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.*

*Next Generation Science Standards: Ps3.C*

When objects collide, contact forces transfer energy so as to change the objects' motions..

#### **Technology and Engineering:**

*Standards for Technology Literacy: Standard 10.*

Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Benchmark A. Asking questions and making observations helps a person to figure out how things work.

*Standards for Technology Literacy: Standard 11.*

Students will develop the abilities to apply the design process.

Benchmark B. Build or construct an object using the design process

#### **Math:**

*Common Core Math Standards (Geometry): CCSS.Math.Content.2.G.A.1*

Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces.

*Common Core Math Standards (Measurement & Data): 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.

#### **Big Ideas:**

- Attributes of shapes and their effect on sustainability
- Analyzing materials due to their properties
- Understanding of Engineering Design and presentation of model

#### **Essential Questions:**

How can you build a structurally sound house that will withstand the winds of a tornado?

### Scenario:

You have just finished reading *The Three Little Pigs – An Architectural Tale* by Steven Guarnaccia. The three little pigs had to use creative thought and problem solving to build a sustainable shelter to remain safe from the big, bad, wolf. You will now need to create a model shelter that can withstand the winds of a F3 tornado or a super strong wolf.

### Challenge:

You will need to work as a member of an architectural STEM team.

You will need to complete each step of the Engineering design sheet before building your house. Your house must be at least 18 inches tall. Your house must have an external covering (walls). Your team is only allowed to use the given materials, so you will want to plan carefully and work together.

After you create your model, it will be tested to determine its ability to withstand the high winds created from a **simulation** tornado.

### New Vocabulary Terms:

Classifications – Grouping items together based upon their similarities

Cylinder – Circular shape

Instability – The sense of being uncertain.

Fujita Scale – A classification system that determines the strength of tornados

Simulation – A product that is created to represent a separate event or circumstance

Sustainable – Ability to stay strong or upheld.

### Materials and Resources:

<b>Structure &amp; Covering:</b>	Newspaper – 10 pages
<b>Adhesive:</b>	Tape – 8 inches

### Content Information:

Structures are designed to stand strong for many years. One of the most important things to remember when building structures is the shapes used.

Tornados are a forceful rotating wind storm that occurs when warm wet air mixes with cold dry air. When these two different types of air meet they create **instability**. This instability can then cause the air to spin and blow in different directions causing an updraft. When the tornado forms it will continue to spin and looks like a **cylinder** reaching from the sky to the ground. Tornadoes can come in different sizes and strengths depending upon the air type, temperature, rain, and wind. A tornado's severity is measured on a **Fujita scale**. The following table explains the different strengths of tornados and their **classifications**.

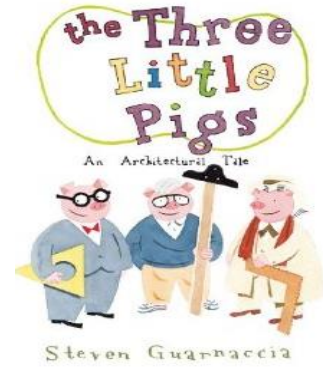
SCALE	WIND SPEED	POSSIBLE DAMAGE
F0	40-72 mph	Light damage: Branches broken off trees; minor roof damage
F1	73-112 mph	Moderate damage: Trees snapped; mobile home pushed off foundations; roofs damaged
F2	113-157 mph	Considerable damage: Mobile homes demolished; trees uprooted; strong built homes unroofed
F3	158-206 mph	Severe damage: Trains overturned; cars lifted off the ground; strong built homes have outside walls blown away
F4	207-260 mph	Devastating damage: Houses leveled leaving piles of debris; cars thrown 300 yards or more
F5	261-318 mph	Incredible damage: Strongly built homes completely blown away; automobile-sized missiles generated

## Student Copy

**Title:** STEM - Building Like an Architect

**Unit:** Structures, Force, Motion

**Literacy:** *The Three Little Pigs – An Architectural Tale*  
By Steven Guarnaccia



### Essential Questions:

How can you build a structurally sound house that will withstand the winds of a tornado?

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### Fujita Scale:

SCALE	WIND SPEED	POSSIBLE DAMAGE
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F5	261-318 mph	Incredible damage: Strongly built homes completely blown away; automobile-sized missiles generated



Sketch your final design or attach photo on backside of design loop!

How did the model work?  
What can be improved and shared?

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What shapes can be identified in your design?  
How tall is your final design?

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What is the question asking? What are the parameters?

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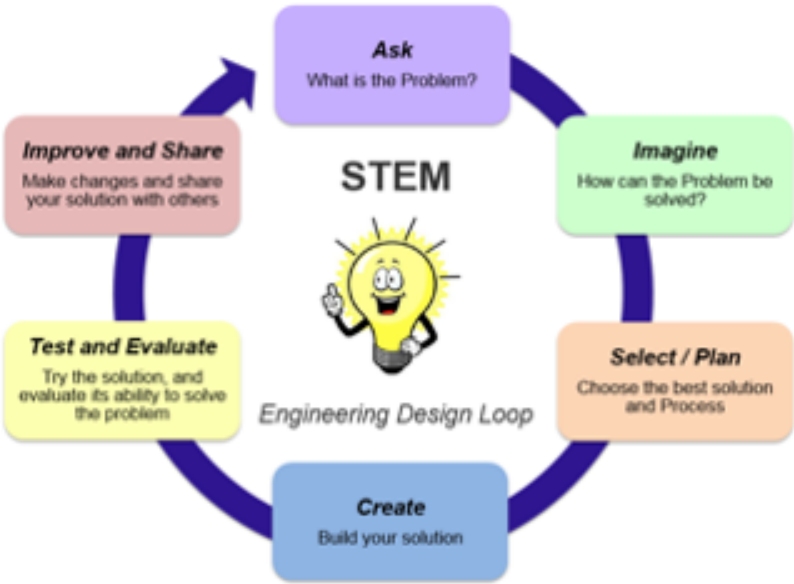
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Idea Sketch

Idea Sketch

Idea Sketch



Describe the best idea. Why did you choose this idea?

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## Olaf – Frozen States of Matter



**Grade Level:** 2<sup>nd</sup> Grade

### STEM Content Standards

#### Science:

Next Generation Science Standards: 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

Next Generation Science Standards: 2-PS1-4

Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot

#### Technology and Engineering:

Standard 8: Students will develop an understanding of the attributes of design.

Benchmark B: Design is a creative process

Benchmark C: The design process is a purposeful method of planning practical solutions to problems.

Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Benchmark A: Asking questions and making observations helps a person to figure out how things work.

Benchmark E: The process of experimentation, which is common in science, can also be used to solve technological problems.

#### Math:

Common Core Math Standards: CCSS.Math.Content.2MD.A.1

Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

Common Core Math Standards: CCSS.Math.Content.3.MD.A.2

Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l)

#### Big Ideas:

- Proper use of Design Process
- Understanding of water properties within different states
- Use of measurement regarding time, length, and volume/mass

#### Content information:

What is cold?

- Cold is the absence of heat. A refrigerator stays cold because it keeps the heat out. If you leave the door open, the refrigerator will quickly warm, regardless of being plugged in.

What is water?

- When solid ice is warmed to its *melting point*, it melts into water.
- Water is present when bonds connect very loosely

What is ice?

- When liquid water is cooled below a temperature known as the *freezing point* of water the liquid water becomes solid ice.
- When ice freezes, its properties change, making it take up more space.

- Ice is the only element that expands when it freezes, without this occurrence the world would not exist as is.

Relationship between ice and water?

- Water can be a liquid or a solid and can go back and forth from one form to the other. For example, if water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

How do you measure water and ice?

- The mass, size, and volume of ice can be measured with different units such as liters or grams.

**Scenario:** [https://www.youtube.com/watch?v=UFatVn1hP3o&feature=player\\_embedded](https://www.youtube.com/watch?v=UFatVn1hP3o&feature=player_embedded)

Olaf has decided to visit Fayetteville Arkansas, which is far from his current home in the magic kingdom. He is concerned that his magic may not work here, so he needs you to design a device that will keep him cold during his visit.

**Essential Question:**

How can you modify a device that will slow the melting of Olaf the snowman (ice cube) when exposed to various heat sources?

**Challenge:**

After reviewing the different properties of the materials available and completing the Olaf STEM news questions, you will need to work as a part of an engineering design team to build a suitable structure for Olaf to use during his visit to keep him cold.

