

# Rube Goldberg Machine

For our “STEM in a box,” we want students, (middle and high school ages) to learn more about physics and engineering interactions through building a Rube Goldberg Machine.

The Rube Goldberg Machine is the idea of making a simple task overly complicated through engineering.

We aim to provide different types of machine concepts through instruction manuals (in addition to the materials needed and how to construct it) for students to recreate and adapt to their liking.



# Here are a few questions to consider before and after making your Rube Goldberg machine!

## Pre-Activity Thoughts:

- What am I hoping to accomplish?
- How complex do I want to make it?
- How much room will be needed?
- How safe is this?
- What kind of physics do I think I need to understand?
- Do I need any tools?
- Can I work on this with the help of someone else?

## Post-Activity Thoughts:

- What did I learn?
- What did I use?
- Was this what I expected? If not, what was different?
- Did I make changes to the complexity or items?
- Could/did working on this with someone make it easier or harder?
- Did it work?
- How can I improve upon this?
- What interactions can I replace with something else?
- Can I apply another physical concept to this?

# Easy



## “Feeding Pet”

*Cup with food hanging over the bowl that flips into bowl*

### Materials to use:

- Phone
- Book
- Dominos
- Ping Pong Ball
- Toy/Box Tunnel
- Toy Car
- Car Rails
- Ball
- Tunnel that fits the ball
- Strings
- Cup
- Empty Water Bottle

### Recommendations:

A large space (maybe half the size of a living room is suggested)  
Supervision is recommended.  
When failed, this can be messy - which is okay! :)  
but be sure to pets are appropriately protected  
Take precaution necessary.  
This experiment involves:  
Pouring a glass of water  
Popping a balloon  
Water applied to a plant  
Shutting a door  
Breaking an egg

# Medium

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**"starting a phone call"**  
*put toothpaste on a toothbrush*

## Materials to use:

- Pinball
- Spring
- Tubes
- Cups
- Gears
- Wooden Plank
- Protractor
- Glue
- String
- Acrylic Paste
- Toothpaste
- Toothbrush
- Roller
- Small Wooden Hammer

## Recommendations:

Approximately 20 in x 20 in  
Expected to do mainly in the bathroom  
Student should be old enough to know how to brush teeth properly -- no supervision necessary  
Should not be too messy as toothpaste is quite slow to take out



# Hard

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**“Striking a match”**

*Mousetrap/ mechanism that strikes quickly*

## Materials to use:

- Pinball
- Hair Dryer
- Hair Dryer Holder
- Flask
- Tape
- Wood or cup that has a hole the size of the pinball
- Box
- Scissors
- Toy Slide
- Two Containers
- String
- Mentos & Coke
- Balloon
- Dominos
- Stacks of toy blocks
- Mouse Trap
- Match

## Recommendations:

30 in x 30 in

Can do in a medium sized room

Student should be old enough to understand fire and the dangers behind it

Adult supervision necessary as fire is hazardous

Can also learn about fire and using that match to do something (no sure what people use matches for anymore tbh. Candles?)

Launching a paper airplane

# Physical Concepts

## Laws of Motion:

- **Newton's First Law:** An object in constant motion will stay in constant motion and an object at rest will stay at rest unless acted on by an external unbalanced force.
- **Newton's Second Law:** The acceleration of an object is directly related to the forces acting on the object and inversely related to the mass of that object.
- **Newton's Third Law:** Every action has an equal and opposite reaction.

