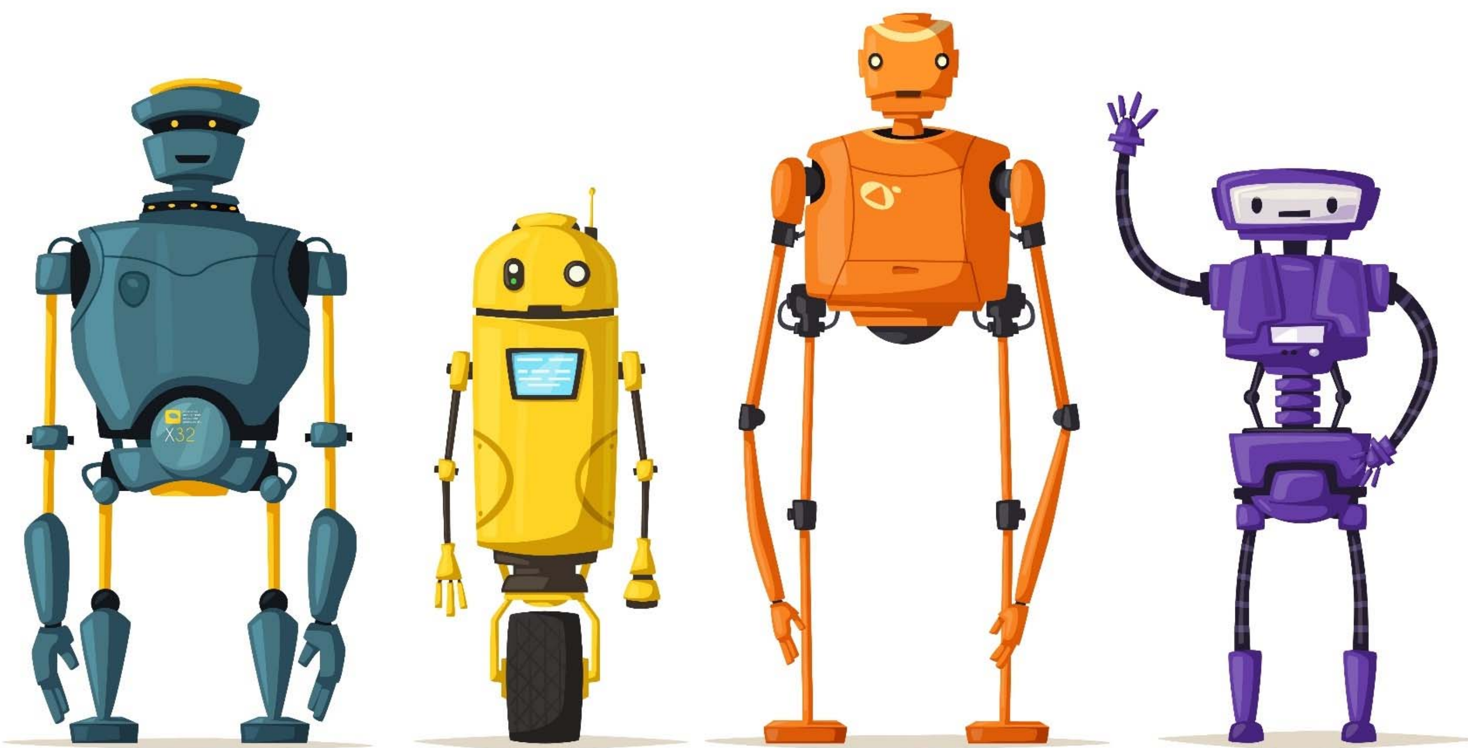
ROBOTS



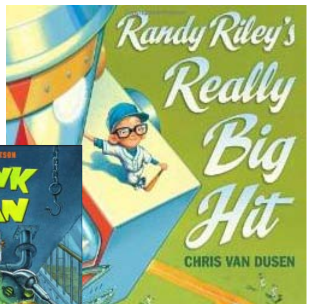
An exploration of mechanics, motion, simple machines, chain reactions, circuits, basic coding, and more!

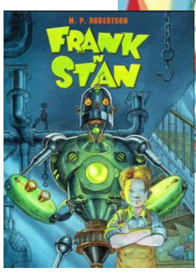
INDEX

Robots, Part One, p.2
Part Two: The Illusion of Life, p. 57
Part Three: Building Trust, p. 92
Part Four: Evolution, p. 127
Part Five: We Like to Move it! p. 163
Part Five B: Challenge! p. 196

