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**Lesson Plan:**

# Recycling Sorter



# Real-World Application



# Inside a Recycling Facility

Every day at the Sims Municipal Recycling facility in Sunset Park, Brooklyn, roughly 800 tons of recyclables are sorted. (Video 4:43)



Source: Science Friday YouTube Channel: <https://www.youtube.com/watch?v=nUrBBBs7yzQ>

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Check out these cool factory robots on  
[robots.ieee.org](https://robots.ieee.org)

Meet YuMi



Meet Nextage



Check out more cool factory robots on [robots.ieee.org](https://robots.ieee.org)



Photo Source: <https://robots.ieee.org/>

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# AI-driven Sorting Robots

MIT and CSAIL\* developed “RoCycle” a robot that can automatically sort recyclables. It uses soft Teflon “fingers,” which have fingertip pressure sensors to detect object size and stiffness. Since it doesn’t depend on vision, it can distinguish a metal object from one that simply looks like it’s metal by sensing it’s conductivity.

Researchers at MIT say robots could someday presort recyclables before curbside pickup. You just might find one of these in your home in the future.



Photo: Jason Dorman



CSAIL - Computer Science and Artificial Intelligence Laboratory  
Source: <http://news.mit.edu/2019/mit-robots-can-sort-recycling-0416>

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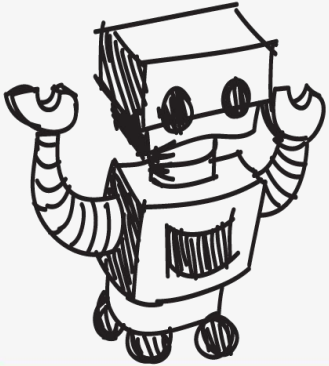
# Plastic Bags and Single-Stream Recycling

- Did you know that plastic bags are not single-stream recycling friendly?  
(Video 2:29)



Source: YouTube - PBS NewsHour Channel [www.youtube.com/watch?v=kWuBfqvfUC4&feature=youtu.be](https://www.youtube.com/watch?v=kWuBfqvfUC4&feature=youtu.be)

# The Design Challenge



# The Design Challenge

- You are an engineer working to design a system to sort a mixed-up recycling bin. The goal is to gain an understanding of the challenges waste management centers face and different methods they use to sort recycling.





# Defining the Challenge: Criteria & Constraints



## Criteria

Separate recyclables into four categories (plastic, glass, metal and paper)

## Constraints

- You can help run the system by acting as part of the machinery design but you cannot handle the recyclables directly.
- The paper materials must remain dry.



# Materials

## Required

- Variety of clean, dry recyclables (plastics, glass, metal/aluminum cans, and paper) in a large recycling bin or box
- Four smaller bins or cardboard boxes to separate recyclables
- Broken-down cardboard boxes or other sheets of cardboard
- Roll of paper (wrapping, art) or shelf liner sheets (used for conveyer belt)
- Loose netting
- Long table or a few short tables placed together

## Optional

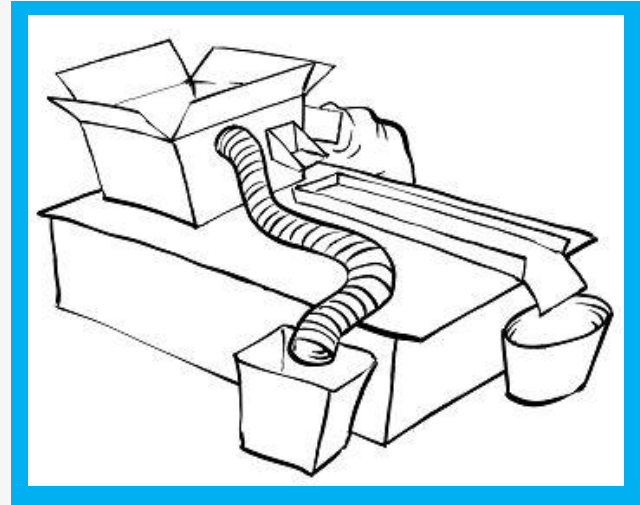
- Fans or hair dryers
- Ladder or step stool (to allow changes in height for chutes, etc.)
- Magnetic wands or other large magnets



# Consider...

Before you get started brainstorming...consider the following...

- Shape and weight of recyclables
- Are any of the recyclables magnetic?
- Will gravity play a role in your design?



