CATAPULTS (G3-6)

In this workshop, students will engineer a working catapult to take home. The Works Museum's educators will provide a prescribed set of materials to use during building and a basic outline for construction, with details left to the individual student to decide. The Works Museum educators will also instruct and monitor students for safe tool use. Students will have time to test their catapults' flinging ability, in order to refine the design and understand how projectiles fly. See p. 3 for standards this workshop supports.

SCIENCE CONCEPTS

Catapults are excellent examples of objects using simple machines and **transfer of energy.**

- The launch arm is a **lever** that rests on a **fulcrum**.
- The catapult works when the **potential energy** stored in a stretched rubber band is converted to **kinetic energy** when it snaps back to its loose shape, moving the catapult arm—and the projectile!

After students build their catapults, they will test them by launching projectiles. For the workshop, these will be pom-poms and pieces of paper.

- Students will investigate how a projectile's **mass** (how heavy it is) and **surface area** (its shape) affect how it flies.
- The kinetic energy of the catapult will give the projectile a force moving up and away from the catapult. But **air resistance** will create an opposing force known as **drag**, slowing the object.
- The smaller the projectile's surface area, the less drag it has. Students might explore this concept by crumpling a piece of paper to decrease the surface area, or covering a pom-pom's fluffiness with tape.

Educators will also stress the **Engineering Design Process** to students.

- Students will have ample time to test their catapults with provided projectiles.
- They will investigate weak areas of their catapult's build, and strengthen and improve on their first attempts.
- Educators will stress that the cyclical process of design, create, test, and redesign is more important than attempting to achieve a working catapult on the first try.

 | Support for this teacher guide is generously provided by Xcel Energy Foundation.

BEFORE YOU VISIT

What are simple machines?	Devices that help multiply force, so the strength we exert goes much further. Levers, pulleys, and ramps are all examples of simple machines. Many complex machines build upon these basics.
What is potential energy?	Energy that is stored in some way. Think about stretched rubber bands, a pendulum held high, or a ball balanced on top of a hill. People also store chemical energy in batteries, but this workshop will focus on mechanical energy.
What is kinetic energy?	The energy of motion. All moving things have kinetic energy. Energy can change from potential to kinetic, and even back again.
What is drag?	A force that pushes back against motion. Think about shapes of planes, missiles, or sports balls. They are built to decrease drag so objects go farther.

AFTER YOU VISIT

Questions

- Ask students to discuss the changes they made to their catapults during the workshop. What specific changes did they make? Why? Here is a good time to talk about vital changes (i.e., part of their catapult fell apart and required strengthening), versus improvements (i.e., the student wanted their projectile to go farther and made appropriate changes).

Activities

Students should have time during the workshop to refine their catapult design and discuss projectile engineering as well. But teachers can take this further.

- With different or more materials, how can students design better projectiles? Students might cut shapes out of foam. Marshmallows and gummy candy might also be appropriate, but teachers should beware of hard objects that could be effective—but dangerous!—projectiles.
- Teachers and students can compare and contrast the shape of the path projectiles take from different catapults.
  1. Where the fulcrum is balanced affects the projectile's path. Most students will place the fulcrum in the middle of the arm, but moving it toward one end will change how the projectile flies.
  2. The tension in the rubber band is the strongest predictor of how far a projectile travels. Try changing how the rubber band is attached, or even the thickness of the rubber band by swapping it out for other kinds.

CAREERS THAT USE ENGINEERING

Carpenter: For people who like working with their hands, carpentry is a field with many different kinds of work. Carpenters might be responsible for creating and building furniture, like cabinets and tables. Or they might do the physical work of building a house.

Mechanical engineer: More highly technical than a carpenter, in many ways mechanical engineers use the same basic skills. They spend their time figuring out how to design and build a machine or object to do a specific job. Mechanical engineers might design a new car motor, or build a skycrane to drop a robot on Mars.

Biomechanical engineer: If people seem more interesting than machines to some students, bioengineering might interest them. These engineers need to study biology and anatomy, but do not need to become doctors. They combine the science of living things with physics and mechanical engineering concepts to design and build medical devices, including prosthetic arms, legs, and hands.

Learn about **more careers** that use engineering!

MINNESOTA ACADEMIC STANDARDS FOR SCIENCE K-12

4.1.2.2.2 Generate ideas and possible constraints for solving a problem through engineering design.

4.1.2.2.3 Test and evaluate solutions, considering advantages and disadvantages for the engineering solution, and communicate the results effectively.

5.2.2.1.1 Give examples of simple machines and demonstrate how they change the input and output of forces and motion.

5.2.2.1.2 Identify the force that starts something moving or changes its speed or direction of motion. For example: Friction slows down a moving skateboard.

6.1.2.1.4 Explain the importance of learning from past failures, in order to inform future designs of similar products or systems.

6.1.2.2.1 Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system to solve a problem.

6.1.3.1.1 Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.