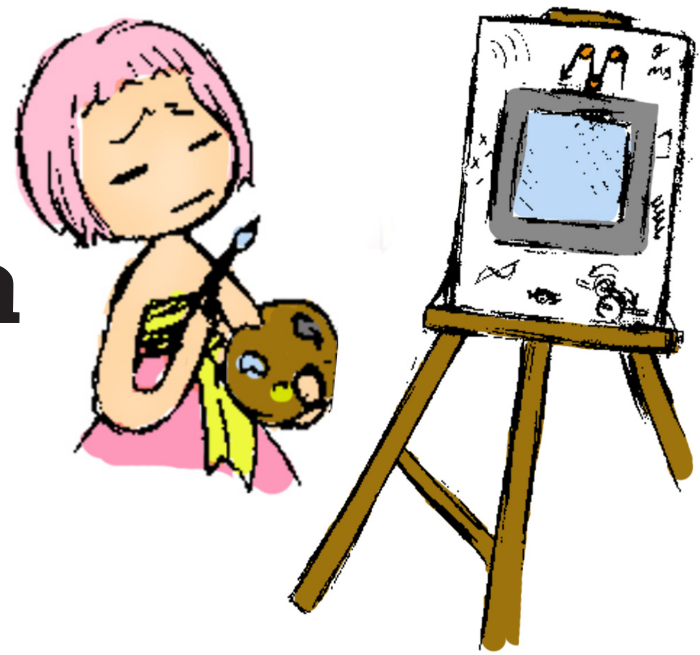
Analog Flash

A collection of student work



Designed by Peter Pham
Illustrated by Emily Dykheng

Contents

Mechanical Advantage

Important Equations:

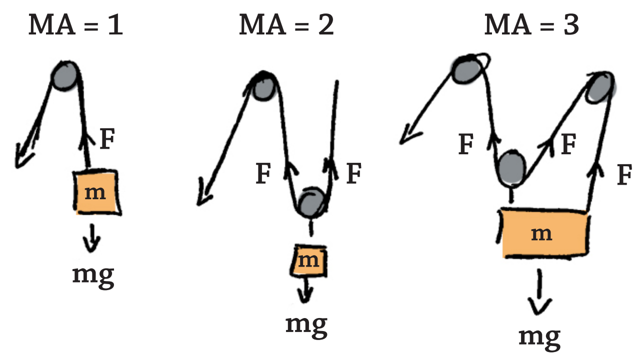
$MA = \frac{F_o}{F}$

Tension = F
(same at all points)

$F_o = mg$

$T = F \times d$

"Work Done" = Force x Distance



Pulleys are simple machines used to reduce the amount of forced needed to lift or move an object. A **machine** being defined as something that multiplies the force you put in by a "number." That number being **mechanical advantage** (MA). In the case of pulleys, the more pulleys there are the higher the mechanical advantage, meaning less force is needed.

Inclined Planes

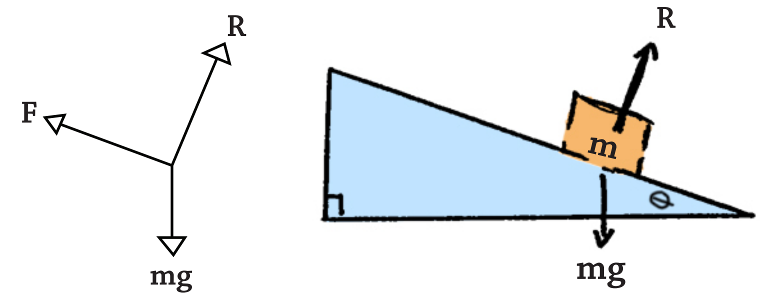
Important Equations:

$$MA = \frac{F_o}{F}$$

$$R = mg \cdot \cos\theta$$

$$MA = \frac{1}{\sin\theta}$$

Critical Angle : $\mu = \tan\theta_c$



Acting Forces

Incline planes are similar to pulleys in that they are also simple machines. However the reason they are mechanically advantageous is that they split the force needed to move an object into separate components. Without an incline plane, the forced needed to lift an object would be the force of gravity. By using an incline plane, the previously downwards force of gravity is split into a vertical component, and a horizontal component.

Springs

Important Equations:

Hooke's Law: $F = -k \cdot x$

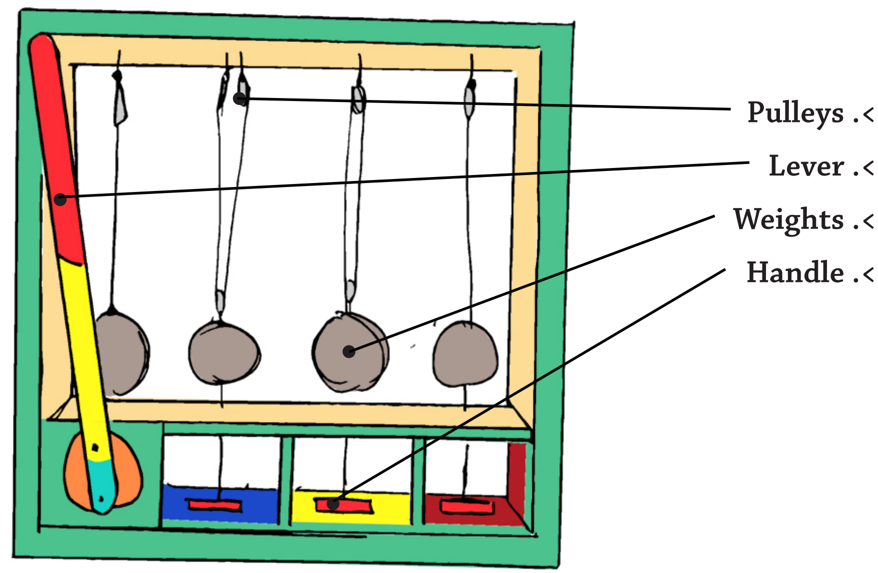
k = spring constant
x = distance through spring is stretched or compressed

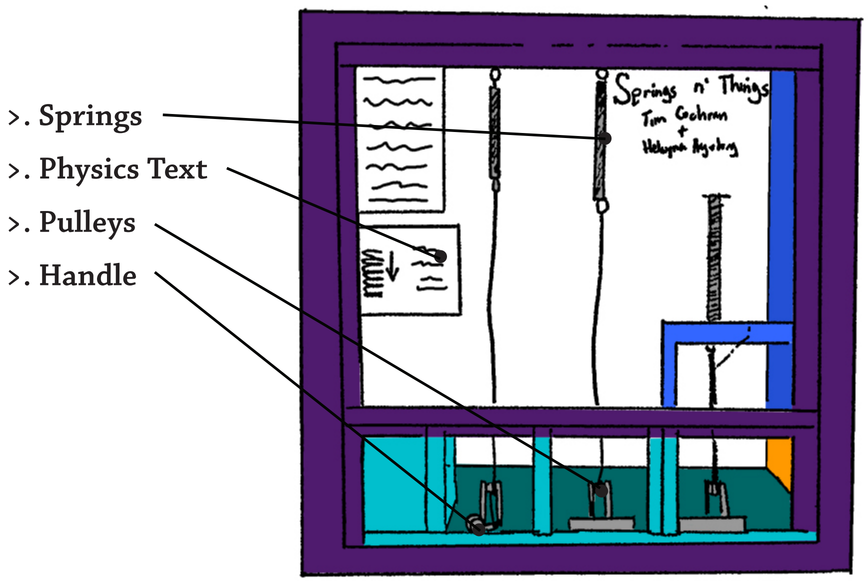
Springs another form of simple machine we see very often in our everyday routines. Hooke's law is the main governing property of springs. In the equation $F = -k \cdot x$, x is the distance that the spring is stretched or compressed from its natural length. The negative k is the spring constant which is different for each spring and it is here that you get your mechanical advantage, depending on the particular spring.

Pulleys

Jeff, David & Andrew

Inside this box are a series of pulleys, ropes, and weights. One weight is connected to one pulley, then to a handle outside the box; the next weight is connected to two pulleys; and a third weight is connected through three pulleys. Also on the outside of the box is a lever which is connected to its own weight. This project demonstrates basic mechanical advantage is a way that it can be easily understood.