ROBOTS

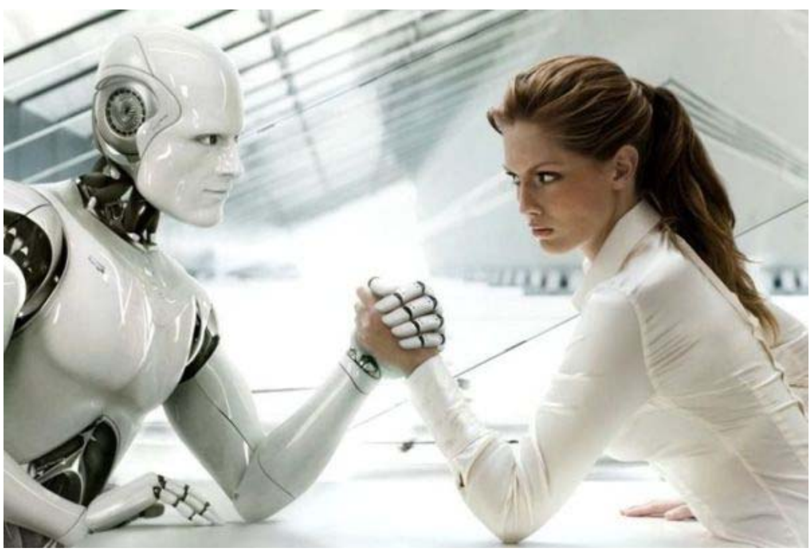
Lesson One

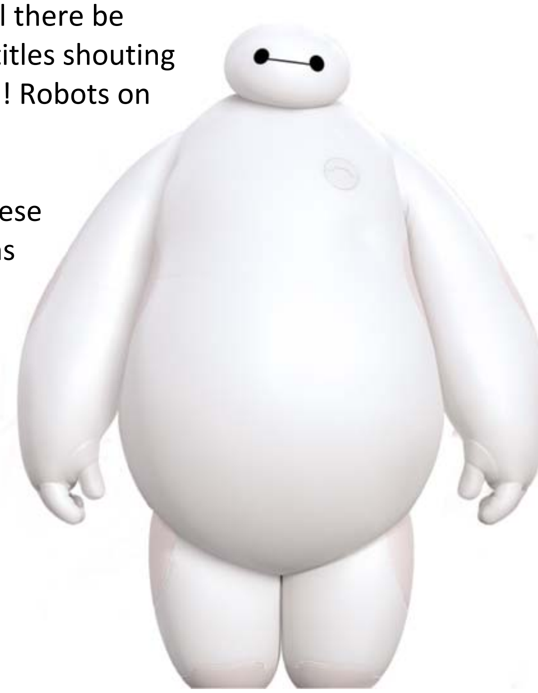




Access Prior Knowledge, introduce the topic, and instigate discussion with a short film such as the sweet Robot *from Eduard Grigoryan http://vimeo.com/36822409, or the fun and funny BURN-E [https://www.youtube.com/watch?v=M4JYdi04KGY] If* ***BURN-E*** *(a welding robot) had known how much trouble he'd be caused by WALL-E's pursuit of EVE, then he'd have taken the day off! [on the WALL-E dvd, at Amazon, or at https://www.youtube.com/watch?v=M4JYdi04KGY (sound cuts out partway through.)* Or read a robot related book, such as *Frank n Stan* by M.P. Robinson or *Randy Riley's Really Big Hit*.

Humans have long enjoyed arguing and mulling over questions such as, what makes us human? And others like, what makes something alive? If something has the ability to think, acquire and apply knowledge and skills, in essence to learn, is it alive? Robots have a mysterious appeal and often prompt questions about what human interaction with robots will ultimately mean for society. [Will there be newspaper titles shouting "Extra, Extra! Robots on the march! They're miffed!"] These are questions we're asking even today. We live in a time where teams of search-and-rescue robots can be driven to the site of a tragedy from thousands of miles away and can crawl through wreckage and spaces humans can't go, their video cameras sending back pictures to help in the desperate search for survivors. [That's what many working robots do best: extend the abilities of humans and working in environments too dangerous for humans to enter]





But robots don't just do dangerous tricky or boring work for us. Robots can do many different kinds of jobs, whether it's assembling massive cars, or the tiniest of computer chips. They help doctors perform life-saving surgeries, and hunt for hidden bombs in war zones. Robot toys play with us, follow our commands, and respond to our moods. Experimental robot pets keep the elderly company in nursing homes and many popular musicians use robots in their music!
We have robot vacuum cleaners, pool cleaners, and lawn mowers; GPS devices that track our movements and tell us where to go; robot dogs that can learn and play; prototypes for remarkably life-like robot companions; robot healthcare providers that can interact with patients; and robot telemarketers programmed so well they know to lie and say they're human. We live in a time with military and civilian drones, and Pentagon-owned bots that can run faster than humans.
Robots are even taking over the theaters, ex. Robots, Wall-E, I Robot, the Iron Giant, Meet the Robinsons, Transformers, & Big Hero Six (full of robots!) among many others.

I, Robot

The future is not written yet and who knows whether robots will ever truly be dangerous to humanity or not. What is for sure is that humans, being curious beings, will always work to develop new advanced generations of robots.
Robots may be machines, but for many people the goal is to build robots that act as if they're, well, alive! We seem to be intrigued with trying to create a mechanical version of ourselves, building them so they look like us, behave like us, and think like us. The 'ideal' robot would be indistinguishable from a human being. And even as we strive for that ideal, it scares us. Because besides the faces and bodies we give them, we can't read their intentions and that makes us nervous.
When you toss someone a ball, you can read their intentions in their eyes, their face, their body language. That's not really possible with a robot. But…and this is where it gets interesting, this inability to read actually goes both ways. Humans are irrational, unpredictable, and robots cannot anticipate human action, they can't predict what we'll do next. Which is why humans and robots find it difficult to work in close proximity and accidents are bound to happen.
The very first story about robots? In fact the story where the word robot came from…well, they turned against their creators. The word "robot" comes from the Czech word for forced labor, slave labor, or boring work. In 1920, Karel Capeck, a Czech playwright invented the word for his futuristic play R.U.R. aka Rossums Universal Robots. (The play was one of the first stories about a society that became enslaved by the robots that once served them as they rebel against their human masters and try to take over the world. This idea is now a common theme in popular culture, ie Frankenstein, Terminator, The Matrix etc.) The meaning of the word tells us something about what early robot scientists hoped robots

1900

L. Frank Baum invents one of the literary world's most beloved robots in *The Wonderful Wizard of Oz*: the Tin Woodsman, a mechanical man in search of a heart. By some readers, the character is seen as a symbol for the soullessness of mechanized industry. He also invented another robot man Tik-Tok of Oz.

would do. Robots would handle the boring stuff and humans would be left with, well, the fun stuff. This would also give people more free time to think about creative things like art, philosophy and music.

Greek philosopher Aristotle made this famous quote:
“If every tool, when ordered, or even of its own accord, could do the work that befits it... then there would be no need either of apprentices for the master workers or of slaves for the lords.” Sounds like he was hinting how nice it would be to have a few robots around.

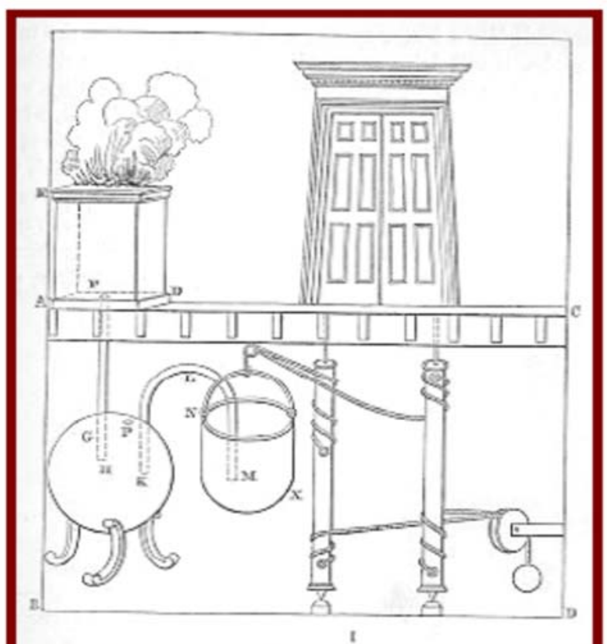
Working robots have come a long way from the first assembly-line operators—robots that could perform tasks such as welding and painting with a movable arm and a grasping hand, but were otherwise fixed in place on a factory floor. But even as robots become smarter and more mobile, some of the fear of robots replacing human workers has faded as it becomes clear what robots are good at, and what they aren’t.

