Rube Goldberg Machines

“Imagination is more important than knowledge.”
- Albert Einstein
Hey Teachers!

We’re so glad you picked up this booklet. WEMADEIT was designed to make engineering relevant for you and your students. Too often, students drop math and science courses in high school, only to discover their decision has had a profound impact on their career path. Our hope is to help keep their doors open by introducing engineering in a fun, collaborative and creative way. This project is designed to captivate your students by the power and potential of STEM – especially girls, who we’ve really been missing the mark with.

The WEMADEIT curriculum was developed as a response from working with a Youth Think Tank: 36 high school girls from Ontario who interviewed 300 of their peers and created a brand, website and campaign for girls, by girls. By combining innovative STEM curriculum, insights gathered from girls today and the knowledge and experience you have as a teacher, we’re going to get students excited about engineering!

Our goal is to make science and math engaging for kids – it’s not profit – so feel free to copy and distribute this material. Please share the resources with your friends and colleagues at:

www.wemadeit.ca/teachers

This booklet contains:
Everything you’ll need to get your students building, designing and problem solving like engineers!

1. Lesson Overview
2. Learning Goals
3. Curriculum Connections and Cross-Curriculum Connections
4. Activity 1: What do you see?
   - Learning Goals and Materials List
   - Reference Chart of Teacher & Student Participation
   - Activities & Discussion
5. Activity 2: Design and Build a Crazy Machine!
   - Learning Goals, Materials List and Success Criteria
   - Reference Chart of Teacher & Student Participation
   - Activities & Discussion
6. Student Activity Worksheets

The world is facing unprecedented changes that affect climate, technology and humans at a global scale. Engineers solve these massive problems, however, the shortage of women in Engineering poses a great weakness. Without including female perspectives, our solutions may not be enough. Taking a never-been-done-before approach, Hydro One funded four universities: Ryerson, Waterloo, Western and UOIT to improve outreach to women.

The consortium collaborated with 36 high school girls to rebrand Engineering for girls. Our goal is to talk about Engineering in a way that actually relates to young women when they’re making choices about their future. WEMADEIT is a brand, a website and now a movement, offering free innovative curriculum for grade 7&8 students designed to bring Engineering to life. Finally, there’s a real tool to get kids interested in STEM careers. Join us at the forefront!

connect with teachers, training and free resources www.wemadeit.ca/teachers
**Rube Goldberg Machines**

**PURPOSE**

Engineers are creative thinkers and problem solvers. Systems engineers are often given an idea for a machine and asked to make it reality. They work closely with other engineers to come up with solutions so that each part of the system they design works together in the safest and most efficient way possible. Through this hands-on, fun activity, grade 8 students will learn how the individual parts of a system work together when they create contraptions based on the whimsical cartoons of Rube Goldberg.

**LEARNING GOALS**

- Using technological problem-solving skills students will work together to design and build a multistep system that performs a specific function

- Students will be able to identify and describe the different components of their system and what function it performs

**TIME NEEDED**

6 periods (total)

Part 1: What do you see?

45 minutes

Part 2: Design and Build a Crazy Machine

A. Researching & Planning Design  2 periods
B. Building Rube Goldberg  2 periods
C. Gallery Walk & Crit  1 period

**Curriculum Connections:**

**Understanding Structures & Mechanisms: Systems in Action**

2.4, 3.1  How systems are designed to accomplish specific tasks

3.2, 3.3  Input & Outputs of systems

2.6  Clearly explain systems in action using appropriate vocabulary

**Cross-Curriculum Connections:**

**History:**

- Have students research and report on a famous inventor at the turn of the 20th century (1885-1914) and how their invention helped Canadian workers or society and/or improved technology or industry (e.g. Guglielmo Marconi, who invented the long distance radio transmission or Alexander Graham Bell, who invented the telephone).

- Have students report on and describe the components of a system that has improved the working conditions and/or reduced labour for miners, farmers, forestry workers or factory workers (or other). Compare and contrast with past and present systems.

