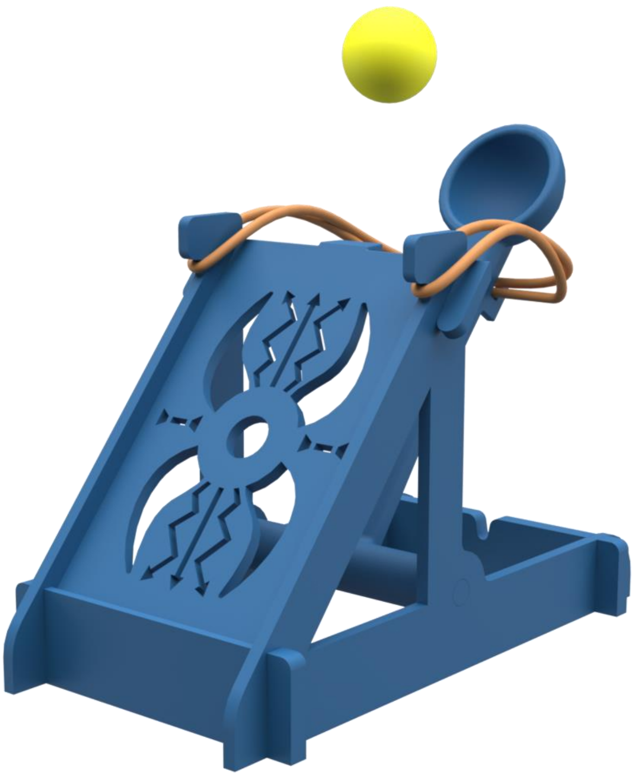
DESIGN PROJECTS



CATAPULT

GRADE LEVEL

Grades 9-12

MODELING TIME

4-6 hours

DESIGN OBJECTIVES

- 3D Printed
- Flat-Pack Design
- Launches 7/8" Diameter Foam Ball
- Rubber Band Powered
- No Fasteners or Adhesives

MATERIALS

- Filament – Approximately 72g
- 1 package of #2 size rubber bands
- 1 package of (30), 7/8" diameter foam balls

DESCRIPTION

Step back in time and explore the fascinating world of medieval engineering with a modern twist! In this STEM project, students will design their very own catapult using CAD software.

