Sound Automata

Category: Physics: Force & Motion; Sound & Waves

Type: Make & Take

Rough Parts List:

2	Clear plastic cups, large
2	Bamboo skewers
2	Straws
1	Sheet of cardboard or foam core
1	Bottle cap
1	Wire hanger
2-3	Metal washers
1	Can with a metal bottom
	Wire or string, thin

Tools List:

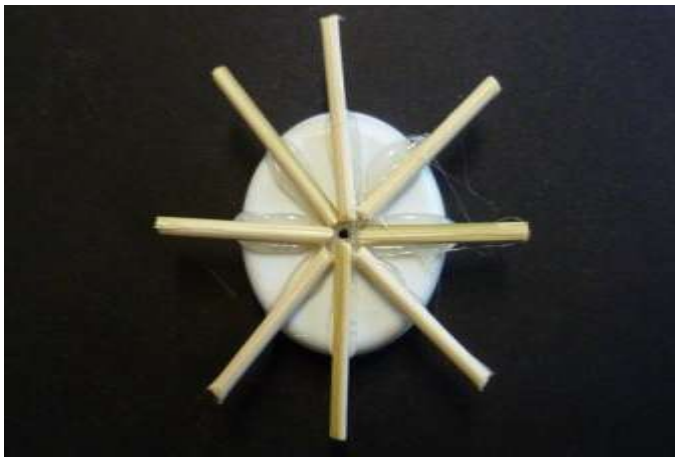
Screwdriver
Scissors
Hot glue gun
Utility knife
Pliers

Video: http://youtu.be/KK0Z1Xw-kKE

Blog Link: www.oaklanddiscovery.blogspot.com

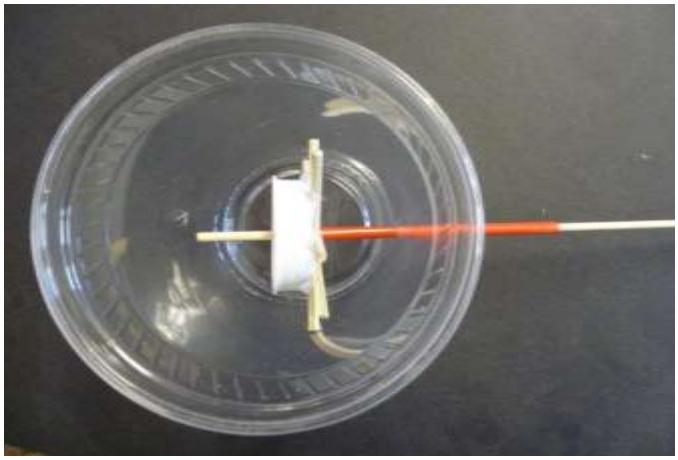
How To:

Punch 2 holes into the sides of a cup.
Use a screwdriver or the tip of a glue gun to punch the holes.

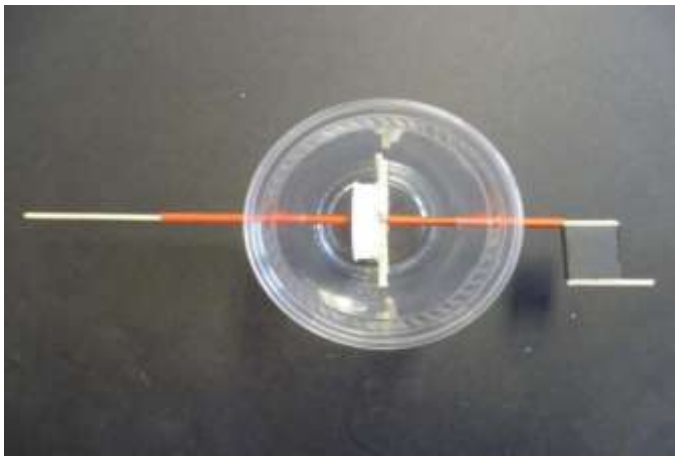


Poke a hole through the center of the bottle cap using a screwdriver. Hot glue 6 small pieces of bamboo skewer onto the bottle cap like bicycle spokes.

