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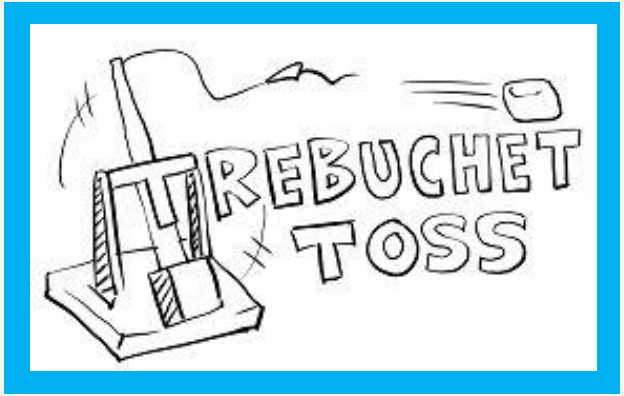
TRY Engineering

Lesson Plan:

Trebuchet Toss



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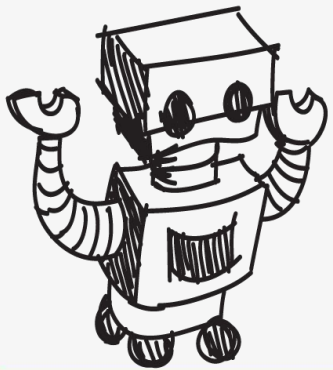
Real-World Application



How Does a Trebuchet Work?

Did you ever wonder how a trebuchet works? A high school student and a mechanical engineer tell you how. (*Video 2:35)*

Source: National Geographic Kids YouTube Channel: https://www.youtube.com/watch?v=W5RFoowvGkw

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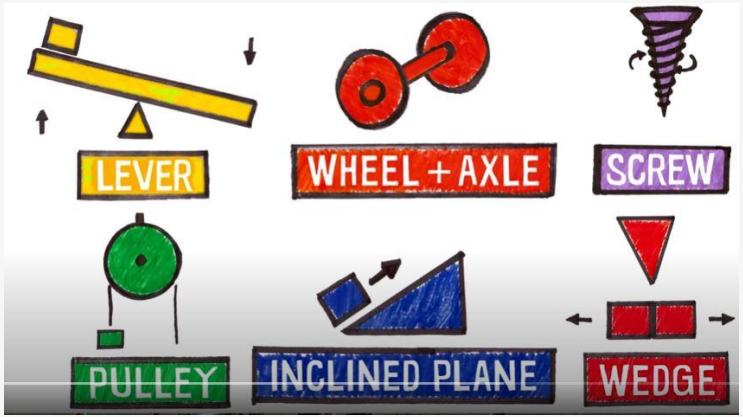
What is a Simple Machine?

Trebuchets are “gravity powered” throwing devices made up of several simple machines. In fact, all six simple machines (lever, pulley, wheel and axle, inclined plane, screw, and wedge) can be used in trebuchet design. Learn more about simple machines. *(Video 4:08)*



Source: Design Squad Global YouTube Channel: https://www.youtube.com/watch?v=JjSmXCdZsKk

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Largest Trebuchet in Europe

Watch as the largest trebuchet in continental Europe launches for the first time. (*Video 6:17)*

Source: Discovery Canada YouTube Channel: https://www.youtube.com/watch?v=M1iPxY3FYNE

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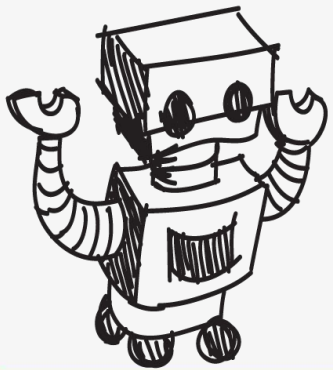
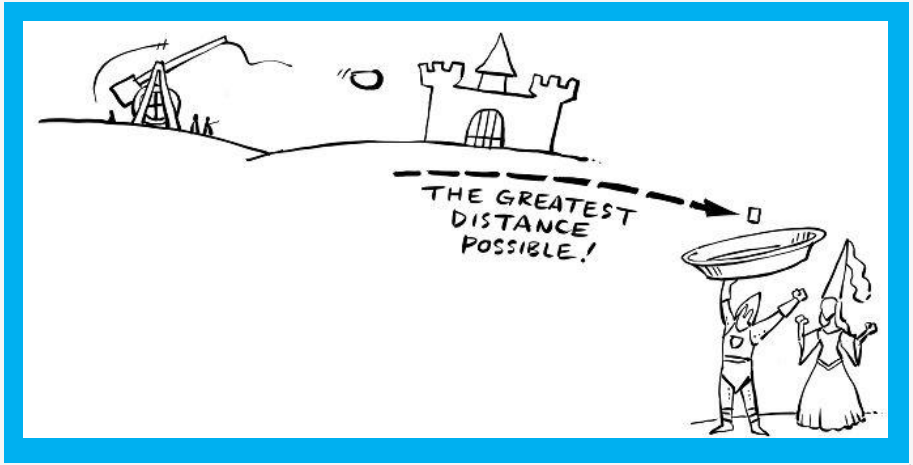
The Design Challenge



