

## LESSON: Care Package Launch (Grades 2-3, 5, 7)

### + OVERVIEW



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Students will engage in a STEM challenge to design a catapult that can land on two different targets. In this design challenge, students will learn about forces and motion in the operation of the simple machine known as a lever. Students will then design a catapult to hit two targets at two different distances. The students will be presented with the following problem: The Kingdom of All You is looking to deliver care packages to the town of Teastem, but is prevented from doing so by a large canyon. Students will put on their engineering hats to build a catapult to deliver care packages to two different target locations. Bonus points will be awarded to those who wish to build a catapult capable of successfully launching a heavier care package to both locations.

### + 2021 Science TEKS covered in this design challenge

Grade 2 TEKS: 2.1.B, 2.1.E, 2.1.G, 2.2.D, 2.6.A, 2.6.C, 2.7.B

Grade 3 TEKS: 3.1.B, 3.1.E, 3.1.G, 3.2.D, 3.7.B, 3.8.B

Grade 5 TEKS: 5.1.B, 5.1.E, 5.1.G, 5.2.D, 5.7.A

Grade 7 TEKS: 7.1.B, 7.1.E, 7.1.G, 7.2.D, 7.7.D

### + Math TEKS covered in this design challenge

Grade 3 TEKS: 3.4.F, 3.4.G

Grade 5 TEKS: 5.3.K, 5.10.F

Grade 7 TEKS: 7.3.A, 7.3.B

**+ The students will be able to meet the following objectives:**

- > Plan and conduct a descriptive investigation to demonstrate how the strength of a push and pull changes an object's motion
- > Plan and conduct a descriptive investigation to demonstrate and explain how position and motion can be changed by pushing and pulling objects
- > Plan and conduct investigations that demonstrate how the speed of an object is related to its mechanical energy
- > Investigate and explain how equal and unequal forces acting on an object cause patterns of motion and transfer of energy
- > Analyze the effect of balanced and unbalanced forces on the state of motion of an object using Newton's First Law of Motion
- > Solve a problem using the engineering design process

**+ Students will use the following STEM fluency skills:**

- > Communication
- > Collaboration
- > Creativity
- > Critical Thinking
- > Resilience
- > Time/Resource Management
- > Innovation
- > Adaptability

**+ Materials needed for this design challenge:**

|                              | <b>Grades 2</b>   | <b>Grades 3, 5, and 7</b> |
|------------------------------|-------------------|---------------------------|
| > Care Package (Marshmallow) | Free              | Free                      |
| > Small Popsicle Sticks      | 1 counter for 10  | \$10 for 10               |
| > Large Popsicle Sticks      | 3 counters for 10 | \$30 for 10               |
| > Straw                      | 1 counter         | \$10                      |
| > Glue                       | 2 counters        | \$20                      |
| > Hot Glue                   | 3 counters        | \$30                      |
| > Rubber Bands               | 1 counter for 10  | \$10 for 10               |
| > Bottle Cap                 | 1 counter         | \$10                      |
| > Plastic Spoon              | 2 counters        | \$20                      |
| > Scissors                   | 2 counters        | \$20                      |

**+ Facilitator materials:**

- > Projector and computer
- > Internet access or download video
- > Slide deck for the lesson
- > Copies of the scorecard for each group
- > Fan with multiple speeds
- > Tape to mark targets
- > Basic lever with a jumbo popsicle stick on top of a stack of regular popsicle sticks (fulcrum)