Note: We use the word "Robot" today to mean any man-made machine that can perform work or other actions normally performed by humans, either automatically or by remote control.

Where it all began

You might think that the idea of a mechanical creature or robot-type device is a modern one. It is true that the metal parts and computer chips required to build the robots used today were invented in the last half of the 20th century. However, human beings have daydreamed about robot-like creatures for thousands of years. Evidence of robot dreams can be found in myths, literature, and science fiction films. Some ancient inventors actually created robot-like creatures that are still around today. These artifacts and dreams from the past still inspire modern robotic scientists.

Over 2000 years ago, Egyptian inventors built robot-like devices that appeared to move autonomously (on their own). One such device was found in an Egyptian tomb and looks like a sculpture of a dog. When a lever in the dog’s stomach is pressed, its mouth opens. Another, more complicated device looks like an Egyptian baker. The baker is made of painted wood and has levers and fulcrums (turning points) in its arms. With the assistance of a counterweight at the baker’s back, the arms pound grain into flour. While both of these devices appear to move alone, some human assistance is needed to start movement.



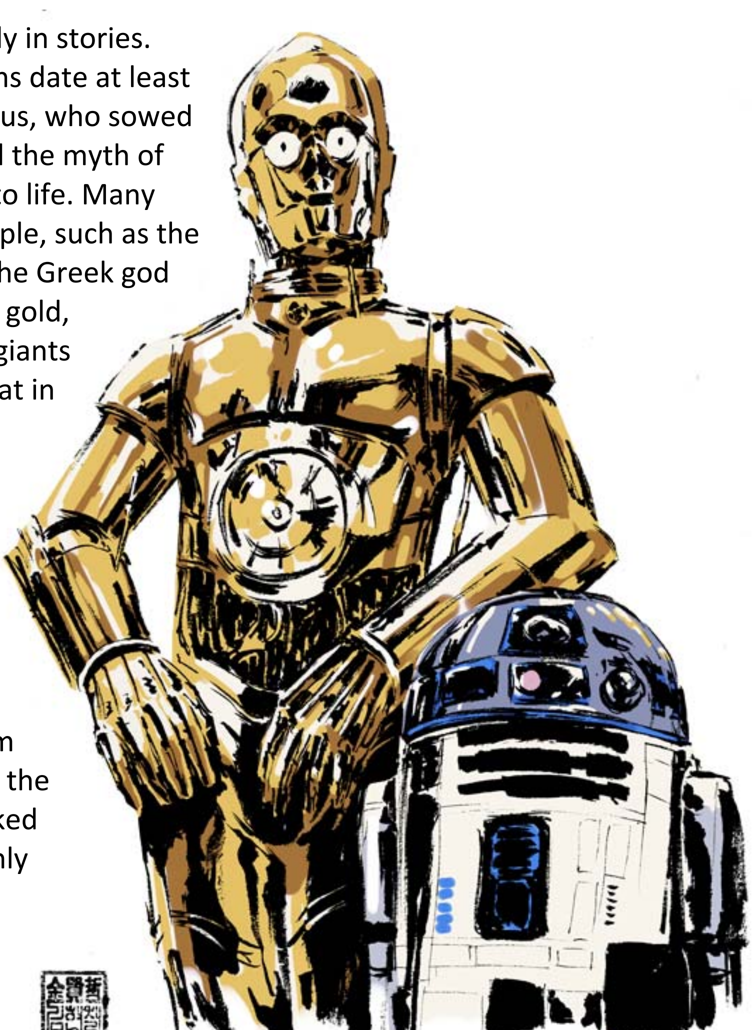
***Hero’s Automatic doors**, the heat from the fire caused the water in the sphere to boil, next siphon L carried the hot water into bucket M. As the weight of bucket M increased, the poles would turn and the temple doors would open.*

Greeks mention mechanical devices in many of their myths. In Homer's Iliad, mechanical gold women serve as assistants to the god, Hephaestus (or Vulcan). Hephaestus also created Talos, a gigantic animated statue made out of bronze that guarded the island of Crete. While these examples are only myth, the Greek inventor, Hero of Alexandria drew actual designs for real robotic devices. Hero understood the concepts of siphons, and the use of air pressure to make things move. He drew designs for automatic doors (shown in the diagram to the right), moving statues, animal statues that drank, and bird sculptures that sang.

Hero was a man before his time; his inventions were built and used a thousand years after his death but few attempted to try them during his lifetime.

Android Dreams

Some of the best known robots appear only in stories. Stories of artificial servants and companions date at least as far back as the ancient legends of Cadmus, who sowed dragon teeth that turned into soldiers, and the myth of Pygmalion whose statue of Galatea came to life. Many ancient mythologies included artificial people, such as the talking mechanical handmaidens built by the Greek god Hephaestus (Vulcan to the Romans) out of gold, the clay golems of Jewish legend and clay giants of Norse legend. Chinese legend relates that in the 10th century BC, Yan Shi made an automaton resembling a human.



In the Islamic legend of Rocail, the younger brother of Seth created a palace and a sepulcher containing autonomous statues that lived out the lives of men so realistically they were mistaken for having souls.

R2-D2 and C-3PO: These helper droids from the 1977 movie Star Wars may be some of the most famous robots of all time. R2-D2 looked like a large rolling can and 'talked' using only beeps and whistles. C-3PO was a golden colored metallic man who could speak many languages. Both worked with Luke Skywalker to fight the Empire and the evil Darth Vader.

Read below about Talos, a mythological robotic being. Have students think about the types of characters in a typical myth: heroes, kings and strange beasts.

Talos

'The first robot in history,' Talos, was not born, but made. He was a giant, bronze automoton or living statue forged by the divine smith Hephaistos. He had a single vein of molten metal which gave him life, running from his neck to his ankles. A bronze peg in his ankle stopped the life-giving ichor from pouring out. Zeus presented him to Europa, as her personal protector (to protect her from persons who would want to kidnap her), after he brought her (some say he kidnapped her himself) to the island of Krete (Crete.)

Talos became the guardian of Crete, patrolling the island, running and circling it three times in a day, and driving pirates or any foreign ship from the shore with volleys of great boulders or a fiery death-embrace (hug). Whenever he saw strangers approaching, he made himself red-hot – by jumping into a fire –, and then embraced the strangers when they landed. When people from Sardinia tried to invade Crete, Talos made himself glow in the fire and he kept everyone in a fiery embrace with a wild grimace and laughter. This led to the term "sardonic grin" and "sardonic laugh." (The scornful mirth of the winner of a contest who boastfully mocks the losers.)

