Life Size Mousetrap

What You Need to Know

Teacher Overview

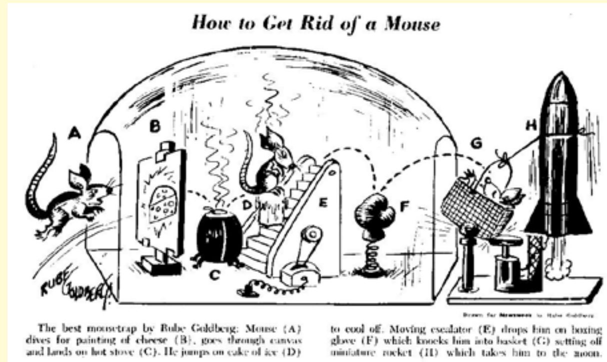
This performance art piece and wonder of grassroots, homegrown mechanical engineering takes the classic board game "Mouse Trap" to new heights. Scaled up so that the game's marble is now the size of a real-life bowling ball and full-grown humans wearing fuzzy ears act as the mice, it uses "the tools of wonder and excitement to plant the seeds of curiosity with a 25-ton Rube Goldberg machine!" The crew of five to 20 mice dance, sing, and keep the "marble" rolling through the contraption, until a grand finale.

See Life Size Mousetrap Maker Mark Perez in a two-minute CNN video: **tinyurl.com/LSMT-cnn** (originally **youtube.com/watch?v=Rdqrdw8qt3Y**)

Read more: **tinyurl.com/LSMT-smith** (originally **blogs.smithsonianmag.com/artscience/2012/10/teaching-physics-with-a-massive-game-of-mouse-trap**)

Simple machines—in song!

At its core, Life Size Mousetrap combines 16+ mechanical movements. All mechanisms can be boiled down to one or more simple machines: lever, wheel and axle, pulley, inclined plane, wedge, and screw. Read about these in greater detail in the next section, or turn to song! Esmerelda Strange explains some of the physics behind Mousetrap with How To Defy Gravity With 6 Simple Machines, a CD of physics-friendly tunes: "It's as if Mary Poppins puts on an accordion and goes to the county fair to teach kids about simple machines, basic physics and scientific inquiry."
See **tinyurl.com/LSMT-music**
(originally **cdbaby.com/cd/esmereldastrange2**)



Rube Goldberg machines

The original board game of Mouse Trap was designed by Marvin Glass who was, in turn, inspired by the entertainingly complex drawings of Rube Goldberg (1883–1970), a cartoonist, sculptor, author, engineer and inventor. He designed these whimsical chain reactions for ridiculousness and not for necessity or practicality. They are over-engineered to get a very simple task accomplished. With younger students, you can share David Wiesner's *Lights Out*, a nearly wordless picture book about a very complicated contraption built by a young mouse. Or browse Rube Goldberg's original cartoons at **rubegoldberg.com**. They are a delight!

Photo of Life Size Mousetrap, below, by Cory and Catska Ench (detail.)

Life Size Mousetrap
The Science Behind It

Life Size Mousetrap and its crew of performing mice have been touring science museums and schools across the country. Teachers find it to be a great introduction to some of our oldest physics knowledge: how simple machines, gears, counterweights, and gravity work together to create sometimes surprising motion.

For any machine, you can calculate the mechanical advantage by dividing the force you put into a machine by the force you get out of the machine. Arguably, with Life Sized Mousetrap and just about any Rube Goldberg device, the overall mechanical advantage is quite low, because there's a lot of energy put into one small task! But the steps along the way illustrate how a little bit of energy/work/effort can translate into something grand.

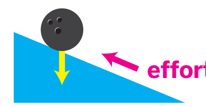
In Life Size Mousetrap, stored energy, mostly gravitational, is released over its many convoluted steps. Before the ball starts rolling, energy is stored in lifted objects or stretched springs. The ball releases this energy so that it can keep moving. Examples of translating between potential and kinetic energy in the Life Size Mousetrap include:

1. pulling a spring back and then releasing it will tug a cable that swings a hammer to hit a boot;
2. releasing a compressed coil spring will push a rod that nudges a bowling ball into motion.

A mechanical advantage reduces the force needed (that is, you don't have to push as hard) but you must apply that force for a greater distance. So the energy or work done ends up being the same (or more due to friction.) For example, it takes less force to go up a ramp than climb a ladder, but the length of the ramp is longer than the length of the ladder. We sometimes use mechanical advantage to increase the force we need, as with bicycle gears which make our wheels spin faster.

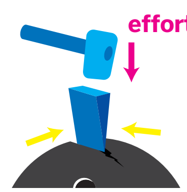
There are six special machines we call simple machines: the wedge, the inclined plane, the screw, the lever, the pulley, and the wheel and axle. To the average person, these may seem too basic to be called machines, but they form the basis for many other ideas in physics and engineering. For each mechanism, there's a trade-off in how much force you put into it and the distance it travels.