**+ FACILITATION GUIDE**

| SECTION      | PROCEDURE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| INTRODUCTION | <p><b>Slide 1: Care Package Launch</b></p> <ul style="list-style-type: none"> <li>&gt; Introduce today's lesson on catapults. This lesson may include unfamiliar vocabulary for students. The facilitator may need to review the terms simple machine, lever, fulcrum, and catapult.</li> </ul> <p><b>Slide 2: Lever</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students if they know what a simple machine is. Ask for examples of simple machines. Ask students if they know which simple machine is on the slide. <ul style="list-style-type: none"> <li>▪ Explain to students that a lever is a simple machine with a beam pivoted at a fixed point known as a fulcrum. <ul style="list-style-type: none"> <li>• <i>Teacher's Note: If students are unsure of what a simple machine is, explain that a simple machine is a device used to change the direction or magnitude (strength) of a force. In other words, they multiply the amount of force.</i></li> </ul> </li> <li>▪ Show students an example of a lever (see-saw) and ask students if they have seen something like this before and where.</li> <li>▪ Explain to students that the purpose of a lever is to provide leverage. This allows the output force to exceed the input force.</li> <li>▪ Demonstrate the popsicle stick lever for students. Alternatively, it may be demonstrated with a pre-built catapult.</li> </ul> </li> </ul> <p><b>Slide 3: Catapults!</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students if they have seen a catapult before. Ask students to explain why they are used. <ul style="list-style-type: none"> <li>▪ Explain to students that catapults are used to launch very heavy objects over long distances.</li> <li>▪ Play <a href="#">video</a></li> </ul> </li> </ul> <p><b>Slide 4: Engineering Design 1</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students the question. What is engineering? <ul style="list-style-type: none"> <li>▪ Explain to students that engineering is when engineers take what they know and apply it to solve problems by designing a product or process.</li> <li>▪ For example, phones could only be used at home or in specific locations. Why is this a problem? (Needing to make a call outside the home). What solution did engineers design to fix that problem? (Cell phones).</li> </ul> </li> </ul> |

- *Teacher's Note: Any example can be used here, but focus on examples that students are familiar with.*

**Slide 5: Engineering Design 2**

- > Ask students the question. What are some examples of engineering jobs?
  - *Teacher's Note: If students have trouble giving examples, ask students who they think makes the things they use. Who makes refrigerators, cars, helmets, cell phones, and sneakers?*

**Slides 6-7 STEM Careers**

- > Show students pictures related to careers connected to the challenge.
- > Mechanical Engineering
  - Ask students what they see in the pictures.
  - The people who designed and built catapults are mechanical engineers. They design and build many different kinds of machines with their understanding of kinetics and ballistics.
- > Materials Engineering
  - Ask students what they see in the pictures.
  - Materials engineers use their understanding of science to improve the materials used to build something. Materials engineers work in all areas, from the shoes you wear to the materials used in catapults and the things we put on them.

**Slides 8-9: Try the Trade**

- > Carpentry
  - Ask students what they see in the pictures.
  - Explain to students that these are carpenters at work. Ask students what they think a carpenter does. Explain that carpenters build strong structures such as homes, furniture, playgrounds, and catapults.
  - Ask students why it is important for homes to be built carefully and with strong materials. Explain that carpenters must think about strength, stability, and safety when designing structures. If a product is poorly built, strong winds, storms, or other forces could damage it.
- > Construction Inspection
  - Ask students what they see in the pictures.
  - Explain to students that these are construction inspectors at work. Ask students what they think a construction inspector does. Explain that construction inspectors check projects during and after construction to make sure they are safe, are built according to the plans, and meet all requirements.
  - Ask students why it is important to test and inspect something before it is used. Explain that construction inspectors look for problems, identify safety concerns, and make sure the project is built correctly and works as intended.

- Explain to students that engineers design and build solutions, while inspectors carefully examine the work to make sure it is safe and meets the project goals.

**Slide 10: Engineering Design 3**

- > Ask students the question: Who can be an engineer?
  - Anyone!

**Slide 11: Engineering Design Process Steps**

- > Ask students if they think all engineers solve their problems in one try. Explain to students that it takes many tries to get something correct in engineering. In engineering, there is no such thing as a mistake; there are only opportunities to learn. It is okay to fail. Just find the mistake and correct it. In engineering, there is never one correct solution. There are always many solutions to a problem, and there are always improvements that can be made. The steps that engineers take to find these solutions are called the *engineering design process*.
- > Ask students to read the first big step (Identify).
  - What does identify mean? (To point out or find). Engineers design solutions: what do they need to know first to find the answer? (The problem)
  - How do people know when they have found the correct answer? In engineering, there are no correct answers, just better ones. Explain to students that there are expectations that engineers must meet, called *criteria*. For example, when engineering a football, what does a football need to do? (Bounce, look a certain way, have laces, have air inside, etc.). Those things are all called criteria. By comparing the design to the criteria, an engineer knows a solution will work. Is a child-sized football the same as an adult football? The criteria for both footballs include leather, white laces, and shape. However, the two footballs would have different size criteria. The footballs are similar but differ in certain criteria.
  - Once the criteria are understood for the design challenge, what could make it difficult for an engineer to design their solution? (Money, time, materials, etc.) Explain to students that these rules are called *constraints* or rules that engineers must follow. Engineers are given constraints they must follow when solving a problem. Think about football again. What are college and professional footballs made from? (Leather). What if, instead, the rule (or constraint) was not to use leather? Could another type of football be made instead? Many of the footballs for sale are made of rubber because the engineer had different constraints.
- > Ask students to read the next step (Imagine).
  - Ask students what imagine, or imagination, means. Are these things real or tangible? They may not be real, but they help us imagine what things could be. In this step, see what materials are

