iBlocks™

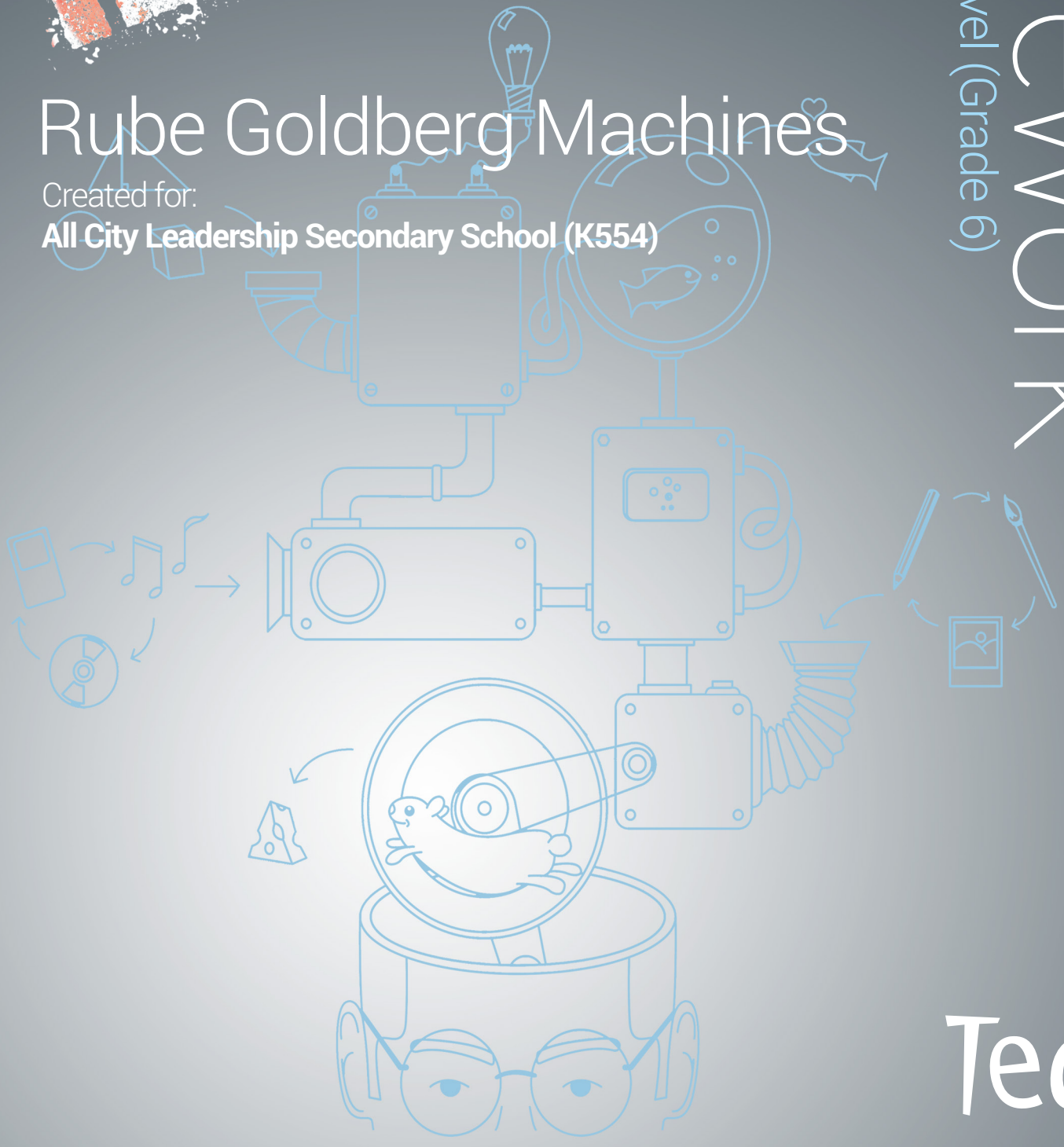
Framework

Middle School Level (Grade 6)

Rube Goldberg Machines

Created for:

All City Leadership Secondary School (K554)



Teq™

OBJECTIVE

Rube Goldberg Machines accomplish a simple task through an elaborately humorous and overcomplicated method.

