UWindsor Engineering
OUTREACH

University of Windsor
Faculty of Engineering

Building a Rube Goldberg Machine: Grades 11 to 12

YOUR MISSION

In this activity, you will learn about simple machines and build your own Rube Goldberg machine. Simple machines are the building blocks for many of the mechanical devices, both ancient and modern, used by society for improving everyday challenges. Both high- and low-tech cultures use simple machines to accomplish daily tasks and improve our lives.

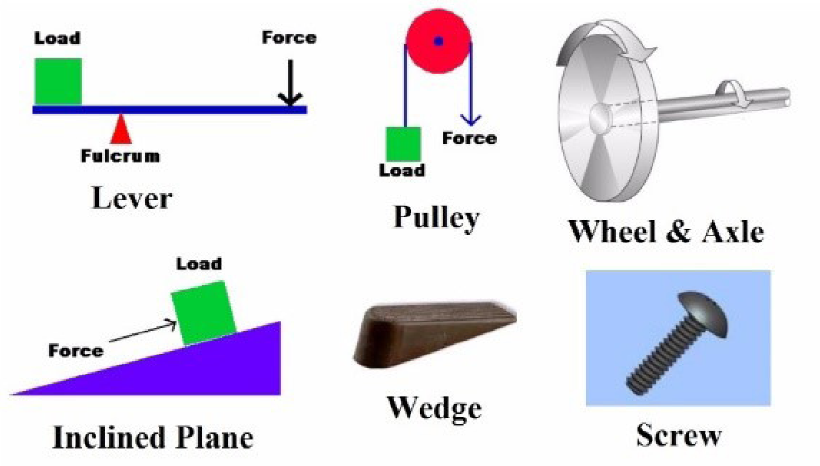
Watch this video for an introduction to Rube Goldberg machines.

WHAT'S GOING ON

Engineers are problem solvers and they come up with solutions to problems to better the lives of everyone around them. They do this by coming up with designs, products, technologies, innovations, procedures and systems to make the world a better place.

Mechanical engineers are responsible for coming with designs and products that involve any type of machinery and moving parts and consider how things move. Simple machines are used to make work easier and more efficient. Some basic concepts are needed to understand the types of machines, the concept of work done by a machine, the energy produced and a machine's mechanical advantage.

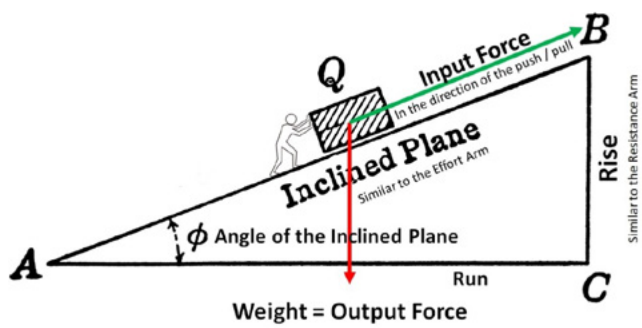
Mechanical engineers draw upon their understanding of the six simple machines when they are inventing new or reinventing existing machines. There are **six simple machines**, they are the **inclined plane, wedge, pulley, wheel and axle, screw, and lever**.



KEY TERMS

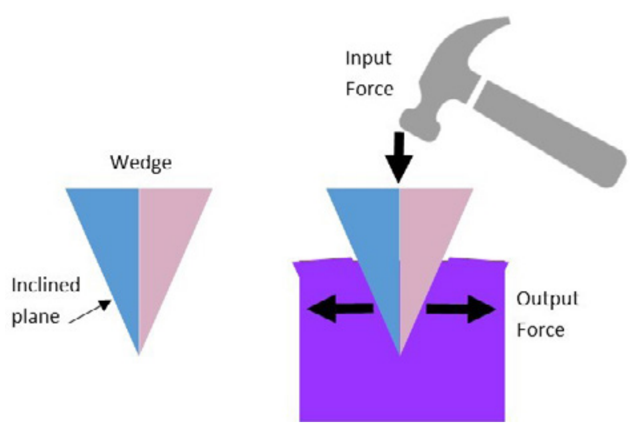
- **Inclined plane:** An inclined plane or ramp provides a flat surface that is at an angle to the horizontal ground. Traveling along an inclined plane enables objects to be moved to a higher point without having to lift them straight up. This increases the distance the object needs to be moved, but reduces the force required because of less opposition from gravitational force.

  e.g. A ramp used to build the ancient pyramids. The Egyptians pushed massive blocks up ramps to the top of the pyramid. Today, ramps are often used to lift heavy objects, such as moving furniture from the ground into a truck or van.



