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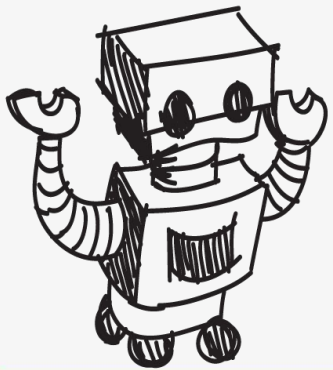
TRY Engineering

Lesson Plan:

Pulleys and Force

IEEE

The Design Challenge



The Design Challenge

You are a team of engineers who have been given the challenge of operating a single pulley to lift a container.

Defining the Challenge: Criteria & Constraints

Criteria

- Can use only 1 pulley
- Pulleys can be tied to door handles, drawer pulls, or other stable objects with twine/string
- Twine/string may be used to run through the pulleys and tied to the neck of the bottle.

Constraints

- Use only the materials provided.

Material

Materials – Required (Per Team)

- Twine/String
- Two 2" or larger pulleys
- Weight (1 small plastic water or soda bottle filled with liquid or sand)

Teacher Resource (to assist students with pulley designs)

- Single Pulley Set Up - The direction of force exerted to lift the bottle is the opposite of the motion of the bottle - you pull down to lift the bottle up.

Material

- Step One: Tie one pulley to a door knob, drawer pull, or some fixed object that can withstand the weight of the bottle.
- Step Two: Tie a length of twine to the neck of the bottle and thread through the pulley.
- Step Three: Pull down on the twine and notice the amount of force needed to lift the bottle. Observe that the direction of force (down) is the opposite of the resulting bottle movement (up).

- Two Pulley Set Up - Another option is to do the set up using two pulleys. This second pulley should reduce the amount of force needed to lift the bottle by one half. Additional pulleys should further reduce the force needed.

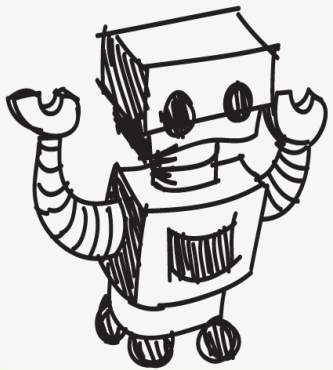
Material

- Step One: Tie one pulley to a door knob, drawer pull, or some fixed object that can withstand the weight of the bottle.
- Step Two: Affix the neck of the bottle with string to the second pulley.
- Step Three: Tie string to the bottom of the top pulley. Wind the string through the bottom pulley, then back up and around the wheel of the top pulley, then back down through the wheel of the bottom pulley for the second time, and back up through the wheel of the top pulley. Now the string has wound twice through the two pulleys.
- Step Four: Pull on the string and compare the force needed to lift the bottle to the one pulley system described previously.

Consider...

- Before you get started building, consider the direction you would be pulling (or exerting force) and how, when using one pulley, it is the opposite direction of the intended work (lifting the container).

Reflect & Debrief



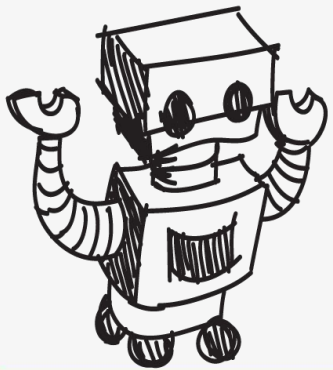
Reflection

- Do you expect the force you will have to apply to move the bottle will be reduced? By how much?
- Do you think that adding ten more pulleys would make a difference? Why, or why not?
- Do you think the size of the pulley impacts how much force is needed to lift the bottle? Why, or why not?
- Do you think the smoothness of the rope or twine pulley impacts how much force is needed to lift the bottle? Why, or why not?
- Did you find you had to pull the rope or twine further the more pulleys you added to your system?