In this iBlock, challenge your students to think outside the box and discover the unexpected kinetic properties in everyday objects as they design their own Rube Goldberg Machine (RGM). In order to build their contraption, students will research and explore simple machines and chain reactions and how they both relate to the world around them. From ideation to interaction, students will engage in creative thinking, critical reasoning, and teamwork as they engineer these truly unique machines.

PRIMARY FOCUS

- **Problem-Solving**
- **Engineering Design**

SECONDARY FOCUS

- **ELA**

ADVANCED LITERACY

An array of advanced literacy styles and techniques is included in every iBlock. To promote academic success, and encourage diverse spoken/written communication in increasingly diverse ways, this iBlock contains suitable vocabulary, writing prompts, discussion starters, and pitch and argument crafting.

TRANSFERABLE SKILLS

With the goal of developing transferable skills that will sustain students throughout their lives, this iBlock engages students in the design process, ensuring that they build proficiencies around critical and inquiry-based thinking, problem solving, communication, and decision making.

SOCIAL AND EMOTIONAL LEARNING

Social and emotional learning (SEL) is intrinsic to every iBlock. While students engage with their project-based learning, they will be prompted to assess their performance, talk about challenges they faced, learn how to overcome them, and build resilience. In addition, students will build teamwork skills, learn how to give and receive peer feedback, and engage in responsible decision-making.

iBlocks:
Rube Goldberg Machines

Table of Contents

Teq™

Skills Matrix

Phases:

- **Research & Planning**
- **Design & Construction**
- **Testing & Learning**
- **Share & Showcase**
- **Extensions**

Module	Gathering Research	Making Logical Inferences from Text	Producing Informative and/or Persuasive Texts	Identifying Challenges	Producing Multiple Solutions	Justifying Decisions Using Research	Identifying Constraints and Improvements
Understanding the Engineering Design Process	✓		✓	✓		✓	✓
The History of Rube Goldberg	✓	✓	✓				
The Physics of Rube Goldberg Machines	✓	✓	✓				
Plan Your Machine and Theme	✓		✓	✓	✓	✓	
Design Your Machine Blueprint	✓	✓	✓	✓	✓	✓	✓
Build a Rube Goldberg Machine	✓		✓		✓	✓	✓
Tell Your Story	✓		✓			✓	
Test and Evaluate	✓		✓	✓		✓	✓
Plan an Improvement	✓	✓	✓	✓	✓	✓	✓
Inventor Showcase	✓		✓			✓	✓
Making Movie Magic	✓		✓		✓	✓	✓

You've got this!

This skills matrix shows your **iBlock modules on the left**, and across the top are the **skills** that you'll practice as you work through your iBlock challenge.

Applying Scientific Ideas to Design, Test, and Improve a Device	Understanding Proportional Relationships	Collecting and Analyzing Data	Providing and Receiving Constructive Feedback	Producing Creative Writing Texts	Identifying Parts of Stories and Story Structure	Evaluating and Using a Variety of Media to Present Information	Editing Photos/ Videos Using Software
		✓	✓				
					✓	✓	
			✓	✓		✓	
✓	✓	✓	✓	✓	✓		
✓	✓	✓	✓				
✓	✓	✓	✓		✓		
			✓	✓	✓	✓	
✓	✓	✓	✓				
✓	✓	✓	✓		✓		
			✓			✓	
			✓		✓	✓	✓

Defining the iBlocks Challenge

At this time teachers should lay the foundational knowledge students need to get started with their iBlock and provide expectations up front, so students know what they are working towards. This foundational knowledge may include an overview of the Engineering Design Process as detailed in the Understanding the Engineering Design Process section. All modules listed in this iBlock are meant to support students as they work through their iBlocks challenge.

