# STEM Stories: The Knights Before Christmas
## Lesson Plan

**STEM Career Connections:** Mechanical Engineering, Civil Engineering, Construction and Architecture

**STEM Disciplines:** Science, Technology, Engineering and Mathematics

**Non-STEM Disciplines:** English Language Arts

**Design Challenge Problem/Scenario:**

You have arrived at a castle with a load of presents for the people inside, but the Knights in the castle won't open the door! In order to get the presents to the people inside, you will need to build a catapult and fling the presents over the walls! A great amount of force is being applied to the presents in order to transfer enough kinetic energy to them and give them enough speed to make it over the castle walls. Many presents are being damaged when they hit the ground at high speed. You will need to solve this problem by designing a way to protect the presents from being damaged as they are sent into the castle and hit the ground.

**Engineering Design Challenge:**

Your team's challenge is to build a catapult that will fling presents--represented by a cracker--over the walls. You also want to make certain that the cracker does not break when it hits the ground. So, you will design a way to safely transfer the potential energy in the catapult into kinetic energy in the cracker without the cracker breaking upon impact. Your design can include only the materials provided.

**Essential Question Students Investigate:**

How can my team design and create a catapult to fling presents into a castle? How can my team design and create a cushioning system to protect the presents?

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**Enduring Understandings:**

- Using the engineering design process when approaching problems results in unique solutions.
- Collaboration and following the engineering design process lead to more creative and effective solutions to problems.
- Increasing the strength of a force applied to an object will increase the amount of kinetic energy transferred to the object; the object's speed and distance traveled also increases.
- Increasing the speed an object travels also increases the force of impact the object experiences as its kinetic energy is suddenly stopped by an opposing force (such as the ground).

**English Language Arts Standards:**

- RL.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RL.3.3 Describe characters in a story (e.g., their traits, motivations or feelings) and explain how their actions contribute to the sequence of events.
- W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.
- 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.
- SL.3.6 Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

**Science Standards:**

Science Inquiry and Applications, Technological and Engineering Design
During the years of PreK to grade 4, all students must develop the ability to:

- Plan and conduct simple investigations
- Employ simple equipment and tools to gather data and extend the senses
- Communicate about observations, investigations and explanations
- Review and ask questions about the observations and explanations of others
- Identify problems and potential technological/engineering solutions
- Understand the design process, role of troubleshooting

Grade 1: PHYSICAL SCIENCE: Motion and Materials

- Objects can be moved in a variety of ways, such as straight, zigzag, circular, and back and forth.

Grade 2: PHYSICAL SCIENCE: Changes in Motion

- Forces change the motion of an object.

Grade 4: PHYSICAL SCIENCE: Electricity, Heat, and Matter

- Energy can be transformed from one form to another or can be transferred from one location to another.

Grade 5: PHYSICAL SCIENCE: Light, Sound, and Motion

- The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

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**Mathematics Standards:**

- Represent and interpret data. CCSS.MATH.CONTENT.3.MD.B.4 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.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Multiply one-digit whole numbers by multiplies of 10 in the range 10-90 (e.g., 9 x 80, 5 x 60) using strategies based on place value and properties of operations.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Interpret products of whole numbers, e.g., interpret 5 x 7 as the total number of objects in 5 groups of 7 objects each.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.
- Multiply and divide within 100. CCSS.MATH.CONTENT.3.OA.C.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 x 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

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**Materials List:**

| Material | Quantity per Team | ✓ | Quantity per Kit | ✓ |
|---|---|---|---|---|
| *The Knights Before Christmas* by Joan Holub | ~ | | 1 | |
| Craft Sticks *(standard-size)* | 8 | | 104 | |
| Craft Sticks *(jumbo-size)* | 2 | | 26 | |
| Cotton Balls | 2 | | 26 | |
| Tissues | 2 | | 26 | |
| Cracker Packets *(Individually wrapped)* | 1 packet | | 13 packets *(Individually wrapped)* | |
| Coffee Filters | 1 | | 13 | |
| String | 1 foot | | 13 feet | |
| Scotch Tape | 4 inches | | 72 inches | |
| Rubber Bands | 5 *(Catapult-3 / design-2)* | | 65 | |
| Catapult *(for testing)* | ~ | | 1 | |
| Paper | 5 sheets | | 40 sheets | |
| Pencils | 5 | | 40 | |

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**Activity 1**

**Introduction: 15 minutes**

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Describe the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc.).
- Introduce *The Knights Before Christmas* by Joan Holub by reading the title and author and examining the cover illustration. What might our Design Challenge be about this time? Invite predictions.
- Build background knowledge by asking students how they celebrate winter holidays. Make a list of the different holidays students know about (Kwanzaa, Hannukah, etc.). One way to celebrate is by preparing for a visit from Santa Claus.
- In this story, three knights who live in a castle get a visit from Santa Claus.

