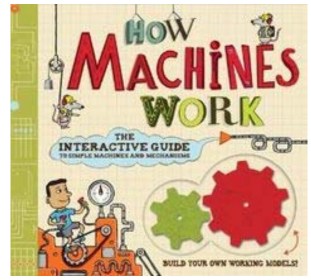
# Creativity in Motion!

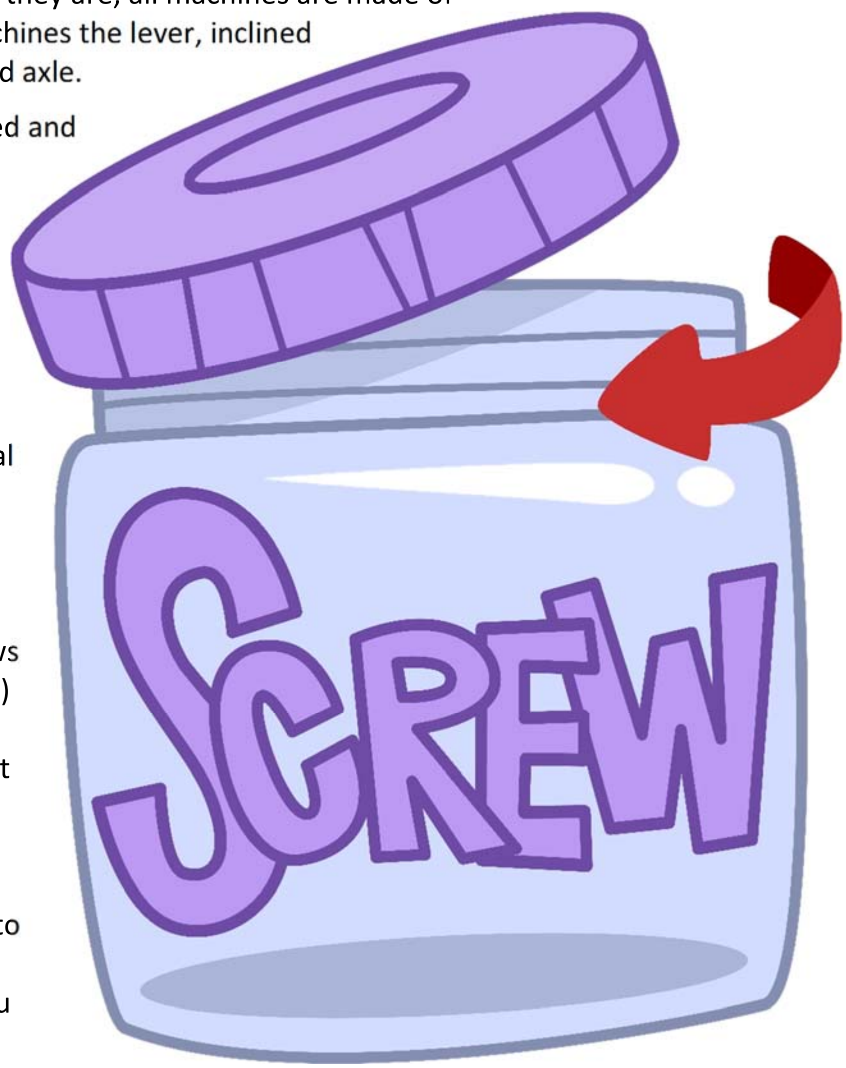
## Six Machines to Do It All




A good introduction to this topic might be reading a book, such as: *How Machines Work: The Interactive Guide to Simple Machines and Mechanisms* by Nick Arnold, Allan Sanders or *Simple Machines: Wheels, Levers, and* Pulleys by David A. Adler

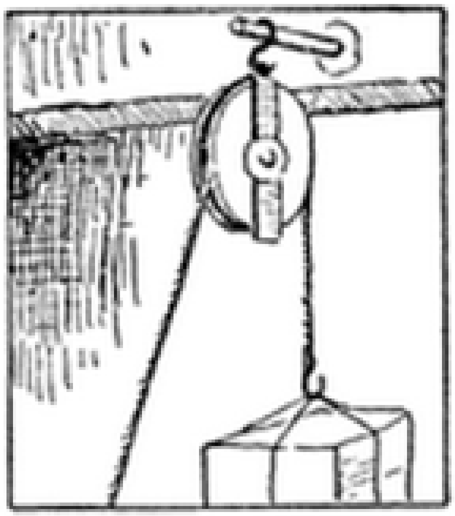
There are six simple machines that physicists use to redistribute forces. They are as follows: lever, wheel, pulley, incline plane, wedge and screw.