**Literacy:**

- Students will gain practice in writing and speaking for an intended purpose and audience using a variety of literary and stylistic elements (e.g. students can write a report on how their contraption is the next best toy invention, or a humorous and descriptive free verse or narrative poem that goes along with the explanation of their machine.)
**MATERIALS**

**Part 1: What do you see?**
- Rube Goldberg image (provided on page 8)
- Computer/internet access to show videos
- Observe & Infer hand-out
- Small post-its in two colours

**Activity 2: Design and Build a Crazy Machine**
(These materials can vary from classroom to classroom, based on the resources available)
- Classroom items: books, markers, math manipulatives, etc.
- Recycled materials: small, medium and large plastic containers, paper tubes, cardboard, water bottles, etc.
- Dollar store items: straws, skewers, dowel, dominoes, marbles, styrofoam balls, paper clips, etc.
- Other items: small balls, marbles, dominoes, Lego, snap cubes, tape, glue, scissors, rulers, pencils, etc.

**TIME NEEDED**
45 minutes

**LEARNING GOALS**
- Students will be introduced to unconventional systems through one of Rube Goldberg’s contraptions

**MATERIALS**
- Rube Goldberg comic (on page 8) without the explanation (more images available at www.rubegoldberg.com/gallery)
- Observe & Infer handouts provided
- Small post-it notes (in two colours)

**WEMADEIT Spotlight!**

Ann Makosinski is an amazing young talented student who contributed in the field of engineering by creating a power-less battery and only using the human hand. She greatly impacted society positively and helped others without electricity see in the dark. (And she even made it on to Jimmy Fallon!)

Ann Makosinski: www.wemadeit.ca/engspirational/engbeaut/ann-makosinski/
### Overview of Teacher & Student Participation

<table>
<thead>
<tr>
<th>WHAT TEACHERS DO</th>
<th>WHAT STUDENTS DO</th>
<th>NOTES</th>
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<tbody>
<tr>
<td><strong>Before</strong></td>
<td><strong>Gather materials:</strong> <strong>Observe &amp; Infer</strong> posters along with a stack of post-its in two colours.</td>
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<tr>
<td></td>
<td>**Make observations and inferences using the post-it notes and the <strong>Observe &amp; Infer</strong> handout.</td>
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<tr>
<td><strong>During</strong></td>
<td><strong>Note:</strong> Students will use technical terminology referencing the different functions of, as well as the input/output of the system. This is a good opportunity to talk about these terms and open the floor to discussions about other terms related to systems and structures.</td>
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<tr>
<td></td>
<td><strong>Note:</strong> You don’t need to tell them what the picture is. Sometimes waiting until the next day keeps them more interested and wanting to learn more about the topic!</td>
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<tr>
<td><strong>After</strong></td>
<td><strong>Gain an understanding that in order to have strong inferences they need to have support through valid observations.</strong></td>
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**Hand out **Observe & Infer** posters along with a stack of post-its in two colours to students.**

Tell the students that they will be viewing an image and will need to write down what they observe, with one thought per post-it. They will have 2 minutes to do this. Encourage them to complete this part on their own, but assure them they will have time to discuss their answers with the class.

**Post the image and allow students 2 minutes to write down their observations.**

Using the **Observe & Infer** poster draw out answers from the class as to what they observed. Note some students will automatically jump to inferences (i.e. it is an invention that does something). However, it is important to ask them why they think that and focus on the difference between what an observation and inference.

Once you collect 7-8 observations have the students make inferences about what they think they are looking at. Using the other colour post-it, have them write down their ideas. Allow students to talk with their peers about what they think it is.

Again use the **Observe & Infer** posters to draw out their inferences; stress that each inference must have supporting observations.

**Debrief with students about the importance of observation and inferences with regards to science and engineering. When design decisions are made there needs to be valid evidence (observations) supporting that decision (inference). Students will be using these skills when they create their own Rube Goldberg machine.**

**Note:** You don’t need to tell them what the picture is. Sometimes waiting until the next day keeps them more interested and wanting to learn more about the topic!
The professor gets his think-tank working and evolves the simplified pencil sharpener.

