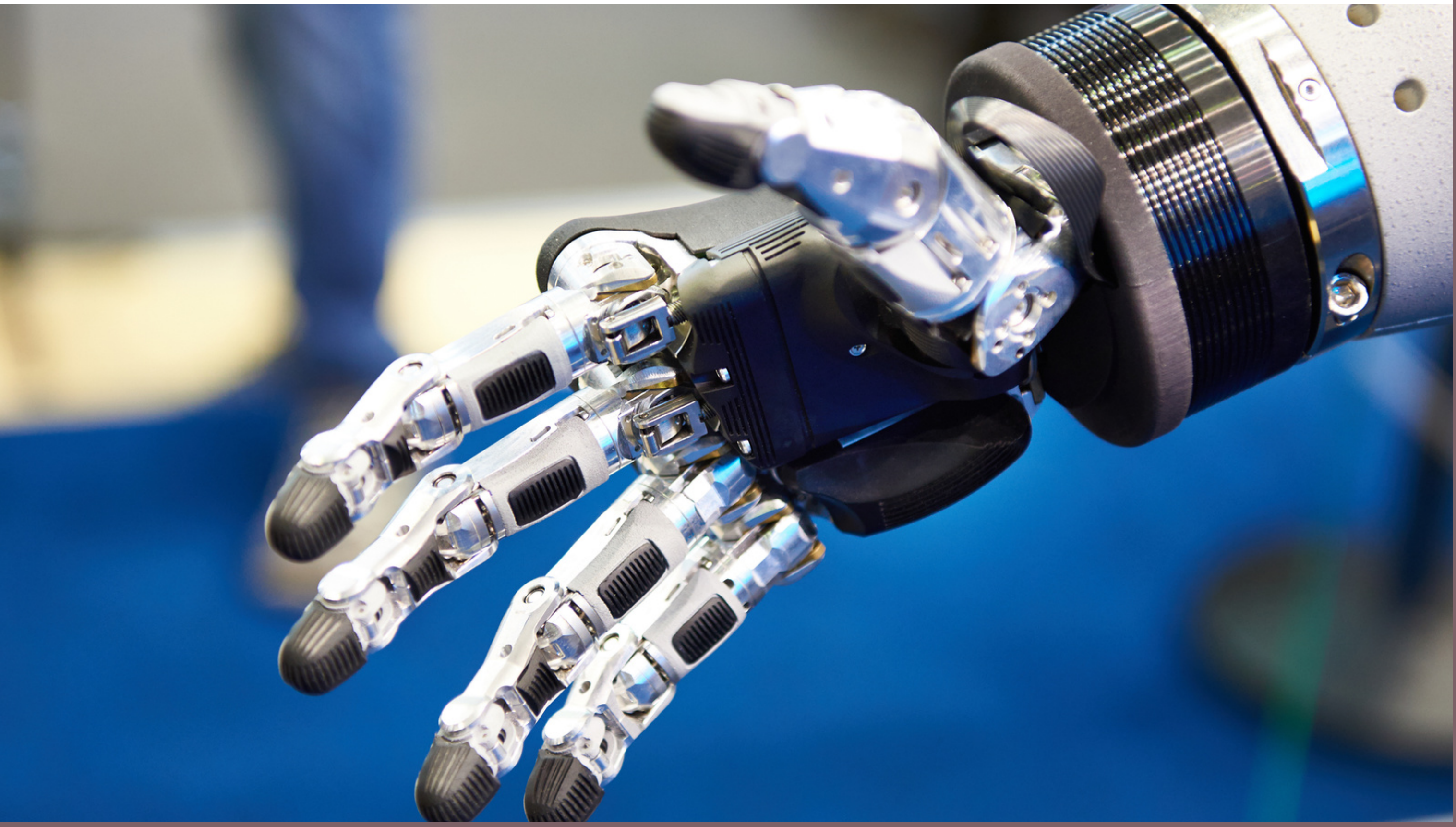
Grade 9-12 STEM Challenge

Lend a Hand

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.