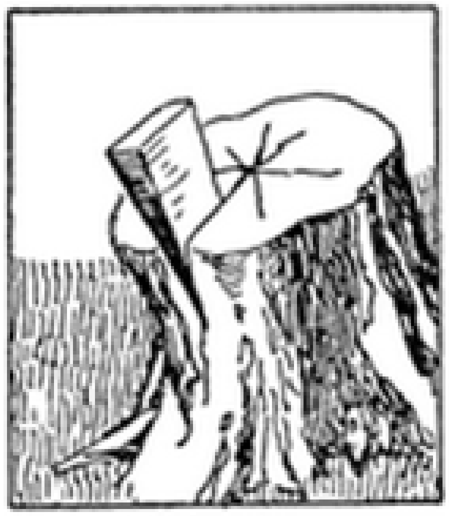
Theoretically, machines are devices that help make work easier for people. Most machines consist of a number of elements, such as gears and ball bearings that work together in a complex way. But no matter how complex they are, all machines are made of one or more of the six types of simple machines the lever, inclined plane, wedge, screw, pulley, and wheel and axle.

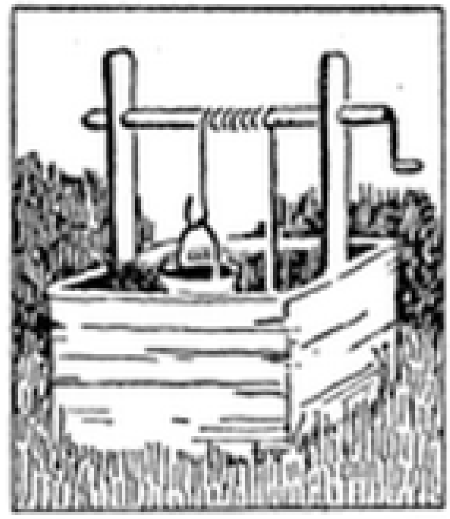



Historically, simple machines were invented and used long before anyone ever classified them. We use simple machines every day without realizing it. Teeth are wedges and so are knives, forks, and thumbtacks. Many toys such as slides, which are inclined planes, and seesaws, which are levers, are also simple machines.

Simple machines can give you a mechanical advantage—in other words they allow you to spread the force you apply to move an object over a distance. This means you don't have to apply as much force at any given point in time. (ex. You can find screws (inclined planes wrapped around cylinders) on the tops of water bottles, what do they help you do?) Simple machines can make it possible for you to lift something or move something that would be too heavy otherwise. For example, consider the difficulty in trying to lift a 200lb load up into the back of a truck. But placing a ten foot plank from the truck to the ground lets you slide the load up into the truck easily. This principle is used in conveyers as well.

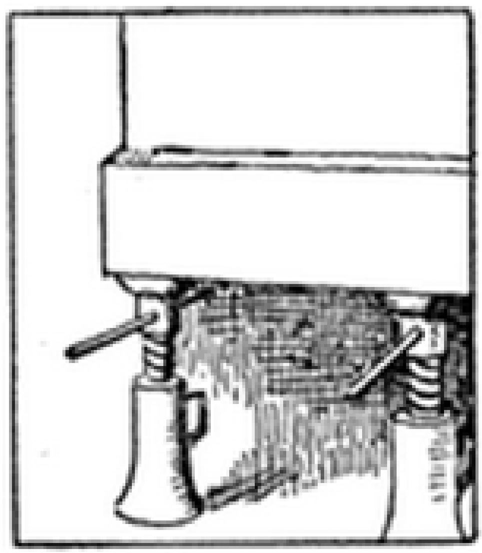

Pulley


Wedge


Wheel and axle


Inclined plane


Lever


Screw

# Simply Easier!


Names don't lie. Simple machines really do make our lives simpler. What's more, they make for some fun and simple learning experiences.

Ask students to describe or give a definition of the word ‘work.’ Tell the group that the definition of work used in science differ from what most people think of as work. Work can be defined as force times distance  (Work = Force x Distance).

### Demonstration:

Ask a student to move a book from one desk to another. Ask: *Is this work by the scientific definition?* (Yes, this is work. ) You are applying force for a certain distance. Ask: *Is doing homework work by this definition?* (No, homework is not work.)

### Why is this work?

Pushing a book across a desk is work because you are applying a force (a push) on a book for a certain distance (the length of the desk). You are not pushing homework anywhere.


### Can I do less ‘work’ and still get the same result?

Imagine that you want the same amount of work to get done using less force. In this example, this means you still want the book to move from one side of the desk to the other, but you don’t want to push as hard.