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|                 | <p>available, then brainstorm possible ideas/solutions to the problems.</p> <ul style="list-style-type: none"> <li>▪ Explain to students that there are no right answers in engineering. Start with as many ideas as possible.</li> </ul> <p>&gt; Ask students to read the next step (Plan).</p> <ul style="list-style-type: none"> <li>▪ The third big step of the engineering design process is to plan out the idea. Make sure that what is designed can be repeated. A plan will help an engineer identify where mistakes happen so they can be fixed.</li> <li>▪ When planning, begin with the brainstorming phase. Each team member will contribute their ideas, and then the team will combine them!</li> <li>▪ Once ideas are combined into a single group idea, determine what materials will be used for the solution and make sure the design meets the criteria and constraints of the project.</li> </ul> <p>&gt; Ask students to read the next step (Create).</p> <ul style="list-style-type: none"> <li>▪ The fourth step is to create! Since this is the very first creation, it is called a <i>prototype</i>. A prototype is a first or preliminary model of something from which other forms are developed or copied. A prototype is created to test the engineer's idea or concept. Engineers ask themselves, "Did the idea work the way we wanted it to?" After testing the idea, the engineer will make improvements to the prototype.</li> </ul> <p>&gt; Ask students to read the last step (Improve).</p> <ul style="list-style-type: none"> <li>▪ Finally, the last step is to improve. How does an engineer know if the prototype did well on the test? It must meet certain expectations and follow some rules. But how do engineers determine how well it met expectations and followed the rules? In school, how do you know if you mastered something? (Grades). The prototypes made today will be scored using a scorecard or rubric. By looking at the score, each team will determine if the design could be better. If improvements are needed, the team will revisit the plan and decide how to improve the score. Remember, there are no correct answers in engineering, just better solutions.</li> </ul> |
| <b>IDENTIFY</b> | <p><b>Slide 12-13: Identify – Problem</b></p> <ul style="list-style-type: none"> <li>&gt; Have students read the bolded section. <ul style="list-style-type: none"> <li>▪ Ask students to <i>identify the problem</i>.</li> </ul> </li> <li>&gt; Explain to students that they will put their engineering hats on to design a catapult that can send their care package to two different target locations.</li> </ul> <p><b>Slide 14: Identify – Criteria (Desired Outcomes)</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students what criteria or desired outcomes mean. <ul style="list-style-type: none"> <li>▪ Explain to students that the criteria are what engineers use to determine if they are successful.</li> </ul> </li> <li>&gt; Ask students what determines if the solution is successful today.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

- A successful catapult design should include the following:
    - A seat for the care package
    - An accurate launch system (measured by the package landing in both locations, as indicated by the tape, within five tries)
    - A lever
    - Maintain structural integrity during use
    - At least three different materials
- Bonus points will be awarded if the catapult successfully sends a larger care package to both locations.

**Slides 15-18: Identify – Constraints (Limitations)**

*\*DELETE OTHER GRADE SLIDES\**

- > Ask students what constraints or limitations mean.
  - Explain to students that those constraints are rules the engineers must follow.
- > Explain the constraints for this engineering design activity:
  - Time Limit: Students will have 30 minutes to build the catapult.
  - Materials: Students may only use the available materials.
  - Budget: Students will have \$100 or 10 counters to complete this challenge.
    - *Teacher's Note: For grade 2, 10 counters will be given to each group instead of money. Pre-bag the counters for easy distribution to each group. When students go to the supply table, they will hand the teacher one counter for each item they buy.*
    - *Teacher's Note: If play money is available, we recommend using it. Monetary values may feel too abstract for students, so providing something more tangible will help.*
  - Collaboration: One design element from each team member must be used in the final design. Explain to students that a design element is taking one part of someone's idea and adding it to another.
  - Redesign: Each team can test its prototype as often as needed during the 30-minute design phase. Remind students what a prototype is. It is the first creation of our design.
    - *Teacher's Note: When a team is ready to test their design, they should raise their hand, and the teacher should assist the team with their score. If the team receives a low score on any part of the design, the team should redesign if they still have time.*

## IMAGINE

### Slides 19-20: Imagine – Explore Materials

*\*DELETE OTHER GRADE SLIDES\**

- > Students will be presented with the materials needed to create a catapult. The teacher or facilitator will hold up a working example of a catapult built with only popsicle sticks and rubber bands. The default care package is a tiny marshmallow. Let students know there are additional points for sending a jumbo marshmallow.

