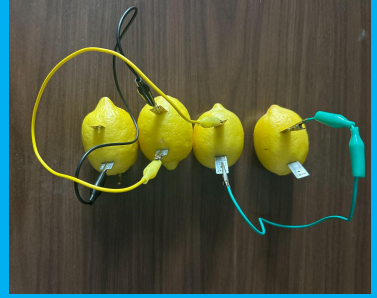
Powered by IEEE
TRY Engineering

DIY Power: Battery Modules for Emergencies



IEEE

Lesson Overview

- **Introduce the Design Challenge**
- **Research and Brainstorm:** Research the problem. Brainstorm possible solutions and explore potential real-world applications for emergency power solutions.
- **Skill Build 1:** Create a Simple Cell Battery
- **Skill Build 2:** Create a Battery Module
- **Engineer Solution:** Experiment with different combinations of the listed variables to find the most efficient, cost-effective, and safe configuration.

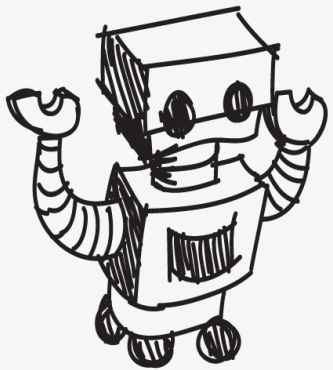
Battery Power

Electric transportation like: electric cars, buses, trucks, trains, bikes, and scooters use **battery power**.

Instead of using fuel to power an engine, these vehicles use batteries and electric motors.

What other technologies use battery power?

The Design Challenge



The Design Challenge

Severe weather has left several counties in your state without power. Your team of electrical engineers are challenged with using what you have in your home to create some light.

Criteria

- Design a reliable and efficient emergency battery cell system
- Must produce a measurable electrical current sufficient for LED lighting

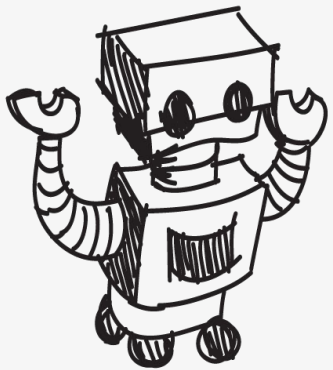
Constraints

- Use only the material available

Materials

- 4 - Zinc Strips per student
- 4 - Copper Strips per student
- 4 - Aluminum Strips per student
- 2 lemon cut in half or 4 whole per student
- 2 potato cut in half or 4 whole per student
- ½ cup of vinegar and saltwater per student
- 4 - Alligator Clips w/ Electrical Wires per student
- 2 - each color LED light bulbs per student
- 1 - Multimeter per group of 2 students
- Data Collection Chart
- Student worksheets

Research The Problem



The Problem

Severe weather has left several counties in your state without power. Your team of electrical engineers are challenged with **using what you have in your home to create some light**.

Criteria

- Design a reliable and efficient emergency battery cell system.
- Must produce a measurable electrical current sufficient for LED lighting.