**Parameters or constraints:**

- Completion of the *Olaf's Design Journal*
- Completion of the *Frozen* news article
- Only use the materials and tools provided

**Tools, Materials, and Resources:**

<b>Heat Stations:</b> Hot air (hair dryer/space heater), Heat lamp, Sunlight		
<b>Tools</b>		
Markers Pencil	Scissors Rulers	Timers Scale
<b>Materials</b>		
<b>Given:</b>	Choose 3 pieces of pre-cut materials, can be same or different.	<b>Pick 1</b>
<ul style="list-style-type: none"> <li>• 1 cup Will be used to contain Olaf (ice cube)</li> </ul>	Card Stock Aluminum Foil Wax Paper Saran Wrap Newspaper Bubble wrap	Tape Glue
<b>Resources</b>		
<i>Frozen</i> news article sheet & <i>Frozen</i> Engineering journal		

**Deliverables:**

- *Olaf's Design Journal*
- *Frozen* news article
- Presentation of design and results

**Evaluation:**

Rubric in Olaf's design journal

# STEM – Frozen States of Matter

## Scenario:

Olaf has decided to visit Fayetteville Arkansas, which is far from his current home in the magic kingdom. He is concerned that his magic may not work here, so he needs you to design a device that will keep him cold during his visit.



## Essential Question:

How can you modify a device that will slow the melting of Olaf the snowman (ice cube) when exposed to various heat sources?

## Challenge:

After reviewing the different properties of the materials available and completing the Olaf STEM news questions, you will need to work as a part of an engineering design team to build a suitable structure for Olaf to use during his visit to keep him cold.

## Things to Remember:

- Complete Olaf’s Design Journal
- Complete the *Frozen* News article
- Only use the materials and tools provided



## Tools, Materials, and Resources:

<b>Heat Stations:</b> Flashlight, Hot air (hair dryer/space heater), Heat lamp, Sunlight		
<b>Tools</b>		
Markers Pencil	Scissors Rulers	Timers Scale
<b>Materials</b>		
<b>Given:</b>	Choose 3 pieces of pre-cut materials, can be same or different.	<b>Pick 1</b>
1 cup • Will be used to contain Olaf (ice cube)	Card Stock Aluminum Foil Wax Paper Saran Wrap Newspaper Bubble wrap	Tape Glue
<b>Resources</b>		
<i>Frozen</i> news article sheet <i>Frozen</i> Engineering journal		



# BREAKING STEM NEWS

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ARKANSAS'S FAVORITE NEWSPAPER

- Since 1871

## Olaf from *Frozen* to visit local elementary school in Fayetteville, Arkansas



### Olaf to visit Williams Elementary School

The lovable snowman from the hit movie *Frozen* is set to visit Williams Elementary school in Arkansas within the coming weeks.

This is the first time that Olaf will be making a visit outside of his current magical kingdom.

Olaf's decision to visit this class was not by coincidence. He chose this class due to their ability to problem solve and follow directions. He knows they can create a safe place for him to cool off if the heat becomes too much.

Ana, who is the primary care taker for Olaf, is skeptical but is open to his visit if the class can show they are indeed future STEM engineers.

Let's show Ana what you know about ice and its properties. Complete the following task in order to show that you have what it takes to save Olaf if the need arises.

1. Observe your ice cube. What is its length and width?

2. Using the scale provided, weigh your cup with the ice cube in it. How much does it weigh in grams? \_\_\_\_\_ grams

3. After 2 minutes at each heat station, pour the melted water into a new cup. Weigh this cup to see how much of the ice has melted. What is the weight in grams?

Flashlight: \_\_\_\_\_  
Lamp: \_\_\_\_\_  
Hot Air: \_\_\_\_\_

4. Observe your ice cube. What is its length and width? \_\_\_\_\_

5. Add all of your melted water measurements together. What is your total? \_\_\_\_\_ grams

6. What is the total melt weight of the ice cube? This would be the starting weight – the melted weight. \_\_\_\_\_ grams

7. What heat sourced melted the ice cube the most? \_\_\_\_\_

8. What heat source poses the least threat?  
\_\_\_\_\_

Use what you have learned about the effects of heat to design Olaf a safe environment.

*Narrative STEM Lessons: Suggested Grade Level 3 - 4*

## *Dogzilla* - Constructing a Dog Bone Slinger

**Disciplinary Area:** STEM

**Grade Level:** 3<sup>rd</sup> Grade

**Literacy Connection:** *Dogzilla* by Dav Pilkey

**STEM Standards:**

### **Next Generation Science Standards**

PS3.C Relationship between energy and forces

When objects collide, contact forces transfer energy so as to change the objects' motions.

PS2.A Forces and motion

The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

### **Standards for Technological Literacy**

Standard 6 - Students will develop an understanding of the role of society in the development and use of technology.

- A. Products are made to meet individual needs and wants.
- B. Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.

Standard 7 - Students will develop an understanding of the influence of technology on history.

- B. People have made tools to provide food, to make clothing, and to protect themselves

Standard 8 - Students will develop an understanding of the attributes of design.

- C. The design process is a purposeful method of planning practical solutions to problems.

### **Common Core State Math Standards**

Measurement & Data

- Represent and interpret data.
  - Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.
- Geometry
  - Reason with shapes and their attributes.

### **Common Core English Language Arts**

CCSS.ELA-Literacy.SL.3.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.

### **“Big Ideas”:**

- role of brain storming to problem solve
- applied creative thinking for innovation
- interactions of matter and energy and the energy transformations effective use of resources as technology
- engineering design

**Essential Question:** How can you design a machine that will shoot a dog bone to keep Dogzilla’s puppies distracted from invading the town?

### **Scenario:**

The mice of Mousopolis have realized they need a new plan of attack in order to defeat the dreadful puppies who threaten to ruin their beautiful city and precious second annual barbeque cook-off. They thought up the idea of using a machine that will shoot dog bones as far away as possible so that the pups will chase them and never return. The only problem is that the mice don’t know how to build such an incredible machine. Help the mice by building them a machine that can fling dog bones as far away as possible from the city while still remaining easy enough for a mouse to operate. This should be done in groups of 4 using the resources available below. Be creative in your ideas and use your resources wisely. You must plan out your idea on the Brain Blast sheets before any materials will be passed out.

**Materials & Resources:** (assigned teams of 3-4)

rubber bands	hot glue	paper	masking tape
pencils	small cups	clothes hanger	spoon
ruler	toilet paper roll	cardboard	scissors

### **Content Information:**

According to Newton’s first law of physics, an object in motion will stay in motion and an object at rest will stay at rest unless acted upon by an outside, unbalanced force. This means that any object will not accelerate on its own or decelerate on its own. An object will actually resist change in its motion. It could be said that an object will keep on doing what it is doing. This tendency is called inertia. However, as stated earlier, an object will change its motion if acted on by an unbalanced force.

To understand an unbalanced force, we must know that there are always two forces acted upon an object at rest, gravity (the force that pulls all objects down towards Earth’s surface) and the force from the base of the object (such as the floor) pushing it up. These two forces are balanced and allow the object to stay at rest. Whenever a new force is introduced though, such as a push from the side, there is no force to compensate for it, or balance it out. Therefore, the force is unbalance and the object will move. This is also true when an object is in motion. This is why a ball that is rolling will eventually stop. The force of friction is acting upon the ball causing it to slow down.

(Source: <http://www.physicsclassroom.com/class/newtlaws/u2l1a.cfm>)



Dogzilla video: <https://www.youtube.com/watch?v=A5u96lvVB-g>

**Deliverables:**

In your designated groups, design and create a machine using the materials given that effectively shoots a dog bone as far as possible from the machine. Each design will be tested in a competition to see which machine would best be suited for the mice of Mousopolis.

**Parameters:** The completed machine must:

- be capable of shooting a dog bone as far as possible from the machine
- be easy to operate
- be designed with the engineering design model in mind
- be turned in to instructor along with brain blast activity sheets, showing that the ideas were purposeful, thoughtful, and creative
- demonstrate the knowledge of force and motion through design

**Evaluation:**

**Constructing a Dog Bone Slinger Grading Sheet**

Machine Name:

Group Members:

Assessment Criteria:

1) Machine was submitted along with Engineering Design Loop	_____ /20
2) Machine demonstrated creative, thoughtful and intentional use of materials to carry out design	_____ /15
3) Students in group clearly and effectively presented their project to the class	_____ /15
4) Machine shot the dog bone some distance across the room	_____ /15
5) Machine was easy to operate	_____ /10
6) Demonstrated understanding of learning; completed all activity sheets	_____ /25
	Total _____ /100

# DoGziLLa



## Dog Bone Slinger Design Challenge



### Situation:

The city of Mousopolis is in trouble once again now that Dogzilla's puppies are free! The Big Cheese and all the other mice must find a new way to keep the puppies away from their precious city and of course the Second Annual Barbeque Cook-Off! They decide to create the incredible Dog Bone Slinger to run the pups far, far away from the city. The only problem is that the mice don't know how to build it!