If you use half as much force to push the book, then you will have to push the book twice as far to do the same amount of work. Or, you could use a simple machine to make up the difference in the force you are applying. Explain that people often use simple machines to make work easier. Ask students if they’ve ever heard of simple machines. List the ones they come up with.

### What are simple machines?

Introduce the class to the names of various simple machines and show them a picture of each. (The wheel and axle, pulleys, screws, and inclined planes.) Tell the class simple machines make work easier by increasing mechanical advantage.

### What is mechanical advantage?

Tell students that an example of mechanical advantage is using the claw of a hammer to remove a nail. A small force applied to the

> Note: For  older grades, include ways to calculate work by measuring force and recording distance. Have students create word problems to be solved by classmates that incorporate using force and distance to calculate the amount of work done. Students can practice solving the equations submitted by their classmates.

handle of the hammer produces a greater force at the claw end of the hammer, allowing for the removal of stubborn nails.

### Can simple machines be combined?

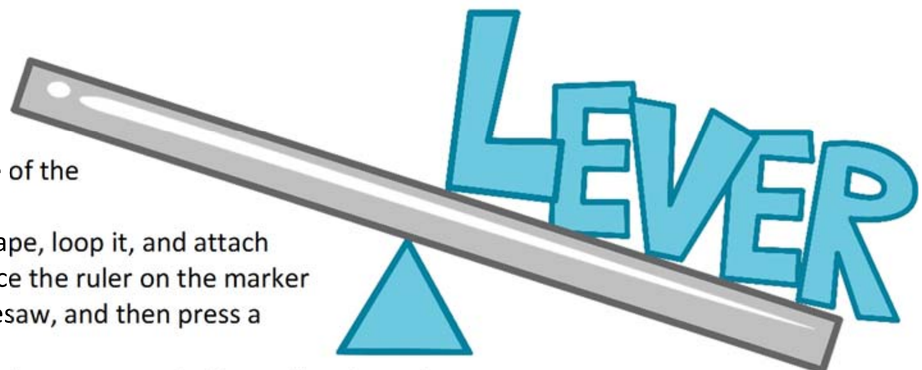
Explain that complicated machines, such as robots and cars, are made up of combinations of simple machines and other parts. Robots are complex machines that contain many simple machines. Some examples of simple machines that are used in robot construction are wheels and axles for mobility, allowing robots to move from place to place, and robot arms, which are levers, enable them to manipulate objects.

Explain that students are going to try simple experiments with simple machines, and then use those simple machines to solve challenges.

Notes and Tips: If resources are limited, each group can be assigned one machine to experiment with and then report on their findings to the class. Other objects may be substituted for the listed objects as long as they work in similar ways.

Older students can construct some of the simple machines on their own, or the review of each type of simple machine can be shortened.

## Levers




### Demonstrations:

1. Construct a lever by taping a marker parallel to the edge of the table.
2. Tear off a piece of masking tape, loop it, and attach it to the end of the ruler. Place the ruler on the marker at the center point, like a seesaw, and then press a tennis ball firmly to the tape.
3. Invite a student volunteer to demonstrate the lever; first, have the student gently lift the ball by applying force to the end of the lever (ruler) opposite the ball.
4. Second, instruct the student to reposition the lever (ruler) so the ball is as close to the fulcrum (marker) as possible. Have the student press the lever again to lift the ball.
5. Lastly, reposition the lever (ruler) so the ball is as far away from the fulcrum (marker) as possible while still leaving a portion of the lever (ruler) to be pressed down.
6. Have the student press the lever to lift the ball again.

Discuss what the class saw and what the volunteer observed. Ask: *Which lever configuration made the ball easiest to lift? Which lever configuration made it the most difficult to lift the ball? Which lever configuration moved the ball the farthest from its starting position? How does the lever provide a mechanical advantage when moving the ball?*

## Lever up! Lever Challenge!

Introduce the lever challenge. Explain that each group will attempt to move a tennis ball from the table to the center of a roll of masking tape at varying distances. Introduce the rules.

### Materials for each group:

- a tennis ball
- a rigid ruler

- a cylindrical marker
- a roll of masking tape

### The Rules!

Hands may not be used to move the ball to the goal, but hands may be used to place the ball on the lever and to operate the lever. Nothing may be used to secure the ball to the lever. The marker may not be moved from the edge of the table. The masking tape roll may not be moved unless the teacher instructs it. The winner will be the group that moves the ball to the center of the masking tape roll from three different distances with the least amount of attempts.