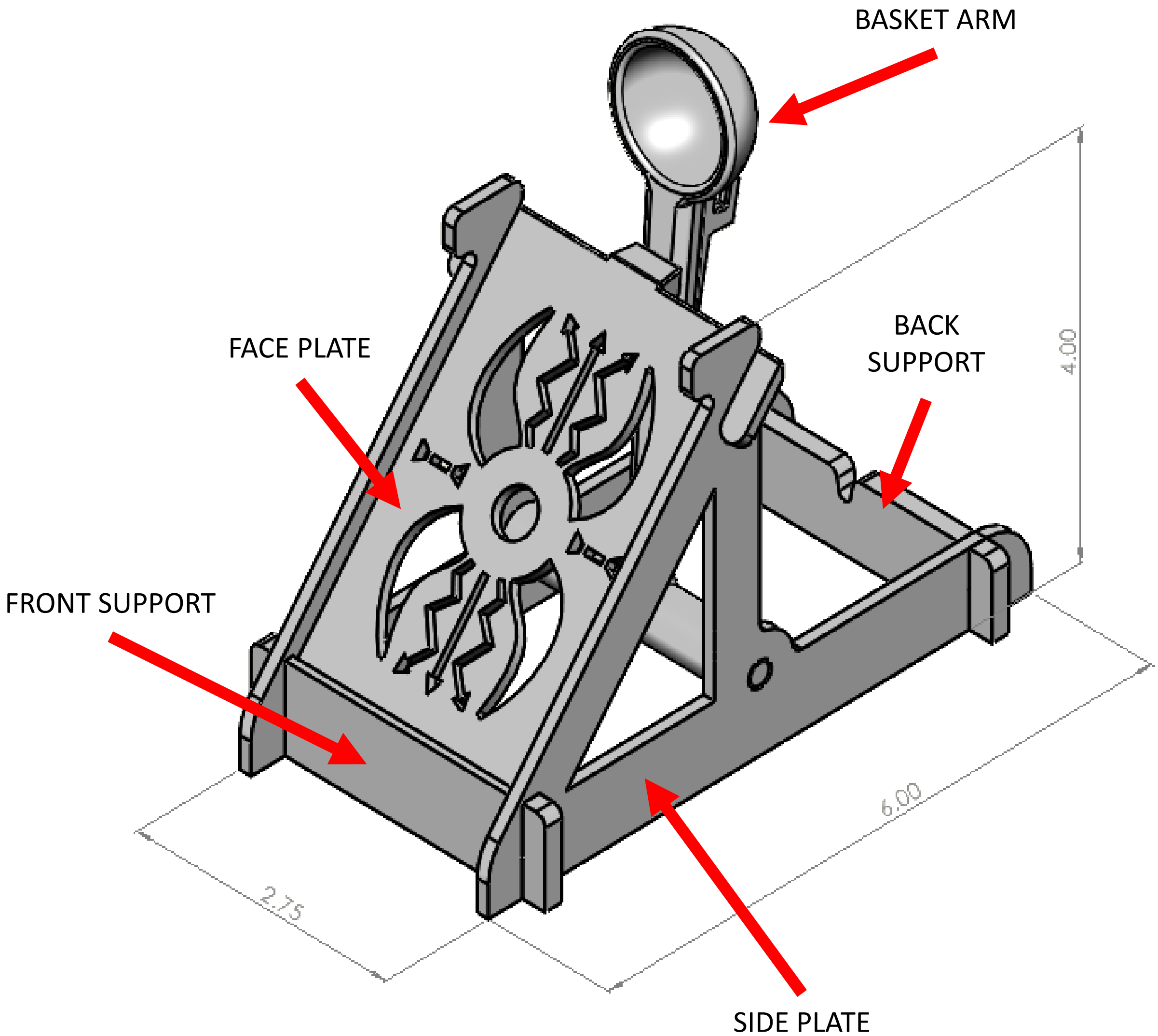
Students will design each component of their catapult, print the components using a 3D printer, assemble their models, and test them in a series of fun challenges.

This project is more than just a hands-on activity; it's a journey into problem-solving, teamwork, and the engineering design process. By the end, students will have a working model and the satisfaction of seeing their ideas leap off the screen and into reality.

HISTORY

The inspiration for this design was the Roman Onager, a siege weapon used to knock down the walls of a fortress, employed by the armies of ancient Rome. Due to the nature of its design, it was named onager. When operated, it kicked like a mule! An onager is a species of wild African ass which was characterized as an exceptionally fast runner with an unruly disposition.