### Challenge:

In your assigned engineering design team, you will help the mice design the most incredible Dog Bone Slinger. Using the design loop and the materials below, create a machine that is easy to operate and will fling dog bones as far away as possible from the city.

### Tools:

(6) Rubber bands	(6) pencils	ruler	hot glue
Toilet paper roll	masking tape	pencil spring	bottle cap
Paper	cardboard	clothes hanger	plastic spoon

### Test:

1. Test out your solution and make any needed adjustments.
2. Once your design is at its very best, your group will present to the class
3. Then we will put all the designs to the test and see which group's Dog Bone Flinger could shoot the bones the farthest away



## Flash, Crash, Rumble, and Roll – The Ultimate Storm

**Disciplinary Area:** STEM

**Grade Level:** 3

**Unit:** Extreme Weather

**Literacy:** *Flash, Crash, Rumble, and Roll* by Franklyn M. Branley

**Content Standards:**

### Science

- *Next Generation Science Standards: 3-ESS3-1*, Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.
- *Next Generation Science Standards: Ps3.C*, When objects collide, contact forces transfer energy so as to change the objects' motions.

### Technology

- *Standards for Technological Literacy: Standard 8*: Students will develop an understanding of the attributes of design.
  - d. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.

### Engineering

- *Standards for Technological Literacy: Standard 2*: Students will develop an understanding of the core concepts of technology.
  - j. Materials have different properties.

### Math

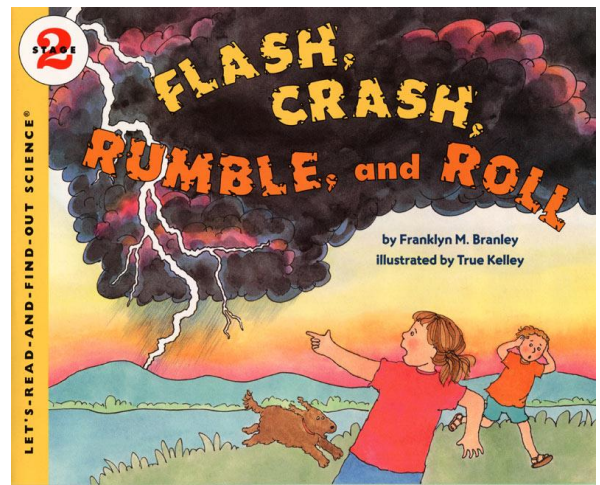
- *Common Core Math Standards: CCSS.MATH.CONTENT.3.MD.D.8*  
Solve real world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters.

### English Language Arts

- *Common Core ELA: CCSS.ELA-LITERACY.SL.3.4*  
Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

### Big Ideas:

- Effects of weather
- Problem solving and design
- Perimeter



**Essential Question:** How can you use creativity and innovation to design a structure to withstand a hailstorm using selected materials?

**Scenario:** The weatherman is forecasting the hailstorm of the century to visit your neighborhood within the week. The city mayor has called upon you to share your knowledge of STEM and problem solving skills to teach the community how to protect themselves from the upcoming storm. How can you design and build a structure to protect you and your family?

**Challenge:** Build a structure that can withstand the forces of a hailstorm using only the materials provided. Your structure must meet the parameters and constraints of the design challenge.

**Parameters and Constraints:**

- Use only the materials provided
- Hail may not enter any part of the house- that would hurt!
- Structure must adhere to a base which will be provided
- Structure must be a minimum of 15" tall

**Tools:**

Ruler

Hailstorm simulator (we used the *Hog Wild Bullseye Power Popper* and *nerf blaster*)

**Materials:**

Recycled newspaper

Masking Tape

Cardboard base

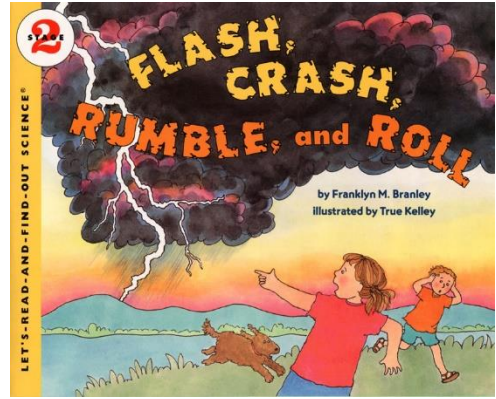
**Content Information:**

- A thunderstorm is a storm with lightning and thunder
- Thunderstorms are produced by cumulonimbus clouds
- Thunderstorms sometimes produce hail
- Hail is created when small water droplets are caught in an updraft of a thunderstorm. The water droplets are lifted higher and higher into the sky until they freeze into ice. Once they freeze, they become heavy and start to fall.
- Hailstones get caught in the updraft again and again, getting larger and heavier, until they become so heavy that they fall from the sky.
- Weather information adapted from <http://www.weatherwizkids.com/weather-thunderstorms.htm>
- Perimeter- measures the distance around an area
- Perimeter is found by adding together all of the different sides of a shape or object
- Formula for perimeters:
  - Square-  $4a$  (where  $a$  is one side)
  - Rectangle-  $2a+2b$
  - Triangle-  $a+b+c$

**Evaluation: Grading Rubric**

<b>Points Available</b>	<b>17-25</b>	<b>9-17</b>	<b>0-8</b>	<b>25</b>
<b>Component</b>	<b>Excellent</b>	<b>Good</b>	<b>Poor</b>	<b>Total Points</b>
Completion of Perimeter Worksheet	Accurately completes Perimeter Worksheet	Completes Perimeter Worksheet, but not accurately	Does not complete worksheet	
Proper use of the Design Loop to build a hail proof structure	Uses the Design Loop worksheet to brainstorm multiple solutions Creates a hail proof structure using content understandings	Uses the Design Loop worksheet to brainstorm one solution to the problem. Fails to use content understanding in design of hail proof structure	Does not use the Design Loop worksheet and/or demonstrate content understanding in design of hail proof structure	
Presentation	Is able to present final project to peers and discuss choices made during the design process	Is able to present final project to peers but does not include the design process	Is unable to present project to peers and does not discuss design process	
Understanding of Extreme Weather	Demonstrates an understanding of extreme weather and protective measures to be taken	Demonstrates understanding of extreme weather OR protective measures to be taken	Does not demonstrate an understanding of extreme weather and protective measures to be taken	
<b>Total Points:</b>				<b><i>/100</i></b>

# The Ultimate Storm – STEM Design Challenge



**Disciplinary Area:** STEM

**Grade Level:** 3

**Question:** How can you use creativity and innovation to design a structure to withstand a hailstorm using selected materials?

**Scenario:** The weatherman is forecasting the hailstorm of the century to visit your neighborhood within the week. The city mayor has called upon you to share your knowledge of STEM and problem solving skills to teach the community how to protect themselves from the upcoming storm. How can you design and build a structure to protect you and your family?

**Challenge:** Build a structure that can withstand the forces of a hailstorm using only the materials provided. Your structure must meet the parameters and constraints of the design challenge.

**Parameters and Constraints:**

- Use only the materials provided
- Hail may not enter any part of the house- that would hurt!
- Structure must adhere to a base which will be provided
- Structure must be a minimum of 15" tall

**Tools:**

Ruler

Hailstorm simulator (we used the *Hog Wild Bullseye Power Popper* and *nerf blaster*)

**Materials:**

Recycled newspaper (given amount)

Masking Tape (given amount)

Cardboard base

Sketch your final design or attach photo on backside of design loop!

What can you improve?

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What would you share with others about your design?

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How tall is your design? \_\_\_\_\_

How did your design work?  
Did your design keep the *hail* from entering inside? Why?

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How did your design react to the force of being hit with the *hail*?

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What is the question asking? What are my parameters?