### Procedure

1. Separate the class into groups of 2-4.
2. Distribute materials to each group.
3. Instruct students to tape the marker parallel to the edge of a desk or table, as was demonstrated earlier by the teacher.
4. Now, instruct groups to measure 24 cm (9.5 in) out from the marker and place the edge of the masking tape roll, flat on its side, at this point.
5. Allow groups a few minutes to collaborate on different ideas for getting the ball into the goal.
6. Next, allow five minutes of exploration and experimentation.
7. Instruct students to record the distance of 24 cm (9.5 in) in their journal and sketch the lever configuration that worked best at this distance directly beneath the number.
8. Follow the same steps at a distance of 15 cm (6 in) and 5 cm (2 in).
9. Lastly, the teacher will observe as groups demonstrate their lever configurations at the different distances. The group with the lowest total attempts after completing all three distances wins.


## Pulleys

Tell the class that pulleys make work easier by reducing the effort needed to lift an object.

### Demonstrations:

1. Instruct a student to lift a milk jug filled with water using only his or her hand.
2. Next, have two additional students hold a broom handle at shoulder level between them.
3. Now, tie a thin rope to the handle of the jug and let it rest on the floor.
4. Instruct the student who earlier lifted the jug to pull the rope over the broomstick and pull down on the end of the rope to lift the jug.
5. Ask the student to describe the difference between the two experiences.
6. Now, untie the rope from the jug and tie one end of the rope to the broomstick.

7. Have the two students continue to hold the broomstick at shoulder level while the other volunteer slips the free end of the rope through the handle of the jug and then back over the broomstick.
8. Have the same student pull the end of the rope to lift the jug.
9. Ask the student to describe the differences in the three experiences.

## Can you pull it? Pulley challenge!

Introduce the pulley challenge. Each group will lift metal objects from the floor using a pulley system they design.

### The Rules!

Only materials provided may be used in the design. Hands may not be used to pick up objects. An object lifted to at least 10 cm (4 in) in the air may be removed from the pulley using the hands. At least two spools must be incorporated into the design. No more than 15 cm (6 in) of tape may be used. Part of the pulley system may be taped to a fixed object, such as a desk.

### Materials for each group:

- three plastic spools;
- a meter (3.2 ft) of string;
- a 1¼-inch donut magnet;
- various small metal objects, such as paper clips;
- masking tape;
- three pencils

### Procedure

1. Separate the class into groups of 2-4.
2. Distribute the supplies.
3. Allow groups time to collaborate on different ideas for pulley construction.
4. Next, allow five to ten minutes of exploration and experimentation with the materials. Encourage students to make sketches of ideas in their journal.
5. At the conclusion, each group will demonstrate for the teacher the most successful pulley system the group designed.

# The Wheel and Axle


Tell students the wheel and axle uses rotational movement to make work easier. When effort is applied to the wheel, it produces movement in the axle, and when it is applied to the axle, it produces movement in the wheel. Ask a student to hold the narrow end of a funnel and use it to roll the large end of the funnel along the table. Ask: *Is this an example of effort being applied to the axle or the wheel?* (Effort applied to the axle.) Next, have a student tape the end of a 1 m (3.2 ft) piece of string to the narrow end of the funnel. Now have the student turn the funnel in a circular motion using the large end of the funnel. Ask: *Is this an example of effort being applied to the axle or wheel?* (Effort applied to the wheel.)

## Wheel and Axle Challenge!

Introduce the wheel and axle challenge. Each group will attempt to move a tennis ball 3 meters (roughly 10 ft) using a design incorporating the wheel and axle.

### The rules!

Only materials provided may be used. The ball may not be touched after it begins to move. The wheel and axle must be the primary mechanism by which movement of the ball is achieved.

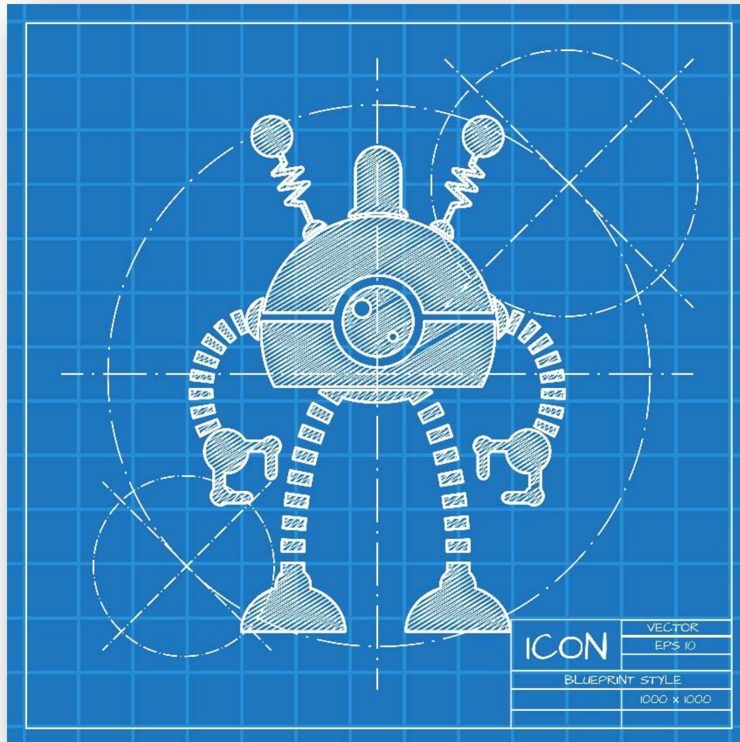
### Materials for each group:

- two pieces of cardstock paper
- approximately 57 g (2 oz) of modeling clay
- two drinking straws
- 30 cm (12 in) of masking tape
- 30 cm (12 in) of string

### Procedure

1. Separate the class into groups of 2-4.
2. Distribute the supplies to each group.
3. Allow groups time to collaborate on different ideas for moving the ball.
4. Next, allow ten minutes of exploration and experimentation.
5. Encourage students to make sketches of ideas in their journals.
6. When all groups are ready, they will compete to determine which design can move the ball the greatest distance.

7. Give groups five minutes to reengineer or repair their vehicles after the first test and test a second time.




## Are You so Inlcined?

### Design in Mind!

Ask the class to imagine how the simple machines they experimented with could be used to construct various working parts of a robot. Ask the following questions: *How could a lever be used?* (Perhaps as part of the arm or leg.) *How about a pulley?* (It could be used to operate the gripper on a robot's arm.) *What about the wheel and axle?* (It could be used as part of the mobility unit.)

Instruct students to create drawings of their own robots incorporating all of the simple machines they experimented with in class.

Note: This basic design plan could be incorporated into a later project with student 'junkbots.[1]

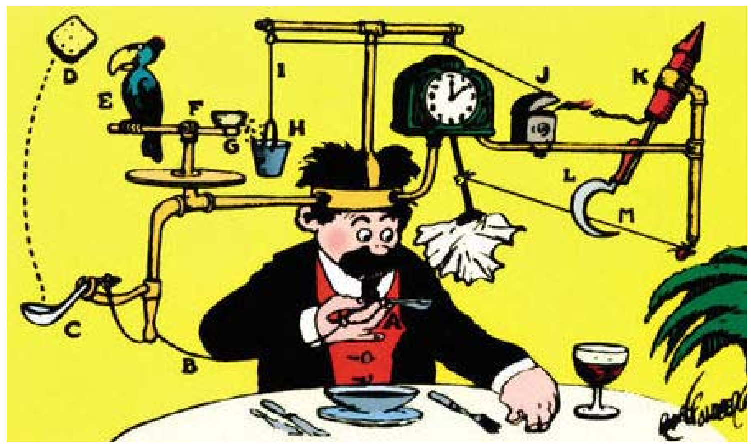
[1] Kathleen Havens, Houston Museum of Natural Sciences, National Geographic: https://www.nationalgeographic.org/activity/simple-machine-challenge/

# Rube Goldberg Project: Creativity in Motion

**Rube Goldberg** (rōōb gōld'berg), a comically involved, complicated invention, laboriously contrived to perform a simple operation – *Webster's New World Dictionary*

*Rube Goldberg is the ® and © of Rube Goldberg, Inc.*

These machines might not be practical, but they're definitely fun, creative, and educational! Building a Rube Goldberg machine is a great hands-on activity for all ages, plus it encourages children to flex their STEM muscles.



Rube Goldberg was famous for combining the 'simple' machines we just explored in creative, complicated, and comical ways to use chain reactions to perform a simple task.

## Chain, chain chain…Reaction?

Chain reaction is an intuitively simple concept, but one that allows for an incredibly complex and deep investigation into something we experience every day: the relationship between cause and effect.

For example, Popsicle sticks are great for holding frozen treats and reading the occasional joke off of, but did you know they're excellent for demonstrating potential and kinetic energy and chain reactions? It's true! If you weave popsicle sticks together just right, you can create an 'explosive' chain reaction that will create a dazzling display of flying popsicle sticks!

This chain reaction is usually called the cobra weave. It's challenging to get started at the beginning, but – once you master that, it's not so bad. The chain stays together as long as you hold down the end that you are building onto. Release the end and…!