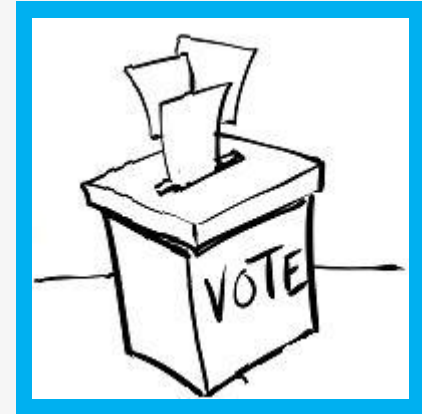
# Teamwork

- Begin working in small teams of 3-4 to brainstorm solutions and draw a diagram of your planned sorting machine on paper.
- Each team then decides on their best ideas, and takes turns sharing their ideas with the class.

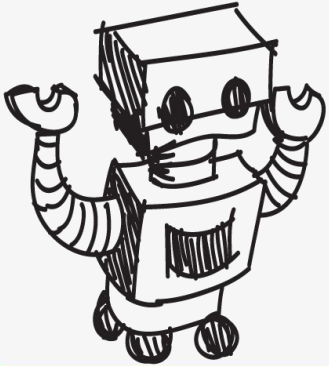


# Teamwork

- As a class, vote for the best team ideas. Elect one member from each team to work together to build the sorter based on the combined best ideas. The remaining students observe and advise the building team.
- The design team presents the design and demonstrates the sorting machine.

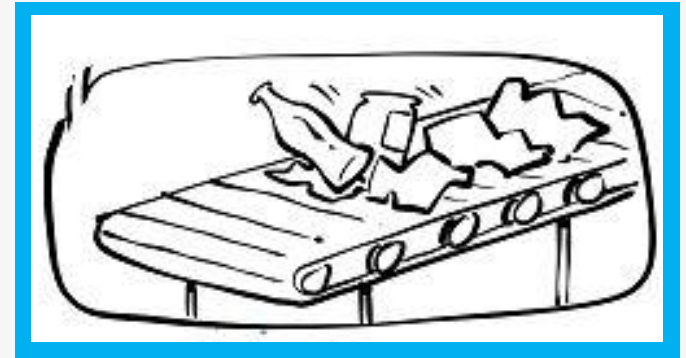


# Reflection & Debrief

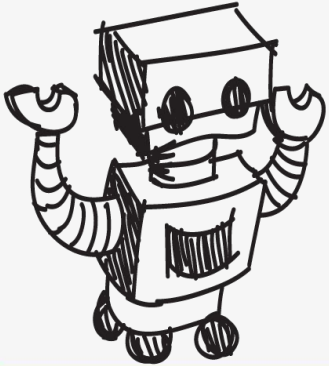


# Reflection

- What were the characteristics (magnetism, weight, etc.) of each type of recyclable that allowed it to be sorted?
- How important do you think human eyes and hands would be to a single-stream sorting process?
- Given the advantages and disadvantages of single-stream recycling, do you think it's a worthwhile system? Why or why not?
- What do you think could be done to improve recycling where you live?



# The Engineering Design Process





# 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 3 or 4
- 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

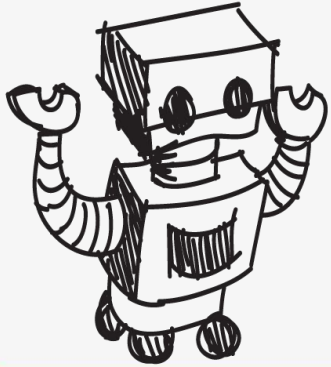


# Productive Failure

- The engineering design process involves productive failure: test, fail, redesign. Repeat (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.



# Vocabulary



# Vocabulary

- Chute: A steep, narrow slope down which things can slide.
- Constraints: Limitations with material, time, size of team, etc.
- Conveyor Belt: A continuous moving band of fabric, rubber, or metal used for moving objects from one place to another.
- Criteria: Conditions that the design must satisfy like its overall size, etc.
- Engineers: Inventors and problem-solvers of the world. Twenty-five major specialties are recognized in engineering ([see infographic](#)).
- Engineering Design Process: Process engineers use to solve problems.
- Engineering Habits of Mind (EHM): Six unique ways that engineers think.