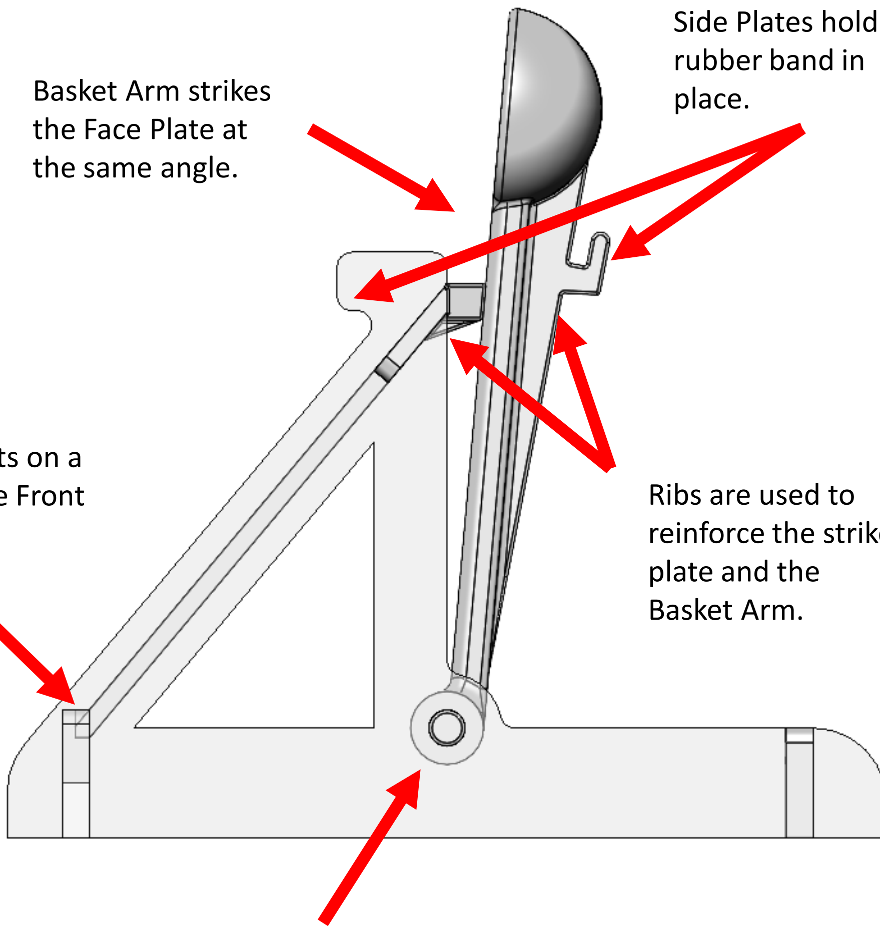
CATAPULT COMPONENTS



CATAPULT COMPONENTS

Hooks on the Basket Arm and the Side Plates hold the rubber band in place.

Basket Arm strikes the Face Plate at the same angle.



Face Plate sits on a groove in the Front Support.

Ribs are used to reinforce the strike plate and the Basket Arm.

Basket Arm rotates about the centerline of the assembly.

EDUCATIONAL CONCEPTS

A catapult design and construction project is an excellent way to integrate multiple STEM concepts. Here are some potential teaching approaches:

SCIENCE

- Explore projectile motion: teach students about velocity, trajectory, angles, and gravity.
- Discuss energy transfer: potential energy (e.g., a stretched rubber band) converting to kinetic energy.
- Compare how the principles of levers and fulcrums are mirrored in human body movements.

TECHNOLOGY

- Teach students to use 3D modeling for creating their catpult designs.
- Demonstrate how 3D printers work, from slicing software to the actual printing process.
- Discuss additive manufacturing principles and how they differ from traditional methods.
- Emphasize the importance of DFAM, Designing for Additive Manufacturing, by minimizing waste through smart design.

ENGINEERING

- Explain lever mechanics and how changing arm lengths or pivot points impacts performance.
- Discuss structural stability and how to prevent the catapult from tipping or breaking.
- Introduce failure analysis to identify and fix weak points in the design.

MATHEMATICS

- Analyze the angles required for optimal launch trajectories.
- Calculate angles, lengths, and dimensions for accurate CAD modeling.
- Solve for unknown variables such as range or initial velocity.
- Have students estimate material costs, factoring in 3D printer filament usage.

OPTIONAL CHALLENGES

- Use the 3DEXPERIENCE Cloud apps to collaborate on catapult designs in teams.
- Divide students into design, testing, and construction teams to simulate real-world engineering roles.
- With the class divided into teams, have each team design a unique catapult and have a competition using the models, i.e. most hits on a target within a specified amount of time.

DISCUSSION STARTERS

- How will the trajectory of the ball be affected by changing the angle or size of the area where the basket arm strikes the faceplate?
- How will different types of elastic bands affect the power of the machine?
- What tolerance is needed to be loose enough for easy assembly, yet tight enough to hold the components together?

ASSESSMENT CRITERIA

- **SUSTAINABILITY** – Did the project meet flat-pack design requirements?
- **ASSEMBLY** – With no adhesives or fasteners, does the model hold together on its own?
- **MANUFACTURABILITY** – Do the components fit within the parameters of the 3D printer?
- **PERFORMANCE** – Does it launch the specified foam ball?

ADDITIONAL RESOURCES

LINK TO DOCUMENTS

LINK TO YOUTUBE VIDEO

LINK TO STEP-BY-STEP