Constraints

- Use only the material available

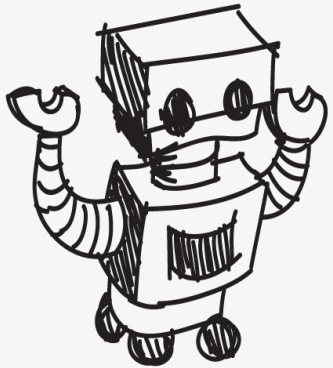
Research Questions

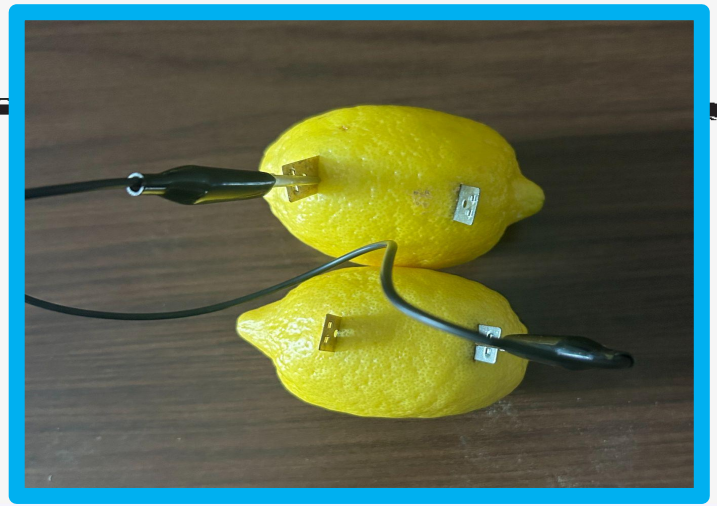
- In what real-life situations (natural disasters, remote areas, etc.) would a homemade battery be most useful?
- How do emergency responders or humanitarian organizations use improvised power sources in crisis zones?
- What are the limitations of homemade batteries compared to commercial emergency lighting systems?
- What are the environmental impacts of using disposable batteries versus homemade or rechargeable alternatives?
- How can we design a battery system that is both effective and environmentally friendly?
- What simple materials can we use that we have in our home?

Research Questions

- What items should every household keep on hand to be better prepared for power outages?
- How can families use this knowledge to create a basic emergency lighting kit?
- What are the safety considerations when building and using homemade batteries at home?
- How do engineers design backup power systems for hospitals, data centers, or critical infrastructure?
- What lessons from this project could be applied to designing low-cost energy solutions for off-grid communities?
- What careers involve designing or maintaining emergency power systems?

Skill Build 1:
Create a Simple Cell Battery



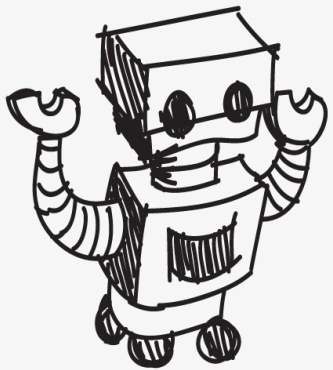


What is a Lemon Battery?

A simple type of battery that uses the acidic juice of a lemon to generate electricity.

Group Discussion:

How are lemon batteries and electric vehicles batteries similar?



Safety Tips

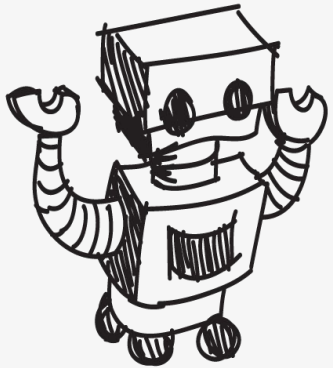
Challenge 1: Simple Battery Cell

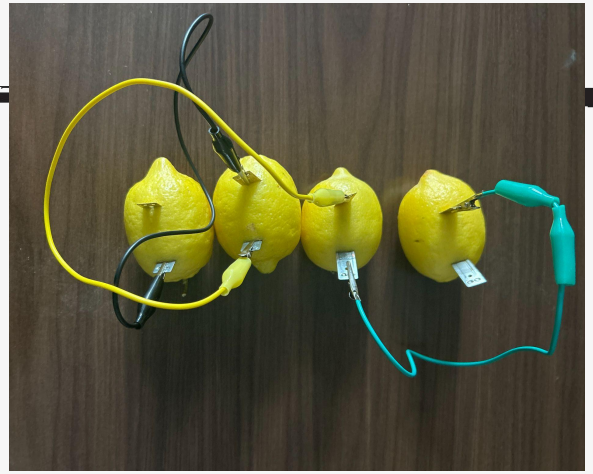
1. Prepare the Lemon
   - Roll the lemon on the table so the juices flow easily
   - Make two incisions in the lemon on opposite sides
2. Prepare the Electrodes
   - Insert the copper strip into one side of the lemon
   - Insert the zinc strip into the other side of the lemon, making sure the two items do NOT touch each other.
3. Connect the Wires
   - Attach one end of a wire with an alligator clips to the copper strip
   - Attach one end of another wire with an alligator clip to the zinc strip

Challenge 1: Simple Battery Cell

4. Test if Current is Flowing using the Multimeter:
   - Turn on multimeter
   - Set the multimeter for DC voltage (usually indicated by a “V” with a straight line and dash line beneath it).
5. Connect the Probes
   - Insert the black probe into the common (COM) port.
   - Insert the red probe into the port labeled for measuring voltage. (V □mA)
6. Measure the Voltage of the Battery Module:
   - Touch the black probe to the zinc strip (negative electrode)
   - Touch the red probe to the copper strip (positive electrode)
   - Read the Voltage displayed.