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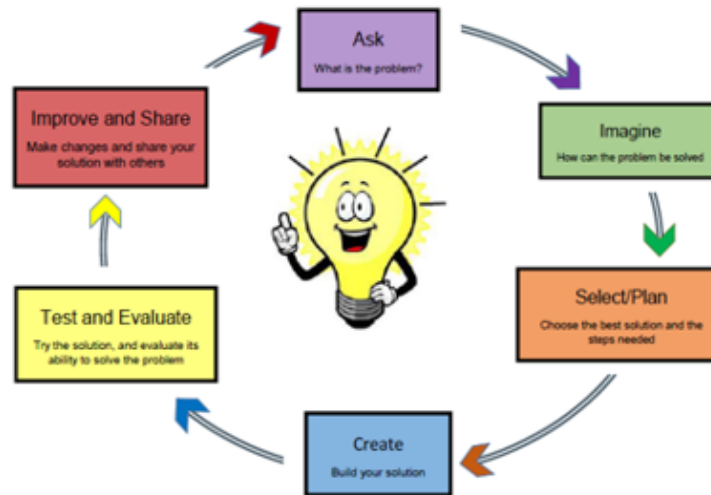
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## Engineering Design Loop



What do you know about weather conditions that contributed to your design?

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What do you know about shapes and measurement that contributed to your design?

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My Idea Sketch

My Idea Sketch

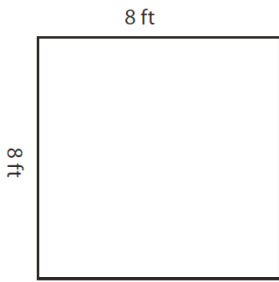
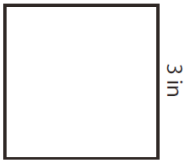

Team Idea Sketch





## Problems with Perimeter and Area – Content Worksheet

In order to help your community build sustainable shelters against the upcoming storm, you will first need to demonstrate your knowledge in calculating perimeters. Exact measurements are crucial for those who work in architecture, and engineering and miscalculations can cause many problems such as going over budget or in building structurally sound buildings and houses. Solve the problems below, before moving on to saving the town!

Find the perimeter of each square.

<p>1.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Perimeter = <span style="border: 1px dashed black; border-radius: 15px; display: inline-block; width: 80px; height: 20px;"></span></p>	<p>2.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Perimeter = <span style="border: 1px dashed black; border-radius: 15px; display: inline-block; width: 80px; height: 20px;"></span></p>	<p>3.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Perimeter = <span style="border: 1px dashed black; border-radius: 15px; display: inline-block; width: 80px; height: 20px;"></span></p>
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Find the area of each rectangle.

<p>4.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Area = <span style="border: 1px dashed black; border-radius: 15px; display: inline-block; width: 80px; height: 20px;"></span></p>	<p>5.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Area = <span style="border: 1px dashed black; border-radius: 15px; display: inline-block; width: 80px; height: 20px;"></span></p>
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Good job on calculating the parameter of these practice polygons. You may now begin your STEM design challenge, and solve the following problems based upon your designs.

What shape was your design? \_\_\_\_\_ What was the perimeter? \_\_\_\_\_ What was the area? \_\_\_\_\_

How did you solve for the perimeter? \_\_\_\_\_

How did you solve for the area? \_\_\_\_\_

Solve the perimeter for one of your classmates' designs.

What was their perimeter? \_\_\_\_\_ What was their area? \_\_\_\_\_

## California Gold Rush – Cookie Mining

**Suggested Grade Level: 4**

### **STEM Standards:**

**SCIENCE:** Next Generation Science Standards

ESS3.A, Energy and fuels humans use are derived from natural sources and their use affects the environment. Some resources are renewable over time, others are not

**TECHNOLOGY/ENGINEERING:** Standards for

Technology Literacy

Standard 1: Students will develop an understanding of the characteristics and scope of technology

- D. Tools, materials, and skills are used to make things and carry out tasks

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology

- C. The use of technology can have unintended consequences

**MATH:** Common Core Math Standards

CCSS.Math.Content.4.MD.A.1: Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table

**ENGLISH/LANGUAGE ARTS:** Common Core English Language Arts Standards

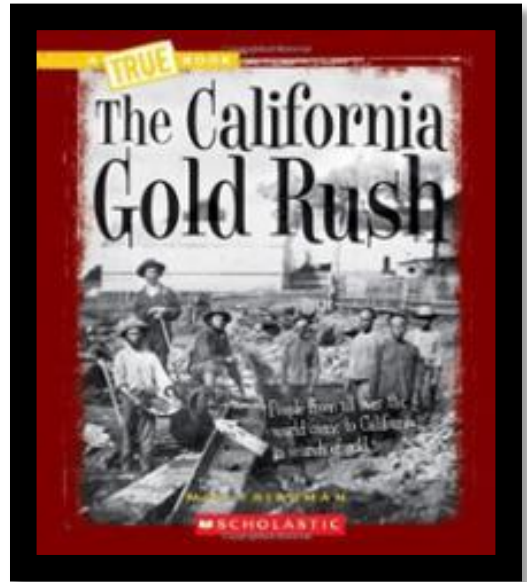
CCSS.ELA-Literacy.RI.4.3: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

**ECONOMICS:** National Standards in Economics

Standard 5: Trade. Exchange is trading goods and services with people for other goods and services or for money.

### **Big Ideas:**

- Natural resources and their uses
- Proper use of the design loop
- The role of creativity in problem solving
- Design under constraint
- Being able to relate the real world and physical science



**Essential Question:** How can you minimize the impact of mining on the local environment while gaining resources?

**Scenario:** It's 1850, and you've just received word from your uncle in the California Territory that gold has been discovered. He tells you that all you have to do is walk the land and pick up the gold nuggets. You load up your family and head west, purchasing your own claim. How can you mine your land to get the gold out without destroying the beautiful land?

**Directions:** Students will develop a plan by following the design loop. The students may not purchase their resources until they have completed steps 1-3 of the design loop on their worksheets. After students have designed a solution to the problem, each student or group should get 15 credits with which to purchase supplies. Students must develop a crumb catcher that will catch the crumbs caused by mining chocolate chips or M&Ms out of their cookies. After their structure is built, you will start a timer and they will all begin mining at the same time. After mining, they will finish the budget worksheet to see which team mined the most chips using the least resources.

**New Vocabulary Terms:**

**Cultures-** the beliefs and ways of life of nations or people

**Discriminated-** judged or treated unfairly because of race, religion, gender, or other factors

**Forty-niners-** nickname for the people who went to California in search of gold in 1849

**Gold fever-** the desire to rush to California to find gold

**Gold rush-** the mass movement of people to an area where gold has been recently discovered

**Hydraulic-** operated by or powered by moving water or another liquid

**Miners-** people who remove gold from a mine

**Pioneers-** those who are the first to explore or live in a place

**Prospectors-** people looking for valuable minerals and metals, especially gold

**Revolted-** rose up or fought against a government or other territory

**Territory-** an area or region of land that belongs to and is governed by a country

**Materials/ Resources:**

<b>Straws</b>	<b>Toothpicks</b>
<b>Construction Paper</b>	<b>Netting</b>
<b>Tape</b>	<b>Craft Sticks</b>
<b>Paper Clips</b>	<b>Plastic Spoons</b>
<b>Paper Towels (for cleanup)</b>	<b>Index Cards</b>

**Content Information:** Mines around the world provide us with many of the luxuries and necessities we use everyday. Just today, you have probably used a variety of products derived from crude oil alone, such as gasoline, ink, plastic, and deodorant- and that is only one of the things we mine! While the earth provides us with many wonderful products, the mining process itself can be detrimental to the environment. Possible hazards include erosion, release of dangerous chemicals used in the mining process, destruction of animal habitats, and surface or groundwater pollution. Modern mines work hard to reduce this impact. *Tip: Tie this lesson in with a social studies lesson on the Gold Rush of 1849 in California.*

# Cookie Mining

## Student Handout

**Situation:** It's 1850, and you've just received word from your uncle in the California Territory that gold has been discovered. He tells you that all you have to do is walk the land and pick up the gold nuggets. You load up your family and head west, purchasing your own claim. How can you mine your land to get the gold out without destroying the beautiful land?

**Challenge:** Can you design and build a structure to catch all of the cookie crumbs created in your mining operation, lessening the environmental impact of your mine?

**Constraints:** You will have 15 credits with which to buy the supplies to build your structure and mine your cookie. Keep in mind that you will also need to factor in labor costs at 1 credit per minute. The crumb catcher must elevate the cookie a minimum of 1" off the surface of the table. When mining, you must use an implement to do so- **the use of your hands to pry out the chips is prohibited.** The team who completes the challenge with the highest profit will receive a prize!

