PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN'

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Unit Overview

In this project-based unit, medieval times provide a platform for students to learn about projectile motion and practice advanced algebra skills. Students learn about motion, velocity, acceleration, and parabolic equations to design and build catapults. Students then compete in a "Punkin' Chunkin'" competition and see the results of their catapult designs. The unit concludes with students collecting and analyzing data from the catapult launches and reflecting on the unit.

Standards Addressed

1. **S.P.1**: Students will analyze the relationships between force, mass, gravity, and the motion of objects.
    a. Calculate average velocity, instantaneous velocity, and acceleration in a given frame of reference.
    c. Compare graphically and algebraically the relationships among position, velocity, acceleration, and time.
    e. Measure and calculate the magnitude of gravitational forces.
    f. Measure and calculate two-dimensional motion (projectile and circular) by using component vectors.

2. **S.P.3**: Students will evaluate the forms and transformations of energy.
    c. Measure and calculate the vector nature of momentum.
    e. Demonstrate the factors required to produce a change in momentum.
    g. Analyze and measure power.

3. **M.9-12.F.IF.4**: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

4. **M.9-12.F.IF.5**: Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*

5. **M.9-12.F.IF.6**: Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN': WEEK ONE				
Day One	**Day Two**	**Day Three**	**Day Four**	**Day Five**
Standards Addressed (SA):	**SA: 1, 3, 4, 5**	**SA: 1, 3, 4, 5**	**SA: 1, 3, 4, 5**	**SA: 1, 3, 4, 5**
Ask students the following questions: a. If you lived in medieval times, what would it be like to try and attack a medieval castle? b. How would you break in? c. How would the technology of the time shape the way people chose their attack strategy? Then, have students create a list of questions about medieval siege warfare.	As a class, review one-dimensional motion and gravity. Additionally, review concepts of motion and constant velocity. On the board, draw a diagram of a one-dimensional, vertical projectile motion. Use this diagram to remind students of kinematic equations, initial conditions, and final conditions. Then, solve a practice kinematic problem as a class. Next, draw a diagram of a one-dimensional, constant-speed motion. Use this diagram to remind students of the equation for velocity. As a class, solve a practice velocity problem.	Discuss the concept of two-dimensional motion as a combination of the two concepts from the previous lesson: one-dimensional vertical projectile motion (on the Y-axis), and one-dimensional constant-speed lateral motion (on the X-axis). Then, show an *example* of the connection between horizontal and vertical motion. Students continue practice calculating velocity for the remainder of the lesson.	Begin the lesson with a guided class discussion, asking the following question: "What is the biggest challenge for someone trying to break into a castle?" Draw a parabolic path on the board, showing an object going over the wall of a castle. As a class, complete the parabolic equation for the diagram. For homework, students research castle designs, bow and arrow ranges, and calculate the trajectory of a parabolic path for an arrow to successfully shoot over a castle wall.	Students share their calculated trajectories from the homework. Then, discuss catapults and historical catapult designs as a common tool of medieval warfare. Show *pictures* and diagrams of historical catapults. Show a *catapult simulation* on the Promethean board. Use the simulation to encourage students to think of their own catapult designs. Conclude with a discussion of the challenges of designing a catapult and how to use parabolic equations to create a successful catapult design.

PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN': WEEK TWO				
Day Six	**Day Seven**	**Day Eight**	**Day Nine**	**Day Ten**
SA: 1, 2	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2**
Introduce torsion catapult designs, showing *diagrams* and examples. Discuss the details of designing a torsion catapult. Refer to the **Catapult Model Guide** and build a *Torsion Catapult Model* using pencils, rubber bands, and a plastic spoon. As you build the model, discuss each design step.	Introduce trebuchet catapult designs, showing *diagrams* and pictures. Discuss the details of designing a trebuchet catapult. Refer to the **Catapult Model Guide** and build a small *Trebuchet Catapult Model* without a sling. As you create the model, discuss each step with the class. Then, show the catapult failing to work. For homework, students answer the following question: "What improvements can be made to the trebuchet catapult design to make it work?"	Discuss if anyone discovered in their homework that the trebuchet catapult failed because it did not have a sling. Then, discuss the mechanisms of slings and pendulum mechanics. Explain how the sling, which acts as a pendulum, swings at a standard angular rate in all situations and this rate must match the motion of the swing arm for the catapult to correctly fire. Students try to solve the pendulum mechanics problem by hand. Then, show students that the open length of the sling equals the length of long arm of the trebuchet.	Introduce the unit project, "Punkin' Chunkin.'" Show *videos* and *examples* of the project and previous design winners. Then, discuss the parameters of the project. Tell students they will design, build, and test a catapult. Designs are categorized into three size divisions: (1) marshmallows, (2) mini pumpkins, and (3) large pumpkins. Students can work individually or with a small group.	Students brainstorm and work on catapult designs. Students use computers and the *Virtual Trebuchet* to test their designs. For homework, each student or group submits a mission statement for their project, including their division choice, performance goals of their design, a construction method, and a detailed diagram of their catapult.

PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN': WEEK THREE				
Day Eleven	**Day Twelve**	**Day Thirteen**	**Day Fourteen**	**Day Fifteen**
SA: 1, 2	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2**
Students submit their mission statements. Teacher works with each group or student to determine the feasibility of the project design and helps students build a schedule, budget, and add or change performance goals to their project. Students finalize their project design.	Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.	Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.	Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.	Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.

PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN': WEEK FOUR				
Day Sixteen	**Day Seventeen**	**Day Eighteen**	**Day Nineteen**	**Day Twenty**
SA: 1, 2	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2**	**SA: 1, 2, 3, 4, 5**
Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.	Students build their catapults. Teacher conferences with students and groups throughout the building process to improve and strengthen the students' catapult designs.	Students test and revise their catapults, using the **Test and Revise Questions** as a guide. Teacher conferences with students and groups throughout.	Students test and revise their catapults, using the **Test and Revise Questions** as a guide. Teacher conferences with students and groups throughout.	Students finalize their catapults. As a class, review the **Punkin' Chunkin' Safety Rules and Procedures**. Students create a datasheet to record results of the Punkin' Chunkin'.

PROJECTILES, PHYSICS, AND PUNKIN' CHUNKIN': WEEK FIVE			
Day Twenty-One	**Day Twenty-Two**	**Day Twenty-Three**	**Day Twenty-Four**
SA: 1, 3	**SA: 3, 4, 5**	**SA: 1, 2, 3, 4, 5**	
The class participates in the Punkin' Chunkin' and launches each catapult outside. Make sure students follow the **Punkin' Chunkin' Safety Rules and Procedures**. Students record data of each launch.	Students create scatter plots using data from the Punkin' Chunkin'. For each scatter plot, students calculate the best fit line and predicted values of the line. Discuss as a class how to interpret the data on the scatter plot Students work on graphing and analyzing data. Teacher conferences with students and checks for understanding throughout. Students finish any data analysis or graphing for homework.	Students submit their final data analysis. Lead a class discussion on the following: a. What launch angle produced the greatest range? b. How did the average speed change as the launch angle changed? c. Did the projectiles follow a perfect parabolic path? d. Did the measured range match the measured altitude calculated for the parabola? e. What caused some of the problems with the catapults? Students complete a one to two page reflection paper on their experience, discussing what concepts they learned throughout the process.	Conclude the unit with students sharing their reflection paper, showing pictures from the Punkin' Chunkin' launch, and give awards for the catapults that launched the furthest distance and had the most accurate designs.