Talos had a duty to protect Crete not only from enemies but also from any kind of injustice. He went round all the villages of the island three times a year, carrying on his back bronze tablets inscribed with the divine laws. The aim was to ensure that the laws were kept in the provinces. According to Plato, Talos' task was also to walk through the Cretan villages three times each year to display the laws of Minos inscribed on a bronze tablet. [*There is an assumption that Talos was a judge, walking through the towns and villages, deciding the disputes of inhabitants in harmony with the law, which he carried with him on this big bronze tablet.]*

Talos managed to defeat the enemies of Crete for many years, until his time finally came. Of course a bronze "robot" could not be killed by arrows or other weapons, as it was invulnerable, nor could it succumb to old age. Talos was killed by trickery.

The Argonauts, returning from Colchis, attempted to stop in Crete to obtain some drinkable water for their next journey. When the Argo approached Crete on the way back from obtaining the Golden Fleece, as guardian of the island, Talos kept the Argo at bay by hurling great boulders at it.

Jason tried to convince Talos that they were in an emergency situation and that they were going to leave immediately, but Talos refused to let them stop in Crete. With the help of Medea the Argonauts devised a trick, which meant the end of Talos.

Talos had a single vein full of 'blood' or rather, liquid lead, which ran from his neck to his ankle and was closed by a single bronze nail. Medea hypnotized him from the deck of the Argo, deceiving him into believing that she would make him immortal by removing the nail, so that he dislodged the nail, and "the ichor ran out of him like molten lead", exsanguinating (all of Talos' blood ran out) and killing him, thus enabling the ship to land.

What Talos symbolizes through myth

The bronze hero Talos symbolizes technological development in the field of metalworking in prehistoric and Minoan times. The Minoans were so advanced that they imagined a bronze superhero to protect them.

Another major attribute of Talos was as an upholder of justice. This shows how important justice was in ancient Crete. It was no coincidence that the laws were considered divine; Minos received them from his father, Zeus, and so they had to be obeyed.

Getting Mythical

Now, have students write their own, or work in groups, or as a class to create their own Greek myth, using a robot like creature(s) as part of the story. Be certain to include an introduction of setting and characters, a problem faced by the main characters and a solution to the problem in the conclusion.

Talo's Island! [Tag Game]

Equipment:

- Large rope
- cones for boundaries (especially if you are playing outside)

Set Up: Using a rope make a large island in the center of the playing area. The leader should let the players know that he/she may change the size and shape of the island during the game.

Game play:

1) Choose one or two people to be 'Talos' aka the taggers. At least one tagger must keep one foot in the island at all times. Taggers may leave the island providing that they are "connected" (holding hands) to each other and the tagger closet to the island has at least one foot in the island.
2) Players start at one end of the playing area. When the taggers say, "Talos!" (or "Go") everyone must try to run to the other side of the playing area without getting tagged.
3) If a player gets tagged he/she joins the group of taggers.
4) Once all the players make it to the other side – they will need to wait until the taggers say, "GO" before they can run back to other side. The game is over when everyone is tagged or when the leader says stop.

Variations:

1) When there are about 4 taggers, the leader can make the size of the island smaller.
2) You can allow players to run through the island. Or, players may only run to the sides of the island.
3) If a player is taking his/her time running to the other side. The leader can count down from 10 and the player has 10 seconds to make it to the other side. If the player does not move within 10 seconds – he/she will need to join the taggers.

Tip: This game may be easier to play indoors, where there are walls that define the space.

Lesson One K-8 Standards Alignment

K

RI.K.9. With prompting and support, identify basic similarities in and differences between two texts on the same topic.

RL.K.9. With prompting and support, compare and contrast the adventures and experiences of characters in stories.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how they are similar or different from each other in characteristics, how people perceive them, and what happened to them.

1

RL.1.9. Compare and contrast the adventures and experiences of characters in stories.

RI.1.9. Identify basic similarities in and differences between two texts on the same topic or theme.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how they are similar or different from each other in characteristics, how people perceive them, and what happened to them.

2

RL.3.9. Compare and contrast the themes, settings, and plots of stories.

RI.3.9. Compare and contrast the most important points and key details presented in two texts on the same topic or theme.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in *characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them.*

3

RL.3.2.a Recount stories, including fables, folktales, and myths from diverse cultures.

RL.3.2. b. Determine the central message, lesson, or moral of a myth and explain how it is conveyed through key details in the text.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them. We'll determine if the central idea of each story is that robots are good, robots are bad, or some other message.

4

RL.4.9. Compare and contrast the treatment of similar themes and topics (e.g., opposition of good and evil, man vs machine) and patterns of events (e.g., the quest) in stories, myths, and traditional literature from different cultures.

RI.4.9. Integrate information from two texts on the same topic or theme in order to write or speak about the subject knowledgeably.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them. We'll determine if the central idea of each story is that robots are good, robots are bad, or some other message.

5

RL.5.9. Compare and contrast stories, ex. those in the same genre, on their approaches to similar themes and topics.

RI.5.9. Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them. We'll determine if the central idea of each story is that robots are good, robots are bad, robots are protectors, or some other message.

6

RL.6.9. b. Compare and contrast texts in different forms or genres (e.g., stories and plays; myths and fantasy stories) in terms of their approaches to similar themes and topics.

RL.6.9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them. We'll determine if the central idea of each story is that robots are good, robots are bad, robots are protectors, or some other message.

7

RL.7.9 Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RI.7.9. Analyze how two or more authors writing about similar topics and themes shape their presentations of key information by emphasizing different evidence or advancing different interpretations of facts.

These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss how robots/artificial people were treated in each of these different stories and how the robots are similar or different from each other in characteristics, where/when the stories took place, how people perceive the robots (benign or dangerous), and what happened to them. We'll determine if the author's central idea of each *story is that robots are good, robots are bad, robots are protectors, or some other message or idea that they seem to be trying to convey.*

8

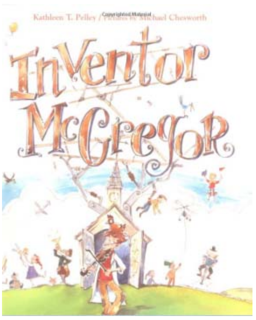
RL.8.9.b. Analyze how modern works of fiction draw on themes, patterns of events, or character types from myths, traditional stories, and religious works from different cultures (including describing how the material is rendered new.)