Open window (A) and fly kite (B). String (C) lifts small door (D), allowing moths (E) to escape and eat red flannel shirt (F). As weight of shirt become less, shoe (G) steps on switch (H) which heats electric iron (I) and burns holes in pants (J).

Smoke (K) enters hole in three (L), smoking out opossum (M) which jumps into basket (N), pulling rope (O) and lifting cage (P), allowing woodpecker (Q) to chew wood from pencil (R), exposing lead. Emergency knife (S) is always handy in case opossum or the woodpecker gets sick and can't work.
ACTIVITY 2: DESIGN AND BUILD A CRAZY MACHINE

TIME NEEDED

A. Researching & Planning Design 2 periods
B. Building a Goldberg Machine 2 periods
C. Gallery Walk & Crit 1 period

LEARNING GOALS

• Using technological problem-solving skills students will work together to design and build a multistep system, which performs a specific function.
• Students will be able to identify and describe the different components of their system and what function they perform.

MATERIALS

• Classroom items (books, markers, math manipulatives, etc.) and small balls, marbles, dominoes, Lego, snap cubes, tape, glue, scissors, rulers, pencils, etc. explanation (more images available at www.rubegoldberg.com/gallery)
• Recycled materials: small, medium and large plastic containers, paper tubes, thin and thick cardboard, water bottles, etc.
• Dollar store items: straws, skewers, dowel, dominoes, marbles, Styrofoam balls, paper clips, etc
• Simple machine videos:
  - www.youtube.com/watch?v=SwaTKYJSDaw The Goonies ‘simple machines’ 1:30
  - https://vimeo.com/62846755 DJ A Track & Kinetic King ‘Tuna Melt’ 3:30

Note: If desired, these supplies can vary depending on what is available in your classroom. Ideally, you want to give your students a wide range of materials to design & build with.

PROJECT TASK

Design a Rube Goldberg machine that successfully transports an object at least three desk lengths using a minimum of four different steps.

SUCCESS CRITERIA

• Creative use of materials.
• Meets the task requirements.
• Presentation: Use suitable science words and speak appropriately for your audience (other engineers).
  - What is the purpose of your contraption? Describe each step and what it does.
  - What areas did you have problems with and how did you solve it?
  - Show us how it works (did you success? fail? why?) This can be done verbally or as a written submission.
• Teamwork and collaboration: Did each member of your team contribute equally to the project? Were ideas shared between members and problems solved with input from all members? A self and peer assessment reflection would work at the conclusion of this activity.

The Youth Think Tankers were more inclined to feel confident in their creative abilities than their science and math skills; help them to see creativity as the back bone of engineering!
### Overview of Teacher & Student Participation

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<tbody>
<tr>
<td><strong>Before</strong></td>
<td>Clear off desk and prepare to observe videos and listen to instructions.</td>
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<tr>
<td>Gather materials and preview videos.</td>
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<td>Divide students into engineering teams.</td>
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<td><strong>During</strong></td>
<td>Engage in discussion, share ideas and listen to others.</td>
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<tr>
<td>Introduce <strong>Project Task</strong>.</td>
<td>Watch videos and take note of interesting and useful ideas.</td>
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<tr>
<td>Optional: Show video clips of Rube Goldberg machines.</td>
<td>Brainstorm ideas with class about use of materials or ideas for machine purpose.</td>
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<tr>
<td>Introduce <strong>Success Criteria</strong> and hand out the rubric.</td>
<td>Join team and begin engineering design process to create machine. Share ideas and listen to others in group. Draw simple designs and write down ideas. Decide on final design and draw it.</td>
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<tr>
<td>Allow the students time to experiment and brainstorm ideas for their Rube Goldberg machine.</td>
<td>Build model. (Use team work to problem solve!)</td>
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<tr>
<td>Review students’ designs prior to them starting to build.</td>
<td>Test, evaluate and redesign. Then retest, evaluate and redesign again. Continue the process until complete.</td>
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<tr>
<td>Monitor groups for participation, collaboration, etc. Refocus groups to task when needed. Provide suggestions or guiding questions for groups that seem “stuck”.</td>
<td>Prepare presentation and answers to questions</td>
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<tr>
<td>Guide groups to progress to next step in design process as needed.</td>
<td>Present machine to other engineers (class) using appropriate voice and vocabulary.</td>
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<tr>
<td><strong>After</strong></td>
<td>Gallery Walk &amp; Crit: Create a gallery walk for your students where half of the students present their designs, while yourself and the other students view their work. Encourage the students to give helpful, positive comments to each other. The class can then switch so those that were presenting can now become the audience.</td>
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<tr>
<td>Give students time to prepare presentation using their <strong>Rube Goldberg Vocabulary Organizer</strong>.</td>
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<tr>
<td>Assess presentations based on success criteria.</td>
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**Rube Goldberg Vocabulary Organizer**