The Design Challenge

- You're a team of engineers who have been given the challenge to design your own trebuchet out of everyday items. The trebuchet should be designed to launch a marshmallow so it can land on a pie tin from as far a distance as possible.



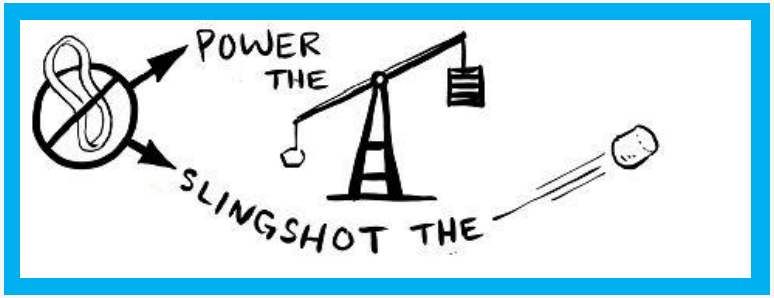
Defining the Challenge: Criteria & Constraints

Criteria

- Must launch a marshmallow to land on a pie tin from as far a distance as possible

Constraints

- Can only use the materials provided
  - Teams may trade materials to develop their ideal parts list.
- Rubber bands may not be used to power the arm or slingshot the marshmallow



Material

Required for Build (per team)

- Counterweight (metal washers, rocks, coins, marbles)

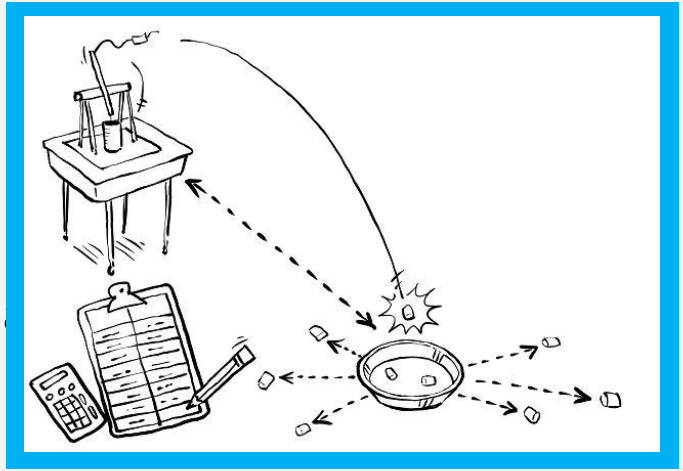
Optional for Build – Trading/Table of Possibilities

- Plastic drinking straws
- Pencils/popsicle sticks/wooden dowels
- Cardboard sheets
- Rubber bands
- Toothpicks
- Paperclips or craft wire
- String
- Small pieces of cloth or sheets of paper

Testing

Testing Material

- Meter stick or measuring tape
- Mini marshmallows
- Pie tin or Paper plate



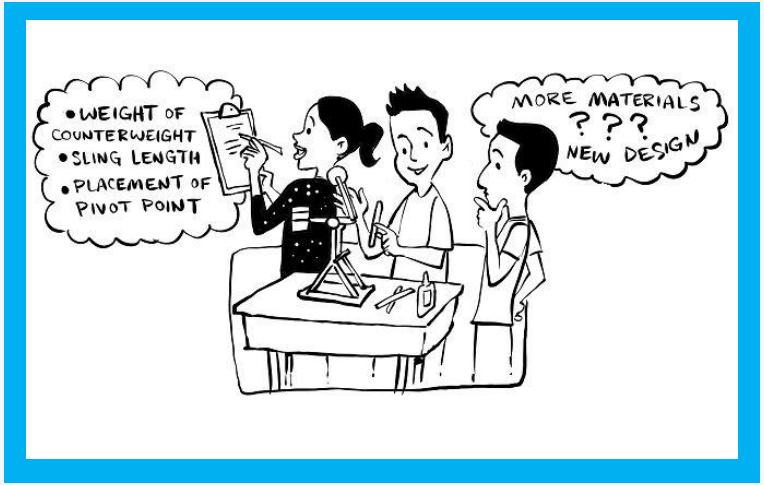
Testing Process

- Each team tests their trebuchet by launching a pie tin placed several feet away. The goal is to launch the marshmallow as far a distance as possible to land on the pie tin target.
- Each team should record the distance their marshmallow travels and how far it lands from the target (accuracy).