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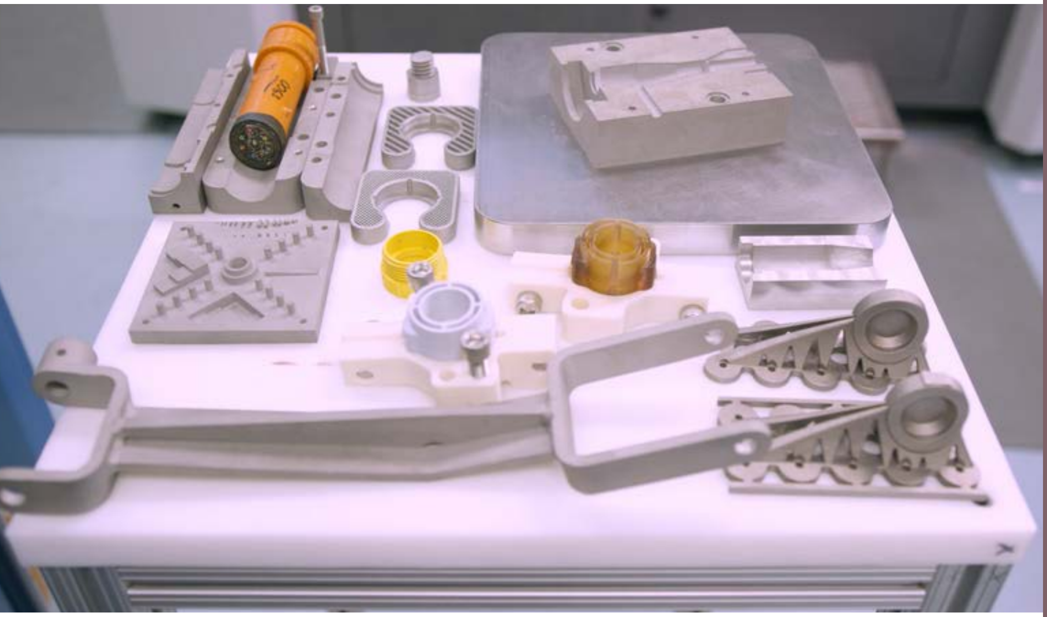
GRADE 9-12 STEM CHALLENGE

Lend a Hand

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.

Students will design and test a hand-like device to pick up and move different objects.



CAREER CONNECTION AND LESSON OVERVIEW

Engineers use the engineering design process as a blueprint for solving problems and devising solutions. Matt is often given complex mechanical challenges that require him to design and prototype new sensor systems as well as the tools needed to install and repair them. Matt uses 3D printing and prototyping to create and test new designs, ensuring that the final products work correctly before they are sent into the field.

The sensor systems Matt helps design allow humans to see or hear objects underwater that they could not observe on their own. Similarly, your student engineers will be designing a mechanical arm and hand that will let them reach out and pick up things they could not reach. This activity will work students through the same kind of fast prototyping that engineers have to do to find working solutions quickly and highlight how engineered solutions help augment our interactions with our world.

LESSON TIMELINE

DAY 1

- Show the inspiration video, "Matt – Mechanical Engineer" (5 Minutes)
- Introduce the Engineering Design Process (10 minutes)
- Introduce the challenge (5 minutes.
- Student work time: Brainstorm, Design, and begin Build (if time) (30 minutes)

DAY 2

- Finish arm/hand designs (30 minutes)
- Test and refine designs (15 minutes)

DAY 3

- Final design performance evaluation (if not completed on day 2)
- Compile lab report and any additional oral reports

Recommended Supplies

General supplies (per group of 3-4):

- 4 Brass fasteners
- Tape (masking tape or duct tape)
- Corrugated cardboard (many pieces, all sizes.)
- Hole punch (single)
- 2 Rubber bands
- Sandpaper
- String
- 4 Toothpicks
- 4 Wooden Skewers
- Yardsticks, paint stirrers, or other thin wooden slats (these may be damaged!)