- Roller Coaster
- Marble Run
- Chain Reaction
- Self-Propelled
- Motor
- Pulley
- Sled
- Escalator
- Ice Slide
- Ladder
- Ramp
ACTIVITY 2

Part 1: Researching & Planning Design
(2 periods)

Divide the students into groups of 3-4 and explain the task that they will need to complete.

“You will be working as systems engineers in your engineering teams to design, build, test and re-design a contraption which successfully transports an object at least three desk lengths using a minimum of four different steps. Systems engineers are engineers who take an idea and design the steps that are needed in a system to get from the beginning (input) to the final product (output). This is an open-ended project so be creative!”

Explain the success criteria from the previous page and provide a rubric that outlines these requirements.

Show students a video of a Rube Goldberg machine to inspire them that uses every day materials:

- www.youtube.com/watch?v=SwaTKYJSDaw
  The Goonies ‘simple machines’ 1:30
- https://vimeo.com/62846755
  DJ A Track & Kinetic King ‘tuna melt’ 3:30

Allow students time to experiment with different materials and research different steps that they can incorporate into their system.

Have students meet with their engineering teams to brainstorm solutions to their presented task and ensure that they have someone within their group taking notes.

Design a Solution

Once they have a few good ideas, they should make a list or draw diagrams to show the steps. They will likely be making a lot of changes as they go along but remind them that this is part of the process and where much of the learning takes place for engineers. Make sure you show them the materials they can use before they start designing. Although it can get frustrating at times, it can also become fun and creative!
Part 2: Building a Goldberg Machine
(2 periods)

When the students are happy with their design and the teacher has reviewed and approved their plan they can start the next step and Build A Model. Remind them to write down/draw any changes that they make and why they needed to change it.

Test, Evaluate and Redesign

Once the model is built, they need to Test, Evaluate and Redesign. Even if they have a working model, have them check each step and look for areas that could work better or try to add another step.

Part 3: Gallery Walk & Crit
(1 period)

Have your students prepare for their presentations by filling out the Rube Goldberg Vocabulary Organizer (on the next page). Remind your students to use scientific words when they are presenting! The following is a list of key words and concepts connected to the Rube Goldberg activity. This list can be adapted to reflect your own class expectations or assessment requirements.

Key words and concepts:
Simple machine, complex machine, contraption, energy, kinetic energy, potential energy, transfer of energy, work, mechanical advantage, input, output, friction, gravity, forces, momentum, velocity, acceleration and efficiency.

YTT let us know that they and their peers are super-duper hands-on! By having the students build their machines before they discuss the vocabulary, it will be easier to be creative with their building and to get excited about the concepts afterwards. This will also help your students see easy it is to understand important engineering concepts.

Below is an example of a typical Rube Goldberg explanation:

When the teams have finished, give them time to prepare for the presentation of their contraption to the class. Remind them about the success criteria one more time!
Rube Goldberg
Vocabulary Organizer

Now that you’ve built your machines, let’s figure out what all those components are! Fill out this diagram to help explain all of the components that your system is made up of.

Here are some key words and concepts to help you out!