**Pre-Reading: 10 minutes**

- Display Slide 2 of the Power Points: Introduce the vocabulary words students will encounter in this story.
- Paste the Vocabulary Chart into the STEM journals (ENTRY #X).
- Pre-teach each word below by showing an image or video clip to demonstrate its meaning. Invite discussion about the meaning of the words. Ask students to write or draw a meaning of the word in their own words on their charts.
    - Illustrious
    - Dire
    - Decrees
    - Ransack
    - Battlement
    - Lout
    - Consult
    - Duked
    - Chivalrous
    - Bounty
    - Fierce
    - Rapid
    - Volley
    - Bleak
    - Triumph
- Explain that there may be other words in the story that they do not know the meaning of. Review strategies for determining the meaning of unknown words in a story:
    - Read the words around it and try to determine a meaning based on the context.
    - Look at parts of the word you do know and make a guess at the meaning of the word.
    - Look for clues in the picture.

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- Ask someone else! Use your resources. As we read, ask about words you do not know.

**Read Aloud: 20 minutes**

- Distribute the word signs to several students. Explain that those who do not have a sign today will have a turn on subsequent days of the module.
- As we read the book, listen for the word on your sign. When we read it, stand up and hold your sign up!
- After the read aloud, discuss each word (if time allows) again to clarify any misunderstandings. If time is limited, select key words to discuss and clarify.

## Activity 2

**Introduction: 5 minutes**

- If needed, show the students the book again to review, and do a picture walk to remind them of the events of the book.

**Post Reading: 15 minutes (choose one or both depending on time and ability)**

- Frozen Tableau: Put students in pairs and assign them one of the vocabulary words from the previous activity. They should "act" out the word in a "freeze frame", as statues. The rest of the class should try to guess each pair's word. Post the words on the board or chart paper for reference during the activity.
- Word Sort: Distribute the word sort cards to each student. Ask them to cut the words apart (or you can do this ahead of time, but allowing students to cut gives them kinesthetic experience with the words if time allows). Ask them to sort the words into common categories on their desk. They should look for similar patterns, such as "kn", "igh", "wr", and can have an "oddball" group. Ask them to check their sort with a partner when they are finished. You can walk around and check and provide guidance as well. Once the sorts are completed, they should glue the words down onto a blank page of their STEM notebooks, title the entry "Word Sort", date the entry, and add it to the table of contents.

**Quick Write: 15 minutes**

- Distribute a word card to each student. Ask them to write a story about their word in their STEM journals. A story should have a beginning, middle, and end. Adjust the length requirement for individual needs (three sentences, five sentences, several paragraphs, etc.). They can also draw a picture instead of, or in addition to, the story to illustrate the meaning of their word(s).
- Invite students to share their word stories and illustrations with the class.

**Application: 20 minutes**

- Display slide 3 of the PowerPoint: Ask the students to share some ideas about what engineers do for their jobs.
- Slides 4: Continue the discussion about what engineers do for their jobs.

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- Slide 5: Play the Mythbusters youtube videos showing them designing and testing a trebuchet, a type of medieval catapult.
  https://www.youtube.com/watch?v=9-Hwxw4fgqk
  https://www.youtube.com/watch?v=bHs5KC0SafU
- Slide 6: Present the Design Challenge Problem.
  - Design Challenge Scenario: You have arrived at a castle with a load of presents for the people inside, but the Knights in the castle won't open the door! In order to get the presents to the people inside, you will need to build a catapult and fling the presents over the walls! A great amount of force is being applied to the presents in order to transfer enough kinetic energy to them and give them enough speed to make it over the castle walls. Many presents are being damaged when they hit the ground at high speed. You will need to solve this problem by designing a way to protect the presents from being damaged as they are sent into the castle.
- Slide 7: Present the Engineering Design Challenge.
  - Engineering Design Challenge: Your team's challenge is to design a way to safely transfer the potential energy in the catapult into kinetic energy in the cracker without the cracker breaking upon impact. Your design can include only the materials provided.
- Slide 8: Explain or share the Design Goals.
  - Create a working catapult that can fling a cracker.
  - Use only the materials provided to create a cushioning system to protect the cracker from breaking.
  - Have fun!!
- Slide 9: Introduce the resources/materials available.
- Slide 10: Explain the design testing procedures.
  - First get approval for your working catapult!
  - Once the catapult is approved, load a cushioned cracker and launch it.
  - If the cracker travels at least 30 centimeters and survives the impact, the design was successful!
- Slide 11: Explain the Engineering Design Process
  - Give students the Engineering Design Process Graphic Organizer STEM Challenge handout and The Knights Before Christmas: Engineering Design Process student handout.
- Slide 11: Have the students complete the "Ask" step of the Engineering Design Process.
  - Ask the students to notice that the word Ask is in one of the circles of the Engineering Design Process both on the PowerPoint and on The Knights Before Christmas: Engineering Design Process student handout.
  - Students should Ask themselves what materials they would like to use to build their cracker cushioning system.
  - Students should write these materials on their STEM Challenge handout.
  - Walk around as the students complete the Ask step of the Engineering Design Process.
- Slide 11: Explain to the students that the next time they meet, they will spend time on the Imagine step in the Engineering Design Process. In fact, you can ask

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students to start imagining what their cracker cushioning system will look like when they are at home, and they can share their ideas with their families.