### Directions:

1. Design a Cookie Crumb Catcher. This will be used to catch the crumbs created when you mine your cookie. Be sure to follow the steps of the design loop! After you have formulated a design, you may purchase the items needed from your instructor.
2. Build your crumb catcher.
3. Test your design and make any needed adjustments.
4. Fill out the "Before You Build" section of the Cookie Mining worksheet.
5. Wait until all of the other miners are ready.
6. The instructor will start a 5-minute timer. During this time, mine as many chocolate chips out of the cookie as you can- without touching the cookie with your hands!
7. Once 5 minutes are up, observe what happened to your cookie and write about it in the Final Results space on your worksheet.
8. Challenge (optional): Use the scale to weigh your mined chips and compare the weight to the pieces of coal or some other material which can be mined. Which is heavier?

**Materials/ Resources:**

<b>Straws</b>	<b>Toothpicks</b>
<b>Construction Paper</b>	<b>Netting</b>
<b>Tape</b>	<b>Craft Sticks</b>
<b>Paper Clips</b>	<b>Plastic Spoons</b>
<b>Index Cards</b>	

**Information to Know:** Mines around the world provide us with many of the luxuries and necessities we use everyday. Just today, you have probably used a variety of products derived from crude oil alone, such as gasoline, ink, plastic, and deodorant- and that is only one of the things we mine! While the earth provides us with many wonderful products, the mining process itself can be detrimental to the environment. Possible hazards include erosion, release of dangerous chemicals used in the mining process, destruction of animal habitats, and surface or groundwater pollution. Modern mines work hard to reduce this impact.

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**Revolted-** rose up or fought against a government or other territory

**Territory-** an area or region of land that belongs to and is governed by a country

# Cookie Mining Worksheet

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## **Before you build:**

On the Design Loop Worksheet, sketch out your ideas. Decide which idea you will use.

What materials will you need for your design?

What do you think will happen? (This is your hypothesis)

## **Final Analysis:**

Did your crumb catcher work the way you anticipated it would?

Try to explain why this happened.

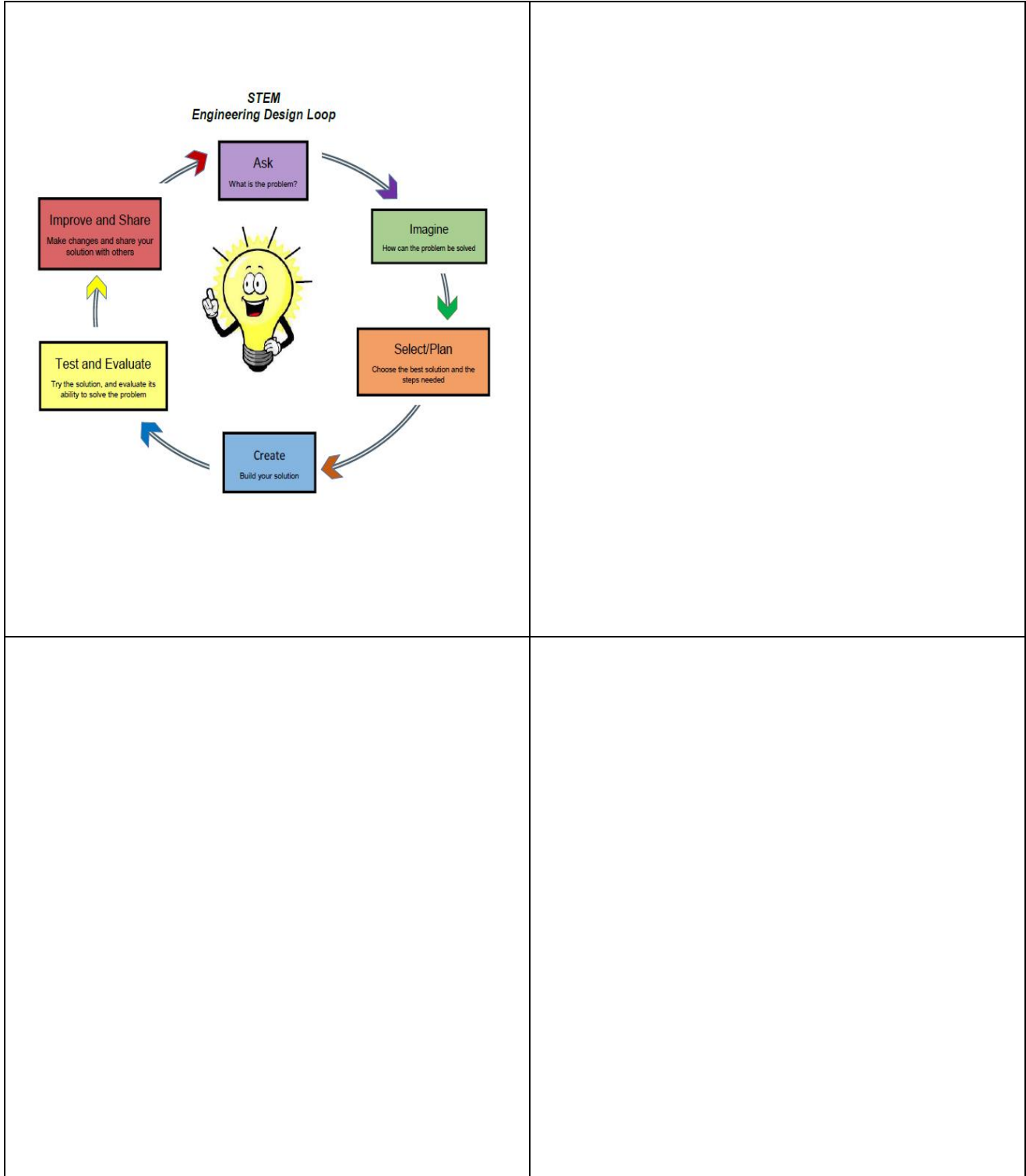
What did you learn from this design challenge?

If you were to do this again, would you change it?

If yes, describe how you would do this.

# Design Loop Worksheet

Instructions: Follow the design loop to come up with 3 possible solutions to the problem.





### Budget Form

Item	Credits	Needed	Total
Netting	2		
Tape	1/ 12 inches		
Construction Paper	1/ 1 sheet		
Craft Sticks	1/ 3 sticks		
Paper Clips	1/ 5 clips		
Plastic Spoon	2		
Straws	1/ 3 straws		
Toothpicks	1/ 5 toothpicks		
Index Cards	1/ 3 cards		

**Total Material Cost:** \_\_\_\_\_

**Labor Cost (add 1 credit for every 1 minute spent mining):** \_\_\_\_\_

**Total Material Cost plus Labor Costs:** \_\_\_\_\_

**You started with 15 credits. After material and labor costs, how much do you have left?**

**Congratulations! The local mining authority will pay you 2 credits for every chocolate chip mined! How much did you make (profit)?**

**Add your leftover startup capital to your profit. What is your final net profit or loss?**

## *Man in the Moon – Zipping through Space*

**Disciplinary Area:** STEM

**Grade Level:** 2<sup>nd</sup> or 3<sup>rd</sup> grade

**Connection to Literature:** *Regards to the Man in the Moon* by Ezra Jack Keats

**STEM Standards**

**Next Generation Science Standards:**

PS2.A, PS2B: Forces and motion and Types of interactions

The effect of unbalance forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force on Earth acting on an object near Earth's surface pulls that object towards the planet's center.

Pushes and Pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it.

PS3.A, PS3.B: Definitions of Energy and Conservations of energy and energy transfer

Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.

**Technology and Engineering Standards:**

Standard 8: Students will develop an understanding of the attributes of design.

*Benchmark B:* Design is a creative process.

*Benchmark C:* The design process is a purposeful method of planning practical solutions to problems.

Standard 11: Students will develop the abilities to apply the design process.

*Benchmark B:* Build or construct an object using the design process.

*Benchmark D:* Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving problems.

*Benchmark E:* The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.

*Benchmark F:* Test and evaluate the solutions for the design problem.