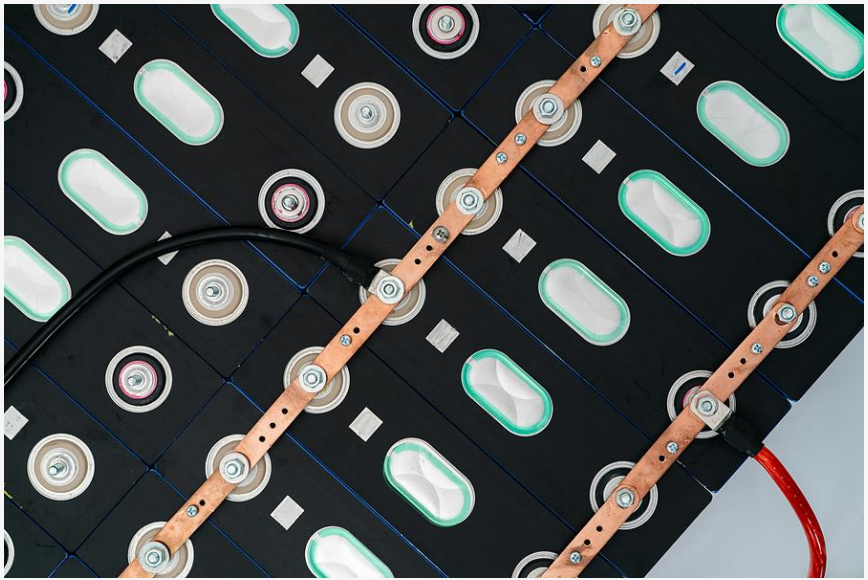
Skill Build 2:
Create a Battery Module





What is a Battery Module

A battery module is like a team of small batteries working together to provide power. Imagine you have a bunch of small batteries, like the ones you use in toys or remote controls. When you connect these small batteries in a certain way, they can work together to create a bigger, more powerful battery. This bigger battery is called a battery module.



How Does it Work?

- **Battery Cells:** Think of each small battery as a cell. A battery module is made up of many of these cells.
- **Connections:** The cells can be connected in two main ways:
  - **Series Connection:** This adds up the voltage of each cell. For example, if you connect two 1.5V cells in series, you get 3V.
  - **Parallel Connection:** This adds up the capacity (how long the battery lasts) of each cell. For example, if you connect two cells with 1,000mAh each in parallel, you get 2,000mAh.
- **Protective Case:** All the cells are put together in a protective case to keep them safe and organized.

Why is it important?

Battery modules are used in many things you see everyday:

- Electric Vehicles
- Portable Electronics
- Backup Power Systems
- Renewable Energy Storage

Where else do you use battery modules?

Design a Lemon Battery System

Connect the Lemons in Series:

- Using the alligator clip wires to connect the lemons in series.
- Connect the copper strip of the first lemon to the zinc strip of the second lemon.
- Continue this pattern: Connect the copper strip of the second lemon to the zinc strip of the third lemon, and so on.

*You should have one zinc strip and one copper strip free at the ends of the series connection.

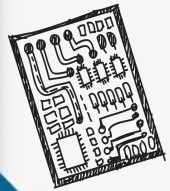
Testing

- **Test if current is flowing using the multimeter:** Turn on multimeter and set it to make sure DC voltage (usually indicated by a “V” with a straight line and dash line beneath it).
- **Connect the Probes:** Insert the black probe into the common (COM) port. nsert the red probe into the port labeled for measuring voltage. (V □mA)
- **Measure the voltage of the battery module:** Touch the black probe to the zinc strip (negative electrode). Touch the red probe to the copper strip (positive electrode). Read the voltage displayed on the multimeter and record it in the provided data collection chart.
- **Add an LED light!** Connect the free ends of the wires to the terminals of the LED bulb. The LED should light up if the circuit is complete.

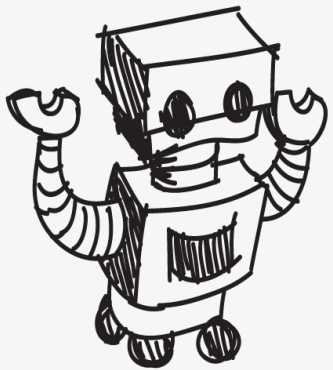
Failure is part of the process

If your LED does not light up, don't worry, we expect that. Engineers fail and they try again and again. So troubleshoot and then redesign until you get your best solution. Failure is part of the process! Have fun!