**Wrap Up: 10 minutes**

Review what was learned during today's lesson.

- Invite a retelling of the book by asking students to share what happened first, second, third, and so on in the story.
- Review the idea that a story has a beginning, middle, and end.
- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will continue the Engineering Design Process so that they can imagine and plan to build their catapult and cushioning system.
- Distribute the parent letter to each student.

## Activity 3

**Introduction: 5 minutes**

- Remind the students that during the previous session they read and discussed the book *The Knights Before Christmas* by Joan Holub and were presented with a Design Challenge Problem/Scenario and Engineering Design Challenge. Generate a discussion about the Design Challenge Problem and Engineering Design Challenge. Do a "picture walk" through the book to remind students of the main idea.

**Engineering Design Process, Imagine: 15 minutes**

- Display slide 11 of the PowerPoint:
    - Ask the students to notice that the word Imagine is in one of the circles of the Engineering Design Process both on the PowerPoint and on The Knights Before Christmas: Engineering Design Process student handout.
    - Students should Imagine what their cushioning device will look like.
    - Students should draw a picture or write a description of their cushioning device on their STEM Challenge handout.
    - Walk around as the students complete the Imagine step of the Engineering Design Process.
    - Ask the students to share their ideas with their team.
    - Walk around as the students share their ideas with their teammates. Make sure that each student is given ample time to share his or her ideas. Students get excited about wanting to build a catapult and cushioning device and often rush through the sharing process. Remind students that the sharing process is extremely important as engineers often alter their designs based on ideas shared during the brainstorming process.

**Engineering Design Process, Plan: 15 minutes**

- Display slide 11 of the PowerPoint:

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- Ask the students to notice that the word Plan is in one of the circles of the Engineering Design Process both on the PowerPoint and on The Knights Before Christmas: Engineering Design Process student handout.
- Students should Plan as a team what their cushioning device will look like.
- Students can use teammates' ideas or a combination of the teams' ideas, but remind them that they must create one cushioning device together as a team.
- Students should draw a picture or write a description of their cushioning device on their STEM Challenge handout.
- Walk around as the students complete the Plan step of the Engineering Design Process.
- Make sure all students are contributing to the planning process. Often the dominant students expect the other students to use his or her ideas. Remind students that coming to a team consensus is important as engineers are often expected to plan with a group of people.
- Ask students probing questions about their cushioning device:
  - How did you combine your individual design ideas?
  - Why did you choose that design?
  - How did you create the idea for this design?
  - What are your reasons for selecting the material for your cushioning device?
- Before allowing teams to build their catapult and cushioning device, require them to gain approval of their sketch of the team's prototype design idea. You can write "Approved" beside the sketch on a student's paper or hand them a note card with "approved" written on it. A colored note card works nicely as you can easily see if a team has the note card on their desk or table before they begin to work with the materials.

**Engineering Design Process, Create a Catapult: 30 minutes**

- Slides 11, 12, & 13: Teams create their catapult
  - Display slide 11 and ask the students to notice that the word Create is in one of the circles of the Engineering Design Process both on the PowerPoint and on The Knights Before Christmas: Engineering Design Process student handout. Ask students to draw a picture on the STEM Challenge handout of the catapult and cushioning device they plan to create.
  - Play the video (2m19s) http://www.youtube.com/watch?v=XchdUB-ZnKc showing how to construct the catapult and have the students follow along if possible. After the video is finished, display slides 12 & 13 to help the students create their catapults.
  - It is recommended that you create one catapult yourself to use to help the students during the construction step.

**Wrap Up: 10 minutes**

- Ask students to place their handouts and materials in a safe location and to clean up their area.

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## Activity 4

**Set-Up:**

- Designate space for displaying and gathering available materials.
- Designate space for each team to collaborate and build their design ideas. Also, make sure all students will be able to see the presentation.
- Designate space for design testing. Make sure there is room for all students to observe.