For the class:

- Various objects to test their devices, including tennis balls, ping pong balls, pencils, soda bottles, cotton balls, paper cups, etc.
- A target container to drop them in (box, wastebasket, etc.)

IN THIS CHALLENGE, STUDENTS WILL:

- Design and build a hand-like device that will pick up different objects.
- Test their design to ensure that it can release those objects into a target container at least two feet away.

Standards

Science & Engineering Process Standards
SEPS.1- Posing questions and defining problems
SEPS.2- Developing and using models and tools
SEPS.3- Constructing and performing investigations
SEPS.4- Analyzing and interpreting data
SEPS.6- Constructing explanations and designing solutions
SEPS.7- Engaging in argument from evidence
SEPS.8- Obtaining, evaluating, and communicating information

Preparing for College and Careers
PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers

Grade 9-10 Employability Standards
9-10.M.2 Able to view feedback as data that helps the learning process
9-10.M.3 Demonstrate an awareness of strengths and weaknesses while accepting constructive criticism from others to improve results
9-10.WE.2 Complete tasks or activities with minimal prompting and guidance
9-10.LS.1 Write documents for a variety of purposes and audiences using varied media formats
9-10.LS.7 Predict outcomes to problems based on data and evidence
9-10.LS.10 Able to approach problems with reasoning and logic to hypothesize results
9-10.LS.11 Able to combine concepts in different ways to create new ideas and innovative solutions
9-10.SE.3 Able to listen to others' ideas and respect different ways of being and doing

Planning and Implementation

LEND A HAND

Essential Vocabulary

- ENGINEERING DESIGN PROCESS: A series of steps that a student or engineer follows to come up with an optimal solution to a problem.
- ENERGY: The capacity for doing work.
- LEVER: A rigid bar resting on a point that can move an object with one end when force is applied to the other.
- FULCRUM: The pivot point of a lever.
- PROTOTYPE: A first draft or early model of an engineered solution.

In this challenge, students will:

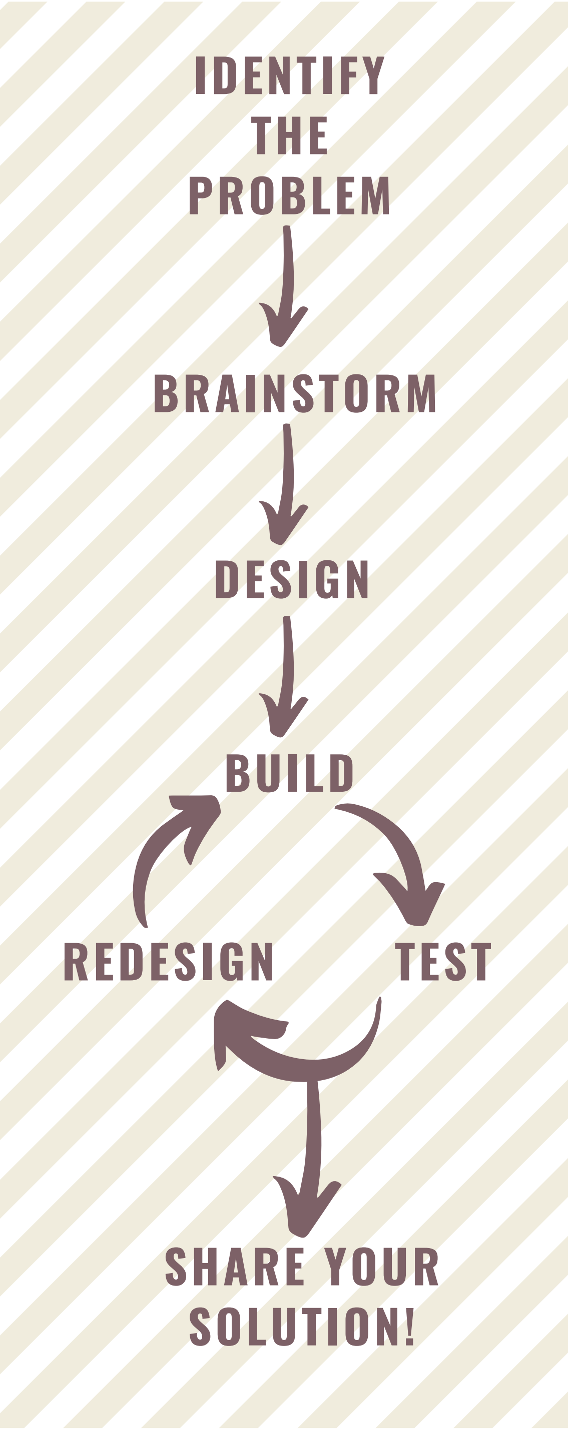
- Design and build a hand-like device that will pick up different objects.
- Test their design to ensure that it can release those objects into a target container at least two feet away.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials. Be sure that you have enough materials and space for students to work in groups of 3-4. Many materials, such as scrap cardboard, can be gathered from recycling bins or collected from students in the weeks before the lesson.
- This activity can take more time, depending on how many class periods can be allotted to the build/test/redesign cycle.