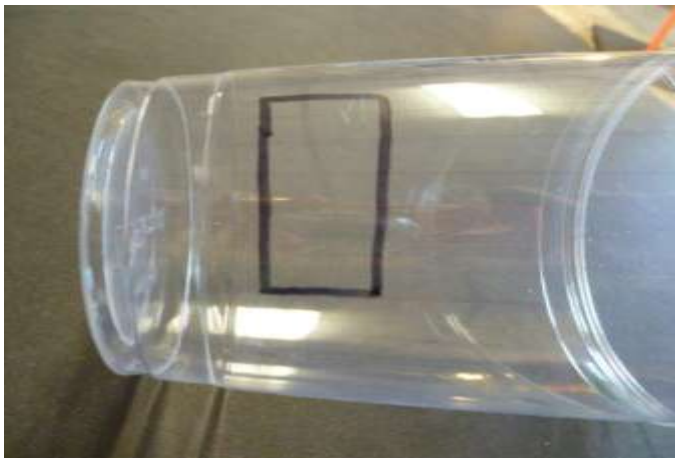
Create a crank and handle by attaching a smaller piece of bamboo skewer to the end of a whole skewer witha small square of cardboard or foamboard in between.



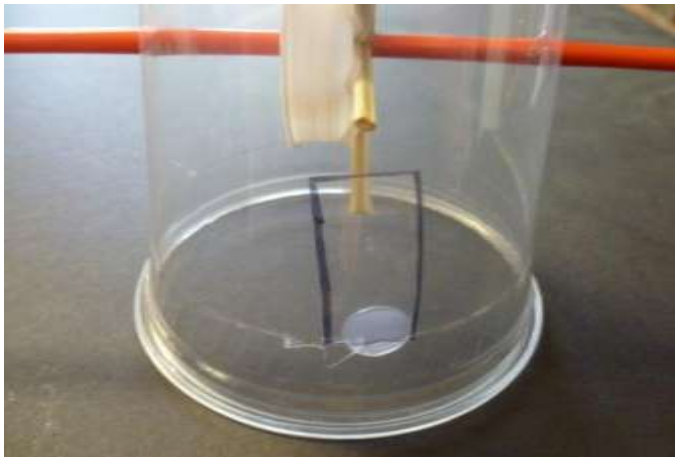
Push half of a straw halfway into one hole of the cup. Insert the free end of the crank through the straw and then slide the bottle cap onto the skewer.



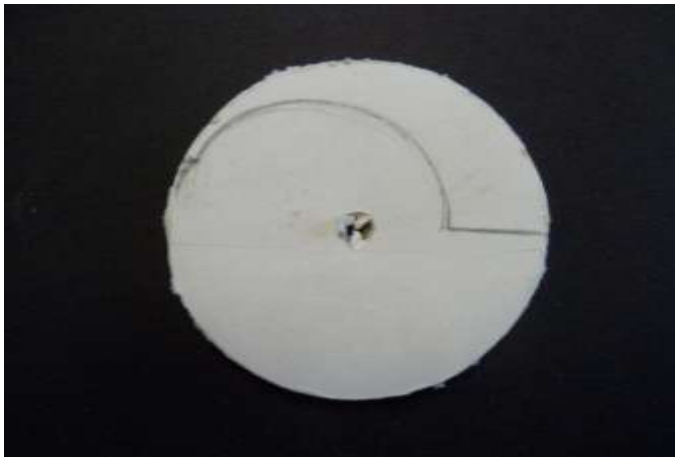
Push half of a straw halfway into the other hole. Insert the crank into the straw as far as it will go. Adjust the straws and handle so the bottle cap stays in the center.



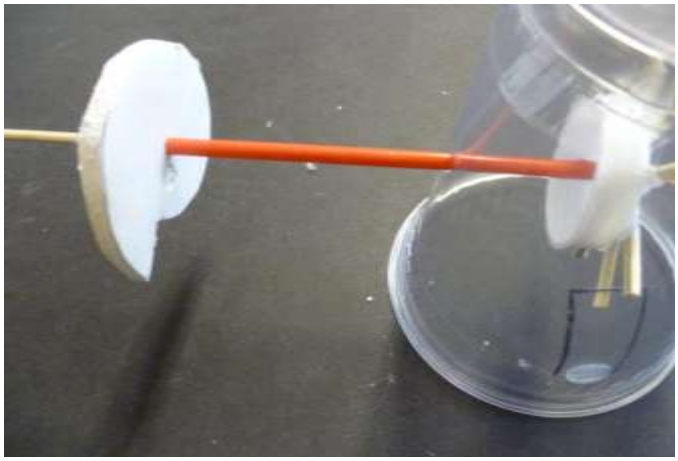
Cut out a small rectangle from a plastic cup.