Spring & Things

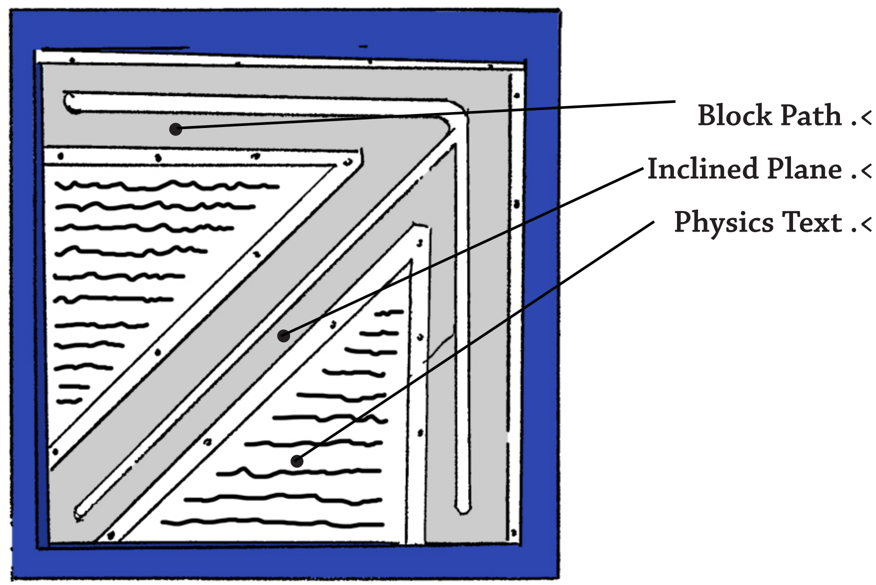
Helayna Hagedorn & Tim Cochran

This project uses ropes to compress springs, demonstrating the physics concept of spring tension and Hook's Law. Two of the springs are stretched in a way that one is easier to pull than the other. A third spring is set up so that when the string is pulled, it compresses.

The Inclined Plane

Sean Stamatelaky & Josh Washington

Though simplistic in appearance, this project demonstrates how one of the world's most useful machines works - the inclined plane. Students can slide the block within this box horizontally on a flat plane, lift it straight up, or slide it up the incline plane. By playing around with this project, students understand how forces are distributed by the plane to make moving things much easier.



The Physics of Waves

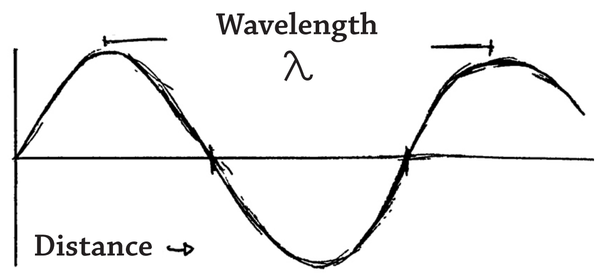
Important Equations

$\lambda \propto v$ → $\lambda \propto \frac{1}{f}$ → $\lambda \propto \frac{v}{f}$

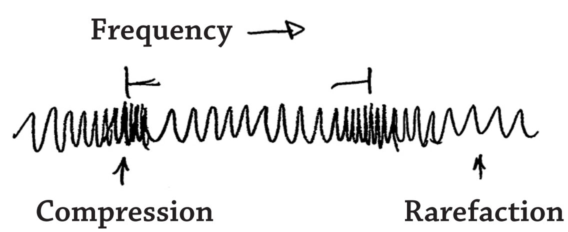
→ **Wave Equations: $v = f\lambda$**

The main components to waves are its wavelength, frequency and period of oscillation. Waves such as transverse waves are what make up sound waves, whereas the string of a guitar creates a standing wave.

Transverse Wave →



Longitudinal Wave →



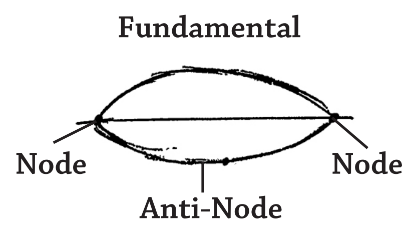
Standing Waves

Important Equations

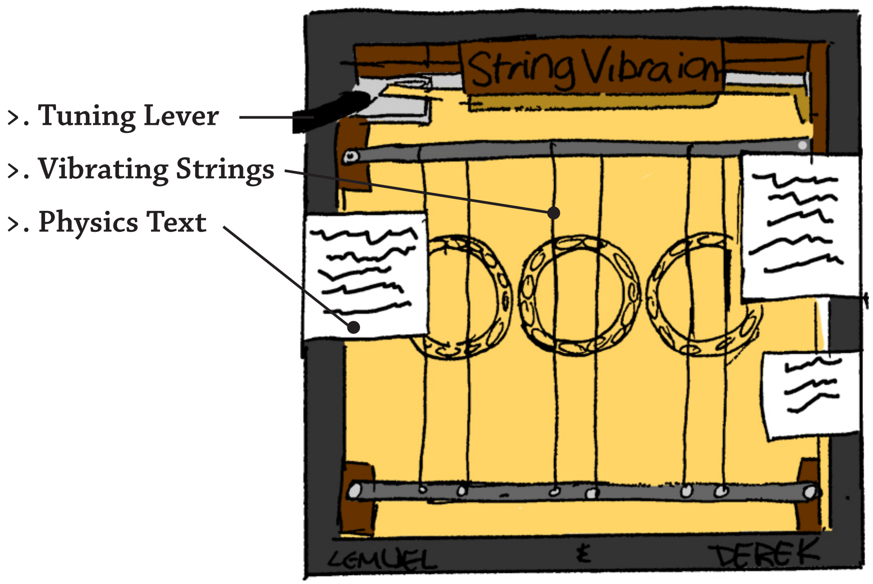
String Length

$\lambda = 2L$ → $f = \frac{1}{2L} \cdot \sqrt{\frac{T}{\mu}}$

Standing Wave →



The form of wave that a fixed string like on a guitar, a harp or even a jump rope is that of a standing wave. This means that the wave oscillates between nodes that are fixed points. In the fundamental frequency, which is the lowest natural frequency, there only two nodes at either end of the string. However strings can have different harmonics, which are just different modes of oscillation in which many more nodes may be involved. With tuning forks, the length of the fork determines the frequency of pitch of the sound emitted. To go up one octave in musical terms is equivalent to doubling the frequency of a note.

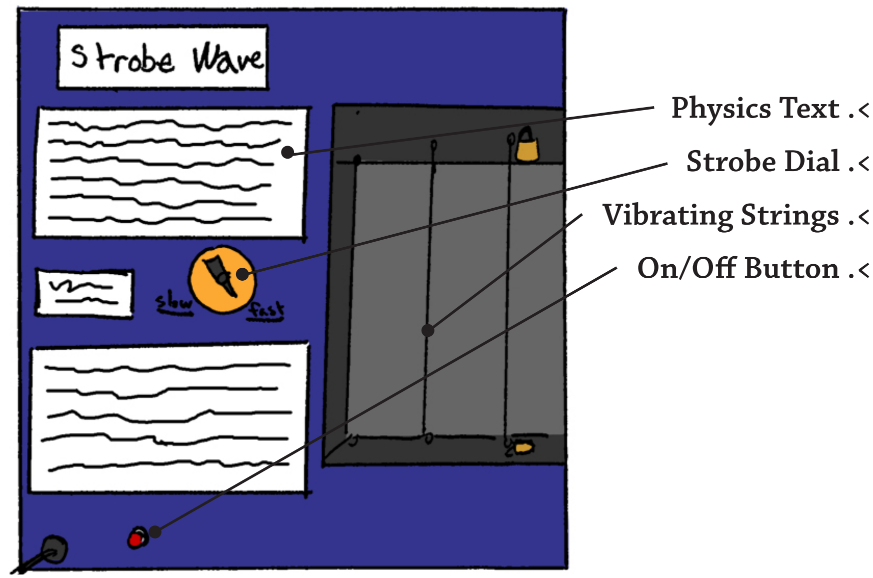


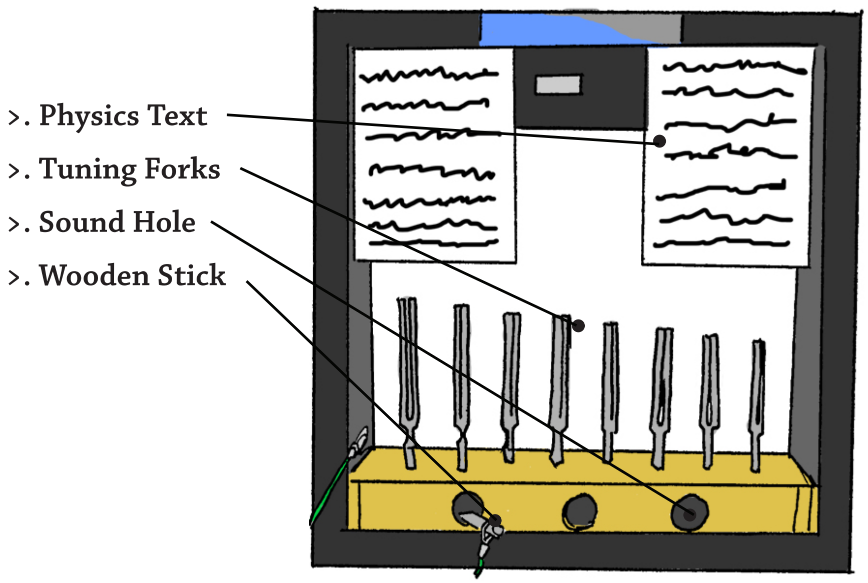
String Vibrations

Looking like a square guitar with three sound holes, this window box demonstrates the physics behind guitar strings. Above each sound hole lies two strings, one which is constantly taut, the other with varying tension controlled by a lever. By pulling and releasing the lever, students can create different tones with the string depending on the tension.