### Materials:

- Large colorful craft sticks
- This helpful video
- And this one: Check out the post at Mom Trusted. They have a great instructional video posted as well as a video of some kids who built a chain reaction with 1,000 sticks! That one is totally worth watching.
- Two people, at least, per group
- Patience
- Variation: Dominoes or KEVA blocks

## Experiment

1. Start off with two popsicle sticks. Lay them in an "X" on a flat surface.
2. Weave the end of a third Popsicle stick underneath the end of the Popsicle stick on the bottom of the "X." The rest of the third stick should go over top of the Popsicle stick on the top of the "X." Make sure to keep pressure on the third stick.
3. Repeat step 2 with a fourth Popsicle stick. This time start underneath the second Popsicle stick and weave over the third.
4. Continue adding Popsicle sticks in this fashion until you have a really long chain!
5. Once you've extended the chain to your heart's content… let go! The popsicles will release in a chain reaction that will have everyone in the area jumping for joy.

## How does it work?

The key to the Popsicle Chain Reaction comes from potential and kinetic energy. As you weave the Popsicle sticks together, you are continually building potential energy. Each Popsicle stick is bent over the stick before it and pinned under the stick before that, creating tension in the wood. When you finally have the chain length that you want, you let go and all of the tension and potential energy is released in a chain reaction of kinetic energy!


[2]

Option: Demonstrate chain reactions using KEVA blocks or dominoes set up in an intricate pattern.

[2] Steve Spangler. Popsicle Stick Chain Reaction. Sick Science. https://www.stevespanglerscience.com/lab/experiments/popsicle-stick-chain-reaction/

# That's So Rube of You

Best known for his “inventions”, Rube’s early years as an engineer informed his most acclaimed work. Most inventions try to make difficult tasks easier. Rube Goldberg discovered ways to make simple tasks amazingly difficult.

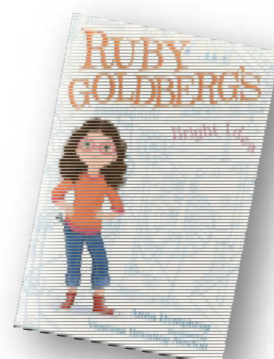
He had solutions for How To Get The Cotton Out Of An Aspirin Bottle, imagined a Self-Operating Napkin, and created a Simple Alarm Clock – to name just a few of his hilariously depicted drawings. One of his inventions used dozens of arms, wheels, gears, handles, cups, and rods that were moved by balls, canary cages, pails, boots, bathtubs, paddles, and animals, just to squeeze oranges for orange juice.

Rube did not build the machines he drew, but his cartoons have become an inspiration to aspiring engineers and scientists across the world, including us!

Now that we know about simple machines, (and a bit more about chain reactions) let’s combine a few into something new, a complex machine (several simple machines working together) to solve a simple problem in a hilariously complex way!

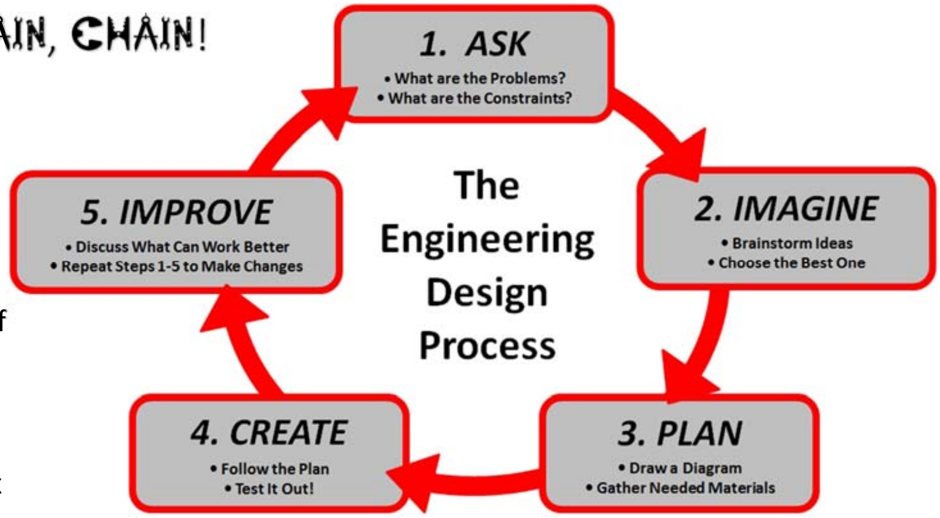
## Finding inspiration!