R.I.8.9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

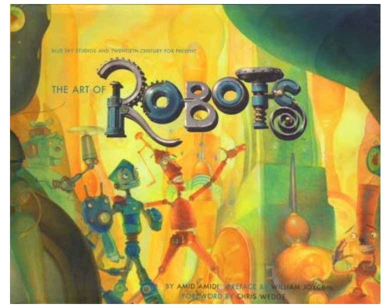
These standards will be met and reinforced as students compare and contrast modern and ancient stories, legends, and perspectives on robots/artificial people throughout history. We will discuss robot stories (including movies (ex. Big Hero 6, Wall-E, iRobot, Star Wars)) they know and ancient ones, ex. Talos, Galatea. We will discuss whether or not any of the modern stories seem similar in any way to the ancient ones. Ex. Do robots help or hurt? What are the roles of the robots? How do the robots behave? Ex. In Big Hero 6 a robot is built and 'comes to life,' how is that similar to the story of Galatea?

Lesson Two

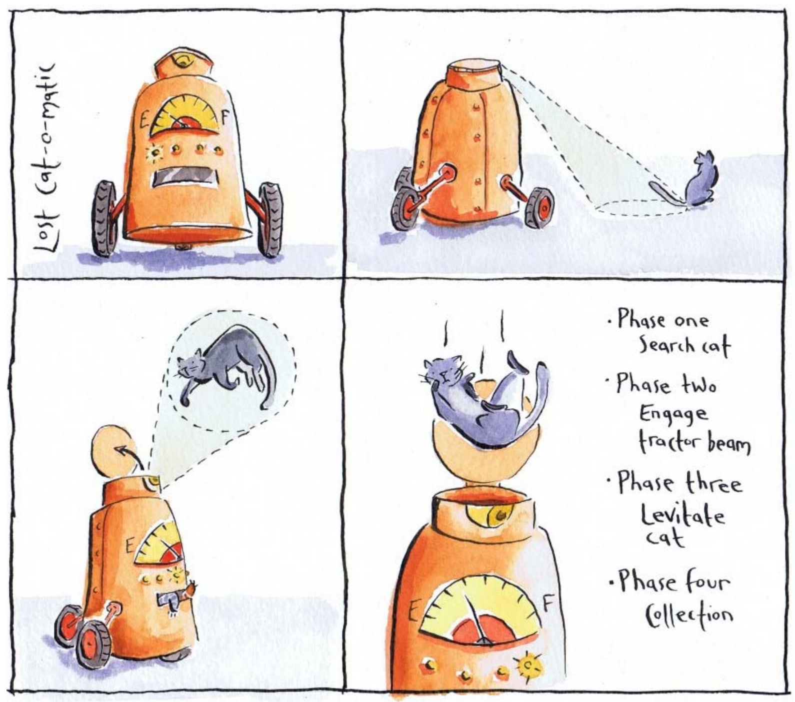
Whim-agination



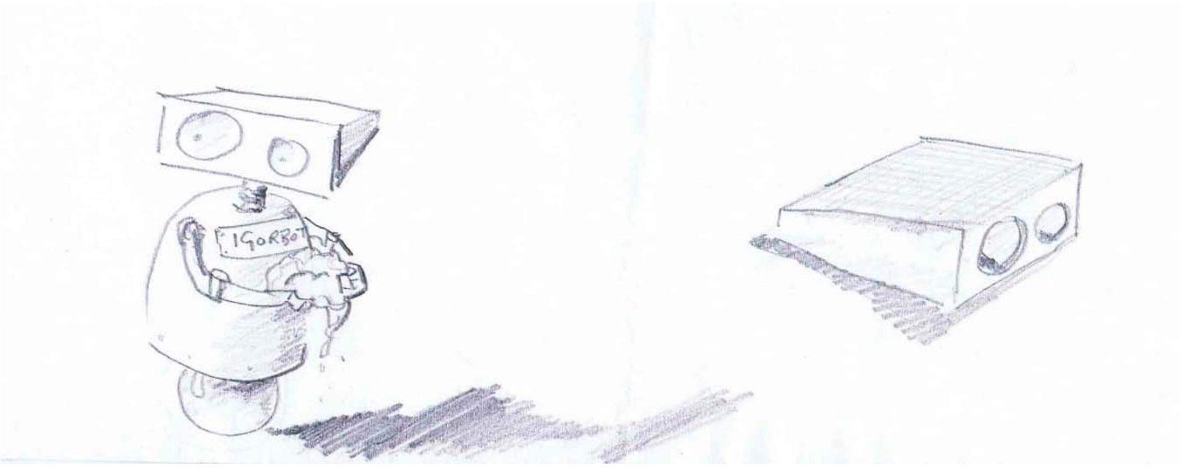
For a fun introduction to finding inspiration read a book such as *Inventor McGregor* by Kathleen T. Pelley and/or look at the images from *The Art of Robots* by Amid Amidi or *50 Robots to Draw and Paint*



So if you could create a robot to do anything, anything at all, what would your robot do? According to Drawsome Illustrations [http://drawesome.co.uk/tag/robot/] we tend to have robots working their way more and more into our lives. Soon, we will have robots for every imaginable whim, perhaps even searching out lost cats…