Guiding Questions

1. How do mechanical engineers use the engineering design process to find solutions to problems?
2. How can engineered solutions help us interact with our world?
3. How can we design a low-tech arm and grabber device to pick up an object and move it to a bin or box?
4. How can we, as student engineers, harness energy and simple machines to find a solution to this problem?



Day 1

Introduction

Show students Matt's career shadow video and discuss what mechanical engineers do. Outline and explain the steps of the engineering design process (sometimes abbreviated EDP). There are many versions of the EDP, some with more steps and some with fewer, but each should include some variation of:

- Identify the Problem
- Brainstorm
- Design
- Build
- Test & Evaluate
- Redesign (if needed)
- Communicate Solutions

This activity is created to give students the opportunity to design a mechanical solution to a problem. Like real engineers, the criteria and constraints can seem daunting but an ordered approach that utilizes the ideas of every member of their group will yield innovative and surprising solutions!

Criteria:

Introduce the students to the challenge. This is a more complicated engineering problem because there are three separate components that need to be designed to work together:

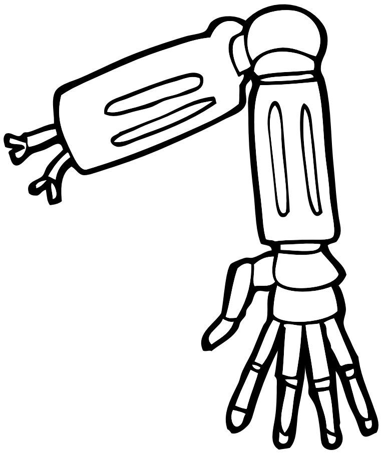
1. The “hand” or “grabber” of the device, which must be able to hold the objects.
2. The mechanism that should be able to open and close the hand to pick things up and release them as needed. This should be able to grab objects, not just scoop them up.
3. The “arm” of the device, which should be long enough to reach out and deliver the objects they pick up to the target.

Constraints:

Student engineers may only use the materials provided. They do not, however, have to use all of the materials.

The Challenge

Introduce students to the challenge, criteria, and constraints.



"Today you’ll turn a pile of junk into a working arm! You’ll need to design a solution that can pick up objects of different sizes and deliver them to a target container. You’ll want to think about what kind of ‘hand’ you’ll want to put on the end of your arm and how to open and close it to grab and release different objects. You don’t need to be able to pick up every single object, but you will want to think about how to design a solution that will work on as many different objects as possible."

This is an excellent activity to get students thinking about rapid prototyping. That is, your student engineers should be trying out many different ideas quickly, failing fast, and coming up with an optimal solution. Encourage students to brainstorm a lot of ideas, pick one, and try it. If it fails, that’s great! Failure is where the learning happens and seeing what doesn’t work is an excellent way to find solutions that do!