In order to build a Rube Goldberg Machine (RGM) students will research Rube Goldberg and his machines. It is important to allow ample time for students to tinker with the materials and technologies they will be using so that they have hands-on experience with how the materials operate and interact. After they have had some time to observe RGM and the materials they will be using, they can design, build, test and improve their machines. It is imperative to emphasize that their RGM will fail often - it is part of the process. Additionally, students will create a theme and a story to go with the machine which can include narration, characters, and of course an intriguing plot! Modules 4 - 8 can work cyclically as you see fit in order for students to be able to produce the best RGM possible. Finally, students will get a chance to show off their work, either at a school event or by entering in the official Rube Goldberg Foundation challenge. This can include an extension of creating a video about their RGM or the process of creating it.

iBlocks Task	Students will design and construct their own complex machines that use a chain reaction to perform a simple task. Engagement activities could include the following: • Have students play a game like Mouse Trap • Have students set up a domino formation (domino toppling), and then use different materials (like Jenga pieces or playing cards) or techniques to test the reaction • Provide videos of Rube Goldberg Machines (RGMs) in pop culture, competitions, and more o For a robust list of RGMs go to RubeTube at rubegoldberg.com
Customization	To determine output mediums, create lesson plans and guiding questions when needed, develop appropriate rubric(s), and identify additional relevant standards for each module.
iBlocks Goal	To develop a basic understanding of the Engineering Design Process, to understand how the design, building, and use of structures can help solve a problem, and to learn the foundations of physics, design, and teamwork. Throughout this iBlock, students will practice planning and carrying out investigations, constructing explanations, and designing solutions. **Next Generation Science Standards (NGSS)** **Content Standards** MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. MS-PS2-2. Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Engineering Standards

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Next Generation ELA Standards

6-8R1: Cite textual evidence to support an analysis of what the text says explicitly/implicitly and make logical inferences. (RI&RL)
6-8R7: Compare and contrast how different formats, including print and digital media, contribute to the understanding of a subject. (RI&RL)
6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W3: Write narratives to develop real or imagined experiences or events using effective techniques, descriptive details and sequencing.
6-8W4: Create a poem, story, play, artwork, or other response to a text, author, theme, or personal experience.
6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.
6-8W7: Gather relevant information from multiple sources; assess the credibility of each source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8SL4: Present claims and findings, sequencing ideas logically and using relevant descriptions, facts, and details to accentuate central ideas or themes; use appropriate eye contact, adequate volume, and clear enunciation.
6-8SL5: Include digital media and/or visual displays in presentations to clarify information and emphasize and enhance central ideas or themes.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.
6-8L4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases, choosing flexibly from a range of strategies.
6-8L6: Acquire and accurately use general academic and content-specific words and phrases; apply vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Understanding the Engineering Design Process

Below is a lesson plan you can use to kick off your iBlock and introduce students to the concepts of the Engineering Design Process! If your students are familiar with the design process or you'd prefer to jump right into your project, please proceed to the "Research & Planning Phase."

Grade Band: K-12

Brief Lesson Description	This lesson is designed to help develop habits of mind for design engineering by conducting a design challenge and having students identify which part of the Engineering Design Process they are working on throughout.
Learning Goals	Students will be able to... • Explain the Engineering Design Process • Identify when components of the process are being employed
Standards	**NGSS Engineering Design Framework Component Ideas** A. Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits. B. Designing solutions to engineering problems begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem. C. Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.
Materials	Materials will vary depending on which project the students will complete. The teacher can have the students choose a project or assign a project to them. • Marshmallow activity materials required: Bottle caps, rubber bands, craft sticks, mini marshmallows • Bristlebots activity materials required: Toothbrush, pager motor, lithium ion batteries, rubber bands, double-sided foam, tape, pliers, wire stripper • Zipline activity materials required: String, two anchors, low-tech materials (cardboard, foam, paper, scissors, etc.), stopwatch, egg, or ping pong ball • Paper table activity materials required: Paper, weights (pennies or nickels work well for this activity)

Prior Student Knowledge: Students are aware of processes and why they are useful. Students are also aware of the Scientific Method.

Lesson Plan

Estimated time for completion (in 40 minute class periods)

Introduction

Start a discussion (use any preferred method - think/pair/share, shout-it-out, etc.) and have the students discuss questions such as the following:

- What is a process? Why is a process useful?
- What is the most interesting invention you know about?
- Why do you think it's a good invention?
- How do you think inventors come up with ideas?
- Have you heard of the Engineering Design Process? If so, explain it! If not, can you guess what it is?

