Catapulting into Denmark

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Target Grade: 5th Grade Science

Time Required: Two 45-60 minute class periods

Standards:

- **5.ETS1.1 Engineering Design** Research, test, re-test, and communicate a design to solve a problem
- **5. ETS1.2 Engineering Design** Plan and carry out tests on one or more elements of a prototype in which variables are controlled and failure points are considered to identify which elements need to be improved. Apply the results of tests to redesign the prototype
- **5.ETS1.3 Engineering Design** Describe how failure provides valuable information toward finding a solution
- **5. PS2.1 Motion and Stability: Forces and Interactions** Test the effects of balanced and unbalanced forces on the speed and direction of motion of objects.
- **5.PS2.2 Motion and Stability: Forces and Interactions** Make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion
- **5.PS2.3 Motion and Stability: Forces and Interactions** Use evidence to support that the gravitational force exerted by Earth on objects is directed toward the Earth's center

Lesson Objectives:

The learner will:

- Design and build an army man launcher
- Test the effects of force (applied and gravitational) on the motion of an army man launched from a catapult
- Identify specific factors that will determine and effect how the launcher performs, such as design, applied force, etc.
- Record and analyze data from catapult design tests

Central Focus:

This two day lesson integrates multiple content areas: engineering design, motion, English/language arts, and mathematics. Students have the opportunity to design, create, and test a catapult that launches a plastic army man to model troops launching into Denmark during WWII. Students also are collecting and analyzing data from the army man catapult launching to develop a conceptual understanding of force and motion. The objective of this lesson is to practice engineering design and use their catapult design to understand how factors such as force and mass affect the motion of an object.

Materials

Teacher

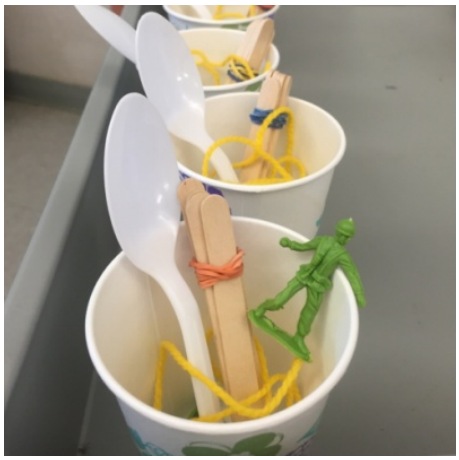
- Smartboard/projector
- Excel (optional)

Individual:

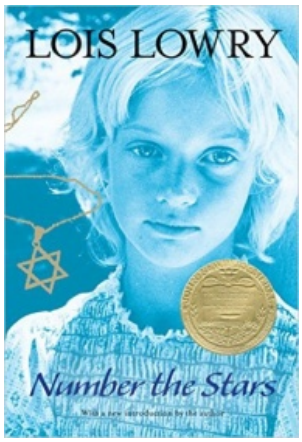
- Activity worksheet
- 1 piece of paper for design purposes (optional)
- 1 pencil

Per group (3-4 students per group):

- 1 scale
- 1 timer (or phone)
- 1 Dixie cup
- 1 Plastic spoon
- 1 toy army man
- 2 Rubber bands
- 2 feet of tape
- 2 feet of string
- 4 popsicle sticks



Background Information:



In ELA, students have read the book Number the Stars. As a STEM extension to their ELA studies, students engage in designing catapults to model troops being sent into Denmark during WWII. The overall purpose of this lesson is to connect and engage with the text using an interacting STEM activity that allows students to use their knowledge of force and engineering to create a launcher or catapult which would send troops over the border into Denmark.

Day 1 Instruction:

Introduction (5-10 minutes)

- Motivator: Like we read in the book "Number the Stars," during WWII, troops were sent to Denmark in an effort to restore order. The goal of our lesson today is to design, construct, and use a catapult that will represent troops being launched into Denmark territory.

- Hook: Does anyone know what a catapult is? (Example= while I don't encourage this, a catapult is similar to the idea of using a spoon to launch food at your friends!)

- Introduce problem for students to solve: The problem we are addressing today is the army men must be strategically and accurately launched over the Demark border in order to successfully "complete the mission", and it is your mission to use provided materials to construct a catapult that will launch a plastic army man at least 3 meters. Plastic army men will represent the troops and a string 3 meters away from the launcher will represent the Denmark border.

- Refer to objectives: 1) Design and build an army man launcher, 2) Test the effects of force (applied and gravitational) on the motion of an army man launched from a catapult, 3) Identify specific factors that will determine and effect how the launcher performs, such as design, applied force, etc., and 4) Record and analyze data from catapult design tests

Activity (35-45 minutes)

Part 1: Divide students into groups of 3 or 4 and pass out materials (Dixie cup, spoon, army man, rubber bands, popsicle sticks, balance scale, tape, tape measure, string, stop watch, and activity packets)
Part 2: Provide directions for the activity, explain the expectations with whole group/small groups, and model how to complete the activity
Part 3: Complete Page 1 of the Activity Packet as a class. Students will choose their group role, students will measure the mass of the army man with the scale, and students will identify the variables of the experiment
Part 4: Groups have 25-35 minutes to develop their first catapult design, test their design, and record the data (students should have pages 1-3 of the activity packet complete)
Part 5: Teacher circulates the classroom asking students higher-level thinking questions and monitoring classroom behavior

Differentiation

Students may be grouped based on mixed-ability rather than by student choice. Additional time may be given to students who need it, as the class schedule allows.