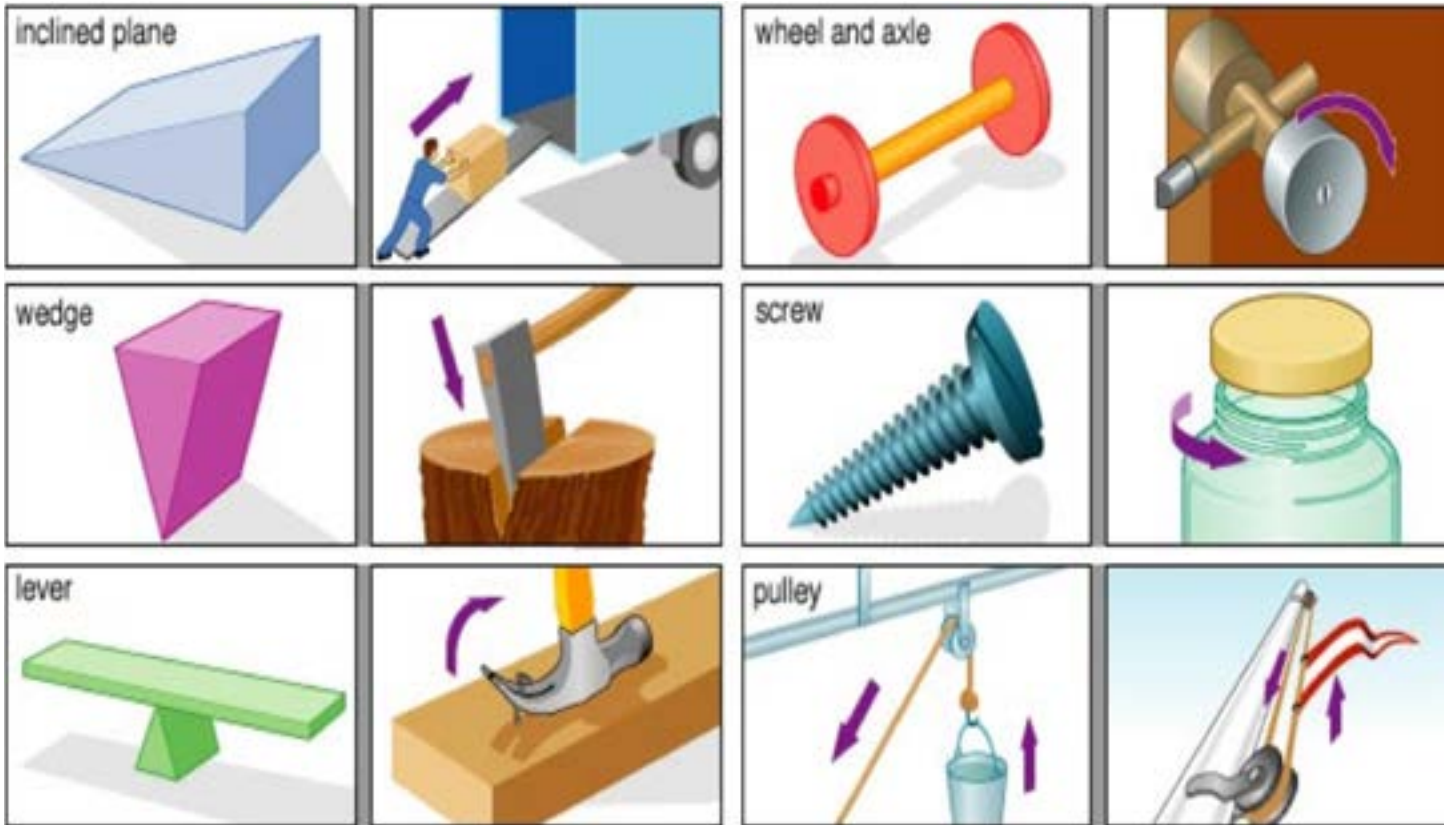
## Energy:

- **Gravitational Potential Energy** is the energy stored in an object because of its height above the ground. The higher off the ground an object is, the more gravitational potential energy it has.
- **Kinetic Energy** is the energy an object has because of its mass and motion. If two objects have the same mass but are moving at different velocities, the faster object has a greater kinetic energy. If two objects are moving at the same velocity but have different masses, the more massive object has a greater kinetic energy. In general, the bigger and faster the object, the greater the kinetic energy.
- **Friction** converts kinetic energy into heat energy. When an object slides against a surface, it tends to slow down because some of its kinetic energy is being lost to heat.
- **Conservation of Energy** is the principle that energy cannot be created or destroyed, only transformed from one form into another. For example, when you drop an object from a high spot, the gravitational potential energy is turned into kinetic energy as it falls.

## Mechanism (Simple Machines):

- **An inclined Plane** (*aka ramp*) is a flat surface tilted at an angle from the horizontal. Inclined planes reduce the force required to elevate and lower objects from one level to another.
- **Levers** are platforms that rest upon support known as a fulcrum. A downward force on one end results in an upward force on the other end. Thus, a seesaw would be considered a lever. Depending on the length of each side, the amount of force is different. This concept is known as leverage. The farther you apply the force from the fulcrum, the more leverage you have and therefore the easier it would be to move whatever weight is on the opposite side of the lever.
- **A pulley** is a grooved wheel with a cord passing over the groove. Its main purpose is to change the direction of force. Using multiple pulleys in the same system can reduce the force it requires to lift an object.
- **A screw** consists of an inclined plane helically wrapped around a shaft. Screws convert rotational forces to linear forces and rotational motion to linear motion. As a screw spins, loads can be carried up and down requiring less force than the weight of the load itself. *Search "Archimedes screw" to see a screw in action!*
- **Wheel and Axle machines** consist of a wheel fixed to an axle such that they rotate at the same time. This allows the force applied to the one end to be transferred to the other. Oftentimes in practice, a rope is connected to the axle such that when the wheel is turned, the rope winds about the axle producing a force greater than the force applied to the wheel. The ratio of the resulting force produced by the machine to the force applied to it is called the mechanical advantage.
- **Wedges** are objects that are tapered so that they are thinner on one end, making a triangle shape. This shape allows them to "wedge" things open as pushing a wedge in one direction applies a force sideways.

# Photos of Mechanisms (Simple Machines)



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**[Want to make more? Check out some additional ideas and materials here.](https://brainpowerboy.com/rube-goldberg-ideas-machine-tasks-and-materials/)**

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## **EASY**

- Pouring a glass of water
- Pop a balloon
- Water a plant
- Shut a door
- Break an egg

## **MEDIUM**

- Starting a phone call
- Turning on the stove
- Turning on a fan
- Opening a door
- Flushing the toilet
- Hanging clothes

## **HARD**

- Launching a paper airplane
- Microwaving food
- Putting on clothes
- Folding clothes

**\*Final Challenge: Create a Rube Goldberg machine that uses all six simple machines!**

*\* Links to referenced videos if hyperlink is broken.*

<https://www.youtube.com/watch?v=OHwDf8njVfo>

<https://www.youtube.com/watch?v=VkJ008VP>

[https://www.youtube.com/watch?v=NuYLk9DaYo4\\_0wKQ](https://www.youtube.com/watch?v=NuYLk9DaYo4_0wKQ)