Possible Vocabulary:

Build:	to construct something by putting together parts or materials over a period of time.
Constraint:	a limitation or restriction.
Design:	to plan the creation of an object, system, model, etc.
Engineer:	to plan, construct or manage a project as an engineer .
Engineering Design Process:	a series of steps that engineers follow to come up with a solution to a problem.
Iteration:	a repetition or version.
Limit:	something that bounds, restrains, or confines.
Procedure:	a series of steps that must be taken in order to do something.
Redesign:	to revise or change in appearance, function, or content.
Test:	the act or process of testing.
Trial:	a tryout or experiment to test quality, value, or usefulness.

Lesson Plan (continued)

Lesson Activity Procedure

1. Choose (or have students choose) one or all of the mini experiences below to explore the Engineering Design Process.

A. Marshmallow activity	B. Bristlebots activity
Design a device that can launch a mini marshmallow to land in a designated place.	Create a robot with a toothbrush and simple motor to race against other robots designed by classmates.
C. Zip Line activity	**D. Paper Table activity**
Quickly transport an egg (or ping pong ball) down a string.	Construct the strongest table using paper.

2. Have students work through the Engineering Design Process. Emphasize that the process is cyclical not linear (a visual would be appropriate):

   A. Ask: Students will identify the problem/need and some of the constraints and parameters that apply.
   B. Plan: Students will sketch, list, and describe how they will create their project.
   C. Create: Students will build their project based on their research, planning and design.
   D. Improve: Students will test their project with the intent to discover issues or weaknesses to improve.
   E. Share: Students will discuss their projects and the process in detail and reflect on each.

3. Students could provide feedback on others' projects and processes. It can be helpful for them to see different approaches to the problem and process.

Closure

Have the students discuss and reflect on the activity using the following questions:

- What are the differences between the Scientific Method and the Engineering Design Process? Similarities?
- What parts did you find challenging? What was easy?
- Which design worked the best? The worst? Why?

Lesson Plan (continued)

Assessment

Summarize:

Ask students to summarize the steps they took for each mini activity using the vocabulary from the above section.

Reflect:

Ask students to complete the self-assessment question:

- How comfortable do you feel with the Engineering Design Process? Explain.

Resources

- How to Write a Problem Statement:
  http://bit.ly/iblocks_resource_1
- Engineering Design Process Explained:
  http://bit.ly/iblocks_resource_2
- Engineering Design in the NGSS:
  http://bit.ly/iblocks_resource_3
- Science and Engineering Practices NGSS:
  http://bit.ly/iblocks_resource_4

Research & Planning Phase

Module 1 The History of Rube Goldberg

In this module, students will research Reuben Garrett Lucius Goldberg, better known as Rube Goldberg. Students will learn that he was not only an American inventor, engineer, and Pulitzer Prize winning cartoonist, but that he never actually built any of the machines that he's famous for. Students will research his background, learn how these silly, overcomplicated machines came to be known as Rube Goldberg Machines, and discover how this landed him in the Merriam-Webster Dictionary as an adjective! Once students have a good understanding of the man behind the machines, they will dive into exploring the machines themselves. What is a Rube Goldberg Machine (RGM)? Why did Rube Goldberg draw them? Explore the thousands of RGM videos posted online, share favorites, and draw inspiration for your own RGM design.

Suggested Resources:

- Rube Goldberg homepage
  - Visit **www.rubegoldberg.com** for bio, news, challenges, and more.
  - Visit "RubeTube" at **https://www.rubegoldberg.com/video** for information on Rube Goldberg Machines as well as the man himself.
- "A Simple Normal Humdrum School Day" by Jennifer George
  - Available wherever you buy books, or on the above website where you can also download free curriculum that helps you use each RGM illustration as a teaching tool.
  - Intro to Rube Goldberg Machines: **https://otis.teq.com/events/view/14487**

Task	Students will conduct authentic research on Rube Goldberg and his famous invention. Students should be prepared to share their research, as well as use it to inform their project.
Customization	To determine how students will organize and present their research, create question sets to guide student research, develop appropriate rubric(s) and lessons, and identify additional relevant standards.
Goal	To conduct and share research on the life of Rube Goldberg and his famous invention, the Rube Goldberg Machine.