Closure (5 minutes)

Part 1: Revisit the lesson's objectives: 1) Design and build an army man launcher, 2) Test the effects of force (applied and gravitational) on the motion of an army man launched from a catapult, 3) Identify specific factors that will determine and effect how the launcher performs, such as design, applied force, etc., and 4) Record and analyze data from catapult design tests

Part 2: Students return to their individual desks to write on a notecard one thing they plan to alter on their design for the next day. Students must explain why they think this new design will work better.

Assessment

1. Formative Assessment of student activity packets pg 1-3. Students who do not demonstrate the mastery of making observations and taking measurements of the army man's motion will first be paired with another group to identify misconceptions. Next, the teacher will break down the scenario of the launching into small chunks to aid in understanding.

2. Performance based assessment of students completing the engineering design process. Students who do not demonstrate mastery of planning a test, communicating their ideas, and applying areas of improvement to new designs will be grouped with students who have modeled this engineering design standard.

Day 2 Instruction

Introduction

Part 1: Refer to objectives: 1) Design and build an army man launcher, 2) Test the effects of force (applied and gravitational) on the motion of an army man launched from a catapult, 3) Identify specific factors that will determine and effect how the launcher performs, such as design, applied force, etc., and 4) Record and analyze data from catapult design tests

Part 2: Review Page 1 of the Activity Packet: group roles, description of assignment, and variables of experiment

Activity:

Part 1: Students return to their groups from the previous day and teacher provides directions for the rest of the Activity Packet and reminds students of the expectations

Part 2: Students complete Pages 4-9 of the Activity Packet.

- Design # 2 and test of design # 2
- Design # 3 and test of Design # 3
- Graphing data
- Analyzing data and reflecting on experience

Part 3: Teacher circulates classroom asking students higher-level thinking questions and monitoring classroom behavior

Extension: If time allows, students will move with their group outside to test their catapults. Teacher places a line of string 3 meters from the launching pad. The string represents the border of Denmark. If students are able to launch their army man over the "border" then their launcher is successful!

Differentiation

Students may be grouped based on mixed-ability rather than by student choice

Students may be given a bar graph that has the x- and y- axes completely labeled where students are only required to plot the data.

Closure (5 minutes)

Part 1: Revisit the lesson's objectives: 1) Design and build an army man launcher, 2) Test the effects of force (applied and gravitational) on the motion of an army man launched from a catapult, 3) Identify specific factors that will determine and effect how the launcher performs, such as design, applied force, etc., and 4) Record and analyze data from catapult design tests

Part 2: For the last 5 minute of class the students will return to their individual desks to reflect on the experiment and apply the concept to another idea. Students write on an index card an example of another investigation where they could apply the engineering design process and the concept of force and motion.

Assessment

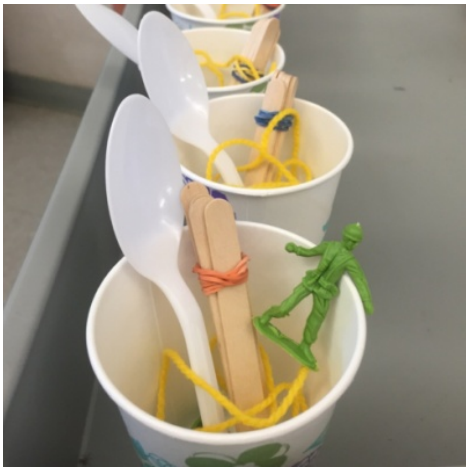
1. Formative assessment of student activity packets pg. 4-7. Students who do not demonstrate the mastery of making observations and taking measurements of the army man's motion will first be paired with another group to identify misconceptions. Next, the teacher will break down the scenario of the launching into small chunks to aid in understanding.
2. Formative assessment of student bar graphs. Students who do not demonstrate the mastery of graphing numerical data and qualitative data onto a bar graph will work in small groups with the teacher. Students will compare their bar graph to a accurately completed bar graph to determine areas of improvement. Next, students will practice plotting the data on the graph with teacher assistance.
3. Formative assessment of reflections and analyses on activity packet. Students who do not demonstrate a mastery of identifying factors that affect an object's motion will be encouraged to review the completed activity packet. Next, these students will meet in small groups with the teacher to review the effects of force (applied and gravitational), mass, and design have on an objects motion.
4. Performance based assessment of students completing the engineering design process. Students who do not demonstrate mastery of planning a test, communicating their ideas, and applying areas of improvement to new designs will be grouped with students who have modeled this engineering design standard in future investigations.