Consider...

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

- Two basic types of trebuchets
- Parts of a trebuchet – arm, base, sling
- Weight of your projectile in comparison to your counterweight
- Which simple machines you will use
- How a lever works
- Importance of force/torque



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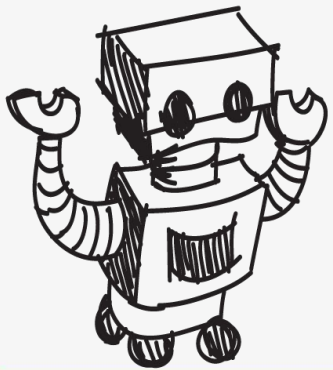
Variations

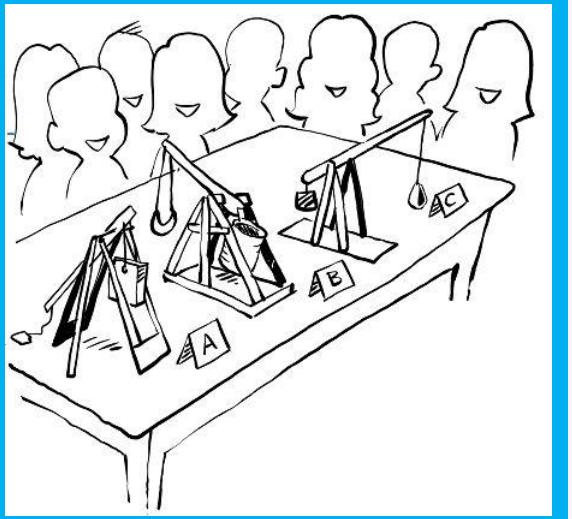
- Try building a wall of paper cups and designing a trebuchet that can launch a marshmallow over it.
- Next, try designing a trebuchet that can launch a marshmallow through the wall of cups with the goal of knocking down the greatest number of cups.

Reflect & Debrief



Reflection

- Did you succeed in meeting the challenge? If so, what was the maximum distance achieved? If not, why did it fail?
- Did you decide to revise your original design or trade materials while in the construction phase? Why?
- If you traded materials with other teams, how did that process work for you?



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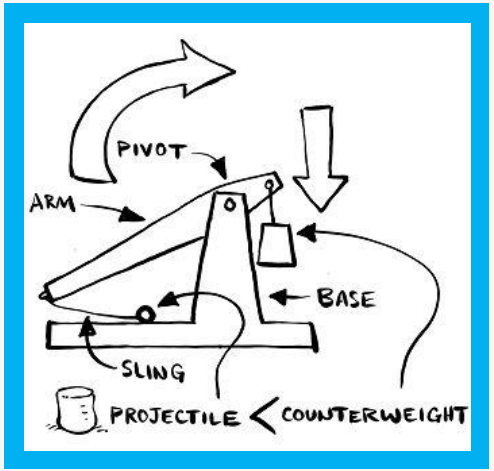
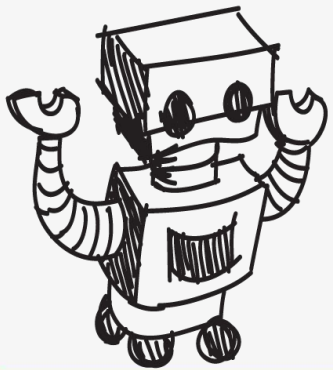
Reflection

- If you had to do it all over again, how would your planned design change? Why?
- What designs or methods did you see other teams try that you thought worked well?
- What were the advantages to working in a team versus working alone?
- How might you measure the maximum height your trebuchet could launch a marshmallow? Try it!



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 2 to 3 (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.

