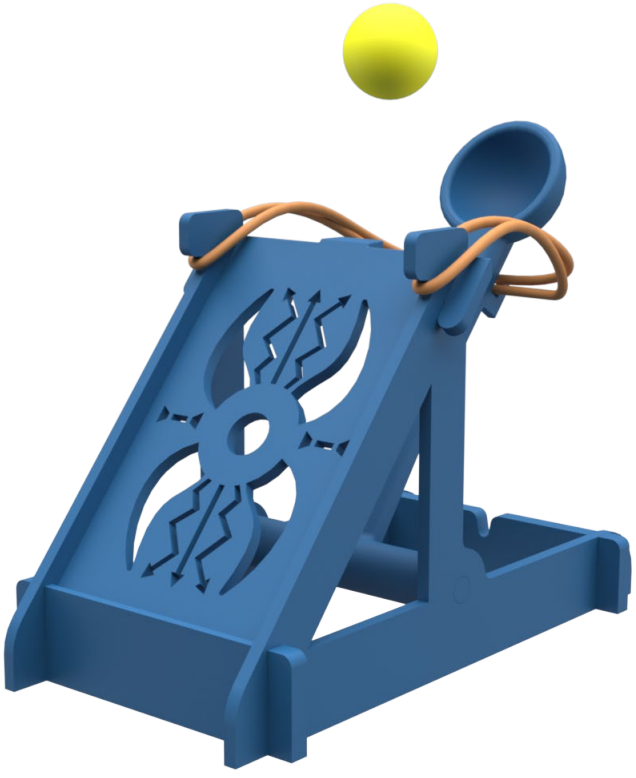
DESIGN PROJECTS



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.

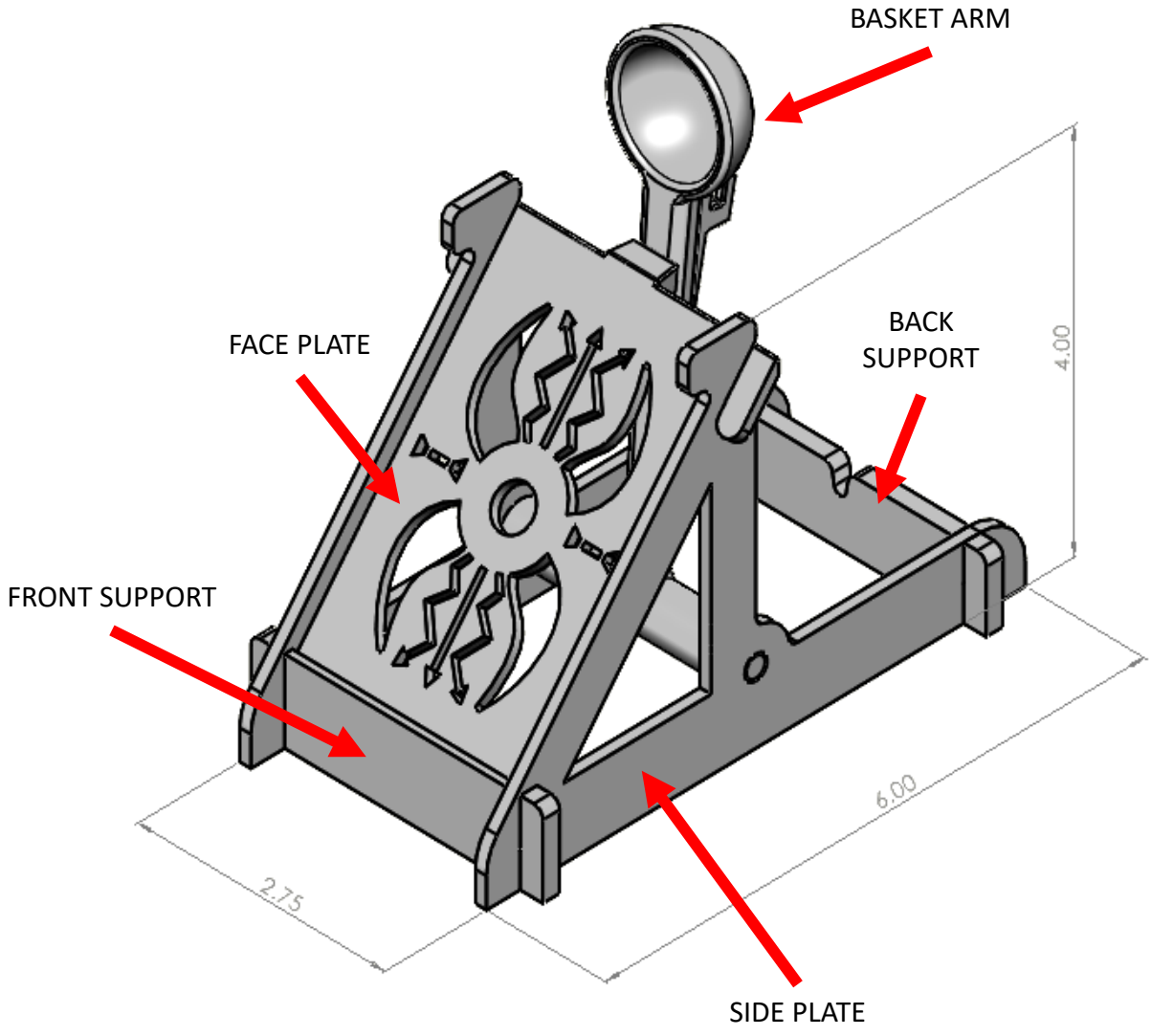
Students will design each component of their catapult, print the components using a 3D printer, assemble their models, and test them in a series of fun challenges.