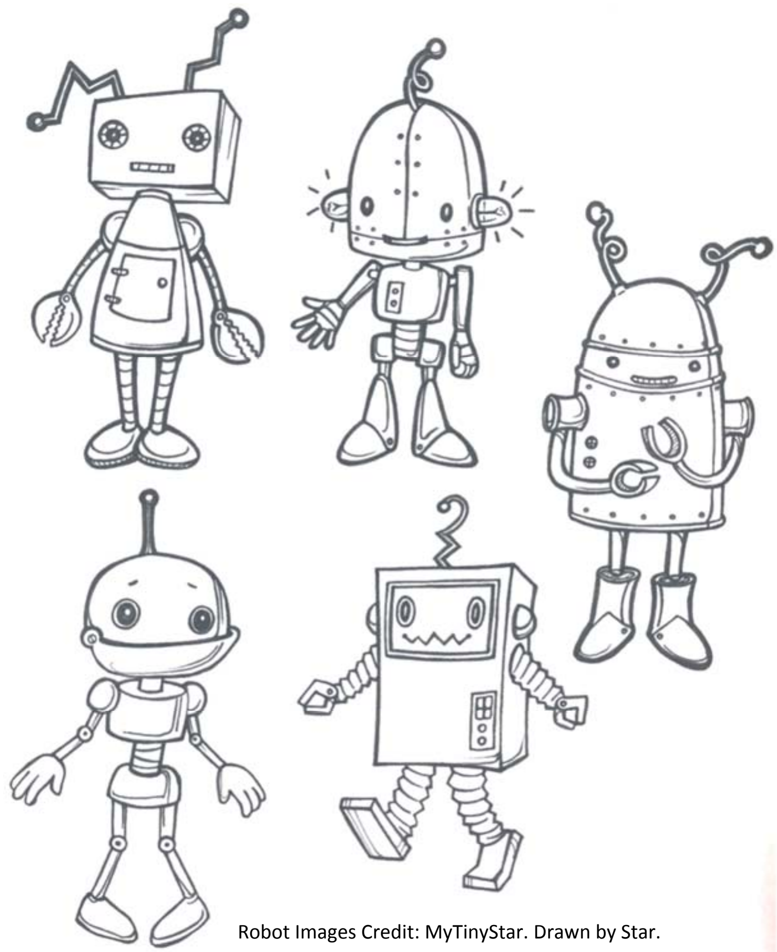
"The Lost Cat-o-matic is fed an image of your lost cat, it then heads out into the wild urban jungle to track down accidentally homeless kittes. Once a lost cat is found, the robot will collect the cat via the scientific gift of a powerful tractor beam. Once a cat (or cats, depending on how successful a trip out is) has been found, it will be returned to its rightful owner."
Look around the room, look around your mind…perhaps you might find inspiration of some kind! Like take pencil sharpener and make it into a robot (as Drawsome did)! The joy of imagination! Here is the Igorbot.



"Igorbot is the robot dogsbody of an evil scientist, sent to fetch brains, cups of tea and tend to the various experiments. He takes his job seriously but has a secret love of cupcakes (which unfortunately don't fit in with his evil job description)."

Materials:

- Watercolor paper
- Sketch paper
- Liquid or pan watercolors
- Paintbrushes
- Cups for water
- Pencils
- A problem & some imagination
- Optional: Salt
- Optional: Rubbing Alcohol
- Optional: Plastic Wrap
  - Optional: Paper doilies
  - Optional: Rice



Robot Images Credit: MyTinyStar. Drawn by Star. http://blog.mytinystar.com/2010/06/robots-hims-and-hers.html. Copyright 2012. All Rights Reserved.

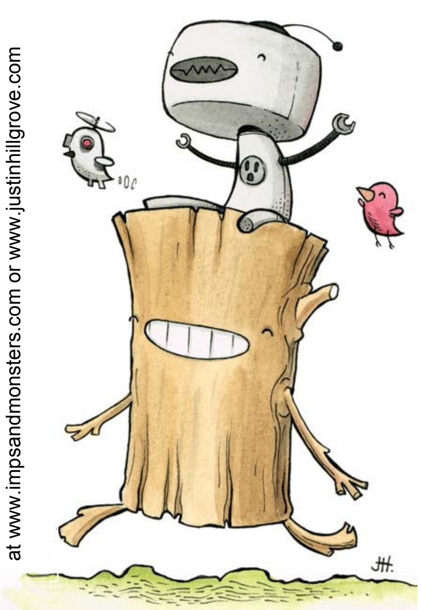


Image Credit: Robot and Log. ©2010 Justin Hillgrove and Imps and Monsters. All Rights Reserved. All works on the Imps and Monsters Website are the original creations of Justin Hillgrove. Visit the artist at www.impsandmonsters.com or www.justinhillgrove.com

- Optional: Crayons or oil pastels
- Optional: Glue

All successful watercolor projects begin with a great drawing and robots are great fun to draw and paint.

Have students think of something they'd like their robot to do (ex. solve some sort of issue from loneliness to moon landings) and what it would need (ex. what kinds of attachments, etc) to be able to do those things.

Optionally, start with a directed line drawing of a robot. It's important to note that even though you may use, "directed line drawing", it's rare that you want to give your students just one option, most of the time you'll end up with many drawings on the white board (like the variations above). Look at pictures, books, and brainstorm together what a robot can look like, and create sketches up on the board. Give lots of examples! Encourage the children to think about what elements a robot may have.

Brainstorm lots of fun ideas and as the children call out things like rivets, wires, solar panels, draw these things on the board. Demonstrate various ways to draw robots using pictures, books and drawings as guides. Stress the importance of working through "mistakes" and having fun with an unexpected line. Draw a few different ones; some realistic, some silly, some animated, then talk with students how you could change the wings, the shape, that sort of thing. This technique works well, as you want the children to learn to draw but also want them to be as individual as possible.

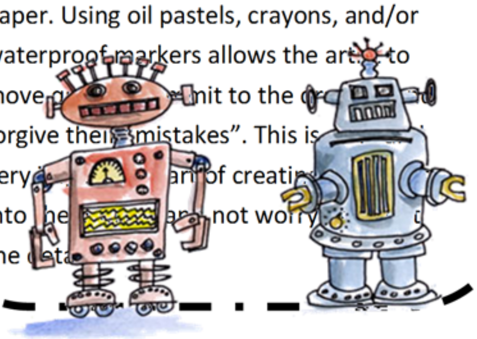
In the process of drawing on the white board, always incorporate mistakes. Always! Laugh at your "mistakes", tell the kids to expect them and then show them how to turn mistakes into something else. It's critical that you show your artistic side, no matter what you privately think of it, and inspire your students

Then have the kids get busy drawing their own robots with an oil pastel, crayon, or a waterproof marker (though the way non-waterproof markers bleed when exposed to water can make some cool effects), etc. Once the drawing is complete, emphasize large shapes, set out a palette of watercolor paints.

Teacher Tip!

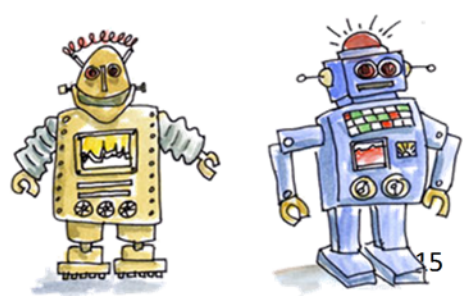
Ban pencils and erasers.