Next Generation ELA Standards

6R1: Cite textual evidence to support an analysis of what the text says explicitly/implicitly and make logical inferences. (RI&RL)
6R7: Compare and contrast how different formats, including print and digital media, contribute to the understanding of a subject. (RI&RL)
6W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Module 1 The History of Rube Goldberg (continued)

6W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6W2c: Use precise language and content-specific vocabulary to explain a topic.
6W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.
6W7: Gather relevant information from multiple sources; assess the credibility of each source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.
6SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.
6L4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases, choosing flexibly from a range of strategies.
6L6: Acquire and accurately use general academic and content-specific words and phrases; apply vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Research & Planning Phase

Module 2 The Physics of Rube Goldberg Machines

Once students have gathered knowledge of Rube Goldberg and the machine he invented, they will research how each component works. In this module, students will observe the domino effect and test various materials to see how they respond and interact differently. Students will also determine how devices may be triggered, and the patterns of chain reactions. From here, students will learn about energy, how the speed of an object relates to the energy of that object, how that energy is conserved as it is transferred and/or converted from one form to another, and about the changes in energy that occur when objects collide. The information gathered in this module will help students understand the concept of simple machines as well as consider design and construction ideas for their own Rube Goldberg Machine in the next phase.

Use the following resource suggestions to build students' understanding as they work towards the Design and Construction Phase. There are many videos available online that students can use as research and observation of Rube Goldberg Machines and the physics principles behind how they work before they begin their own builds.

Suggested Resources:

- **RubeTube -** A great resources for videos of Rube Goldberg Machines: https://www.rubegoldberg.com/video/
- **Dominos -** Students can set up dominos in such a way as to observe what happens after a single "push." Students can then experiment with other materials such as Jenga pieces, playing cards, card stock, etc. to see how different materials (based on their varied characteristics) act or react.
- **Mouse Trap -** Students can play this game for context and practice.
- **Energy transfer -** Background on the basics of energy transfer: http://bit.ly/iblocks_rube_8
- **Colliding marbles -** Energy and colliding objects: http://bit.ly/iblocks_rube_9
- **Algadoo -** This tool gives students the opportunity to use simple drawing tools to design, construct, and explore the physics world: http://www.algodoo.com/
- **Conduct a simple machine scavenger hunt -** Templates provided in Student Workbook.
- **Dissect a broken appliance or toy -** Students can identify parts as their category of simple machines, hypothesize how they come together to make the appliance or toy work, or see if they can put the pieces back together correctly.
- **Rube Works app -** A great tool to help students experiment with simple machines, what they can be made of, and how they might interact: http://bit.ly/iblocks_rube_worksapp.

Task	Students will explore how a Rube Goldberg Machine works through research, tinkering and experimenting with various technology and materials in order to prepare to build their own machine.
Customization	To determine additional case studies, determine how students will organize and present their research, create question sets to guide student research, develop appropriate rubric(s), and identify additional relevant standards.

Goal

To use evidence to construct an explanation relating the speed of an object to the energy of that object, to make observations to provide evidence that energy is conserved as it is transferred and/or converted from one form to another, and to ask questions and predict outcomes about the changes in energy that occur when objects collide.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

MS-PS3-6. Make observations to provide evidence that energy can be transferred by electric currents.

Engineering Standards

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Next Generation ELA Standards

6-8R7: Compare and contrast how different formats, including print and digital media, contribute to the understanding of a subject. (RI&RL)

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.

6-8W2c: Use precise language and content-specific vocabulary to explain a topic.

6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.

6-8W7: Gather relevant information from multiple sources; assess the credibility of each source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.

6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.

6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.

6-8SL4: Present claims and findings, sequencing ideas logically and using relevant descriptions, facts, and details to accentuate central ideas or themes; use appropriate eye contact, adequate volume, and clear enunciation.