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.

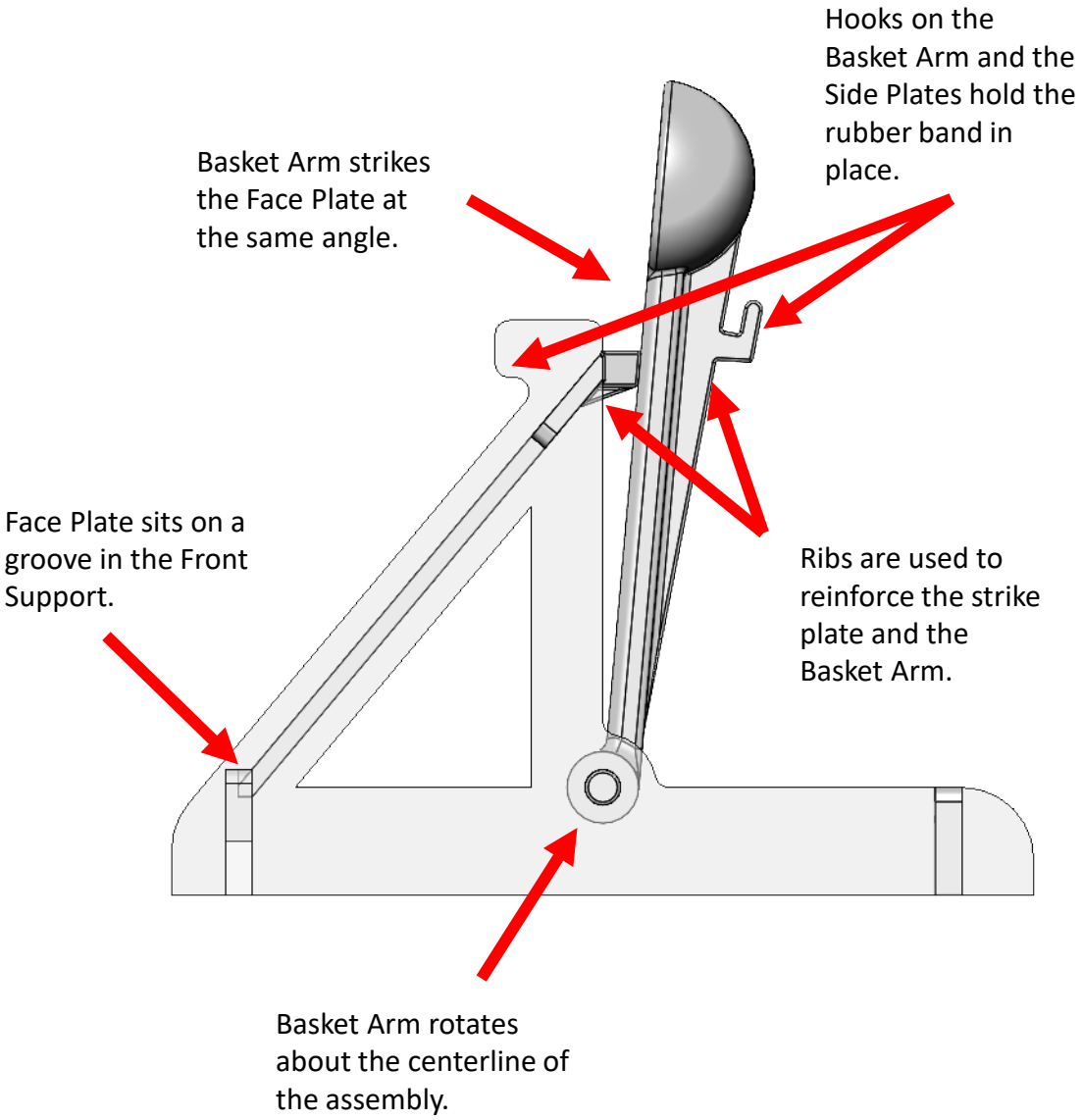
HISTORY

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



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 catapult 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