Sounds harsh, right? It's not being mean, the reason is purely practical: small pencil leads encourage small drawings. If a kinder is drawing a robot and then is required to paint that very robot, using a pencil will surely lead to frustration. It's hard to paint teeny tiny eyes! There is another reason: pencil markings can be erased, which leads to second guessing, which leads to lots of eraser action, which leads to class being over before the child has anything on his paper. Using oil pastels, crayons, and/or waterproof markers allows the art[illegible] to move [illegible] it to the [illegible] forgive their mistakes". This is [illegible] very [illegible] of creati[illegible] into [illegible] not worry [illegible] the [illegible]

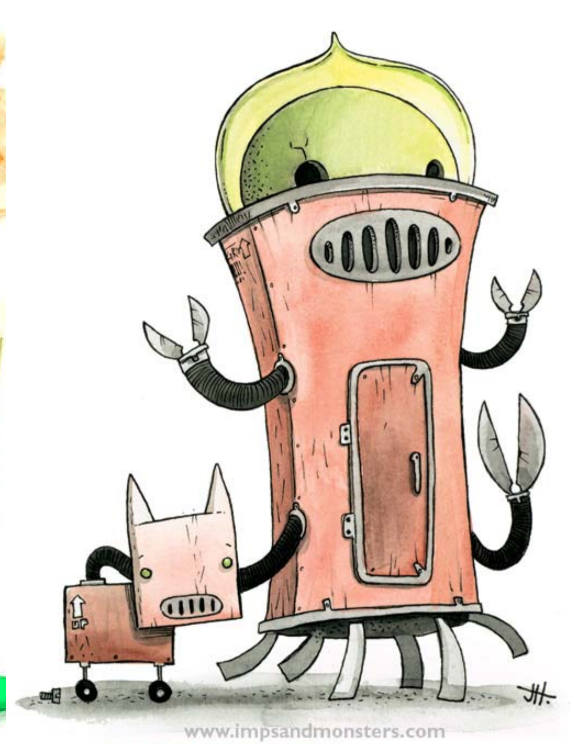


Watercolor Painting Techniques:

- *Drip Drop*: Rubbing alcohol is delightfully unpredictable, like watercolor itself. If you have rubbing alchohol and cotton swabs, alcohol and watercolor don't mix well, but they make some some amazing effects. Dipping a Q-tip into the alcohol have students proceed to tap and drip alcohol directly into the washes. As the alcohol hits the wash it repels the paint, pushing it away while leaving a lighter tint of the wash exposed. The results of their fight on the paper is strangely organic in nature and not achievable using any other technique.



- When they're ready to paint, have students paint the background and its details first and spend some time making the colors ooze and blend together on the page.
- If they used oil pastels or wax crayons, students don't need to avoid painting near or on the outlines, as the watercolor paint will bead off the oil pastel/crayon. Encourage the children to mix paints on their paper, not in paint palettes, and use the double-loading technique when you can. It produces very cool results and clean-up is much easier!
- *Wet-On-Dry Technique:* First, students dilute their pain with water and placing it onto the dry paper. The color lies on solid **without** gradient (Gradient is blending of shades from light to dark or from one color to another). Encourage students to work with quick and spontaneous strokes. Remind them that if they want crisp edges, they must wait for the paint to dry before painting next to it! Otherwise, they are using the following technique.
- W*et-On-Wet Technique*: Which is painting a wash of water (or paint), and then painting on top of that area while it's still wet with quick strokes. The result is a blended or blotchy and clouded effect with gradient.

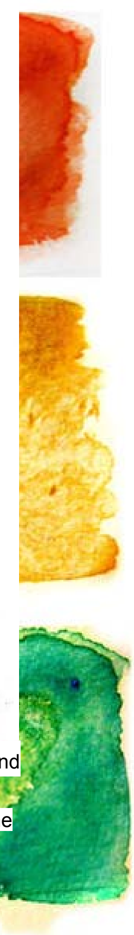


Image Credit: Robot Dog Walker. All works on the Imps and Monsters Website are the original creations of Justin Hillgrove. Visit the artist at www.impsandmonsters.com or www.justinhillgrove.com

- *Oil Pastel/Wax Crayon Resist*: If they want their outlines of the robot to show through, oil pastel will repel the paint, create clear outlines, and allow the drawing to show through the paint. Note: Wax crayons can also work for this, but aren't quite as clear, though they are also a lot less messy.

Plastic wrap (shattered/broken mirror effect)

Generously add watercolor paint to paper using a basic technique, such as wet-in-wet, first. Then, press scrunched-up plastic wrap over the top and leave it to dry. The watercolors will pool under the plastic wrap texture and dry there, creating an interesting, textured look. The effect always gives surprises and is startlingly beautiful to look at. Tissue paper will give a similar effect. *(Image via www.watercolorpainting.com. All Rights Reserved.)*

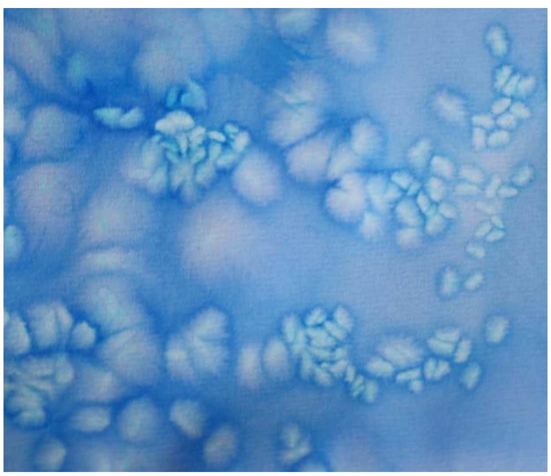
Image via: Truebluemeandyou.tumblr.com

Doily stencil (beautiful lace pattern)

Carefully paint over the lacey part of a paper doily. Be careful not to use too much water or the paint will spread under the doily's surface. Repeat until desired space is filled.

Rice (smooth blobs of absorbed color)

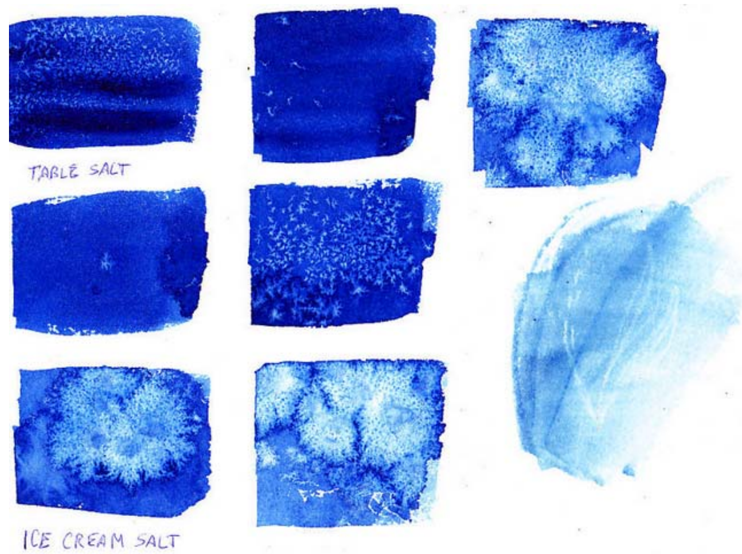
Paint paper as usual (use other techniques like a graded wash to create a more interesting effect). Paper should be very wet with paint before sprinkling dry rice over paper surface. Let dry overnight. *(Image via fairydustteaching.com All Rights Reserved.)*