*Benchmark G:* Improve the design solutions

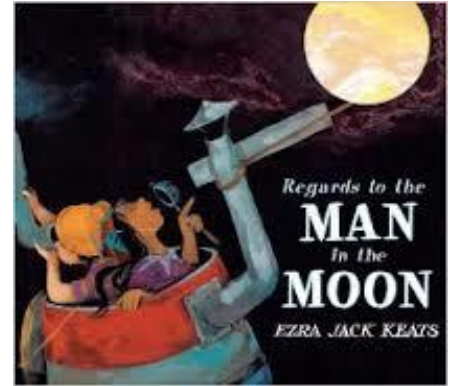
**Math:**

Common Core Math Standards: CCSS.Math.Content.3MD.B.4

Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data making a line plot, where the horizontal scale is marked off in appropriate units- whole numbers, halves, or quarters.

**Big Ideas:**

- Understanding the concept of force, balance, gravity, and motion
- Use of design process



## Content Information

### What makes the “object” move down the zip line?

- The “object” moves down the zip line due to gravity.

### What is gravity?

- The force that attracts a body toward the center of the earth, or toward any other physical body having mass. For most purposes Newton's laws of gravity apply, with minor modifications to take the general theory of relativity into account.

### What is friction?

- the resistance that one surface or object encounters when moving over another

### What is Newton’s First Law?

- An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

### Why is this important to this project?

- This project deals with the concept of energy and motion. When the basket or “object” is propelled downward on the zip line the students will begin to see the effects of gravity. Newton’s first law says that an object in motion will stay in motion and an object at rest will stay at rest, meaning that unless the object is acted on by another force it will continue to do what it was always doing. The behavior of all objects can be described by saying that objects tend to "keep on doing what they're doing" (unless acted upon by an unbalanced force). If at rest, they will continue in this same state of rest. The Zip Line will be propelled downward by the force of gravity and will stop when it hit the pole at the end of the course. The students will also learn about unbalanced forces. They will see that a zip line only works when the two ends are at different heights. If they weren’t at different heights you would have to have another force pushing the object toward the other end. The students will also see that friction plays a role in the speed of their basket on the zip line. The different kind of string that they use will depend on the speed results. Therefore, if they use fishing line it would go faster than if they used yarn. This is because of the different material and the friction that is caused between the basket and the zip line string. (<http://www.physicsclassroom.com/class/newtlaws/u2l1a.cfm> )

### **Scenario:**

- After reading this book, Louie and Susie decided to travel back into space to race the “monsters”, which are the rocks, in a game called Zipping through Space. This game will be done in space and on different planets in space. The game consists of building your own zip line and racing the monsters from planet to planet. However, they are in a terrible time crunch and need a little bit of help designing their own zip line for the race. They need help figuring out which tools to use, which materials would work best, and how to get from planet to planet the fastest. This design will be done in groups of four and you will use the resources provided to build your design. You will first use the student handout sheet to draw out and plan your ideas before you start building your model.

### **Essential Question:**

- How can you design a zip line that will provide the fastest time for Louie and Susie?

**Materials and Resources: groups of 3-4 students**

Foam board	Ruler
Dowel rods	Pencils
Fishing line	small plastic cups
Yarn	clothes hangers
String	Glue
Scissors	Tape

**Deliverables:**

- In your groups, design and create a zip line, using the materials provided, that will effectively move Susie and Louie from one planet to another. Each group's designs will be tested in a competition to see which zip line will get these two friends from planet to planet the fastest without getting beat by the "monsters."

**Parameters:**

The completed machine must:

- Move the basket from one dowel rod to the other without spilling the cargo (rice)
- Be designed through the engineering design process
- Be creative
- Be easy to operate
- Demonstrate an understanding of gravity, the forces of motion, and friction.
- Completed and turned into the teacher with the complete design and design worksheet. The worksheet needs to be not just completed but well thought out and show that the student had a purpose for the design and learned the content knowledge.

# ZIPPING THROUGH SPACE CHALLENGE



## Directions:

1. Read the situation and challenge below to start working through the design process!
2. Look over the design loop provided below and begin to think about how you will build your zip line.
3. Build the zip line!
4. Test and re-test your design to get all flaws worked out! Remember to collaborate with you team!
5. Fill out the student handout sheet with your team!
6. Once your design is complete, we will all compete against each other to see who has the fastest zip line!!

## Situation:

Louie and Susie desperately want to travel back into space to win the race against the monsters! However, they are in a bit of a time crunch because they are going to have to rebuild a rocket and do not have enough time to build the rocket, to get them to space, and to build the zip line for the race! They have asked if our class would be willing to design and build a zip line that will travel from one planet to another with great speed and ultimately beat the Monsters at their own race!

## Challenge:

In your design groups, you will design the fastest zip line ever! Using the design loop and the materials provided, create a zip line that will get Louie and Susie from one plane to another in the fastest amount of time without anyone falling out!

## *Lets Fly a Kite* – Triangles and Kites

**Disciplinary Area:** STEM

**Title:** Kite Flying to Explain Triangles

**Literacy Connection:** *Lets Fly a Kite*, by Stuart J. Murphy

**Grade Level:** 4<sup>th</sup> Grade



**Stem Content Standards:**

### **Science**

Next Generation Science Ideas ETS1.B Designing Solutions to Engineering Problem: Testing a solution involves investigating how well it performs under a range of likely conditions

### **Technology and Engineering**

Standard 8: Students will develop an understanding of the attributes of design

Benchmark C: The design process is a purposeful method of planning practical solutions to problems.

Standard 9: Students will develop an understanding of engineering design

Benchmark C: The engineering design process involves defining a problem generating ideas, selecting a solution, testing the solutions, making the item, evaluating it and presenting the results

### **Math**

Common Core Math Structures: CCSS.MATH.CONTENT.4.MD.A.3

Apply the area and perimeter formulas for polygons in real world and mathematical problems. *For example, find the width of a rectangular room given the area of the flooring and the length, by viewing the area formula as a multiplication equation with an unknown factor.*

Common Core Math Structures: CCSS.MATH.CONTENT.4.G.A.1

Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

### **Literacy**

Common Core Language Arts Standards: CCSS.ELA-LITERACY.RL.4.1

Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

**Big Ideas:**

- Properties of the Design Loop process
- Understanding how to solve for perimeter
- Being able to identify different types of angles (right, acute, obtuse)
- Problems can be solved multiple ways

## Content information:

How can you create a successful design?

- Using the design loop process. If used the process of building a model becomes easier and less chaotic

What is Pythagorean theorem?

- $a^2+b^2=c^2$ . Used to solved for perimeter of a triangle when the measurement of one side is not given

What are the different types of angles?

- Right angle= 90 degrees
- Acute angle= less than 90 degrees
- Obtuse angle=greater and 90 degress

## Pre-Lesson Activity:

Read *Lets Fly a Kite* as a class

In the classroom identify real life examples of each type on angle. For example, the corner of the picture frame is a right angle

Give the students a generic basic problem that needs a solution. Break the class into small groups and ask them to brainstorm possible solutions. After sharing ideas students should understand that there is usually many different ways to solve a problem

## Scenario:

Just like in the book *Lets Fly a Kite*, your babysitter wants to spend the day flying a kite but she does not have one. Build a kite that will be able to fly on a moderately windy day. Be sure to use the Design Loop unlike the babysitter. Once your kite is flying she asks you how high your kite is from the ground

## Essential Question:

Can you create a working kite using the design loop and next tell your babysitter how high the kite is off the ground?

## Challenge:

After reviewing the design loop and Pythagorean theorem, you will need to work as a part of an engineering design team in order to build a kite, make it fly and find how high off the ground the kite is.