Name: _____ Date: _____

Catapulting into Denmark!

Directions: As a class, complete Page 1.

Materials: Dixie cup, spoon, army man, rubber bands, popsicle sticks, balance scale, tape, tape measure, string



Group Member Roles:

Timer_____

Measurer_____

Director _____

Description of investigation:

Mass of the army man: _____grams__

Independent variable (what is it that will remain constant): _____

_____

Dependent variable(s) (what is it that you will change): _____

_____

Design # 1

Directions: In your groups, design a catapult that will launch your army man 3 meters. Use the space provided to draw your first design of your catapult.

Catapult Test of Design # 1

Directions: Once you have designed the catapult and are ready to launch, make sure the Timer group member is ready to time the number of seconds the army man is air-borne. Once army man lands, Measurer uses the tape measure to determine the distance the army man traveled from the starting point.

Observations and measurements for testing Design #1:

Directions: All group members record the data from your observations and measurements in the appropriate spaces below

Motion of the army man:

1. Direction of motion (did army man launch forward or backwards?):

   _____

2. Distance army man travelled (in meters): _____meters
3. Time for army man to travel (in seconds): _____seconds
4. Speed army man traveled (distance/time): _____meters per second

Forces acting on the army man:

5. Balanced force(s): _____
6. Unbalanced force(s): _____
7. Amount of force applied (low, medium, high): _____

Variables that need to be improved and applied to Design #2 (what worked and what didn't work? Do you think the design of the catapult is responsible for the motion of the army man or do you think you need to add more/less force? Or do you think both?)

_____

_____

_____

_____

Design #2

Directions: In your groups, design a catapult that will launch your army man 3 meters. Use the space provided to draw your first design of your catapult.

Catapult Test of Design # 2

Directions: Once you have designed the catapult and are ready to launch, make sure the Timer group member is ready to time the number of seconds the army man is air-borne. Once army man lands, Measurer uses the tape measure to determine the distance the army man traveled from the starting point.

Observations and measurements for testing Design #2:

Directions: All group members record the data from your observations and measurements in the appropriate spaces below

Motion of the army man:

1. Direction of motion (did army man launch forward or backwards?):

   _____

2. Distance army man travelled (in meters): _____meters
3. Time for army man to travel (in seconds): _____seconds
4. Speed army man traveled (distance/time): _____meters per second

Forces acting on the army man:

5. Balanced force(s): _____
6. Unbalanced force(s): _____
7. Amount of force applied (low, medium, high): _____

Variables that need to be improved and applied to Design #2 (what worked and what didn't work? Do you think the design of the catapult is responsible for the motion of the army man or do you think you need to add more/less force? Or do you think both?)

_____

_____

_____

_____

Design # 3

Directions: In your groups, design a catapult that will launch your army man 3 meters. Use the space provided to draw your first design of your catapult.

Catapult Test of Design # 3

Directions: Once you have designed the catapult and are ready to launch, make sure the Timer group member is ready to time the number of seconds the army man is air-borne. Once army man lands, Measurer uses the tape measure to determine the distance the army man traveled from the starting point.

Observations and measurements for testing Design #3:

Directions: All group members record the data from your observations and measurements in the appropriate spaces below

Motion of the army man:

1. Direction of motion (did army man launch forward or backwards?):

   _____

2. Distance army man travelled (in meters): _____meters
3. Time for army man to travel (in seconds): _____seconds
4. Speed army man traveled (distance/time): _____meters per second

Forces acting on the army man:

5. Balanced force(s): _____
6. Unbalanced force(s): _____
7. Amount of force applied (low, medium, high): _____

If you designed a 4th catapult, what variables would you change or improve? Why?

_____

_____

_____

Graphing Data

Directions: Work together to make a bar graph of the data from your measurements. Graph the amount of force applied on the x-axis and the distance travelled on the y-axis.

Teacher note:

Option 1: If computers are available, have students use Microsoft Excel to enter data and create a bar graph of the distance army man travelled compared to the amount of force applied to the catapult (low, medium, high). Each group will create their own graph.

Option 2: If computers are not available, have students draw a bar graph to represent the relationship between amount of force applied and distance army man travelled. Teacher may want to provide a bar graph that has the x and y-axis already labeled.

Reflection and Analysis of Data

Directions: Work together in your groups to answer the following questions and write your answers in the space provided

1. Did the army man reach a distance of 3 meters when launched from the catapult?

2. Based on the graph you created, was there a relationship between the amount of force applied and the distance the army man travelled? How do you know?

3. How did gravity affect the motion of the object?

4. What conclusions can you draw about the army man's motion? Were there any patterns in motion? Use the words force, direction, motion, and gravity.

5. Describe how failure provides valuable information to help find a solution. Think about the Denmark situation and why it was important to test our catapults even if we failed in reaching 3 meters.

6. If we used an object of a heavier mass instead of a light weight plastic army man, what would you need to change in order for the heavier mass object to achieve the same motion?