Ready, Set, Let's Engineer!



Design Challenge:
Best Solution



Best Solution: Different Variables

Now you know what a battery cell is and how to create a battery module using lemons. Next, experiment with different combinations of the listed variables to f**ind the most efficient, cost-effective, and safe configuration**.

Measure and document the voltage and current generated by each battery cell comparing the performance of various battery cell configurations.

Identify which variables had the **most significant impact on the battery cell's ability to power the LED**, noting any issues and proposing improvements. Based on the feedback from iterative testing, they should refine the design to enhance its performance and resolve any identified problems.

Best Solution: Different Variables

Variables:

1. Type of Electrolyte:

- Lemon
- Saltwater
- Vinegar
- Potato

2. Temperature of the Electrolyte:

- Room Temperature
- Heated
- Cooled

3. Type of Metals Used:

- Copper and zinc
- Copper and aluminum
- Zinc and aluminum

4. Distance Between Metal:

- Close proximity
- Medium distance
- Far distance

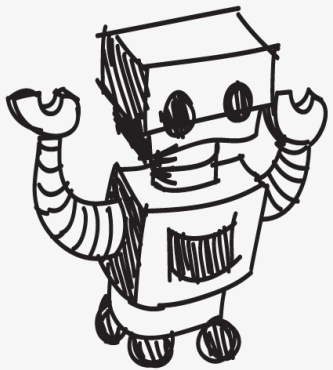
5. Color of LED Light

- Different Colors *(which may have different voltage requirements)*

Best Solution: Different Variables

Presentation: Summarize the findings from the testing and iteration phases. Develop a presentation that highlights the **most effective battery cell configuration** and explores potential real-world applications for emergency power solutions.

Vocabulary

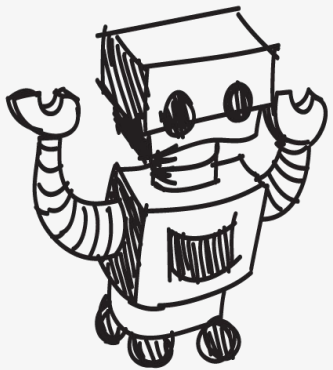


Vocabulary

- **Battery**: An electrochemical device that stores energy and powers things like electric cars, phones, and flashlights.
- **Battery Module**: A group of smaller battery parts (called cells) connected together to give more power.
- **Parallel Circuit:** Allows multiple paths for electricity (current) to flow through
- **Series Circuit:** Allows one path for electricity (current) to flow through
- **Voltage:** Is the measure of how strong the battery's push is to move electricity.

See full list in the lesson plan vocabulary accordion.

Background Knowledge



Key Concepts (Lemon Battery)

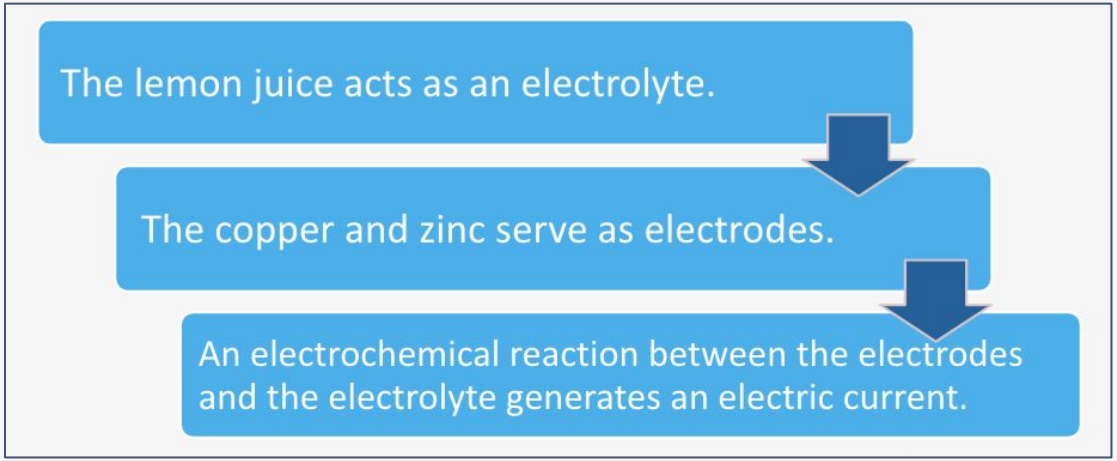
KEY CONCEPTS

Reduction at the Cathode: At the copper electrode (cathode), hydrogen ions (H^+) from the electrolyte gain electrons (reduction) to form hydrogen gas ($2H^+ + 2e^- \rightarrow H_2$).