## Parameters or Constraints:

- Complete engineering Journal
- Use only material provided
- The kite must able to fly using 12 feet of kite string

- Students must give estimation of how many degrees each angle is in their “triangle”. The vertexes of the triangle are the kite, the person flying the kite and the person standing directing beneath the kite
- Use Pythagorean theorem to solve how high the kite is from the ground
- Kite String must be 12 feet long

**Tools, Materials and Resources:**

- One sheet of large newspaper
- Kite string
- Two thin sticks
- Tape
- Craft glue

**Content information:**

- Short math lesson about triangles which includes angles and Pythagorean theorem
- Watch short video from MonkeySee about flying kites  
<http://www.youtube.com/watch?v=QjxJYTEQn6Q>

**Deliverables:**

- Kite
- Completed Worksheet
- Completed Design Journal

**Evaluation:**

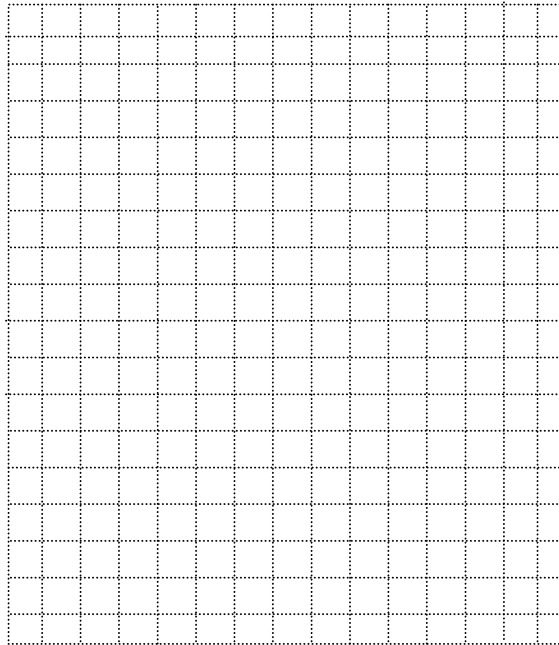
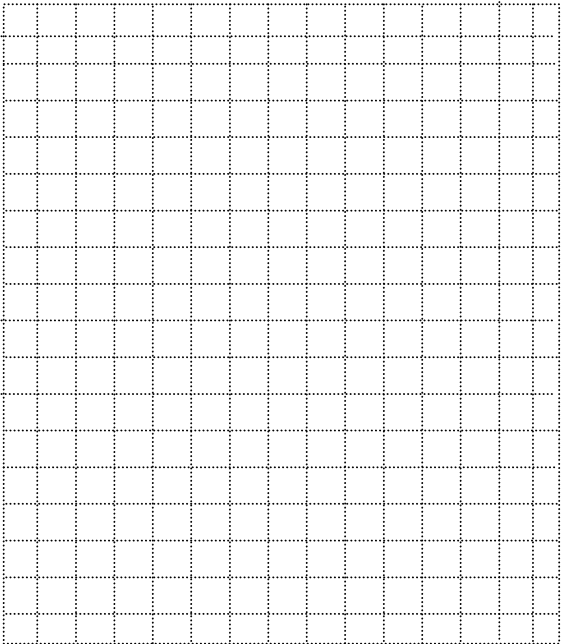
- See rubric



## Design Journal:

**Directions:** Fill in the Design Journal based on how you believe you should construct a kite with the given materials

1. What is the problem? What do I need to do?
2. Brainstorm Solution- What do I already know? What do I need to find out?
3. My First Ideas:



My best idea is .....

The steps I will use:

The tools and materials I will use:

Notes:

4. Test your solution

How did you test your solution?

How do you know if your idea works?

5. Evaluate your solution

How would you change your idea?

Student Worksheet

Directions: Once your kite is flying you have one student stand directing beneath the kite in the air. You should be able to visualize a triangle similar to the one below

Give estimation for the measurement of each angle and decide it is a right, acute or obtuse angle

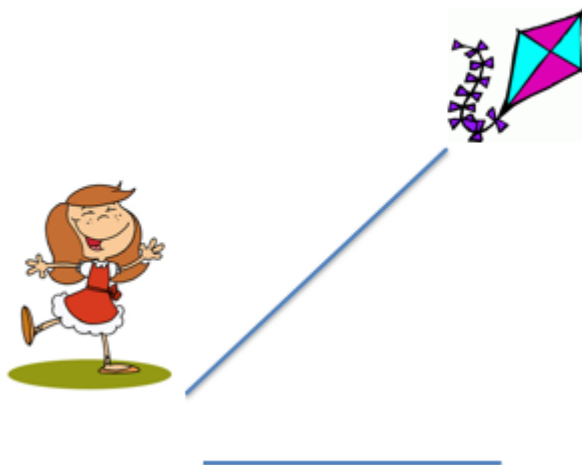
Angle 1:

Angle 2:

Angle 3:

If we know that our kite string is twelve feet long, and we can measure how far away the students are from each other how can we tell how high the kite is from the ground?

Using Pythagorean theorem solve for how high the kite is from the ground. Remember:  $a^2+b^2=c^2$



Rubric:



Task	1 pt	2pts	3pts	4pts
Students effectively applied concepts from the book and design loop to build a working kite				
Students showed a real life understanding of being able to identify a triangle and its angles				
Students were able to successfully apply Pythagorean theorem and solve for the correct height				
Students worked equally as a cohesive group and completed all tasks				

*Narrative STEM Lessons: Suggested Grade Level 5 - 6*

## Wile E Coyote – Spring Into Action

**Grades: 6**

**Unit: STEM - Force and Motion**



### Concepts from Math and Science Content Standards:

Trajectory	Angle	Range	Altitude
Attitude	Distance	Accuracy	Direction
Elasticity	Tension	Compression	Potential Energy
Kinetic Energy	Measurement	Repeatability	

### Technology:

*Standards for Technological Literacy:* Standard 2, Students will develop an understanding of the core concepts of technology.

### Engineering:

*Standards for Technological Literacy:* Standard 9, Students will develop an understanding of engineering design.

### Economics

*National Standards in Economics:* Standard 1, Scarcity: People make choices because they can't have everything they want.

### Big Ideas:

Potential Energy	Conservation of Energy	Trajectory	Measurement
Mechanical Energy	Graphing	Angle	Altitude

### Essential Question:

How can you design a spring rocket that allows Wile E. Coyote to reach his target destination without deforming his spring?

### Scenario:

Wile wants to try his super spring again. After all, he knows it can work! This time, he needs to make sure that he is ejected from the spring before the mechanical energy turns back into potential energy.

**Challenge:**

Work as a member of an engineering design team to design a spring-powered launch system that can be controlled to accurately send Wile to his target destination. Your launch system should be tested for *accuracy* and *repeatability*. The launch system must *propel* Wile over a barrier to reach his destination. The launch device that proves to be the most accurate and repeatable during testing will be determined to be the winner.

**Limitations:**

To complete this engineering design challenge successfully, teams must strictly adhere to the following design parameters:

1. Teams will be allowed one hour to: Brainstorm, conduct ideation, make sketches (using the engineering notebook), test theories, purchase tools/materials, and build a working prototype that solves the design challenge described above;
2. Teams will have a budget (**15 credits**) and may “*purchase*” materials (see Figure 1) needed to construct their launch device.
3. Your launching must be anchored to the given base.
4. After constructing a *prototype*, the engineering design team should experiment with the launch device until some measure of repeatability is achieved.
5. When your launch system is ready to be evaluated, bring it to the launch pad. You will have five attempts to officially test/evaluate your device.

*Care must be taken to not pinch fingers when working with the springs.*

**Figure 1 – Tools**

Purchases/Rentals	Tools	Cost
	1 – Cutting tool	2 credits (rental fee)
	1 – Ruler	2 credit
	1 – Protractor (May be used within design for measurement only – Should not be manipulated or damaged in any way)	3 credits

**Figure 2 – Materials**

Purchases	Materials	Cost
	1 – coil compression spring	4 credits
	1 – 8” length woven string	3 credits
	1 – Assortment recycled materials	5 credits
	1 – 8” length masking tape	1 credit
	1 – plastic tube (straw)	3 credits
	1 – Candy stick	4 credits
	1 – Sticky tack	1 credits

*\* One Paper plate base and target will be supplied to each team at no cost \**

## How Springs Work

In their most familiar form, springs are toughened coils of metal that help things return to a particular position, but they can also be used to absorb energy (car suspension) or store it for long periods of time (watches and clocks). You can find springs in everything from automatic doors to ballpoint pens. Let's take a closer look at how they work! A typical spring is a tightly wound coil or spiral of metal that stretches when you pull it (apply a force) and goes back to its original shape when you let it go again (remove the force). In other words, a spring is *elastic*. It gets longer when stress is applied but (providing you don't stretch it too much) returns exactly to its original length when that stress is removed. Depending on how a spring is made, it can work in the opposite way too: if you squeeze it, it compresses but returns to its original length when the pushing force is removed.

You can make a spring out of more or less anything—even paper or orange peel!—but the kinds of springs we use in machines work effectively only if they're stiff enough to *resist* a pulling force and *durable* enough to be stretched many times without breaking. Typically that means they have to be made from *metals* like *steel*. Some metals have a property called "shape-memory," which means they're naturally springy. Eyeglass frames are often made from nickel-titanium shape-memory metal called Nitinol.