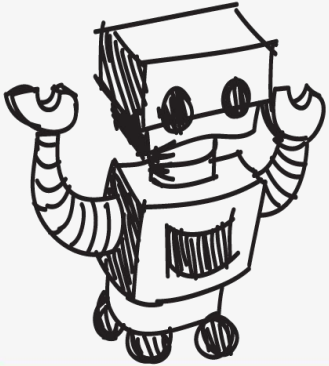


# Vocabulary

- Iteration: Test & redesign is one iteration. Repeat (multiple iterations).
- Materials Recovery Facility (MRF): Facility where recycling materials are separated using conveyor belts and multiple separation methods. Once the materials are separated, they are collected together and sold for reuse.
- Prototype: A working model of the solution to be tested.
- Recycle: Practice of reusing materials in existing products to create new ones.
- Single-stream Recycling: A system in which recyclables, such as paper, metals, plastics, and glass, are mixed together rather than being sorted out before collection.



# Engineering Fields



# 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)*

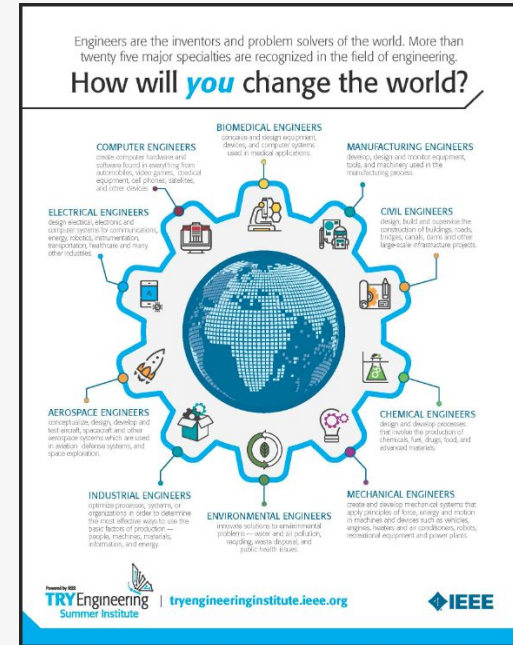


Source: TeachEngineering YouTube Channel - <http://www.youtube.com/watch?v=H9VDkvgGmVo>

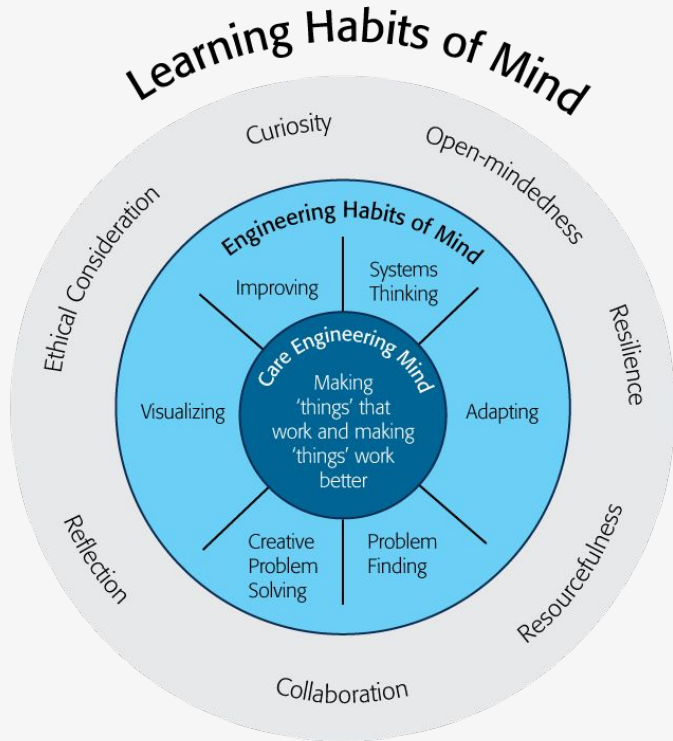


# Related Engineering Fields

- There are many different types of engineering fields that involve recycling. Here are just some of the related engineering fields.
  - Environmental Engineering
  - Industrial Engineering
  - Electrical Engineering
  - Computer Engineering
- Download the [Engineering Fields Infographic](#)  
How will **YOU** change the world?