6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

6-8L4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases, choosing flexibly from a range of strategies.

6-8L6: Acquire and accurately use general academic and content-specific words and phrases; apply vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Research & Planning Phase

Module 3 Plan Your Machine and Theme

There are many ways to go about creating your very own Rube Goldberg Machine. With materials like dominos, marbles, fans, lights, blocks, toy cars, string, cups, pipes and more; the possibilities are endless! You may even decide to complete an Official Rube Goldberg Challenge! The tasks you want your machine to accomplish are also limitless. Do you want to open or close a door? Turn on a light? Pour a bowl of cereal? Drop a marble into a cup? Have you given thought to technology as a solution? Students can utilize available technology such as Ozobots, littleBits, Sphero, LEGOs, and 3D printed components in their designs.

Additionally, students should start to consider the backstory and theme for their machine. Rube Goldberg designs are a great platform for storytelling. Students will be focusing on telling a story about identity. This story can be a personal narrative, a collaborative biography, or a work of fiction that draws inspiration for their own lives. Creativity, self-reflection, and criticality are essential here.

At this time, the teacher may want to provide design constraints, such as space, materials, budget, required/available technology, required simple machines, end goal, and interactive components.

Suggested Resources:

- Rube Goldberg contests: **http://bit.ly/RGMcontest**
- "How to Build a Rube Goldberg Machine" with Joseph Herscher: **http://bit.ly/Howtobuild_RGM**

Task	Students will imagine how both recycled materials and classroom technologies (as well as their accessories and/or software) could be used in their Rube Goldberg Machine design and theme.
Customization	To determine additional case studies, determine how students will organize and present their research, create question sets to guide student research, develop appropriate rubric(s), and identify additional relevant standards.
Goal	To learn how different components and technologies can be incorporated into Rube Goldberg designs and brainstorm the theme and story behind their design concept. Students can return to these goals as they work through the design process.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Engineering Standards

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W3: Write narratives to develop real or imagined experiences or events using effective techniques, descriptive details and sequencing.
6-8W4: Create a poem, story, play, artwork, or other response to a text, author, theme, or personal experience.
6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.
6-8W7: Gather relevant information from multiple sources; assess the credibility of each source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8L6: Acquire and accurately use general academic and content-specific words and phrases; apply vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Design & Construction Phase

Module 4 Design Your Machine Blueprint

Now that students have had time to identify the challenge, tinker with the different potential components, and develop a theme, it's time to start designing original Rube Goldberg Machines! How big is it going to be? What materials will you use? How will you activate the start? These are just some of the questions students should be thinking about at the beginning of this module.

Depending on the resources available, students can create anything from a large system to something as small as a board game.

Suggested Resources:

- How to Make a Rube Goldberg Machine [Website]: **http://bit.ly/iblocks_rube_14**
- Interactive Digital Rube Goldberg Machines [Website]: **http://bit.ly/iblocks_rube_15**
- "littleBits Geeky Techs Rube Goldberg Challenge 2" [Video]: **http://bit.ly/iblocks_rube_littlebits2**
- "Rube Goldberg Meets the Invention Age" [Video]: **http://bit.ly/iblocks_rube_inventionage**

Task	Students will compile a list of design constraints, brainstorm designs, and create a blueprint.
Customization	To develop appropriate rubric(s), determine additional constraints, create methods for brainstorming and design creation, and identify additional relevant standards.
Goal	To recognize what may or may not impact design and start creating a blueprint for construction within determined constraints.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Engineering Standards

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.

Module 4 Design Your Machine Blueprint (continued)

6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL5: Include digital media and/or visual displays in presentations to clarify information and emphasize and enhance central ideas or themes.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Design & Construction Phase

Module 5 Build a Rube Goldberg Machine

Students will build a Rube Goldberg Machine based on their blueprints from Module 4 using consumables, their 3D printed element(s), and the available technology. Students and teachers should be aware of space, timing, and availability of materials. The teacher may want to provide time constraints for development.