Students will also probably notice that their best designs are a combination of many simple machines. Levers and fulcrums will be important to this challenge, as will any other machines that transfer energy from, say, their own hand to the grabber at the end of their device. Mechanical engineers often exploit the abilities of simple machines to increase force and to do complex tasks.

Brainstorm and Design

Frame the challenge and give your student engineers time to think through and plan, both on their own and in small groups. Encourage students to think about the following:

- How could you use the materials provided to build something that lets you grab (not just scoop up) an object?
- What is the difference between scooping something up and actually grabbing it and picking it up? What are the limits of the design?
- What kind of motion do you use in your hand to pick things up?
- What are some devices you've seen that people use to help them grasp or pick up objects without touching them with their hands?

Day 2

Build, Test, Evaluate, and Revise

Potential issues and challenges…

- *Hand or grabber won't open or close.*
  Make sure student engineers have thought of a way to both open and close the hand of their device. Also check that nothing is impeding the movement of the "fingers,"
- *Objects fall out of the hand.*
  Encourage students to think back to their own hands. Is this a strength problem? A grip problem? It may need to be able to apply more force or need more friction on the surface that holds the objects. What do they know about fulcrums and levers that might increase their grip strength?
- *The grabber or arm bends or twists under stress.*
  There are a lot of moving parts here, and heavier items might cause the structure to bend or twist. What could they do to reinforce the strength of their device? What kind of structures can they think of that are both lightweight and strong?

Day 3

Discuss and report

Each student group should share their initial designs as well as any revisions or modifications they made. Ask your engineers to describe their approach in writing through a simple lab report (see template.)

Invite students to think about the STEM connections in this activity:

- What parts of your design were most important in getting the object to stay in the "hand"? Which parts got it to the target container?
- Where are the simple machines in your grabbers?
- While Matt and mechanical engineers like him are using materials that are more high-tech, they're using the same design process. What is another problem you could solve in your day-to-day life that would benefit from the engineering design process?

Career Exploration and Extension

Prompt students to think about and research what a career as a mechanical engineer might entail.

- What does a mechanical engineer do all day? What does Matt do?
- What kind of training would a student need to become a mechanical engineer? What about an engineer in general? What other types of engineers are there?
- Are jobs like Matt's in high demand? Will more people be hired to be engineers in the future?
- What kind of education is needed to be an engineer? Where could a student be trained locally for a career in engineering? What types of classes are important?

Name: ______________

Lend a Hand

Student Lab Report Guide

You will be writing up a brief report on your arm and grabber project. Please be sure to include the following sections. Compile your report either on a separate sheet of paper or on a computer and use complete sentences.

Title: This should be a brief, concise, yet descriptive title.

Example: *"A Design for an Arm and Hand Device"* or *"Better than Nature: A New Way to Move Water Bottles!"*

Introduction: State the problem you are designing to solve. Include the criteria your design must meet and the constraints on your design.

- What was your challenge?
- What did it have to do?
- What were your constraints?

Materials: Include a list of all materials you used in your design.

Procedure: Write a paragraph (don't forget the complete sentences!) explaining what you did. In addition to a written explanation of your process you may want to include:

- Any preliminary designs or drawings your team made.
- Any revisions or changes that you made to your design.

Data: Here you want to include any data you collected. For this project, you'll want to include what objects you were able to lift, how far you were able to carry them, and an redesigning or refining of your device.

Conclusions: Discuss your team's designs and talk about which one was the best solution to the problem. You should also explain:

- What parts of your design were most important for picking up objects? Which parts were important for moving it to or reaching the target?
- What changes did you make to your design after your initial tests? Why?
- What role did energy play in your design? Force?
- How did simple machines help your design?

ACKNOWLEDGEMENTS

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IMAGE AND CONTENT CREDITS

Images

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Still video images from "Matt - Mechanical Engineer," available at http://www.regionalopportunityinc.org/matt

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