### Slide 21: Imagine – Brainstorm

- > Give students one minute to individually design and draw a plan of what they think their catapult should look like. Emphasize that students should not talk during this minute or share ideas. Remind students that their ideas will be used as design elements for the final design.
- > After a minute, give students five minutes to present and share their ideas with their group. Let students know that, when sharing, they should focus on the key aspects of their idea they like and want to use as design elements in the final design.
  - *Teacher's Note: If students struggle with an idea for their design, provide ideas without giving a solution. For example, "This is a design that I tried earlier, but it failed. What could I do to improve it?" Emphasize that the design failed to reinforce that it is okay to fail and to let students know they cannot copy the design and expect success.*

## PLAN

### Slide 22: Plan – Plan Development

- > Hand out the scorecard that will be used during the design challenge. Review the testing criteria with the class and answer questions. The testing criteria will inform their design decisions.
- > Have students collaborate to come up with a final design. Let students know they must include at least one element from each team member for their final design.
- > Ask students again what the design criteria are:
  - A successful catapult design should include the following:
    - A seat for the care package
    - An accurate launch system (measured by the package landing in both locations, as indicated by the tape, within five tries)
    - A lever
    - Maintain structural integrity during use
    - At least three different materials

Bonus points will be awarded if the catapult successfully sends a larger care package to both locations.
- > Teams will need to select the materials to be used for the design and develop a budget for the project. Students will have \$100 to purchase materials for their build at the classroom supply table. The prices used in this challenge can be found in the materials list. Students will raise their

hands when they are ready to purchase materials. The teacher will ensure that the appropriate amount of money is spent on each material, but will not guide students in following their budget. Students can go over budget if they want to, but remind them that they will lose points on their scorecard.

**Slide 23: Plan – Team Member Responsibilities (Career Role-Playing)**

- > Assign each student a career role within their team. As students complete the challenge, they should make decisions and contribute from the perspective of their assigned career. This activity models how STEM and skilled trade professionals collaborate in the real world to design, build, test, and improve their prototype.
  - Carpenter: Builds the catapult with assistance from the group
  - Construction Inspector: Draws the team's plan for the house and ensures the catapult follows the plan and is safe to operate
  - Materials Engineer: Tests that materials are working as planned and keeps track of the building materials and budget
  - Mechanical Engineer: Tests the Catapult's ability to deliver a package and works with the team to make improvements, if needed

**CREATE**

**Slide 24: Create – Design Your Catapult**

- > Let students know to have fun, be creative with their designs, and work together.
- > Remind students that being an engineer is not about getting the solution on the first try. There is no right answer, just better solutions.

**Slide 25: Identify – Criteria**

- > Display the reminder slide for students to look at while working.

**Slides 26-31: Create – Test**

*\*DELETE OTHER GRADE SLIDES\**

- > Students will calculate their scores when testing in front of the teacher or facilitator. The teacher will go through each category on the scorecard with the students. The students will mark their scores and calculate the total.
- > The teacher will recap the point total with the students and how many points the team received for each category to make sure it matches what the students recorded.
- > Students should explain how they are adjusting between each attempt to hit the target. The facilitator or teacher should ask students what happens to the marshmallow as they pull the catapult arm farther back.

## IMPROVE

### Slide 32: Improve – Redesign: Discussion

- > Students will reflect on their scores and discuss the following:
  - What worked?
    - *Teacher's Note: Focus on the materials being used and ask why students think those materials were helpful. Have students compare designs and see what seems to work best and why. If students completed the extension, ask whether they needed to make any adjustments to be successful.*
  - What did not work?
    - *Teacher's Note: Focus on the materials being used and ask why they think those materials did not work as well. Have students compare their designs, noting what seemed to create difficulties and why. If students completed the extension, ask them what made the larger care package more difficult.*
  - What do you want to improve?
    - *Teacher's Note: Focus on engineering aspects, including the following questions. Ask students if they found a solution or just part of one. Reinforce that it is okay not to succeed on the first try and that engineering is about making improvements over time. Ask students how they would design their catapult differently if they had no rules. Ask students if working together was difficult. Learning to work together is very important, and it is easier to find a solution with many ideas rather than just one idea.*