Get students’ creative juices flowing by having them watch clips from the following and seeing how and what others used to make their Rube Goldberg Inspired Machines:




- Rube Goldberg TV
- Isaac Newton vs. Rube Goldberg or Nat Geo’s giant 4 ton machine (a massive machine with 38 triggers and 71 moving pieces, including a few staff members themselves and a car).
- Explore books such as *The Best of Rube Goldberg* by Reuben Lucius Goldberg or *Ruby Goldberg's Bright Idea* by Anna Humphrey.
- Sesame Street: Rube Goldberg Machines (which also does an excellent job of reinforcing concepts about simple machines and how they can all work together.)
- 75 Rube Goldberg Ideas & Inventions [This video is split up into 3 sets of 25 ideas by 3 different youtubers. These short screen linked clips can help you with school projects or making your own chain reaction. This video is intended to help individuals obtain ideas and/or inspiration for building their own Rube Goldberg Machine. It is not meant to look like one actual machine. It is simply screenlinked to give more flow and continuity to the video.]
- Find videos and images at RubeGoldberg.com , such as **A-Trak & Tommy Trash - Tuna Melt** [also at https://vimeo.com/62846755].

# Now, let s chain, chain, chain! Chain a machine




Give students the challenge for the contest (whichever one your group decides)! Discuss the Engineering Design Process and how it relates to this project and draw a diagram of the process up on the board.

## Constraint:

The machine must incorporate all six simple machines at least once.

## Option: Large Scale Chain Reactions

Large-scale chain reactions allow for collaborative building and provide an opportunity for a suitably fun and dramatic conclusion!

Chain reaction can be done as a collective contraption: each participant/group is given a chunk of real estate on a table onto which to build a sequence of events. The only constraint is that it has to set off the contraption built by the next group: in the end this will result in a continuous chain reaction that goes from start to finish seamlessly, each section having been contributed by a different participant/group.

## Option: Sketchy Ideas

Have students sketch their machine before building it. It can help each group choose the right materials and assemble a mechanism that works.

# Testing! Testing! 1, 2, 3!

Don't wait until the end to test!

Have students test and retest elements of their designs as they build to make sure they work before they have built the whole thing. Take notes on which parts of the machine work and which ones do not. Does it achieve the task? If something doesn't work, what can you do to make it work next time?

Remember, the design process is cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way.

By making observations about the ways in which objects and simple machines behave in relationship to one another, new designs can be realized, constructed, and immediately tested. And, seeing common objects such as motors, ramps, toy parts, and kitchen utensils behave in surprising ways leads to unexpected experiments with, and new tests of these things. [Ex. Watch Pythagoras Switch - Japanese Rube Goldberg machine]

## Testing Your Machine:

1. Once the machine is complete, test it (again!) to see if it works.
2. Take notes on which parts of the machine work and which ones do not. Does it achieve the task? If something doesn't work, what can you do to make it work next time?

## Did You Know?

The Rube Goldberg Machine Contest (RGMC) is an annual international competition that challenges teams of students from middle school to college age to compete in building the most elaborate and hilarious Rube Goldberg Machine.

Dating back over 60 years, the contest's namesake is the late American Pulitzer Prize-winning cartoonist, humorist and inventor, Reuben Lucius Goldberg, who specialized in drawing whimsical machines with every-day objects that performed a seemingly simple task.

Goldberg's legacy lives on through the contests -- as students nationwide build crazy machines that complete the annual task, all in the spirit of Rube's illustrations.

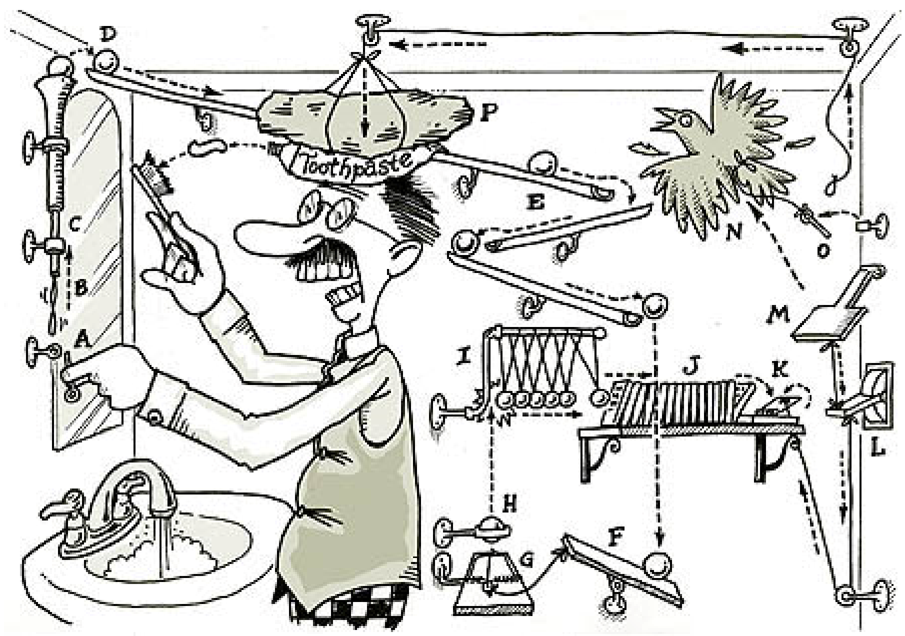
For example: the 2018 Task was: ERASE A CHALKBOARD.