Electron Flow: The electrons flow from the zinc strip through the external circuit to the copper strip creating an electric current.

Ion Movement: The zinc ions (Zn^{2+}) move into the electrolyte, while hydrogen ions (H^+) in the electrolyte move towards the copper electrode to balance the charge.

How Does It Works (Lemon Battery)



- **Zinc** reacts with the acid in the lemon juice to release **electrons**.
- **Copper** collects the electrons, creating an **electric current**.
- The flow of **electrons** powers the **LED light**.

Electric Vehicles

What is an Electric Vehicle?

- An electric vehicle (EV) runs on electricity stored in a battery instead of gasoline.
- The battery powers an electric motor, which moves the car and produces no emissions.
- Used EV batteries can be repurposed for energy storage, helping reduce waste and pollution.

How Do EVs Differ from Gas-Powered Cars?

- EVs use electric motors and batteries, while gas cars use engines and fuel.
- EVs are quieter, cleaner, and produce no tailpipe emissions.
- Charging an EV is like charging a phone, while gas cars need fuel from a gas station.

Battery Basics

- **What is a battery?**
  A battery stores energy in a chemical form so it can be used later to power things like phones, flashlights, or cars.
- **How does it work?**
  Inside a battery are two ends called the **cathode** and **anode**, with a special liquid or gel in between called the **electrolyte**. When the battery is connected to something (like a light), tiny particles called **electrons** flow through wires to make it work.
- **What happens when you charge or use it?**
  In a **rechargeable battery**, electrons and other tiny particles called **ions** move back and forth. When you charge it, energy is stored. When you use it, that energy is released to power your device.

Combining Battery Cells for More Power

- **One battery cell isn't always enough**

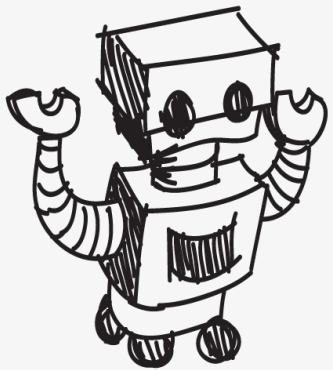
  Devices like cars need more power, so many battery cells are connected together to make **battery modules**, and modules can be grouped into a **battery pack**.
- **Two ways to connect batteries**
  - **Series connection**: Batteries are linked end-to-end to increase **voltage** (how strong the electric "push" is).
  - **Parallel connection**: Batteries are placed side-by-side to increase **capacity** (how much energy they can store).
- **Why it matters**

  These connections help engineers build batteries that are powerful and long-lasting enough for everything from remote controls to electric cars.

Battery Safety

- **Batteries need to be handled carefully**
  When many batteries are combined into a pack, like in electric cars, they can get hot or have other safety risks.
- **Engineers use special systems to keep batteries safe**
  A **Battery Management System (BMS)** watches over the battery to make sure everything is working right and can warn if something's wrong.
- **Heat is a big concern**
  Thermal Management helps control the battery's temperature so it doesn't get too hot. Safety systems also help stop problems like overheating, overcharging, or short circuits.

Dig Deeper



Dig Deeper (Extension Activities)

History

One of the earliest scientists working on electric batteries was Alessandro Volta around 1800 (note that his name gave us the term “voltage” and measurement units of “volt”). By the mid-1800s, scientists developed early rechargeable batteries.

https://batteryuniversity.com/article/bu-101-when-was-the-battery-invented

https://nationalmaglab.org/magnet-academy/history-of-electricity-magnetism/museum/plante-battery-1859/

Resources

How batteries work - Adam Jacobson (TED-Ed) https://www.youtube.com/watch?v=9OVtk6G2TnQ

https://www.acs.org/content/dam/acsorg/education/outreach/kidszone/kids-zone-build-a-lemon-battery.pdf