Hot glue one end of the rectangle inside the cup so that the skewer pieces on the bottle cap flick the other end and make a noise when the handle is turned.



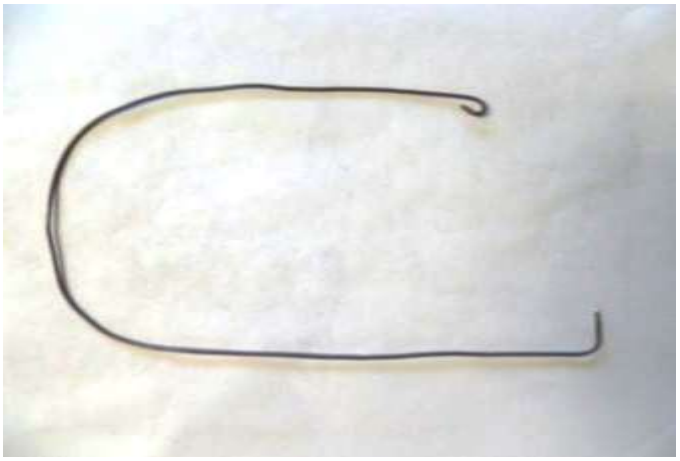
Cut a circle from cardboard or foam core. Poke a hole in the center. Create a drop cam by drawing and cutting out a crescent shape so the circle resembles a snail shell.



Attach the drop cam onto the free end of the crank with hot glue. Don't get glue near the straw!

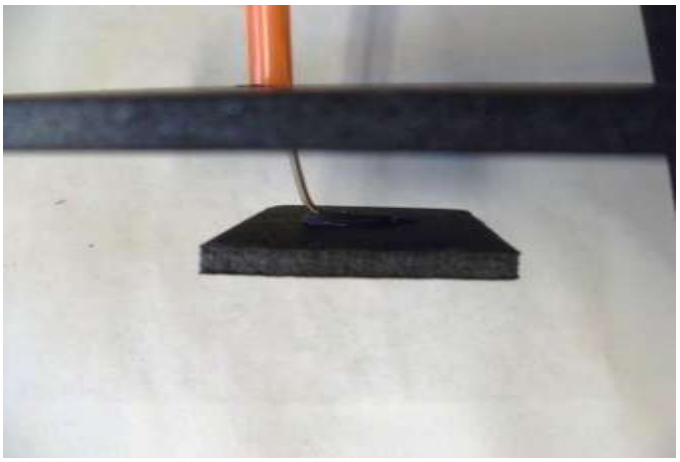
Cut 1"-2" off the bottom of a can. Cut a small rectangle out of the open edge.

Hot glue the can bottom-up onto the edge of cardboard to create a platform that is about as long as the handle. Poke a hole in the other side of the platform and insert ½ of a straw.



Create a U shape out of an 18" piece of wire hanger. Bend one end to create a small loop and the other end to create an L shape.

Attach two washers to the looped end of the wire.



Thread the L end of the wire through the top of the straw by temporarily straightening out the wire. Once it is through the straw, bend it back into an L. Hot glue a small piece of cardboard or foam core to the wire.

Hot glue the platform to the top of the cup. Place the platform so that the small board piece rests on top of the drop cam. Poke in and hot glue four small pieces of bamboo skewers around the small board piece to keep it from twisting.

Bend the wire to make adjusments. The washers should rest just above the can bottom when the largest width of the drop cam is touching the small board piece. Turn the handle to make two different sounds!

Fine Points:

→ To make sure your skewer lines up, after making one hole in the side of the cup, insert the skewer into the cup until it touches the other side, and mark the position of the second hole so the skewer is parallel to the top of the cup.
→ Make sure to leave the hole in the bottle cap uncovered when gluing on the bamboo skewer pieces.
→ Cut the rectangle out of the plastic cup so that the long sides of the rectangle are parallel to the cup top and bottom as shown in the picture. This gives the rectangle a curve that helps it make contact with the bottle cap skewers.
→ Chip cans are perfect for this project. The metal bottom makes a loud noise but the cardboard sides are easy and safe to cut.
→ Make sure the snail shell opening in the drop cam is facing towards the side of the cup without the plastic rectangle or the sound automata will jam. Both the cam and the plastic rectangle tab are examples of a ratchet; a mechanical device that only allows motion in one direction.
→ If the washers are not making a loud enough noise, try adjusting the wire first. Add a weight, such as another washer, to the small square board piece attached to the L end of the wire. If that doesn't help, make a new drop cam with a more exaggerated snail shell shape. The larger the opening of the snail shell, the harder the washers will hit the can bottom.