<table>
<thead>
<tr>
<th>Definition</th>
<th>Word or Concept</th>
<th>Diagram</th>
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</thead>
<tbody>
<tr>
<td>A complicated machine or mechanical device that appears homemade and sometimes looks unsafe or badly made</td>
<td>Contraption</td>
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</tbody>
</table>
Activity 2

Design and Build a Crazy Machine

Systems Engineers, we need you to help us get an object from point A to point B without it touching the floor. (Remember to channel Rube Goldberg and his crazy machines.) Using a minimum of FOUR STEPS we want you to transport your object at least THREE DESK LENGTHS away.

First... Research and understand the problem

You and your engineer team will start by brainstorming all the ideas you can think of. Remember to take notes while you discuss!

Second... Design a solution.

Once you have a few ideas you like, start drawing it out. Make lists of the steps and diagrams of how they will work. Remember to try and draw out a few different ideas. And be creative, this machine can be crazy! Once you're happy with your plans, make a list of materials you need.

Third... Build it!

When you are happy with your design and the teacher has reviewed and approved it, go ahead and get started. Remember, you might make changes to the design as you build it, document these changes! Once the model is built, get ready to Test, Evaluate and Redesign. Check each of step and look for areas that could work better, or try to add a fifth step.

Don't forget to use your vocabulary and definition sheet to help you present your machines.
Who is Rube Goldberg?

Rube Goldberg is a Pulitzer Prize winning cartoonist, sculptor and author. He was born in San Francisco in 1883 and later went on to graduate from University of California with an engineering degree. His passion for drawing and cartooning led him to work for a newspaper in New York submitting daily cartoons. Eventually, his unique, whimsical and comical cartoons led to nation-wide fame. Goldberg was best known for his cartoon drawn “inventions” which drew from his engineering background. These contraptions which take an ordinary task and make it elaborate, intricate and complex are now commonly known as Rube Goldberg Machines. For more information, check out the official Rube Goldberg website at www.rubegoldberg.com/home

Simple Alarm Clock

The early bird (A) arrives and catches worm (B), pulling string (C) and shooting off pistol (D). Bullet (E) busts balloon (F), dropping brick (G) on bulb (H) of atomizer (I) and shooting perfume (J) on sponge (K)—As sponge gains in weight, it lowers itself and pulls string (L), raising end of board (M)—Cannon ball (N) drops on nose of sleeping gentleman—String tied to cannon ball releases cork (O) of vacuum bottle (P) and ice water falls on sleeper’s face to assist the cannon ball in its good work.

What is a systems engineer?

Systems engineers are specialized engineers who focus on how to design and manage complex systems such as those in manufacturing industries. They are often given only a concept which they need to design, build and ensure that it operates safely and efficiently. Systems engineers work together with other types of engineers such as electrical, mechanical and computer engineers to make sure that each individual part in a system works together to produce a final product. Show students one of the following videos:

- www.youtube.com/watch?v=zTBTRzzJ1MM
- www.youtube.com/watch?v=SwaTKYJSDaw
- https://vimeo.com/62846755

These videos demonstrate a complex series of events to do a simple task that could be done in one step.

After the video, tell them that contraptions like these are called Rube Goldberg machines. They are named after a famous cartoon illustrator who used his background in engineering to come up with drawings that showed a combination of crazy events, which ended up doing a simple task that could have been done in just one step. Encourage them to see more on google images.

Links to other cool Rube Goldberg inventions

- Ask students if they have ever played the game “Mousetrap”. You can show the 1990s commercial for the game www.youtube.com/watch?v=wXTBqXNLqgo and a demonstration of the final contraption www.youtube.com/watch?v=4omnjqF3hpA
- www.cnn.com/2012/10/10/us/ideas-lifesize-mousetrap/ that shows a life size working version of the contraption built in the children’s game
- Another cool video that shows how Honda used car parts to build a very long and complex Rube Goldberg machine: www.youtube.com/watch?v=_ve4M4UsJQo
- Pouring milk on cereal: www.youtube.com/watch?v=EjOFeC-Dm7U
- Crushing a grape: www.youtube.com/watch?v=cKb9fB8kHKI
- Blowing out a candle: www.youtube.com/watch?v=3jQXN8SMewo
Connect with teachers, training and free resources

www.wemadeit.ca/teachers