Strobe Wave

Using strobe light technology, this box demonstrates how a wave oscillates in a guitar string. By controlling the speed at which the strobe light flickers, the fundamental harmonic (basic form) of the wave can be seen when the string is plucked. Through experimentation, students can see how this form of standing wave works.



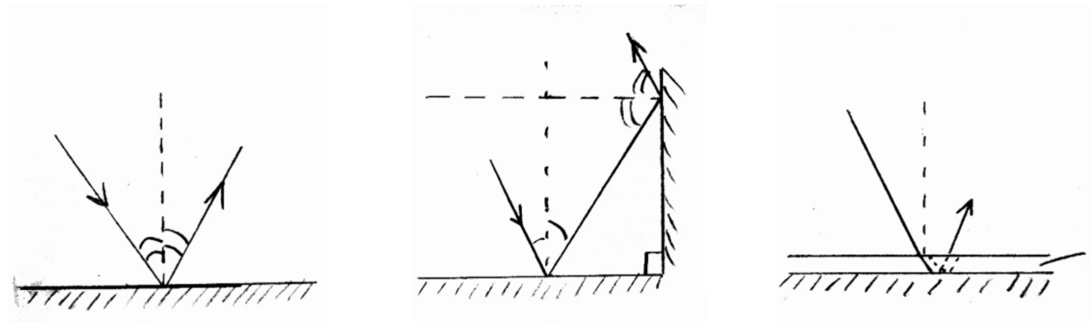


Good Vibrations

Daniel Estrella & Trent Tieger

Within this box is a row of tuning forks of different sizes, in order from longest to shortest. Attached to the box is a small wooden stick with which to strike the tuning forks and create a certain note. Above the tuning forks is an electronic tuning device that shows a pitch reading. By striking different forks, different notes can be produced, and with practice some students have even managed to play simple songs.

The Physics of Light

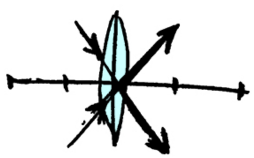


Law of Reflectance

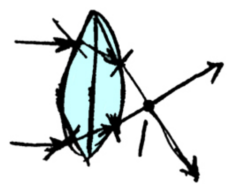
When light hits a surface, the **angle of incident** which is the angle at which it hits the surface will be equivalent to the **angle of reflection**. The best example of this is shown in the diagram below where a beam of light hits the surface of a mirror.

Lenses

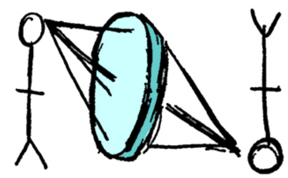
Not all materials are as reflective as mirrors, and bend light more than they reflect it. In the case of lenses, light passes through the lens and is bent or focused to a certain **focal point** which is different for all lenses. These diagrams show how light passing through a **converging lens** acts.



Rule 1: Light passing through center of lens is undiverted

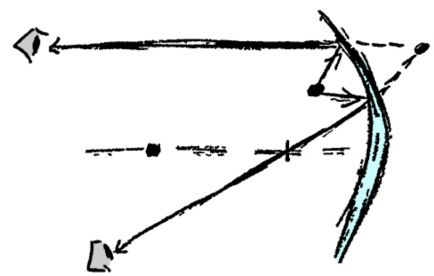


Rule 2: Light moving parallel to principal axis passes through focal point

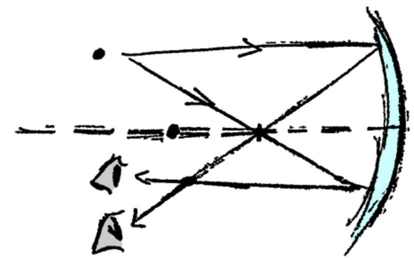


Rule 3: Light passing through focal point emerges parallel to principal axis

Real vs Virtual



Virtual Image

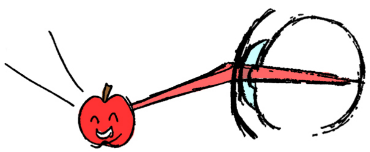


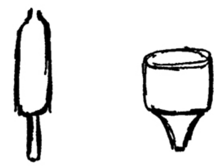
Real Image

The two types of images produced by lenses and mirrors are **real** and **virtual images**. With virtual images, the point of origin of the light, whether real like with lenses, or imaginary like mirrors, cannot be reached and only found by looking through the medium of the lens or mirror. In the case of virtual images, the light actually reflects in a way so that the eyes see an object where it really isn't. The diagrams show the difference between the two.

Color Perception

When we see an image, we are seeing the light that has been reflected or emitted from an object. This light is focused through the lens to the retina on the back wall of the eye. On the retina there are photoreceptors (rods and cones) which are stimulated by different wavelengths of light.





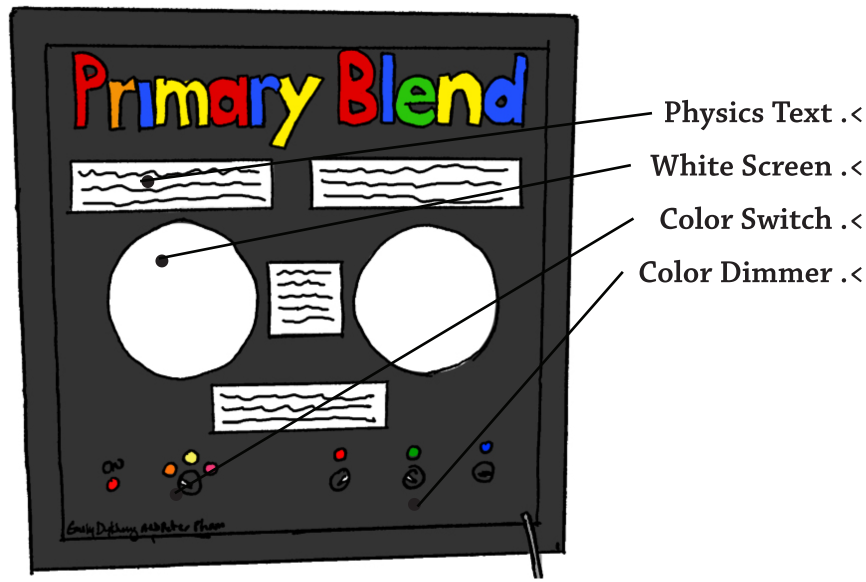
	Black	Red	Orange	Yellow	Green	Blue	Indigo	Violet	White
R	X	O	O	O	X	X	X	O	O
G	X	X	O	O	O	X	O	X	O
B	X	X	X	X	X	O	O	O	O

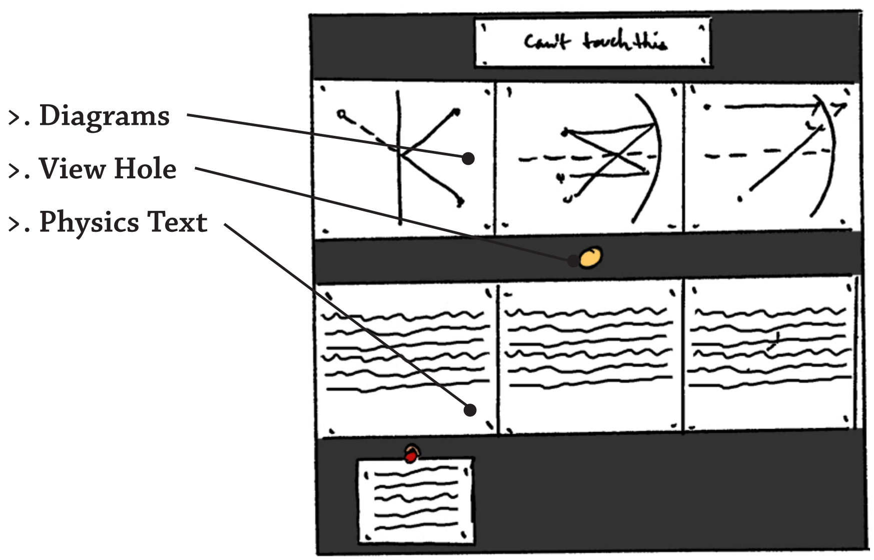
Cones are each sensitive to red, green or blue. Together these cones allow us to see millions of different colors by combining the different levels of impulse they receive. This information is then sent to the brain where the red, blue and green values are pieced together and result in color vision. The brain is essentially fooled into seeing other colors like orange or yellow by detecting levels of both red and green for example.