There are several quite different kinds of springs. The most familiar ones are coil springs (like the ones in your pen). They are cylinders of wire wrapped around a circle of fixed *radius*. Spiral springs are similar, but the coil gets progressively smaller as you reach the center (paper spring). The delicate hairspring that helps to keep time in a watch is another example of a spring. Torsion springs work like the elastic in a rubber band twisted repeatedly between your fingers. Leaf springs are stacks of curved metal bars that support the wheels of a car or railroad truck and bend up and down to smooth out the bumps.

Open up a ballpoint pen (one of the ones with a button you click to retract the ball) and you'll find a spring inside. Look under a car and there are springs there too, helping the shock absorbers to smooth out the bumps in the road. There are springs in watches and clocks, as we've already seen. Once you've started spring spotting, you'll find you can see springs everywhere!



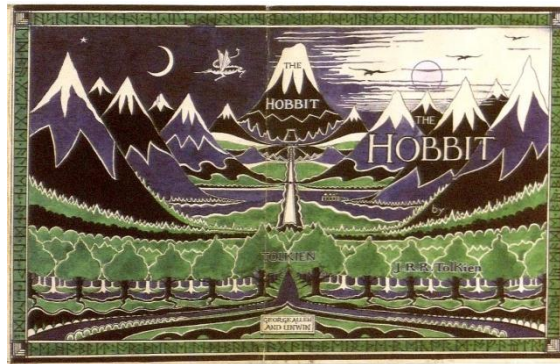
## *The Hobbit* – Lord of the Machine

Grade Level: 6

STEM Content Standards:

### **Science**

*Next Generation Science Standards:* PS3.C,  
Relationship between energy and forces: When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them.



### **Technology**

*Standards for Technological Literacy:* Standard 8. Students will develop an understanding of the attributes of design.

G. Requirements for design are made up of criteria and constraints.

*Standards for Technological Literacy:* Standard 9. Students will develop an understanding of engineering design

F. Design involves a set of steps, which can be performed in different sequences and repeated as needed.

G. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

*Standards for Technological Literacy:* Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies

E. Energy is the capacity to do work.

F. Energy can be used to do work, using many processes

### **Math**

*Common Core State Standards:* Standard 1.G.1. Draw construct, and describe geometrical figures and describe the relationships between them: Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

Big Ideas:

1. Simple machines are everywhere. We use them every day to perform simple tasks.
2. Complex machines make work easier.
3. Gears transmit rotary motion.
4. Without energy, it is impossible to do work.

5. Law of Conservation of Energy

6. Interconnection of parts allow for mechanical energy to be transmitted and provide movement

Essential Question: How can you use your knowledge of simple machines, complex machines, and transmission of mechanical power to remove the boulder and gather much needed intel on Smaug before he wakes up?

Scenario: Your team has been visited by Gandalf the Great! You have been asked to join him, Thorin, and his pack of Dwarfs to venture across the lands to reclaim the stolen homeland of the Dwarfs, Lonely Mountain. Many years ago, Smaug, a dragon that wreaks havoc across the land, conquered Lonely Mountain, claiming all of the Dwarf's ancestral treasure including their precious stone, the Arkenstone.

Gandalf has had his eye on your team and thinks your combined skills would be a great addition to the group! You agree to go on the mission. After a treacherous journey, you reach Lonely Mountain. Gandalf tells your team he wants you to find a way to get inside the mountain to gather intelligence on the dragon that may help them to defeat him. Thorin informs you of a hidden entrance that would lead one into the mountain. However, Smaug has covered this entrance with a large boulder that read "YOU SHALL NOT PASS". As you approach the boulder to take a closer look at the material, your metal button is ripped off your jacket and clings to the boulder. The boulder is magnetic!

Challenge: Your task is to move the boulder aside, scout ahead, and then report your findings back to Thorin and Gandalf! Your first task is to unblock the entryway by building a device/mechanism to remove the boulder. Your team then addresses the next challenge: explore the inside of the mountain. As a team, you both decide to not risk your lives, but to build a "drone" to travel inside the mountain and do the job for you. This is the age of technology after all!

\*Teams of two

Task 1: Remove boulder.

Task 2: Drone must travel from the entrance to the end of the board back to the entrance (one lap).

Tools/Materials/Resources:

Scissors

Ruler

Gluing agent

Cardboard/foam core/wood (if want to use CAD or AutoDesk to cut out body)

4-6 motors

4-6 various sizes of gears

Magnet

Straw

4-6 wheels

2-4 axels

School supplies (thumb tack, paper clip, eraser, pencil, etc.)

### Timeline:

Day 1: Introduce/Choose teams

Day 2: Background Research

Day 3: Brainstorm

Day 4-7: Build!

Day 8-9: Test; modify and make changes

Day 10: Present!

### Content Information:

**Machine:** device with moving parts that work together to accomplish a task; can change the size, direction, and speed of forces; change motion

**Simple Machines:** few or no moving parts; makes work easier

1. **Lever:** rigid bar that rotates around one fixed point called the fulcrum; use to apply force on loads; 3 classes of levers: include fulcrum (point about which the lever is free to rotate), load (weight or force you are trying to move), effort (force you apply)
2. **Pulley:** 2 types: single fixed (changes the direction of the force), single moveable (changes the size of the force)
3. **Wheels and Axle:** used to change the size or distance of a force
4. **Inclined Planes:** use sloping surfaces; by rolling object up a gently sloped ramp, less force is exerted, BUT the amount of energy used is spread over a greater distance.
5. **Screw:** consists of a very long inclined plane wrapped around a shaft
6. **Wedge:** consists of two inclined planes placed back to back; used to split

**Complex Machine:** use two or more simple machines to accomplish a task. Examples include can opener, wheel barrow, bicycle, and hammer.

**Gears:** used to transfer rotational motion; can be used as part of pulley system

\*how two gears turn: depends on the number of teeth on each gear; the “teeth” do not slip

\*gear vs. driven gear [input gear vs output gear]

### **Transmission**

\*machines require that rotating motion be transmitted from one place to another

\*EX- power is transmitted from an engine to the wheels of a motor vehicle.

**Clutch:** connects power source to rest of machine; operate on principle of friction; two surfaces rub against each other and lock against each other

**Pulleys and Belts:** transmit power from engine to drive engine components; five different arrangements possible interchanging the size of the input and output wheel; able to slip

**Chain and Sprocket:** chains and sprockets used as drive system to bring power to wheel; do not slip

**Shafts:** cylindrical pieces of metal used to transfer energy

**Bearings:** used to support shafts and reduce friction between metal parts as they move

\*Bicycle example: Pushing the pedal forward turns the large gear. The teeth on the large gear pull the chain which is attached to a smaller gear on the rear wheel causing the rear wheel to turn moving the bicycle forward.

**Work:** transfer of energy; without energy, it is impossible to do work

#### **\*input/output force**

\*input force includes everything you do to make the machine work

\*output force is what the machine does for you

\***Law of conservation of energy:** Energy is neither created nor destroyed; transformed output work of a machine can never be greater than the input work

**Mechanical Advantage:** increased force, speed, or distance created by machine to transmit force

\*to increase force, speed, or distance using simple machines:

**Lever:** change position of fulcrum; closer to load-increases force; closer to input-decreases strength, increases distance

**Pulley:** increase the number of strings

**Wedge:** increase with shape/size: long/thin has more mechanical advantage than short/fat

**Gear:** power in through small gear, power out through large gear-more torque, less speed; power in through large gear, power out through large gear-less torque more speed

**Magnets:** two ends- North and South

\*like ends repel; opposite ends attract

May be relevant to add content about transportation technologies?

Deliverables:

\*Challenge Worksheet

\*Design Process Worksheet

\*2 Grid Planning Worksheets (1 not to scale; 1 to scale)

Parameters/Constraints:

\*The dragon will wake up if touched! Do not run your “drone” into the dragon and risk awakening the beast!

\*“Drone” has to be controlled with a game controller.

\*The “drone” has to travel one lap: start from the hidden entrance, go to the end of the board, and back out of hidden entrance.

\*Movement on the board only.

Evaluation:

\*Rubric:

Design Process Worksheet

Challenge Completion: Did your team remove the boulder? Did your team complete one lap?

Various other evaluations: neatness, teamwork, etc.

Evaluation Rubric:

How did I do?	Points Possible	Points Earned	Teacher	Students
The problem was understood	5			
Showed ALL steps of the design process (Design Process Worksheet)	10			
Included all drawings made throughout	5			
Project followed constraints/parameters	10			
Used materials correctly	5			
Worked well with team	5			
Project was neat	5			
Presentation was clear	5			