Task	Students will produce a prototype of their top design solution. Multiple iterations of the prototype may occur in this stage.
Customization	To determine output medium, develop appropriate rubric(s), and identify additional relevant standards.
Goal	To produce a Rube Goldberg Machine using consumables and technology.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2. Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Engineering Standards

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8L6: Acquire and accurately use general academic and content-specific words and phrases; apply vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Design & Construction Phase

Module 6 Tell Your Story

This module is intended to operate in tandem with Module 4: Design Your Machine Blueprint. Students will have to use their story telling skills and their engineering skills to make sure that the story they are telling makes sense with the machine they are building. Students can use ideas from Module 3 as a basis. The stories should be written using story structure and story elements, as well as related directly to the machine. Students should feel free to get creative here in what stories they are telling and how they are telling them: do they want the machine to speak for itself? Would they like to include short bits of text in the machine? Will they have someone narrate as the machine performs the actions? The options are legion and should take into account the Share & Showcase Phase and how students would like to present their machine.

Suggested Resources:

- "What is a Story Arc?" [Video] (with sample story): **http://bit.ly/storyarc_video**
- Judy Blume's Masterclass on Narrative Arc: **http://bit.ly/judyblume_masterclass**

Task	Students will write a short story that goes with their Rube Goldberg Machine and decide how that story will be told.
Customization	To develop appropriate rubric(s), determine additional constraints, explore specific genres, provide specific story guidelines and requirements, and identify additional relevant standards.
Goal	To understand and effectively use story elements and narrative arc.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W3: Write narratives to develop real or imagined experiences or events using effective techniques, descriptive details and sequencing.
6-8W4: Create a poem, story, play, artwork, or other response to a text, author, theme, or personal experience.
6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

Testing & Learning Phase

Module 7 Test and Evaluate

Students will test their builds, evaluate performance, and plan an improvement. The modules in this phase are meant to work cyclically, not linearly. Students will most likely have to test, evaluate, plan and then test again multiple times until they have created a functional Rube Goldberg Machine.

To inspire multiple trials and iterations view the video "Audri's Monster Trap":

http://bit.ly/iblocks_rube_monstertrapRGM

Task	Students will test their RGM and/or components of the machine and identify areas in need of improvement.
Customization	To determine output medium, develop appropriate rubric(s), and identify additional relevant standards.
Goal	To develop a scientifically-sound study to test the RGM over multiple trials with the intent of identifying areas in need of improvement.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2. Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Engineering Standards

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8SL4: Present claims and findings, sequencing ideas logically and using relevant descriptions, facts, and details to accentuate central ideas or themes; use appropriate eye contact, adequate volume, and clear enunciation.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Testing & Learning Phase

Module 8 Plan an Improvement

Based on the results gathered in Module 7, students will plan a functional improvement to their design. Functional improvements may vary between designs and materials. For example, a group of students may develop a stronger lever or switch, utilize different materials to move the process along more easily (like a toy car instead of a marble), or find a better way to activate the machine (like a fan instead of a popping balloon). Students can use the technology they learned in Module 3, or they can even go back to this module to choose a different technology to help plan and execute this improvement. Students should also consider how to incorporate art, music/sounds, lighting, and even humor into their final project.

Task	Students will plan improvements to the RGM based on the results from the previous module, or from new understandings and findings.
Customization	To specify goals, determine output medium, develop appropriate rubric(s), and identify additional relevant standards.
Goal	To use results of testing and research to improve the RGM.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2. Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Engineering Standards

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Share & Showcase Phase

Module 9 Inventor Showcase

Now that students have perfected their models, it's time to show them off. One hallmark of a successful learning experience is the exhibition of student work, or in this case, a Rube Goldberg showcase! It is important to create an opportunity where students are able to present their design to an authentic audience. This can be accomplished by creating class videos, having a school assembly, inviting other classes to visit, or organizing a friends and parents event. Students can also prepare for Rube Goldberg Machine Contests, challenges, and hackathons!

Note: Rube Goldberg has both onsite events as well as digital submissions online. If you are having students enter the official competition, please use the resources provided and be aware of timing and submission requirements.