Primary Blend

Peter Pham & Emily Dykheng

“**P**rimary Blend” shows the color additive theory. In the window box, students select a color - pink, yellow, or amber- and try to mix that color using the red, green, and blue dimmers. Just about any color of light in the color spectrum can be created in the mixer, even white light.





Can’t Touch This

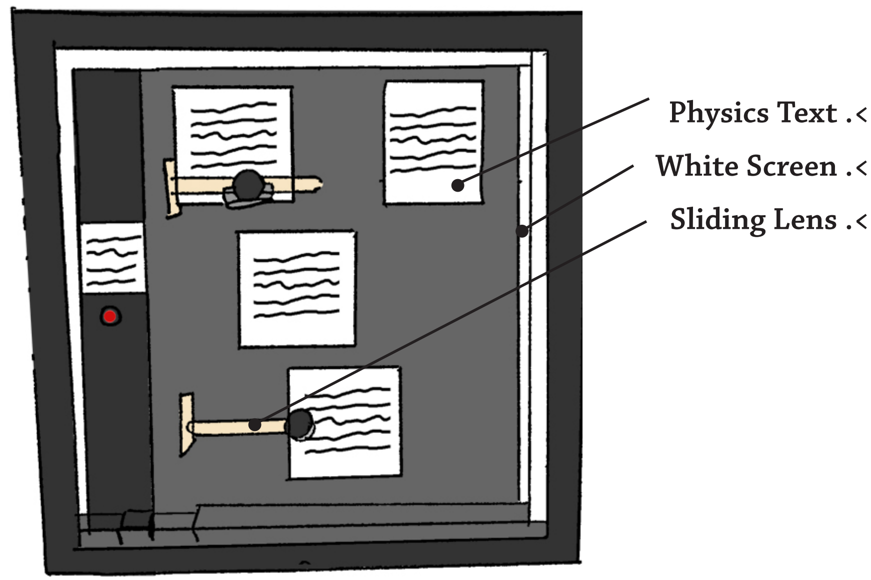
Alex Schmidt & Sophie Gordon

“**C**an’t Touch This” demonstrates how virtual images and light can be used to create the illusion of a real object. When one looks into the small hole on the outside of the box, a plastic farmer can be seen within. However, when students reach in to touch this farmer, all they get is air.

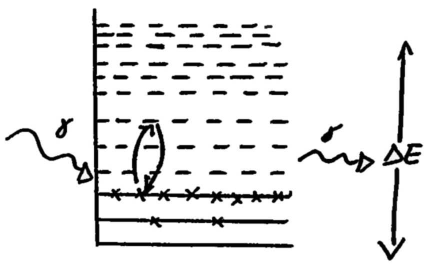
Lens and Slides

Christine Amarila & Alysia Goco

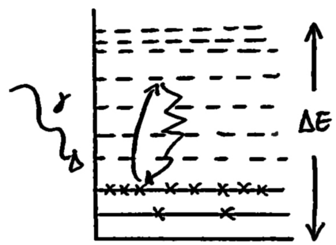
The purpose of this box is to show how lenses work. Inside the box are two lenses that students must move back and forth in order to focus an image onto the other side of the box.



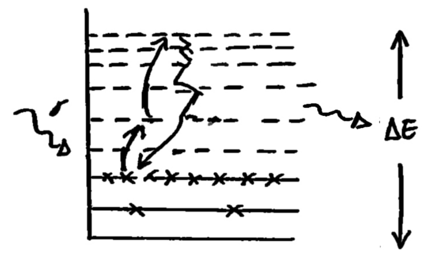
Photon Absorption



Scattered Light



Object Heats Up



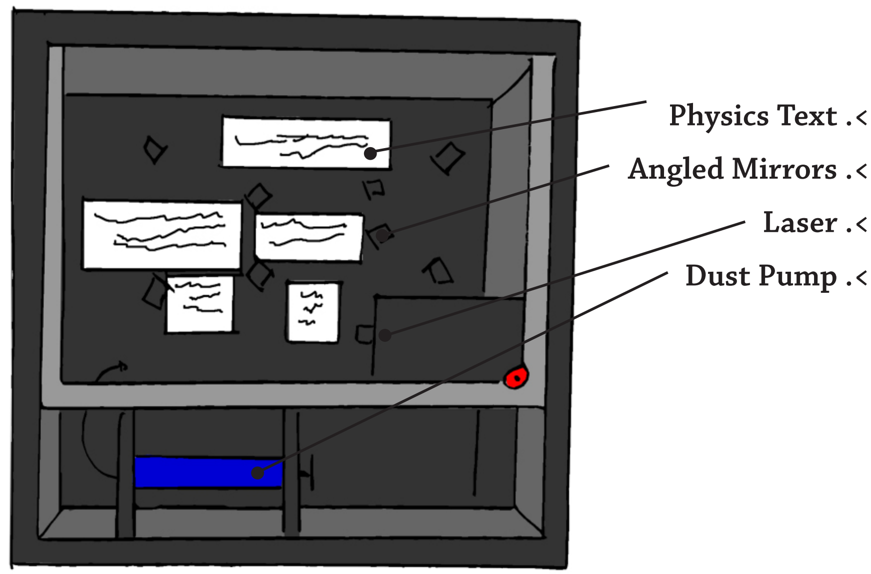
Fluorescent Light

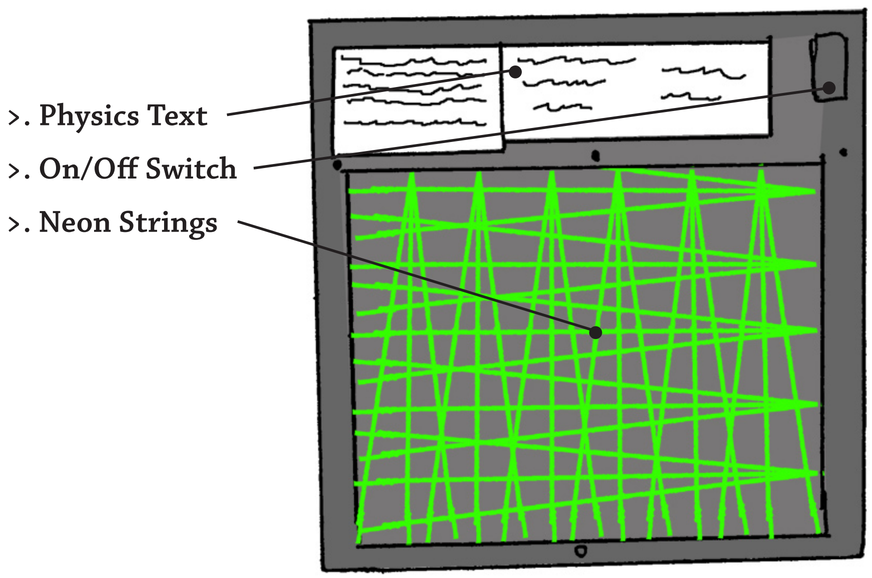
When a photon, a tiny particle or packet of light energy contacts an electron, the electron absorbs all of the photon's energy and causes the electron to jump up to a higher orbital. The way that the electron returns to the ground state determines the type of light emitted. If the electron goes up and jumps right back down it is scattered light. If the electron goes up and slowly zigzags down the levels it causes the material to heat up and if it does a combination of the previous two then it fluoresces. To determine energy output, E = hf is used.

Dusty Laser

Justin Cadlaon & Bryce Steslicki

Inside this box there are a number of systematically positioned mirrors. When students press a button on the front, a green laser dot can be seen on each of the mirrors. If the air pump on the bottom is used, a thin layer of dust fills the box, revealing a beam that bounces around inside the box from mirror to mirror.