Reflection

- Can you think of examples of three machines that incorporate pulley systems?
- Can you think of engineering problems that were solved through the use of a pulley or a pulley system?
- Can you find any examples of pulleys in your school, home, or community?

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
- 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

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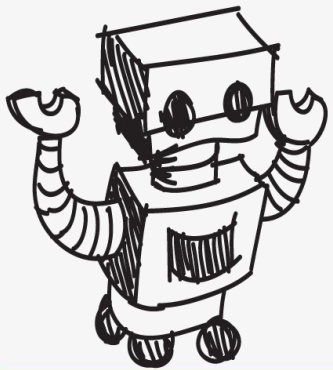
Productive Failure

- 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.

Vocabulary



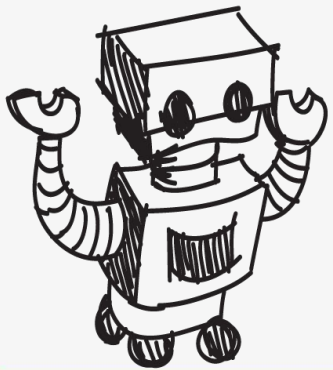
Vocabulary

- Constraints: Limitations with material, time, size of team, etc.
- 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.
- Force: Pushing or pulling on an object to give it energy and cause it to move, stop moving, or change direction

Vocabulary

- Iteration: Test & redesign is one iteration. Repeat (multiple iterations).
- Prototype: A working model of the solution to be tested.
- Pulley: A rotating wheel with a curved convex rim which is mounted on a hook or base for stability.

Dig Deeper



Dig Deeper into the Topic

Internet Connections

- Wikipedia Pulleys (https://en.wikipedia.org/wiki/Pulley)

Recommended Reading

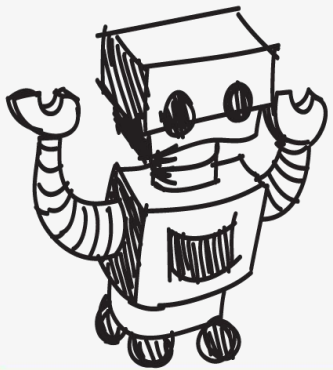
- Using Pulleys and Gears (Machines Inside Machines) (ISBN: 1410914453)
- New Way Things Work, by David Macaulay (ISBN: 0395938473)
- Moving Heavy Things, by Jan Adkins (ISBN: 0937822825)

Dig Deeper into the Topic

Writing Activity

Write an essay or a paragraph describing how pulleys are used in a marina or shipyard.

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)

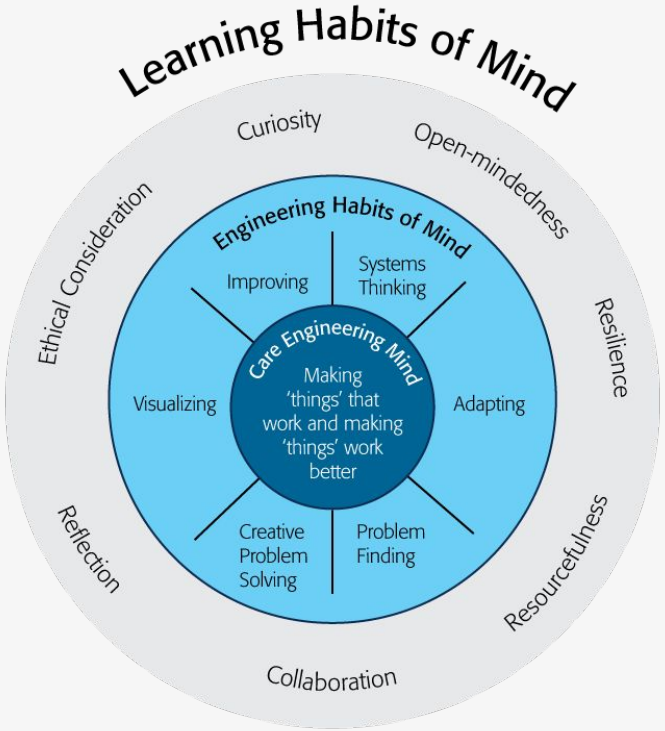
Source: TeachEngineering YouTube Channel - http://www.youtube.com/watch?v=H9VDkvqGmVo

