Engineering in Classrooms

Lesson Name: Ping pong ball / marshmallow catapult
Grade Level: 3 - 6

Next Generation Science Standards:

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions The products of science are explanations and the products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.	**K-PS2-1.** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. **3-PS2-2.** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. **5-PS2-1.** Support an argument that the gravitational force exerted by Earth on objects is directed down. **K-2-ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. **3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**Cause and Effect: Mechanism and Explanation** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts. **Structure and Function** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Common Core Standards:

ELA/Literacy:

SL.3.3 - Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.
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.4.4 - Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
SL.5.1 - Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.
SL.6.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher- led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.6.2. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

Mathematics:

MP.2 - Reason abstractly and quantitatively.
MP.5 - Use appropriate tools strategically.
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.

Background:

Students will be given a bag of supplies and challenged to create a catapult that can accurately and consistently launch a projectile (ping pong ball or marshmallow) into a target. Alternately students could be challenged to make a design that launches the projectile as far as possible. Students can use the measuring tape to find the flight distance.

Vocabulary/Definitions:

- **Accuracy:** The degree of closeness of a measured or calculated quantity to its actual (true) value. For example, in the associated activity, accuracy is the ability to hit the target with the Ping-Pong ball.
- **Catapult:** A toy/machine that launches a projectile.
- **Geometry:** An area of mathematics that studies shape, size, position and properties of space.
- **Precision:** The degree to which further measurements or calculations show the same or similar results. For example, in the associated activity, precision is the ability to hit the same location multiple times with the Ping-Pong ball.
- **Projectile:** An object that is launched or thrown, usually in the air, by a force.
- **Triangle:** A polygon with three sides that is a very strong shape used often in structure design.

Materials: (*In a gallon sized zip-lock bag – 1 per group)*

- Popsicle sticks
- Masking tape
- Straws
- Rubber bands
- Plastic spoons
- Cardboard base – 1 per group

- Markers (to decorate the catapult)

Materials for the entire class

- Marshmallow or ping-pong balls – 1 or 2 per group.
- A bucket or other container to serve as a target. Multiple containers for larger groups.
- Measuring tape to calculate distance the projectile travels.
- Some background images of catapults for students to examine. (Or have students do independent research into what catapults look like before the activity.)

Lesson outline:

a. Start by giving the students a quick background on catapults, making sure to show everyone a few pictures of what catapults look like and talking about how they work. Alternately have students research catapult design before they come into class for the activity.
b. Divide students into groups of 3 or 4, and give each group a bag of supplies.
c. Explain that their challenge is to create a catapult that can launch a projectile into a target, or as far as possible across the classroom, using only the materials in the bag.
d. Have them start by individually brainstorming and drawing designs. After individual brainstorming groups should get together to share and evaluate ideas. Remind them to use productive and supportive language as they evaluate the ideas they other members of their group came up with. Also encourage them to see if multiple designs might be created into one final solution they're going to try to create.
e. After they've agreed on a design as a group, allow them to start building their creations.
f. As groups finish their designs have them test their catapults in an area of the classroom where they aren't risking hitting other students.
g. Once groups do some initial tests have them evaluate how well their design solves the challenge. After the initial test phase each group should try to think of ways to modify their catapult to make it even more accurate.
h. Continue with the process of testing and redesign until each group has had the opportunity to come up with at least three different iterations of their design (or more if time and interest level allow).
i. Have groups present their solution to the rest of the class, explaining what challenges they encountered and the solutions they designed. Ideally each group will have the opportunity to demonstrate the function of their catapult.

Extensions:

- This is a great opportunity to have students use science journals throughout the entire activity. They can draw and write their brainstorming ideas at the beginning and record results, observations and ideas throughout the remainder of the project.
- You can increase the difficult of this activity for older groups by making the target more challenging to hit, either by making it smaller or placing it further from the launch area.
- You can also increase the difficulty of the challenge by limiting the amount of supplies groups can use – or placing a cost on all the materials and giving each group a budget they can spend on supplies.
- For younger groups just challenge them to design something that can launch the projectile as far as possible.
- This is a great opportunity for students to get some experience measuring distance and calculating the average length of multiple launches.
- A great way to connect this with Common Core standards is to have each groups develop a presentation, using graphics, photos and / or videos to describe what their group learned. Allowing each group to redo the challenge one last time after the presentation can also highlight the important process where scientists share information to help improve work and find new solutions.