Black Light

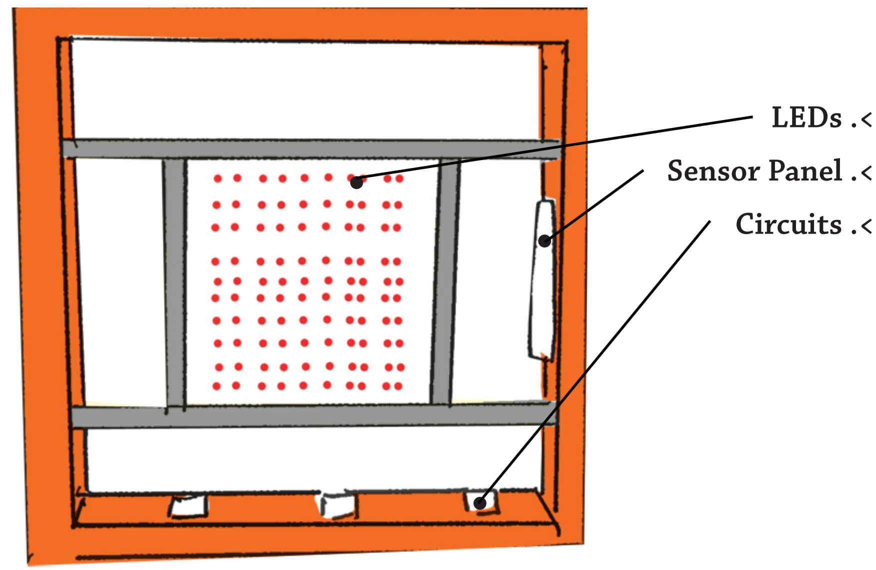
Anna Crisafi & Rauna Landing

At first glance, there is not much happening in this box. But once the switch at the top is turned on, all you can do it step back and admire it. The black light inside that is turned on with the switch illuminates the strings which radiate a glowing green!

LED Lights

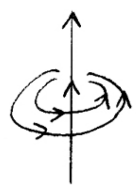
Albert Zarzoso & Nick Doering

Though not flashy in appearance, this box truly interacts with students and reacts to their every move. Using motion sensors and Light Emitting Diodes (LED), this project mirrors shapes and movements. By placing a hand in front of the lights, the motion sensors recognize the hand, and trigger the corresponding lights so that a hand-like shape can be seen made of LEDs.



Electricity & Magnetism

When you have a wire or a coil of wire with current flowing through it, there is a magnetic field around the wire. If you grip the wire with the current going up with our right hand, the magnetic field flows the way your fingers curve.

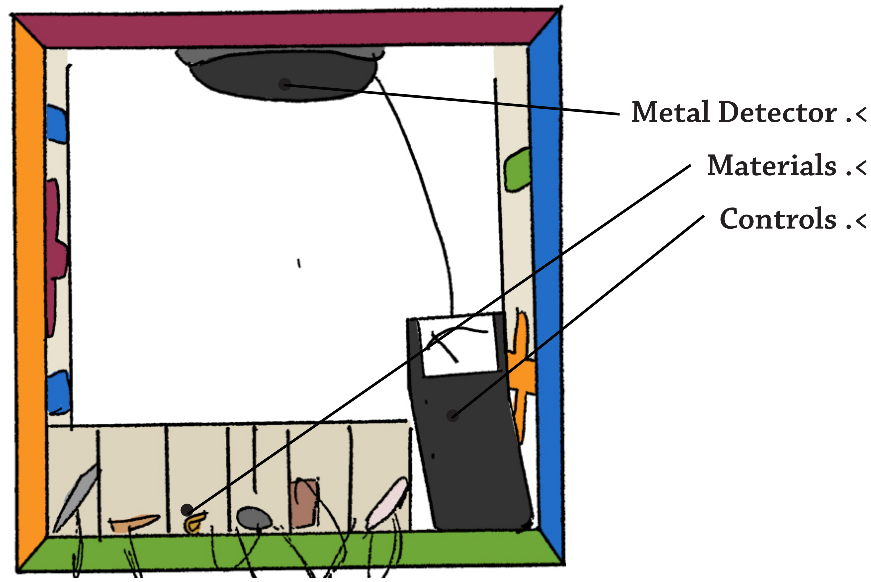


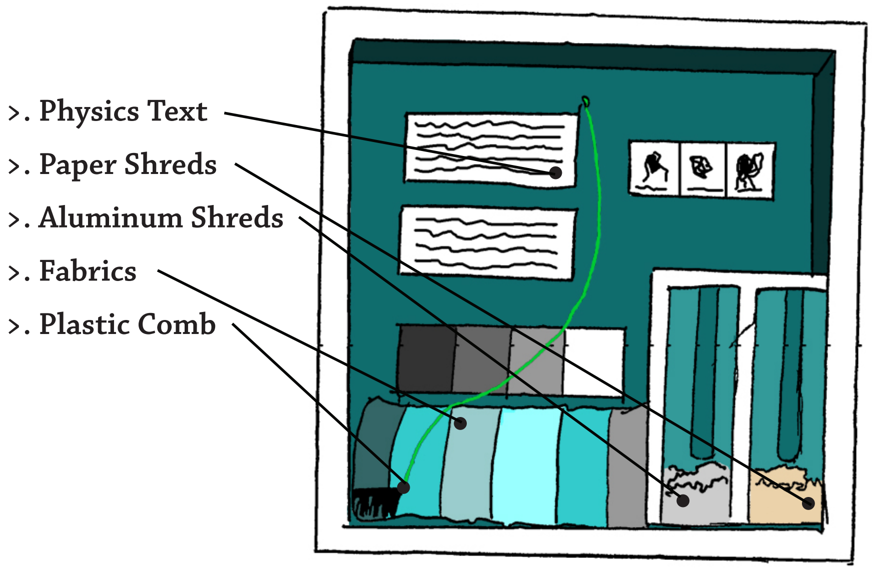
If you have ever brushed or rubbed a balloon on your hair you may have noticed that the hair seems to fly out and stick to the object. This is because there is an imbalance in **electrons**. When a brush or balloon is used, the rubbing or brushing motion strips electrons from the hair atoms and gives them to the object. The object is now negatively charged while your hair is positively charged, causing an attraction. This is static **friction**.

Magnetic Attraction

Eric Blue & Gwen Jones

A beachcomber's dream, this window project shows how a metal detector is affected by different materials such as aluminum, copper, steel, plastic and wood. By adjusting the settings on the device, illuminating insights about the magnetism of certain metals are discovered.





Static

Gabriela Cervantes & Paul Dufor

Ever have your hair stand up on a cold day? This window box describes the physics behind this phenomenon and more. Using the comb attached to the box, students rub different types of fabrics and then place the comb into a container of aluminum foil flakes or paper flakes. Through experimentation, students discover which fabrics provide the right static to attract one of the two materials.

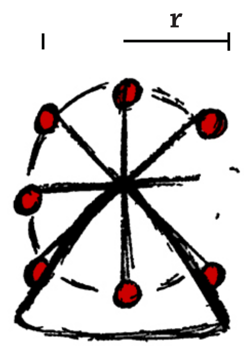
The Physics of Motion

Important Equations:

$F = \omega \cdot r \cdot w^2$ $F = \frac{m \cdot v^2}{r}$ $\omega = 2 \cdot \pi \cdot f$

Angular Velocity:

$\omega = \frac{2 \cdot \pi}{T}$ $v = r \cdot \omega$ ω = Omega



Ferris Wheel

Pelvis

One common mode of motion is **circular motion**. What makes circular motion different from most other types of motion is that new factors come into the picture such as angular velocity and centripetal force. **Angular velocity** is the speed at which something takes to rotate one full turn, this can be found by solving for omega. **Centripetal force** is the force that pulls an object inwards which keeps the circular motion going.

Pendulums

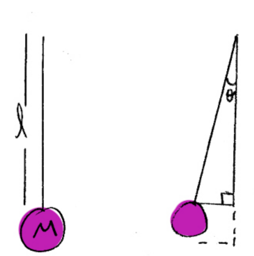
Important Equations:

$$t = 2\pi \cdot \sqrt{\frac{L}{g}}$$

$$a = f^2 s$$

$$f = \sqrt{\frac{g}{L}}$$

t = Period



Pendulums

Pendulums have very interesting physics properties. One thing that is interesting about them is that the weight of the object at the bottom of the string is irrelevant. The part of a pendulum that determines how it acts is the length of the string. The **period** of the string represented by **t** is how long it takes for the pendulum to complete one full oscillation.