Teams and their machines are judged on a range of criteria from absurd complexity, reliability, team chemistry, creativity, humor and story-telling -- along with the successful achievement of the task at hand.

### Past contests have included such challenges as:

2017 Apply a BAND-AID®
2016 Open an Umbrella
2015 Erase a Chalboard
2014 Zip A Zipper
2013 Hammer A Nail
2012 Inflate A Balloon and Pop It!
2011 Watering A Plant
2010 Dispense an Appropriate Amount of Hand Sanitizer into a Hand
2009 Replace an Incandescent Light Bulb with a More Energy Efficient Light Emitting Design
2008 Assemble a Hamburger
2007 Squeeze the Juice from an Orange
2006 Shred 5 Sheets of Paper
2005 Change Batteries and Turn on a 2-battery Flashlight
2004 Select, Mark and Cast an Election Ballot
2003 Select, Crush and Recycle and Empty Soft Drink Can
2002 Select, Raise and Wave a U.S. Flag
2001 Select, Clean and Peel an Apple
2000 Fill and Seal a Time Capsule with 20th Century Inventions

1999 Set a Golf Tee and Tee Up a Golf Ball
1998 Shut Off An Alarm Clock
1997 Insert and Then Play a CD Disc
1996 Put Coins in a Bank
1995 Turn on a Radio
1994 Make Cup of Coffee
1993 Screw a Light Bulb into a Socket
1992 Unlock a Combination Padlock
1991 Toast a Slice of Bread
1990 Put the Lid on a Ball Jar
1989 Sharpen a Pencil
1988 Adhere a Stamp to a Letter
1987 Put Toothpaste on a Toothbrush




The promise and pitfalls of modern technology, including robotics, make Rube Goldberg's inventions even more relevant now than when they were originally created. From think-tanks in Silicon Valley, to the New York Times, to Sunday morning's Meet the Press, hardly a day goes by without the name "Rube Goldberg" being invoked. In fact, Rube Goldberg is an adjective in Webster's Dictionary.

# Creativity in Motion Activities Supply List

## Simple Machines Activities

Levers (per group of students)

- a tennis ball
- a rigid ruler
- a cylindrical marker
- a roll of masking tape

Pulleys (per group of students)

- three plastic spools;
- a meter (3.2 ft) of string;
- a 1¼-inch donut magnet;
- various small metal objects, such as paper clips;
- masking tape;
- three pencils

Wheel & Axles (per group of students)

- two pieces of cardstock paper
- approximately 57 g (2 oz) of modeling clay
- two drinking straws
- 30 cm (12 in) of masking tape
- 30 cm (12 in) of string

Chain, Chain, Chain Reaction

- 300+ large colorful craft sticks
- This helpful video
- And this one: Check out the post at Mom Trusted. They have a great instructional video posted as well as a video of some kids who built a chain reaction with 1,000 sticks! That one is totally worth watching.
- Two people, at least, per group
- Patience
- Variation: Dominoes or KEVA blocks

That's so Rube of You!

- A wide variety of materials to play and build with, e.g, blocks, cardboard tubes, dominoes, string, etc.
- Literally anything!

# Samples of Academic Standards that can be reinforced during 'Creativity in Motion' activities

K

7.T/E.2 Invent designs for simple products.

7.T/E.3 Use tools to measure materials and construct simple products.

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

*These standards will be met and reinforced as students learn about and build models of all six machine and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate those machines into their design for their large-scale chain reaction that they'll build.*

*As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a use for 'everyday objects,' and overcome challenges.*

*Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their chain reactions. They will have to demonstrate their chain reaction and explain how it works and where the six simple machines are incorporated.*

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2

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.

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3

7.T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

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4

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

7.T/E.5 Apply a creative design strategy to solve a particular problem

*These standards will be met and reinforced as students learn about and build models of all six machine and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate those machines into their design for their large scale chain reaction that they'll build.*

*As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a uses for 'everyday objects,' and overcome challenges.*

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7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

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7

7.11.1 Identify six types of simple machines.

7.11.1 Compare the six types of simple machines.

7.11.1 Differentiate between the six simple machines.

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8

1.1.19a Relate work and power to various simple machines.

1.1.19b. Recognize simple machines are combined to form compound machines

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