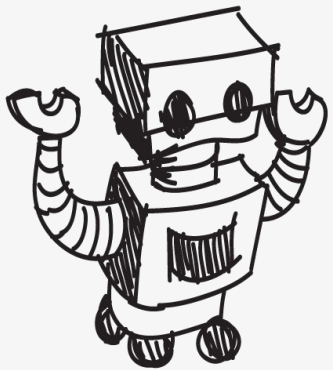
https://www.energy.gov/science/doe-explainsbatteries

https://www.energy.gov/eere/water/electrical-engineer-0

Energy Storage

https://tryengineering.org/news/energy-storage-tryengineering-tuesday/

Engineering Fields



Related Engineering Fields

- There are several types of engineering fields that are involved circuits. Here are just some of the related engineering fields.
  - Chemical Engineering
  - Materials Engineering
  - Electrical Engineering
  - Power Engineering
- Download the Engineering Fields Infographic
  How will **YOU** change the world?
  Engineers are the inventors and problem solvers of the world! More than twenty five major specialties are recognized in the field of engineering. **Engineers make the world a better place!**

What is Engineering?

Learn about engineering and how engineers are creative problem solvers and innovators who work to make the world a better place.
(Video 3:43)

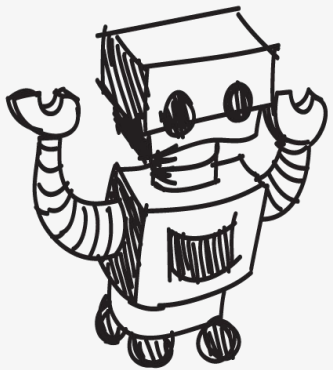
Source: TeachEngineering YouTube Channel - http://www.youtube.com/watch?v=H9VDkvqGmVo

Greatest Engineering Achievements of the 20th Century

Source: http://www.greatachievements.org/

Learn more about how engineers make the world a better place

Engineering Design Process & Habits of Mind



The Engineering Design Process

Learn about the engineering design process (EDP). The process engineers use to solve problems.

(Video 1:47)

Source: TeachEngineering YouTube Channel http://www.youtube.com/watch?v=b0ISWaNoz-c

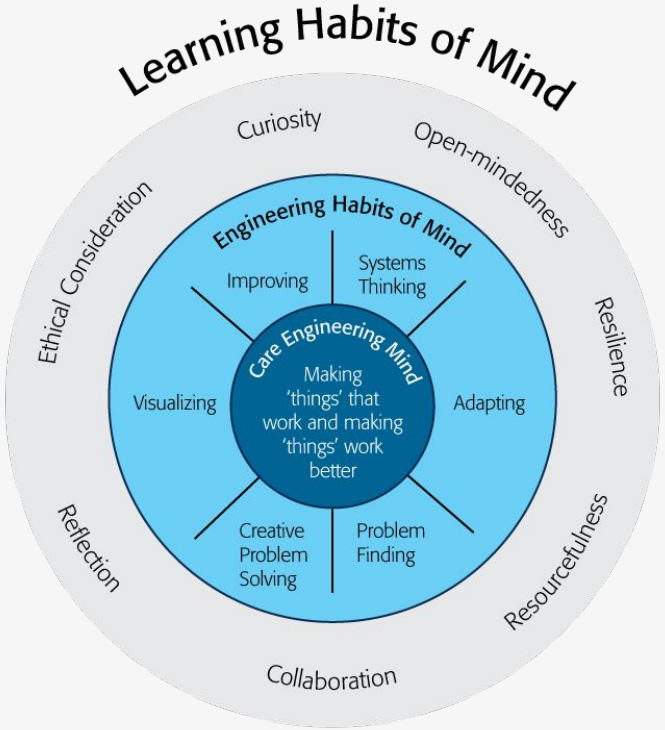
Engineering Design Process

- Divide into teams of two (or up to 4 max)
- Review the challenge and criteria & constraints
- Brainstorm possible solutions (sketch while you brainstorm!)
- Choose best solution and build a prototype
- Test then redesign until solution is optimized
- Reflect as a team and debrief as a class

Productive Failure

- The engineering design process involves productive failure: test, fail, redesign. Iterate again and again until you have the best possible solution.
- It is important to document iterations to keep track of each redesign. Use the engineering notebook to sketch ideas, document iterations and any measurement and/or calculations.
- It’s also important to showcase the fact that there can be multiple solutions to the same problem. There’s no one “right” solution.