Friction

When you stand on a hill, what keeps you in one place? Kinetic **friction** does. Friction is defined as a force that opposes motion. Friction can be determined by using this equation:

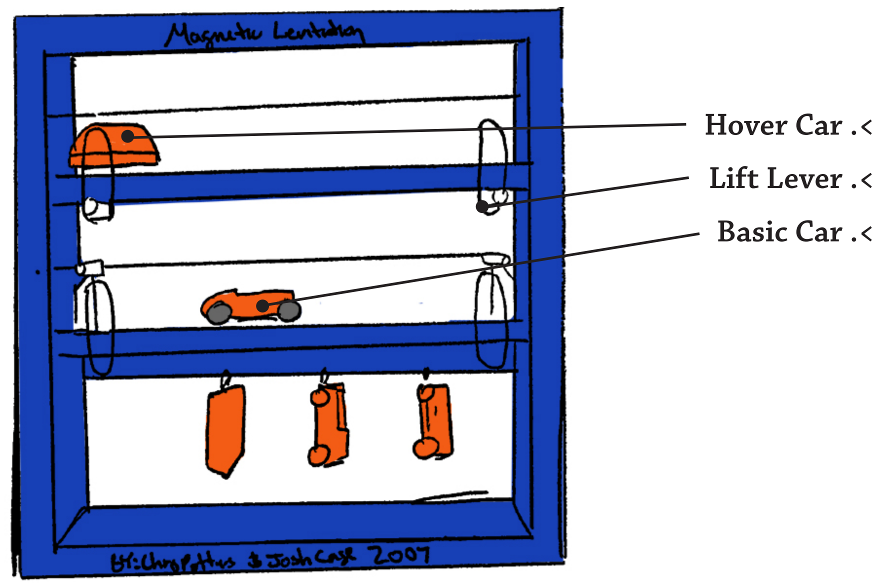
Fr = $\mu \cdot R$

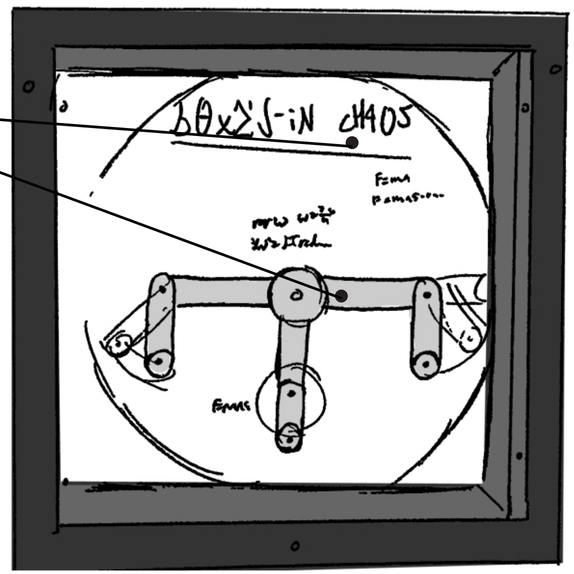
R = Reaction force
μ = Coefficient of Friction

Mag-Lift

Chris Potters & Josh Cage

A prototype of future transportation, this project shows how a "mag-lift hover car" travels on an inclined plane compared to the contemporary four-wheel car. The physics of friction and incline planes is described and shows how different components of forces work.





Box in Chaos

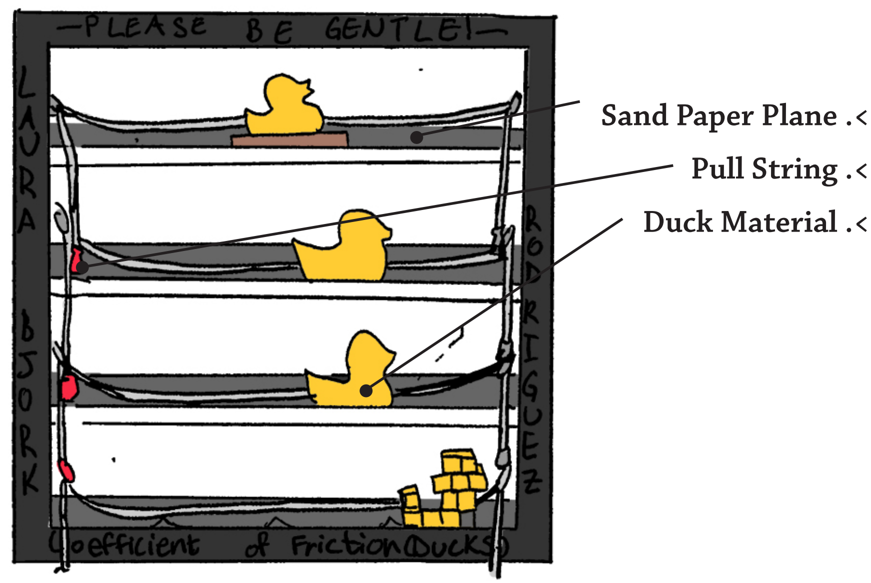
Robert Stelmach & Tyrone Lee

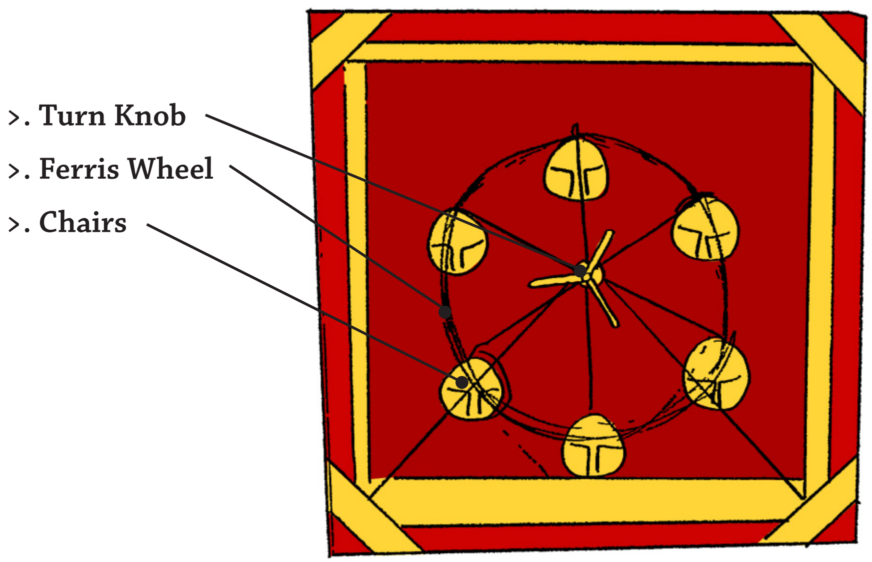
The focus of this window box is chaos theory. To demonstrate this concept there is a chaos pendulum in the center of the box. When spun, the pendulum spins, but unlike the usually fluid movement of a regular pendulum, this one moves erratically. Just when you think it is going to spin one way, it changes direction without warning. However, there is a method to the madness!

Coefficient of Friction

Laura Bjork & Diane Rodriguez

Observers find four yellow ducks inside this box. One is made of metal, one of wood, one of rubber, and one of cardboard. Each duck lies on its own plane on top of a layer of sand paper. When one of the strings that is attached to a duck is pulled, that duck moves across the sand paper plane. Each duck moves with variable difficulty depending on the amount of friction each material causes.





Ferris Wheel

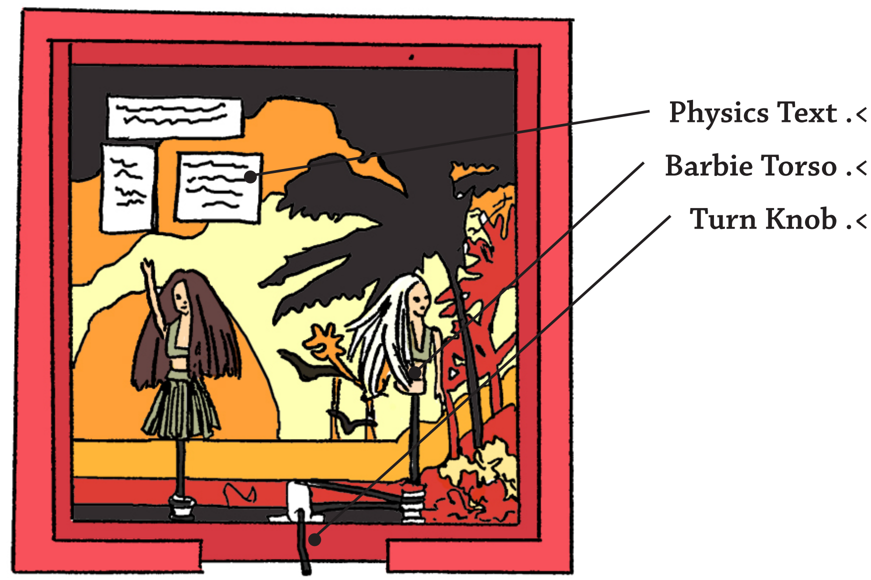
Grace Allen & Morgan Malone

Beautifully painted and craftily constructed, this project demonstrates the physics of circular and centripetal motion through the real world application of a Ferris wheel. Using the handle outside the box, students can spin the Ferris wheel and see how this motion affects the hinged chairs.