Concepts Involved:

- The wheel and axle is a simple machine that can act as a lever to provide mechanical advantage. A crank allows you to turn a wheel and/or axle by providing a force at a distance from the center.
- Cranks and cams can convert circular movement into up and down (reciprocating) motion. Cams can be many different shapes resulting in a variety of motions.
- A follower is the part that is resting on the cam, following the motion of its edge. A drop cam allows for a slow rise and sudden fall of the follower.
- Sound travels in waves.

Focus Questions:

1. What sound would your machine make if you used a circular cam? A square cam? A heart-shape cam? Try it!
2. Try turning the skewer without the handle. Is it easier or more difficult to turn? Does your machine move slower or quicker? What if you had a bigger handle?
3. Why did you cut the rectangle out of the can bottom? What does that accomplish? Would your machine sound quieter or louder without it?
4. What sounds could you make with different materials? Try attaching different items like beads or small pieces of wire in place of the washer. Also, try covering the can bottom with materials like wood or fabric.
5. Your machine makes two different types of sounds: a cymbal sound from the washer and can and a flicking sound from the bottle cap and plastic rectangle. Do you think it's possible to add a third sound? Where and how could you take advantage of the movement of the crank, drop cam, and/or wire to add another sound?

Elaboration:

Automata are self-operating machines that typically consist of a clockwork statue or scene and were first created centuries ago in Europe and Asia. In many ways they were the direct ancestor of what became electro-mechanical robots. Many modern toys use electric motors to achieve movement, but they still rely upon gears and other principles of simple machines. For our purposes, the automaton is a good way to explore the machine's function of converting one form of energy and motion to another. They are also a way to teach simple mechanical problem solving skills. The sound automaton takes advantage of the movements produced by the crank, drop cam, and wire to make noise.

A cam is a mechanical linkage that transforms rotary motion into linear motion, or vice versa. A car engine is a familiar machine that converts the up and down (reciprocating) motion of the pistons to rotary motion to drive the car's wheels. For this automaton, a modified version of the cam is used. A drop cam, often nicknamed a snail cam due to its shape, results in the gradual rise and sudden fall of the follower. In this case, the follower is the wire segment with the small square on the end.

The handle is a type of crank that utilizes torque. Torque is the tendency of a force to rotate an object around an axis. Torque is directly proportional to the product of the force applied and the length of the lever arm, which is the distance between the axis and point of force application ($\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$). If we didn't use a handle, the automaton would be more difficult to turn. A door swinging on its hinges is an example of rotational motion. Try to open a door by pushing it very close to the hinged edge. Another thing rotating on a door is the handle itself. A larger handle makes it easier to turn because the lever arm – the crank – is longer.

Sound is made up of vibrations that travel through the air (or other elastic medium such as water) in waves. When the vibrations reach a person's ear, the eardrum vibrates too and it registers to the brain as sound. Sound waves that have larger amplitudes register as louder sounds. A larger drop in the snail cam causes the washers to hit the can bottom with more force, which transfers more energy into the sound wave and creates larger wave amplitudes.

Links to k-12 CA Content Standards:

Grades k-8 Standard Set Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

Grades k-12 Mathematical Reasoning:

1.0 Students make decisions about how to approach problems:
1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:
2.1 Use estimation to verify the reasonableness of calculated results.
2.2 Apply strategies and results from simpler problems to more complex problems.
2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:
3.1 Evaluate the reasonableness of the solution in the context of the original situation.
3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
3.3 Develop generalizations of the results obtained and apply them in other circumstances.

Grade 2 Standard Set 1. Physical Sciences:

The motion of objects can be observed and measured.
1.c Students know the way to change how something is moving by giving it a push or a pull. The size of the change is related to the strength or the amount of force or the push or pull.
1.d Students know tools and machines are used to apply pushes and pulls (forces) to make things move.

Grade 3 Standard Set 1. Physical Sciences (Energy and Matter):

1.c Students know machines and living things convert stored energy to motion and heat.
1.d Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.

Grade 8 Standard Set 2. Forces:

2.a Students know a force has both direction and magnitude.