Simple Machine #1



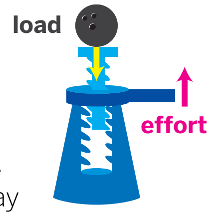
Inclined planes let you use less force to move an object. Ramps, sloping roads and hills, plows, chisels, hatchets, and wedges are all inclined planes. Blades are two inclined planes placed back to back, and they allow the two parts of the cut object to move apart using less force than would be needed to pull them apart in opposite directions. In the Life Size Mousetrap, look for the bowling ball rolling down the Crazy Stairs as an example of an inclined plane. Rather than falling quickly, the ball ambles down the steps.

Simple Machine #2



Wedges are inclined planes that can be moved around for a variety of uses: to separate two objects or one part of a thing from another, to lift a heavy object, or to hold an object in place. When you push on one end, the wedge sends the force out to its sloped edges. An axe is a classic wedge. Knives, scissors, chisels, and even teeth can sometimes be used as wedges, too. A short wedge with a wide angle might do the job faster, but it requires more force than a long wedge with a smaller angle. Nails, with their pointy edges, will sink into wood when hammered, but a bolt with its flat end cannot be pushed in. Wedges are sometimes considered to be inclined planes. Wedges can also be used to hold objects in place, as in a doorstop, where the friction between the bottom of the door and the ground keeps the door from slamming. Wedges are often used in the building of the Mousetrap to lift, position, and steady the contraption for operation.

Simple Machine #3

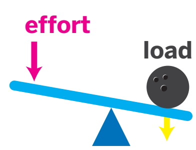


Screws convert rotational motion to linear motion, and rotational force (a "torque") to a linear force. That is, turning this way or that way can be translated into going forward or backward, or up or down. In Mousetrap, a Lifter carries the Ball from the bottom of the Stairs to the top of the Gutter: it uses a large screwy bolt near the center.

Simple Machine #4

Levers convert your downward motion into upward motion. Gravity makes it easier for things to go down than to go up. A lever uses its support and pivot point, or "fulcrum" for "leverage" to lift weight. Depending on where the force and the fulcrum are placed, a lever can multiply either force or distance.

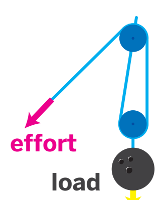
There are three kinds of levers. They differ in where the forces and the fulcrum are placed:



1. In seesaws and crowbars, the fulcrum is between the effort and the load/resistance.
2. In wheelbarrows and wrenches, the load/resistance is between the effort and the fulcrum.
3. In staplers and our forearms, the effort is between the resistance and the fulcrum.

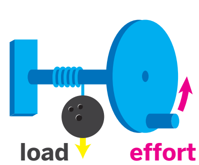
In Life Size Mousetrap, look for levers in the Hammer as well as the Seesaw that catches the bowling ball when it falls out of the Bathtub.

Simple Machine #5



Pulleys just reverse the direction of a force. When you connect two or more pulleys together, you can lift a heavy load with less force, trading a long movement at the end of a rope for a short motion of the load. In Life Size Mousetrap, the Crane has multiple pulleys to help lift the two-ton bank safe.

Simple Machine #6



The Wheel and Axle is a machine in which you trade a long motion at the edge of the wheel for a short, more powerful motion at the axle. Or you can do the reverse. In Mousetrap, the first piece that starts the Mousetrap, the Crank has three wheels and axles. (The interlocking teeth can also be thought of as a bevel gear, which translates rotation in one plane into a perpendicular plane.

Other mechanical elements

Look for mechanisms like gears, rack and pinion, cams, crank and rod, chain and belt, and ratchet in all machines you study.

A good reference for these is Henry T. Brown's 1868 book Five Hundred and Seven Mechanical Movements. It has been digitally recreated (with animations!) at **507movements.com**. We also recommend the automata artists of Cabaret Mechanical Theatre and their book Cabaret Mechanical Movement: **tinyurl.com/CbtMMbook** (originally **cabaret.co.uk/education/cabaret-mechanical-movement**).

The math behind Mousetrap

Consider engaging your students in an exercise about scale: taking the board game into the real world takes a lot of calculation! If the marble is the size of a bowling ball, how large are all the other components? Are the real bathtub and the bowling ball scaled at the same ratio in the game?

Alternatively, calculate the large budgets behind Life Size Mousetrap with your students: It's pricey to be an artist with a big dream: Driving a semi costs $3 a mile. The mice bought a crew bus, too, and that bus costs at least $1 a mile for travel. How much does it cost to travel from Mousetrap's home in San Francisco to San Mateo? To New York City?

The history behind Mousetrap

Introduce Leonardo da Vinci (1452–1519) and Sir Isaac Newton (1642-1727) who described many of the mechanisms and principles used in Life Size Mousetrap. Or examine the ancient discoveries of these energy-saving devices. Wedges, for example, were used as early as the Stone Age. Around 3000 BCE, Ancient Egyptians used wedges to extract blocks of rock for construction. Some Native American tribes used antlers to split and work wood for their canoes, houses, and other wood objects. Levers were first described in writing by Archimedes in 3rd century BCE, and probably known back to the earliest *Homo sapiens*.

Maker Faire

Student Activity Sheet

Life Size Mousetrap

Your Name:

seek-and-find

What's happening in this crazy contraption? See if you can you find these elements from Mousetrap, including the 6 simple machines. What order do they come in? What happens with each thing? Put on your observation goggles and watch for the flying, rolling, hopping, and swinging ball!