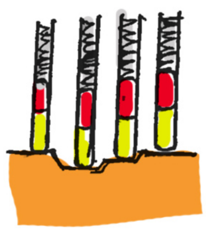
Trop-i-Ganza

Jazmyn Brown & Brittny Collins

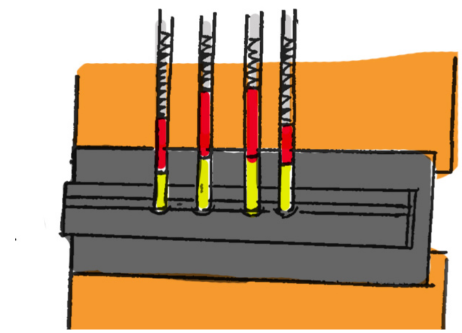
This creative box demonstrates circular motion and how gears work. Two Barbie dolls are positioned within the box with wooden hips connected to a rod. The rod is connected to a handle which can be spun, in turn spinning the hips on the Barbies. The result is a Barbie doing the Hula!



Physics of a Lock



Lifted Pins



Pin System

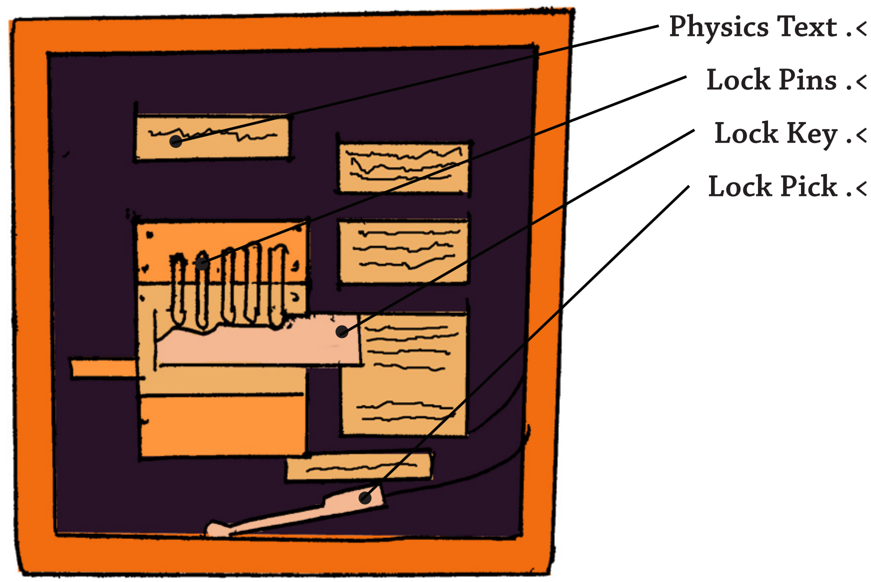
Locks have changed in size, shape and complexity over the centuries, however their basic principles remain the same. Inside a standard key lock for a door, a car, a locker or anything of the sort, there is a series of **pins** like in the diagram to the right. These pins are what keep the **cylinder** within the lock from turning.

When a key is in inserted into the lock, the grooves on the key act like wedges or incline planes to push up pins as the key passes through. If the correct key is used then all of the pins will have been lifted to the correct height which causes the pins to line up in a way that the cylinder can now be turned, opening the lock.

Locked Away

Amelia Pludow & Brooke Castro

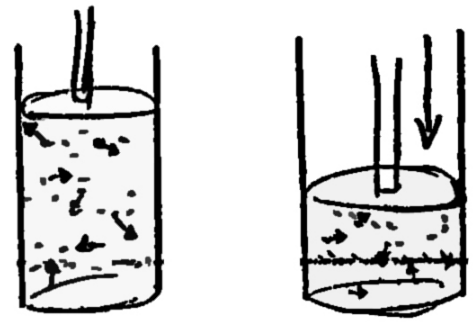
This window demonstrates the components of a lock and how keys and picks are used to open them. In the center is a three dimensional cross section of a lock. Attached to the box is a wooden key which opens the lock, and a pick. Students can use either tool to open the lock. The pick, however, is much more challenging since each pin has to be pushed up one by one.



Air Pressure

Important Equations:

Boyle's Law: $P_1 \times V_1 = P_2 \times V_2$



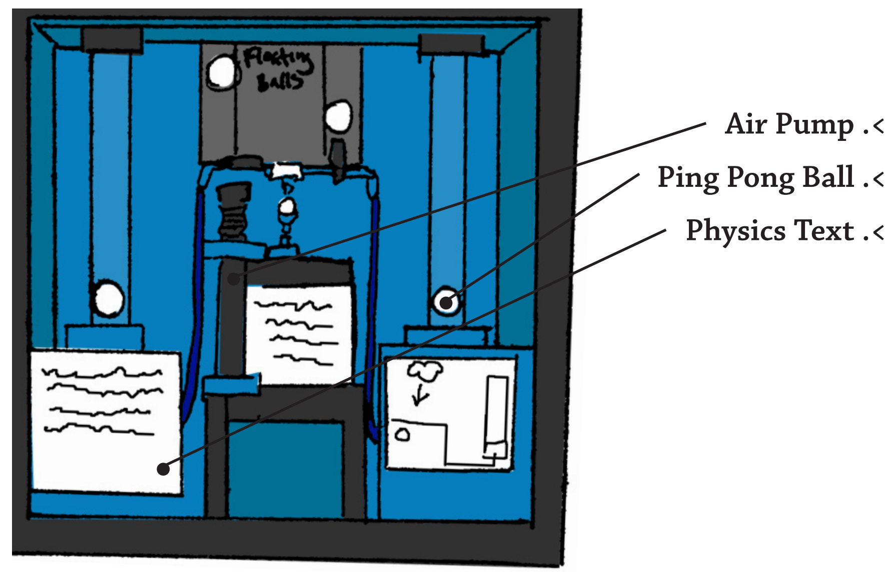
Low Pressure **High Pressure**

Whether its blowing a balloon or piston compressing a cylinder, we encounter **air pressure** often in our everyday lives. Gasses like oxygen, hydrogen, and the air around us are made up of microscopic molecules that fly around in an excited state. When these gasses are enclosed in volume such as a cylinder, the molecules start to run into each other and the walls of the cylinder more frequently. As the piston moves farther down there is less room for the gas to move and the walls of the cylinder are hit by molecules much more frequently causing a greater force to be exerted on the cylinder. The standard unit of measurement for pressure is **psi** or pounds per square inch.

Floating Balls

Mo Black & Michael Martinez

Using the hand pump in the center of this box, students can experiment with different levels of air pressure. On each side of the hand pump is a clear tube with a ping pong ball within. Depending on whether the valves are open or closed, the balls will levitate or shoot up.



Probability

Las Vegas, casinos, horse racing, sports betting all based off of **probability.** If there are six sides on a die, there is a 1 in 6 chance of rolling a five. If there are two dice, there is a 1 in 3 chance of a five, your probability of rolling that number has doubled. In a pachinko machine, there is an array of pegs or pins that a ball must bounce through before landing in a certain slot. The probability of landing in a particular slot can be calculated using a diagram called a **Pascal's Triangle.** Since there are 10 rows of pins on the window box pachinko machine we can use the first ten rows of Pascal's Triangle. The numbers represent the odds of following a certain path. For example, the odds of the ball going straight down and landing between the 126's is 1 to 126. In other words, it would be highly unlikely.