**Buying Time!: 15 minutes**

- Display slide 14: Students work as a team to decide what materials they want to purchase to create a cushioning device. The materials are on slide 14 of the PowerPoint and on the Knights Before Christmas: Buying Time! handout. Students should use the table in the student handout to record the number of each item they want to purchase, the cost associated with each item, and the total cost of all items.
- Walk around the room as the students discuss the materials they would like to purchase.
- Once a team is ready to purchase their materials, have them tell you the cost of the materials they would like to purchase and the change they should receive.

**Engineering Design Process, Create a Cushioning Device: 30 minutes**

- Slide 15: Teams create their cushioning device.
    - As the students are creating their cushioning device, walk around the room and ask them probing questions about their design. For example:
        - Why did you choose those materials for the design?
        - Will the design be soft enough for the cracker to not break?
        - Will the design be sturdy enough that it will not fall off in flight?

**Optional Testing:**

- Inform the students that the cracker cushioning device testing will be tomorrow, but if they have finished building their cracker cushioning device, they can use the remaining time to test their catapults by flinging small erasers at targets. Have the students place the target 30 centimeters away from their catapults.
- It is recommended to use the push-on pencil erasers that have a flat side.
- Students should not launch their erasers at each other.
- Students should draw a bullseye target on a piece of paper and try to get the eraser to land in the center of the bullseye to practice using the catapult to launch projectiles.

**Wrap Up: 10 minutes**

- Ask students to place their handouts and materials in a safe location and to clean up their area.
- Distribute a parent letter to each student.

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**Activity 5**

**Introduction: 10 minutes**

- Show the students the book, *The Knights Before Christmas*, and ask them to raise their hands and offer a one-sentence summary of the book. Invite as many one-sentence summaries as time allows. Alternatively, ask the students to turn to a partner and tell a one-sentence summary of the book. Remind students that they are working on designing and building a cushioning device for a cracker.
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they created a catapult and designed a cushioning device.
- Today, students are going to test their catapult design and cushioning device.

**Cushioning Device Testing: 20 minutes**

- Slide 16: Each team tests their prototype cushioning devices while other teams observe.
    - To test the catapult and impact cushioning system, have the students use the catapult to fling a cushioned cracker. If the cracker travels more than 30 centimeters and does not break the design is said to be successful. If the crackers do not break on the first round, elevate the catapult and do a round two! This time the catapult should be placed on a table in a position where the cracker will be launched off the table to the floor (at least a 60 centimeter drop). Have the students measure the distance from the table to the floor so that it is 60 centimeters.
    - Students should complete the Knights Before Christmas: Test and Improve Your Device handout.

**Reflection: 10 minutes**

- Slide 17: Students should discuss with their team:
    - What do you like best about your cushioning device?
    - What would change about your cushioning device?
    - What aspects of other team designs stood out to you?
    - Did other designs give you any ideas for ways to improve your design?
    - What modifications will you make to redesign your cushioning device?
    - How did the materials you chose affect the ability of your cushioning device to prevent the cracker from breaking?
- Ask some students to share their ideas with the entire class.
- Ask the students if they have any ideas as to what type of engineer might design and build catapults and cushioning devices.

**Engineering Design Process, Improve: 30 minutes**

- Slide 18: Students use what they have learned testing their designs to modify their cushioning devices to make them better.
    - Students should draw a picture or write a description of their improved cushioning device on their STEM Challenge handout.

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- As the students are working on their new designs, walk around the room and ask them probing questions about their redesign. For example:
  - How well did your first design work?
  - Why are you making that change?

**Redesigned Cushioning Device Testing: 20 minutes**

- Each team tests their redesigned cushioning devices while other teams observe.
  - If the cracker travels more than 30 centimeters and does not break the design is said to be successful.
  - Celebrate each team's design by having the class applaud for that team after that team shares their design.

**Wrap Up: 20-30 minutes**

- Ask students to place their handouts and materials in a safe location and clean up their area.
- Discuss text-to-self, text-to-text and text-to-world connections with the students. Put the Text Connections handout on the overhead or Elmo machine so all students can see it and explain each type of connection.
- If time allows, read the story, *The Knights Before Christmas,* again. As you read, ask the students to make text-to-self, text-to-text or text-to-world connections between what they hear in the story and the STEM challenge. Ask them to keep track of their connections using tally marks for each connection on a blank copy of the handout, which can be pasted into the STEM journal as an additional entry.
- Stop periodically throughout the story to share your own connections as a model, then invite students to share their connections. Remind them of the importance of using "textual evidence" to make their connections. Ask, "What sentence or picture in the story helped you make that connection?".
- (Optional Writing Activity) Ask the students to write a one paragraph summary of their connections to the book and the STEM challenge in their STEM notebooks.
- Slide 19: Conclude by discussing the following questions as post-activity surveys are distributed.
  - What ideas do you have for engineering a better world?
  - How can you turn ideas into reality?
- Allow time for students to complete their post-activity survey.
- Distribute the parent letter to each student.

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