Suggested Resources:

- Student Technology Showcase Planning Tips: http://bit.ly/iblocks_rube_1
- Student Work Showcase: http://bit.ly/iblocks_rube_17
- Rube Goldberg Official Contests: http://bit.ly/iblocks_rube_18
- Rube Goldberg Hackathon Guide: http://bit.ly/iblocks_rube_19
- Rube Goldberg Challenge Guide: http://bit.ly/iblocks_rube_20

Task	Students will create and host an event based around their Rube Goldberg Machines in order to showcase their final project.
Customization	To determine event type, determine output medium, develop appropriate rubric(s), and identify additional relevant standards.
Goal	To showcase their machine and explain how the system functions, outlining the processes from start to finish.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Next Generation ELA Standards

6-8W2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, andinformation through the selection, organization, and analysis of relevant content.
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W7: Gather relevant information from multiple sources; assess the credibility of each

Module 9 Inventor Showcase (continued)

source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8SL4: Present claims and findings, sequencing ideas logically and using relevant descriptions, facts, and details to accentuate central ideas or themes; use appropriate eye contact, adequate volume, and clear enunciation.
6-8SL5: Include digital media and/or visual displays in presentations to clarify information and emphasize and enhance central ideas or themes.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Extensions

Module 10 Making Movie Magic

Rube Goldberg and his machines captured the imaginations of millions, in part through clever use of media such as cartoons, movies, animations and more. In this module, students will make some movie magic of their own. Students can make short cartoons, documentaries about their experience creating their RGM, or even create a short film about their story - the only limit here is imagination! There are a plethora of resources for movie creation out there. This module can be started earlier in the design process (especially if students are planning a documentary - they will need to film as they progress through the process). Be sure to bear this in mind before starting the RGM planning and build.

Suggested Resources:

- CommonSense Media Video and Animation Resources: **http://bit.ly/commonsense_mediavideo**
- Japanese Rube Goldberg with elaborate story [Video]: **http://bit.ly/iblocks_rube_japaneseRGM**
- Story of Passover with Rube Goldberg [Video]: **http://bit.ly/iblocks_rube_passoverRGM**
- Film Making Resource List: **http://bit.ly/filmmaking_resources**

Task	Students will create a short film, documentary or animation of their RGM or the process of creating it.
Customization	Choose specific media or creation tools, further define project parameters and guidelines, host a film festival, peer constructive critiquing, create appropriate rubrics, identify additional standards.
Goal	To create a digital story of a RGM or the process of building one with appropriate visual, audio, and story structure elements.

Next Generation Science Standards (NGSS)

Content Standards

MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Next Generation ELA Standards

6-8R7: Compare and contrast how different formats, including print and digital media, contribute to the understanding of a subject. (RI&RL)
6-8W2b: Develop a topic with relevant facts, definitions, concrete details, quotations, or other information and examples; include formatting, graphics, and multimedia when useful to aid comprehension.
6-8W2c: Use precise language and content-specific vocabulary to explain a topic.
6-8W4: Create a poem, story, play, artwork, or other response to a text, author, theme, or personal experience.
6-8W6: Conduct research to answer questions, including self-generated questions, drawing on multiple sources and refocusing the inquiry when appropriate.

Module 10 Making Movie Magic (continued)

6-8W7: Gather relevant information from multiple sources; assess the credibility of each source; quote or paraphrase the data and conclusions of others; avoid plagiarism and provide basic bibliographic information for sources.
6-8SL1: Engage effectively in a range of collaborative discussions with diverse partners; express ideas clearly and persuasively, and build on those of others.
6-8SL1b: Follow norms for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
6-8SL2: Interpret information presented in diverse formats (e.g., including visual, quantitative, and oral) and explain how it relates to a topic, text, or issue under study.
6-8SL4: Present claims and findings, sequencing ideas logically and using relevant descriptions, facts, and details to accentuate central ideas or themes; use appropriate eye contact, adequate volume, and clear enunciation.
6-8SL5: Include digital media and/or visual displays in presentations to clarify information and emphasize and enhance central ideas or themes.
6-8SL6: Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Teq™

7 Norden Lane
Huntington Station, NY 11746
877.455.9369
teq.com