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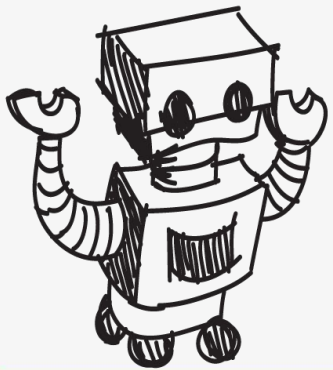
Vocabulary



Vocabulary

- Arm: Essentially a long beam on a pivot that acts as a lever to fling the projectile.
- Base: Provides the support for the device. Often on wheels for mobility.
- Constraints: Limitations with material, time, size of team, etc.
- Counterweight: A weight that provides a balance against something of equal weight. It is the “force” for a trebuchet.
- Counterweight Trebuchet: A counterweight is attached to the short end of the arm, closer to the pivot.
- Criteria: Conditions that the design must satisfy like its overall size, etc.

Vocabulary

- 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: A push or pull on an object. It can cause an object to accelerate, slow down, remain in place, or change shape. In a trebuchet the force (counterweight) is much greater than the load (projectile).
- Fulcrum/Pivot Point: The point on which a lever rests or is supported and on which it pivots. On a trebuchet, the fulcrum is not directly in the middle, as it is on a see-saw.

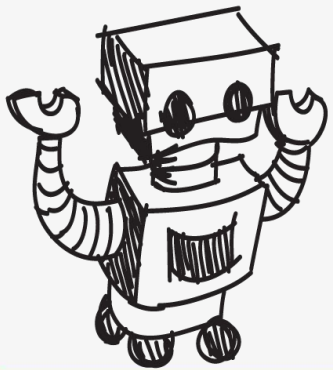
Vocabulary

- Iteration: Test & redesign is one iteration. Repeat (multiple iterations).
- Lever: One of the six types of simple machines. A lever is a rigid object that is used with a fulcrum or pivot point to increase the amount of mechanical force applied to an object.
- Mechanical Advantage: The amount of help you can get by using a simple machine.
- Pivot: A shaft or pin with a pointed end on which something turns.
- Projectile: Something (as a bullet or rocket) thrown or shot especially from a weapon. It is the “load” for a trebuchet.
- Prototype: A working model of the solution to be tested.

Vocabulary

- Simple Machine: A trebuchet is a “gravity powered" throwing device made up of several simple machines.
- Sling: Holds the projectile in place at the long end of the arm.
- Torque: The tendency of a force to turn or twist.
- Traction Trebuchet: Relies on people pulling down on the short end of the arm with ropes.
- Trebuchet: Type of catapult that was used during the Middle Ages to launch projectiles during battle.

Dig Deeper



Dig Deeper into the Topic

Internet Connections

- Trebuchets Wikipedia: https://en.wikipedia.org/wiki/Trebuchet

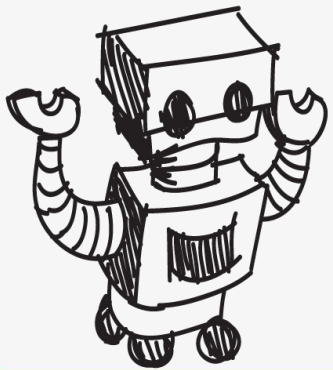
Recommended Reading

- Catapult Design, Construction and Competition with the Projectile Throwing Engines of the Ancients (ISBN: 978-0977649709)
- Engineering in the Ancient World, Revised Edition (ISBN: 978-0520227828)

Writing Activity

- Compare and contrast the trebuchet and the catapult.

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)

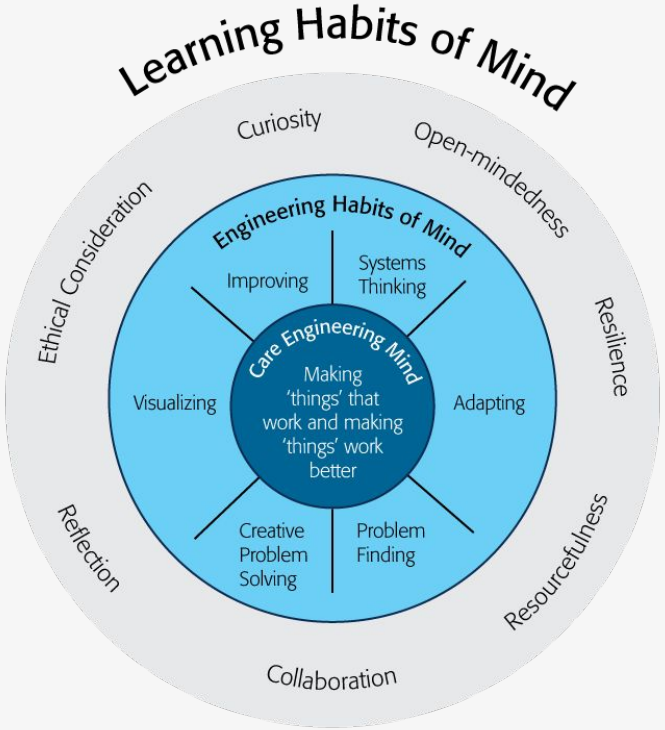
Source: TeachEngineering YouTube Channel - http://www.youtube.com/watch?v=H9VDkvqGmVo