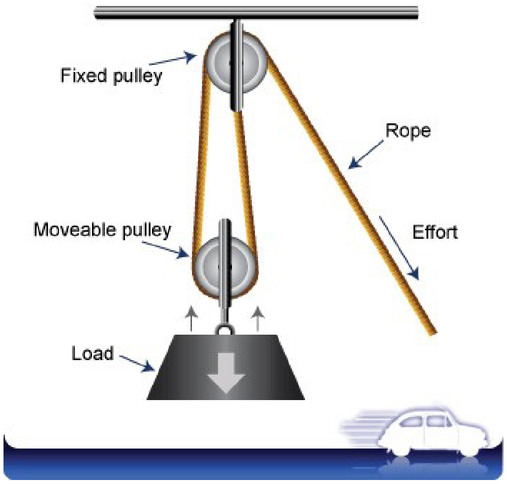
- **Wedge**: Made of two inclined planes or a curved surface reaching a sharp point. Wedges are used to split, cut, or put holes in an object.

  e.g. A nail which has a small, sharp tip and a larger body. A nail is always hammered into a piece of wood tip first because the tip can split through the wood, working as a wedge.



- **Pulley**: A combination of a solid loop and a roller. A pulley reduces the friction of pulling an object up and allows a pulling motion to lift an object.

  e.g. a weight-lifting machine in a gym, in which you pull down on a bar that is connected to a wire that goes through a pulley and connects to the weight, pulling it up.

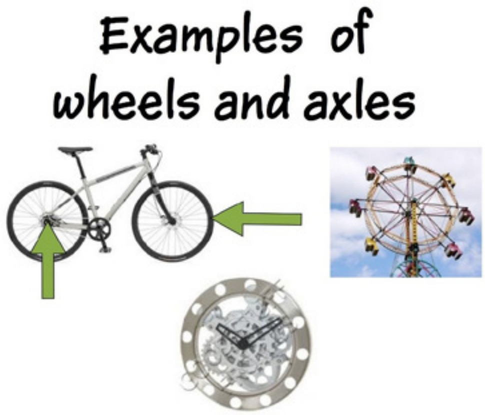


- **Screw**: A simple machine that works to hold something in place. If you look closely, you can see that a screw is composed of two other simple machines, an inclined plane, and a wedge. The tip of the screw is the wedge and the thread of the screw is a very long inclined plane wrapped around the main cylinder body of the screw. The wedge tip enables the screw to make a hole in wood, for example, and then, once the threads are inside the wood, they hold the screw inside the wood.

  e.g. the twisting lid on a jar or a machine vice that tightly clamps a board in place.

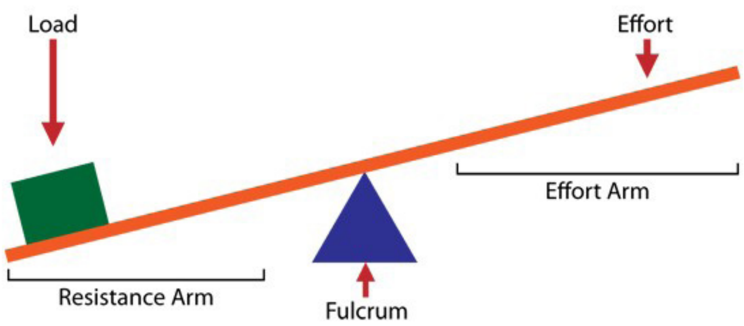
- **Wheel and axle**: Composed of a rod attached to a wheel, which is generally much larger in diameter than the axle. The axle is rotated to turn the wheel. The smaller radius of the rod can be turned with a smaller force then the whole wheel, so by turning the axle the larger wheel can be more easily rotated.

  e.g. wheels on vehicles, skateboards, bicycles, and the axle of a Ferris wheel



- **Lever**: A long straight object that is used to lift something with less force then would otherwise be necessary. Levers may be the most common simple machine because just about anything with a handle serves as a lever.

  e.g. playground see-saw or using the claw end of a hammer to pry a nail out of a piece of wood. The nail could not be pulled straight out but using the lever of the hammer a little bit of force initially can lead to a larger force acting to pull out the nail.



MATERIALS NEEDED

Your materials can be different depending on what task your Rube Goldberg machine will be doing. Be creative in the materials you use – just make sure that any materials you use are appropriate and safe. Below are some ideas!

- KNEX® construction tub or LEGO® kit that includes bricks, rods and connectors for open-ended building
- paper plates
- 1 roll yarn, duct tape and scotch tape
- wooden boards
- mouse traps
- toothpicks
- dominoes
- magnets
- pipe cleaners
- pulley
- toy car
- paper cups
- screws
- small dowels
- rubber bands
- balloons
- marbles
- foam tubes, wide enough that marbles can fit inside
- wooden wedge
- scissors
- large container of soda pop
- aluminium foil
- cereal boxes
- plywood

WHAT YOU NEED TO DO

- Select a simple task for your Rube Goldberg machine to accomplish. Some ideas of tasks can be ringing a bell, turning something on or off (such as a light) or making a ball go into a hole. Prior to starting, sketch out a plan to envision how your Rube Goldberg machine will work.