# Engineering Habits of Mind



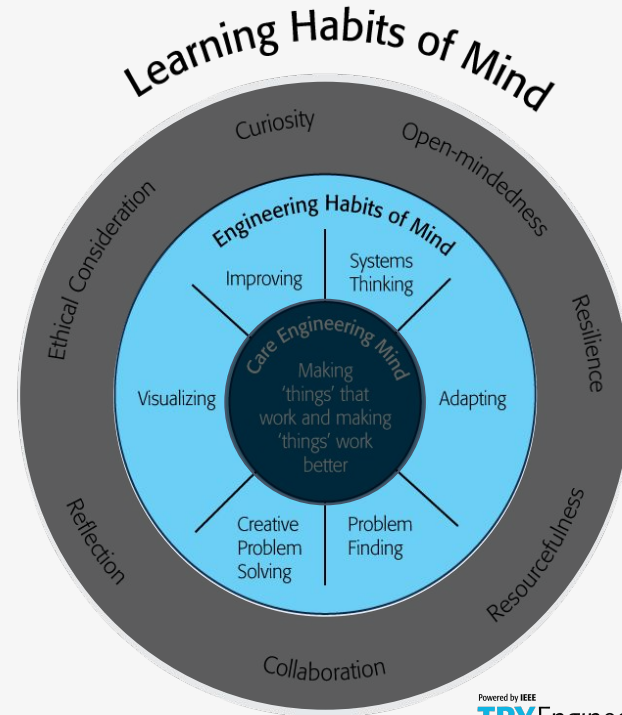
Engineering Habits of Mind (EHM) is about how engineers think everyday. The Core Engineering Mind is about making things that work and making them work better.

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



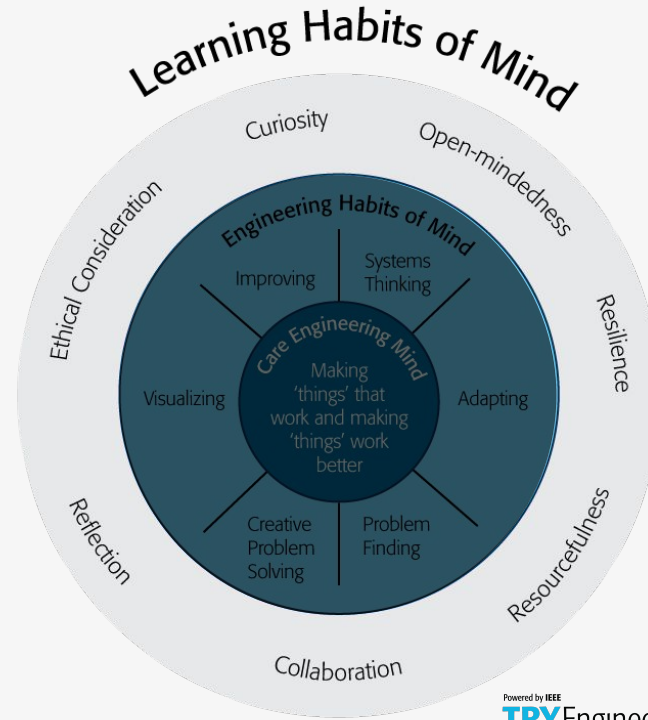
# Engineering Habits of Mind Checklist

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



# Learning Habits of Mind Checklist

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



# Greatest Engineering Achievements of the 20th Century



## Greatest Engineering Achievements OF THE 20<sup>TH</sup> CENTURY

### Welcome!

How many of the 20th century's greatest engineering achievements will you use today? A car? Computer? Telephone? Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration

11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials

**LinkEngineering**



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

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# Learn more about how engineers make the world a better place



The banner features the NAE logo (three interlocking puzzle pieces) and the text "NAE GRAND CHALLENGES FOR ENGINEERING" and "NATIONAL ACADEMY OF ENGINEERING". Navigation buttons for "Challenges", "News", and "Community" are in the top right. The main visual is a large green puzzle piece on the left containing a fusion symbol, with a complex network of glowing green lines radiating from its center. Below the puzzle piece, the text "Provide energy from fusion" is displayed, followed by a paragraph: "Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way." A row of 15 diamond-shaped icons representing various engineering fields is at the bottom.

NAE GRAND CHALLENGES  
FOR ENGINEERING  
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Challenges News Community

## Provide energy from fusion

Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way.



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