Related Engineering Fields

- Mechanical engineers use simple machines (lever, pulley, wheel and axle, screw, wedge, incline) in their designs.
  - 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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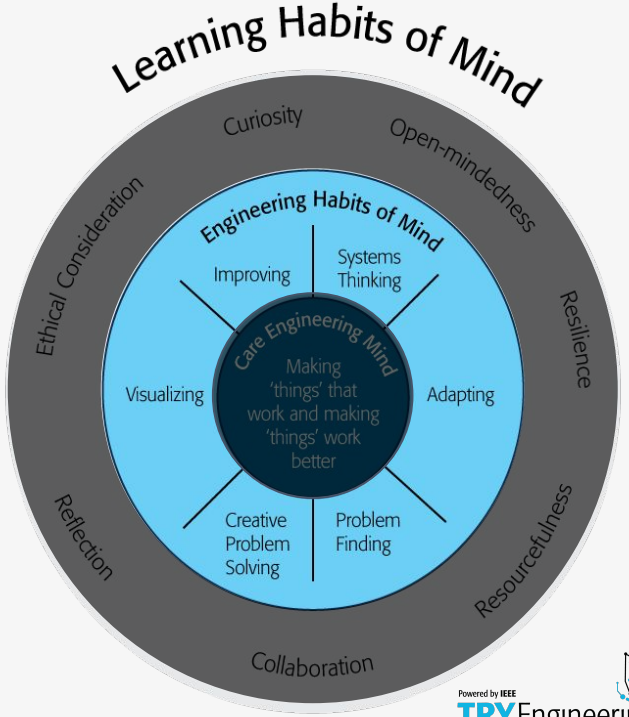
Engineering Habits of Mind Checklist

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



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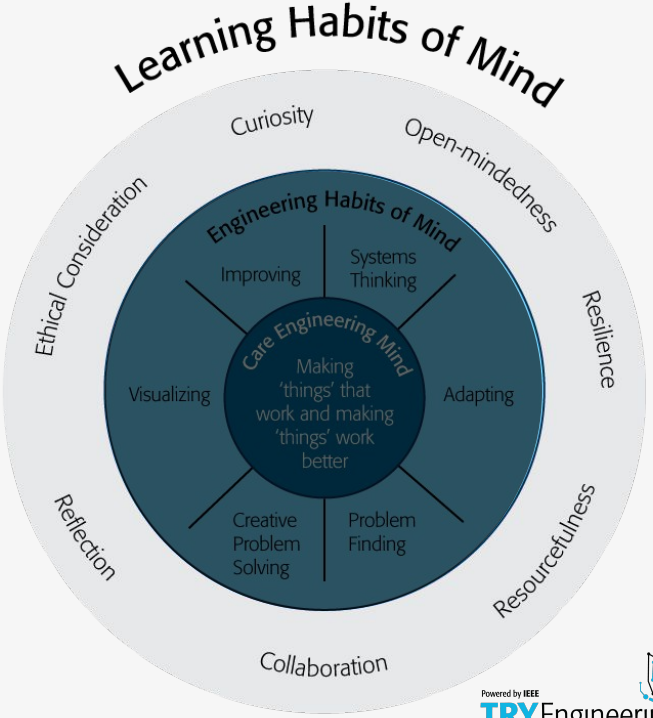
Learning Habits of Mind Checklist

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



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Greatest Engineering Achievements of the 20th Century

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

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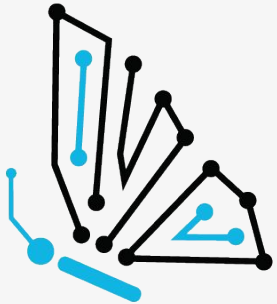
Learn more about how engineers make the world a better place

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



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