Related Engineering Fields

- There are several types of engineering fields that are involved with pulley systems. Here are just some of the related engineering fields.
  - Mechanical 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)

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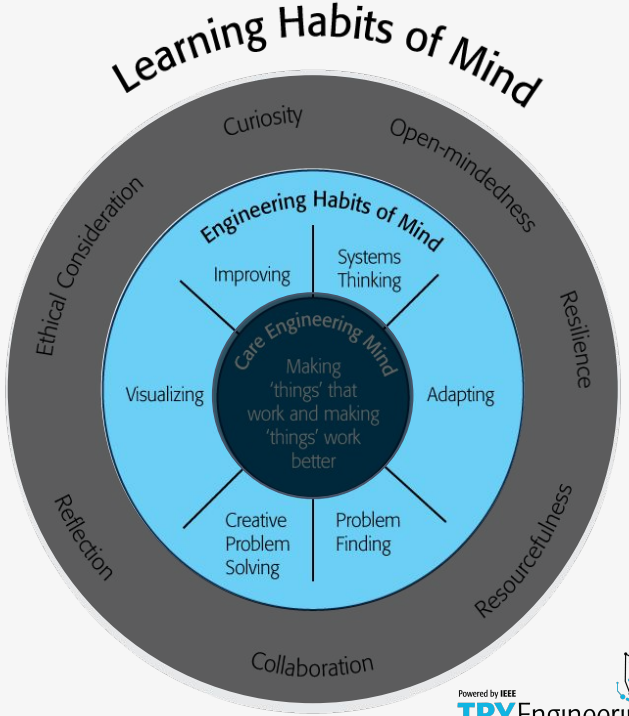
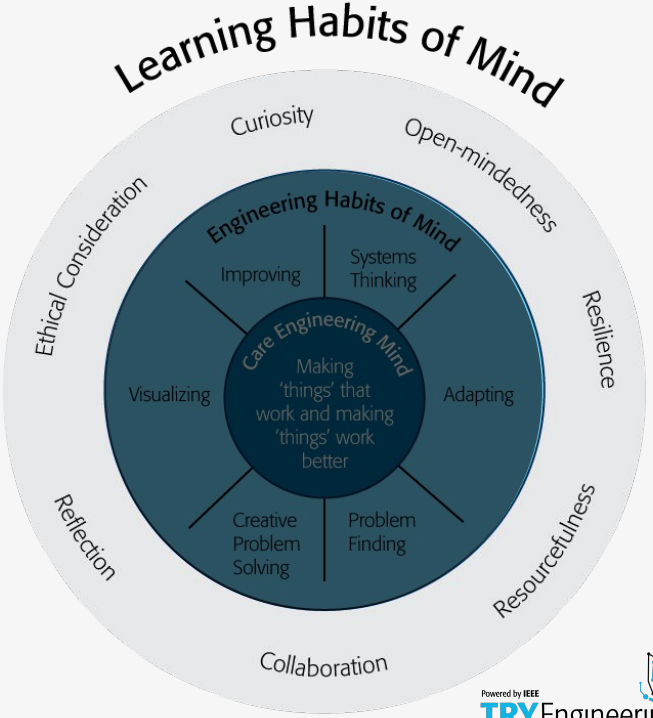
Engineering Habits of Mind Checklist

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



Learning Habits of Mind Checklist

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

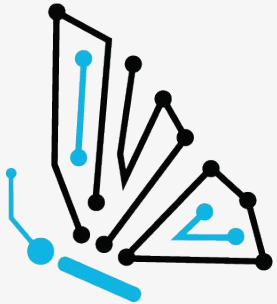


Greatest Engineering Achievements of the 20th Century

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

Learn more about how engineers make the world a better place

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



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