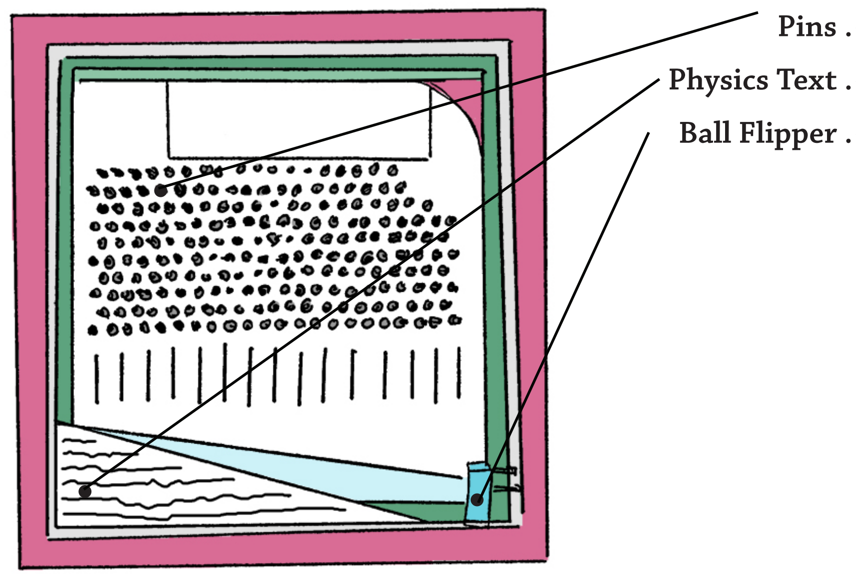
1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1
1 6 15 20 15 6 1
1 7 21 35 35 21 7 1
1 8 28 56 70 56 28 8 1
1 9 36 84 126 126 84 36 9 1

Pascal's Triangle

Ballin’

Fannie Ngo & Nick Compton

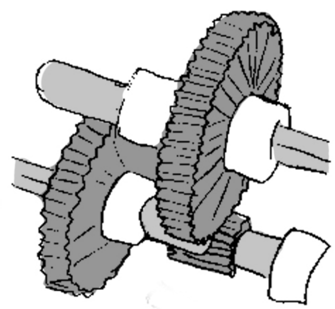
This box is a twist on the classic game of pachinko where a marble is dropped through a system of pegs, making its final position unpredictable. The physics behind this project are probability and chaotic motion. When students use the pinball-like flicker to launch the metal marble high into the box, there is no guessing where it might land.



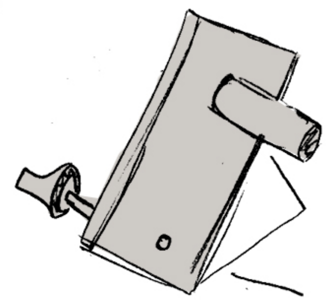
The Physics of Gears

Gears have become an essential component to most complex machines. There are a variety of gears in use today. The some of the most common include spur gears, bevel gears, pinion gears, sun gears and crown gears. However the most important part of a gear system is not the type of gears, but the ratio in which they are set up.

Crown Gear



Spur Gears

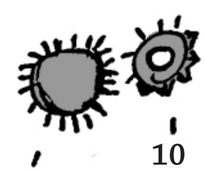


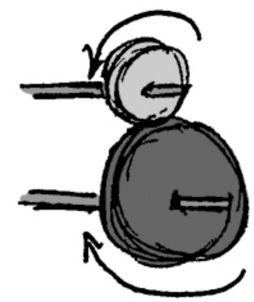
Crank

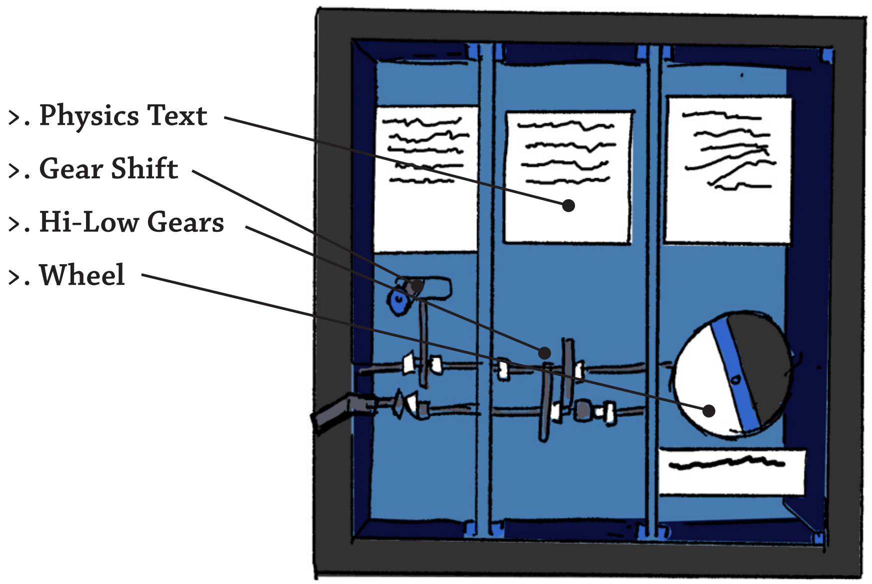
Gear Ratios

Gear ratios are determined by the number of teeth on each gear in relation to the next. Below is an example showing a 30:10 **gear ratio**, also known as 3 to 1 ratio. If the effort is put into the 30 tooth gear,we can find the mechanical advantage by putting the number of teeth on the output gear divided by the number of teeth on the input gear. This is usually good in cars at high speeds because little torque is needed. If the motor was connected to the smaller gear, it would take 5 turns of the motor to turn the connected gear one rotation, helpful when pulling large loads or starting a car in first gear. Another thing that is mechanically advantageous and related to gears is the crank. This is essentially a lever connected to a gear, further reducing the amount of input forced required.

$$\text{M.A.} = \frac{\text{n-output}}{\text{n-input}}$$







The Transmission

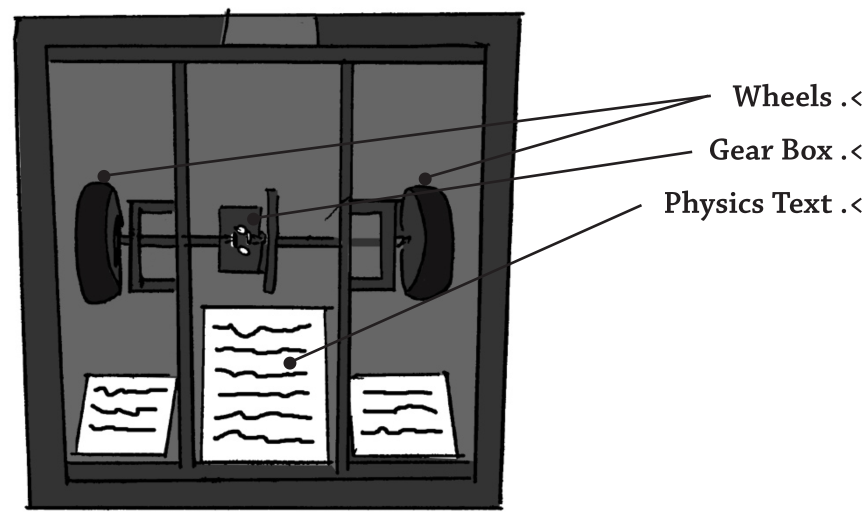
Scarlett A, Jeff S, & Elliot S

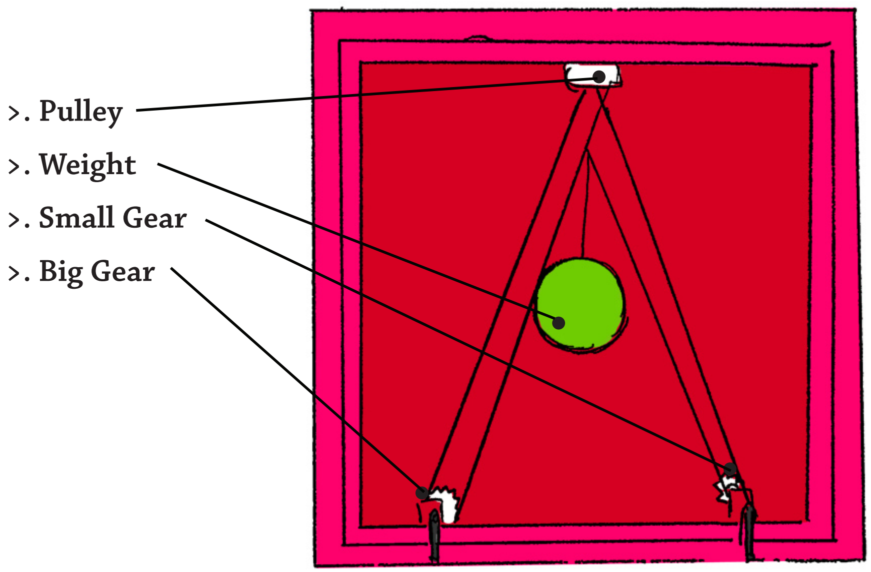
A simpler version of a car transmission, this window project shows how a low-high gear system works and what its benefits are. Students can move a lever similar to a gear shift to switch between a low gear ratio and a high gear ratio. The difference in speed and effort can be easily seen.

The Differential

Dan Vincelett & Dylan O'Bosky

Inside this box there are two wheels on both sides of a set of gears. The box-like configuration of these four bevel gears shows how a car differential works. The center is spun and both wheels turn, even though they are running on independent axes. When one wheel is spun, the other wheel spins also, but at a slower rate, representing a turning car.





The Black Ration

Celeste Byers & Myah Doakes

This very artistic box demonstrates what gear ratios are. There are two cranks connected a pulley that move a block of wood up or down. The crank with the bigger gear turns slower than the smaller gear but requires less time.