Engineering Habits of Mind



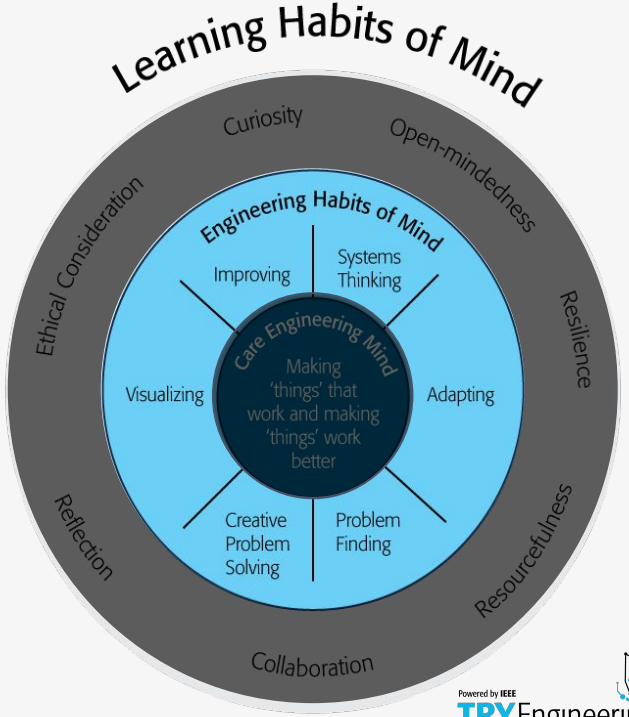
Engineering Habits of Mind (EHM) is about how engineers think everyday. The Core Engineering Mind is about making things that work and making them work better.

Source: https://online-journals.org/index.php/i-jep/article/view/5366)

Powered by IEEE TRYEngineering | IEEE

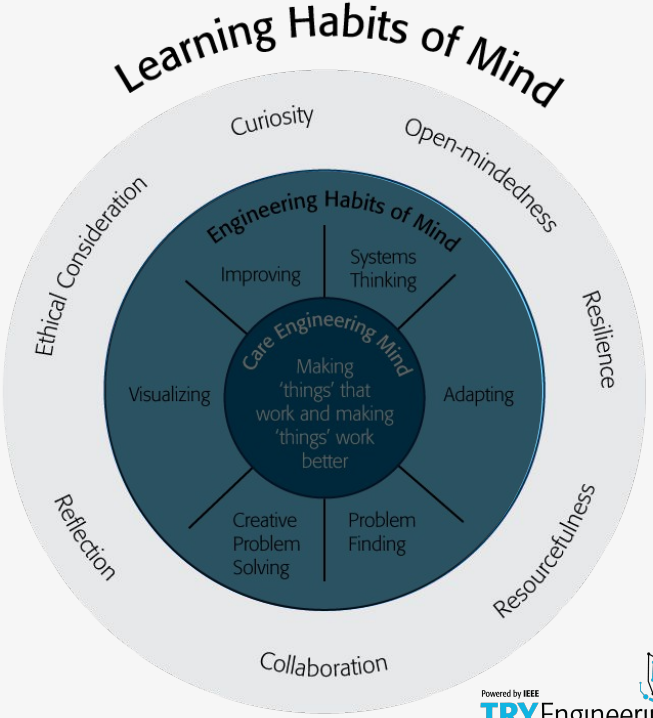
Engineering Habits of Mind Checklist

- ❑ **Systems thinking**
- ❑ **Problem-finding**
- ❑ **Visualising**
- ❑ **Improving**
- ❑ **Creative problem-solving**
- ❑ **Adapting**

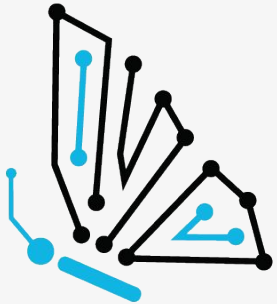


Learning Habits of Mind Checklist

- Open-mindedness
- Resilience
- Resourcefulness
- Collaboration
- Reflection
- Ethical Consideration
- Curiosity



For more engineering lesson plans and resources like games, engineering careers, and STEM opportunities visit IEEE's TryEngineering.org



Powered by IEEE

TRY Engineering