- Using a minimum of 3 simple machines, construct your own Rube Goldberg machine. Your goal is to successfully transition between machines accomplishing the desired task.

FURTHER REFLECTIONS

1. Which simple machine is your favourite, tell us why and give a real-life example of this machine?
2. In your view, what was the most important part of this activity?
3. How would you modify your design to improve it, if costs and time were NOT a factor?
4. Describe an in-home task that could be simplified by using one of these simple machines.
5. Think of 3 materials we could add to this activity to make it more fun (e.g. an egg).

ENGINEERING DESIGN PROCESS

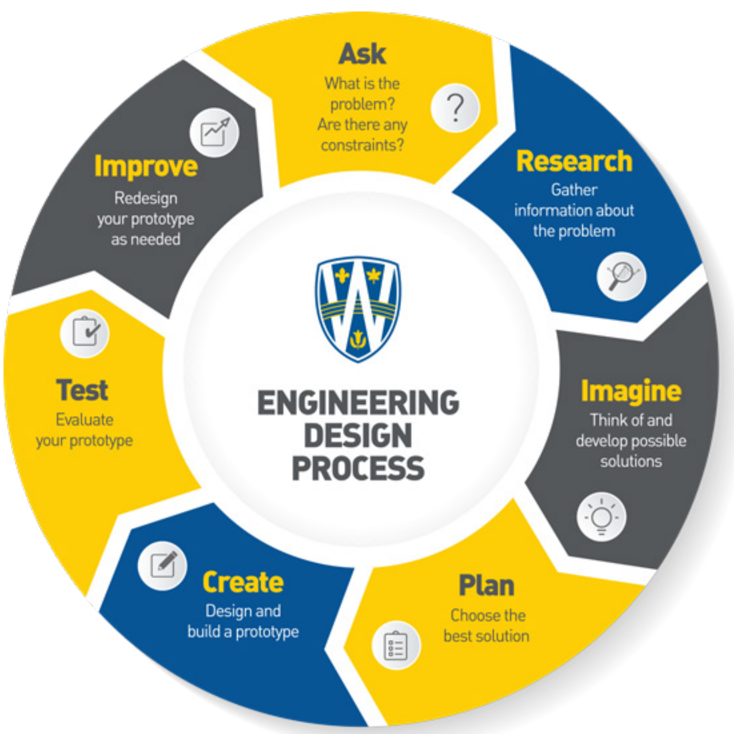
All engineers use the Engineering Design Process to plan, build, test and reflect on their designs and when coming up with solutions to a problem. The steps for the Engineering Design Process are listed below. Use the Engineering Design Process to test and improve your design.

First, think of the problem.

How can you fix it? Think of as many ideas as you can that you think will solve this problem.

It might be helpful to first sketch out your ideas on a piece of paper. Make as many different designs as you can!

Test and compare all of your solutions. Which one solves the problem and works the best?



FORMULAS

Work Done By A Force: the amount of work needed to move an object a certain distance is always the same. Basically, that means that it will always take the same amount of work to move an object from point A to Point B, no matter how you get it there. The simple machines do not change the total amount of work you have to do, but they change how it feels to do that work.

Work (Joules) = Force applied (N) x Distance the object moved (m)

Work done is the amount of energy transferred. Work done = force x distance moved in the direction of the force.

$$W = \Delta E$$

$$W = F \times d$$

W = work done (J)
ΔE = energy transferred (J)
F = force (N)
d = distance moved in the direction of the force (m)

Force applied is any push or pull, such as gravity pulling on a falling apple or a student pushing a table. The units of force are called **Newtons** (named after Isaac Newton, who came up with the concept of gravity). The unit for distance is metres and **work** is measured in **Joules**.

Mechanical Advantage: the extent to which a machine makes work easier is a concept engineers use when deciding what size of machine will best suit a particular task. To calculate mechanical advantage, we need to know how much less force is needed to do the same amount of work. The mechanical advantage number (see equation below) is the ratio of force applied without a machine to the force applied with a machine to do a particular amount of work. When calculating work and mechanical advantage, we use metric units.

Mechanical Advantage Equation

$$\text{mechanical advantage} = \frac{\text{output force (N)}}{\text{input force (N)}}$$

$$MA = \frac{F_{out}}{F_{in}}$$

- **input force** is the force that a person or device applies to a machine
- **output force** is the force that the machine applies to another object

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CURRICULUM UNIT CONNECTIONS

Grades 11 to 12 - Kinematics; Forces; Dynamics; Energy and Momentum

SHARE YOUR DESIGNS WITH US!

Tag us on our UWindsor Engineering Social Media Pages and show us your designs!

Twitter: @UWindsorENG
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