Glue and salt (rough, textured outline)

Begin by drawing with white school glue. Pour small amounts of salt over glue outline. Carefully touch watercolor brush onto glue and salt line. Color will bleed with glue and salt. Let dry at least overnight. Variation (that's less likely to get salt in your paints): Drizzle (or glob) school glue onto a still wet painting. When the glue dries clear, it appears to have removed the paint leaving ghosted lines on the paper. The effect is magical. *(Image via gloster.com. All Rights Reserved.)*

Another Teacher Tip: Don't throw your liquid watercolors away. Use a dropper (think half-size turkey baster) to recycle any left over paint and store them in small condiment containers with plastic lids or baby food jars. This keeps the watercolors well. If a color, like yellow, gets too muddy, toss it, but mostly the colors stay true. This way you can go about a year and a half before you start to run out of basic colors like red, yellow and blue.



Effects of different kinds of salt via www.wetcanvas.com.

Lesson Two K-8 Standards Alignment

K

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.2 Invent designs for simple products.

These standards will be met and reinforced as students address a problem (they pick or from a list put together by the class) by creating a design for a new robot. They will have to show how their robot will solve the problem in their illustration (and labeling) of their design.

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3

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

7.T/E.2 Apply a creative design strategy to design a tool or a process that addresses an identified problem, ex. one caused by human activity.

These standards will be met and reinforced as students address a problem (option: the class may put together a list of problem ideas to help students get started, or they may come up with problems they've seen and want solved) by creating a design for a new robot. They will have to show how their robot will solve the problem in their illustration and explanation of their design and how their design will address the situation/humanity/animals, etc. and impact all involved.

4
7.T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.

7.T/E.5 Apply a creative design strategy to solve a particular problem, ex. one generated by societal needs and wants.

These standards will be met and reinforced as students address a problem (option: the class may put together a list of problem ideas to help students get started, or they may come up with problems they've seen and want solved) by creating and illustrating a design for a new robot. They will have to show how their robot will solve the problem in their illustration and explanation of their design.

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6

7.T/E.2 Apply the engineering design process to design a prototype that meets certain specifications.

7.T/E.5 Develop an adaptive (able to be changed to fit the needs of the situation) design.

These standards will be met and reinforced as students address a problem (option: the class may put together a list of problem ideas to help students get started, or they may come up with problems they've seen and want solved) by creating and illustrating a design/diagram for a new robot. They will have to show how their robot will fully solve the problem in their illustration and explanation of their design.

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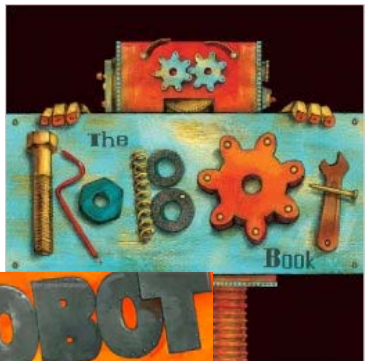
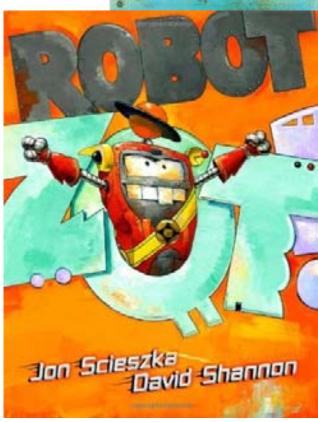
Lesson Three

Mr. Robot? Oh!





Access Prior Knowledge encourage discussion, and introduce the theme by reading a book about robots, such as *The Robot Book by Heather Brown*, *The Robot and the Bluebird* by David Lucas, or *Robot Zot!* by Jon Scieszka and David Shannon.

So, what is a robot, exactly?

Let's talk about what makes a robot a robot. There are many mechanical devices that have been called "robots," that are not actually robots. If we head to the dictionary, we'll find 'robot' defined as a machine that looks and acts like a human being. Ok, that description might work for a movie robot, but in real life is that true? **What do the kids think?** Household vacuum robots look like a giant hockey puck. In a factory, most robots are just giant arms. There are robots in the shape of cars, insects, or even entire houses!

Hey, I Disagree!

Not all roboticists think that a robot has to Sense-Think-Act in order to be called a robot. Some believe that a robot is any machine that can act on its own. So skip the Thinking and on to the Acting!

After all robots that don't have 'brains' can act in really lifelike ways. Some move around at random while others react automatically to signals from their sensors.

Lots of people are interested in these simple behavior-based robots that don't have computers. They're cheaper and easier to build than ones with 'brains' and they can be used first as models to help scientists build more complex robots.

To most roboticists (scientists who work with robots) a robot is a machine that can go through something called the Sense-Think-Act-Cycle. When deciding if a device is a robot or not, we first look for autonomous behavior, which is behavior that happens (without human help) in response to feedback. Autonomous behavior is not planned in advance but happens as a result of outside influences. Devices must receive and react to feedback in order to be considered robotic. So, let's talk about the basics.

Sense: to take in information about what is going on around it (just like we use our eyes, ears, hearing, sense of touch, smell, etc.)

Think: to use that information to select the next step to take.

Act: to do something that affects the outside world

To complete this kind of cycle, a robot needs to have at least three kinds of parts.

Sensors: Detect what's going on. To detect changes and then send feedback, a robot needs **sensors**. Sensors are small devices connected to the brain of the robot that tell the robot about the environment. Humans have five senses: sight, touch, hearing, taste and smell. Sensors for robots mimic these human senses and allow the robot to send messages to the brain. The really cool part about robot sensors is that they can be super sensitive, way more sensitive than we are. Scientist have created sensors that tell exact temperatures, see in the dark, and smell small amounts of poison gas. Humans can't do that!

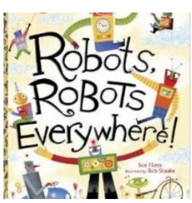
Once the sensors gather information and send feedback, the robot needs a method of receiving it or understanding what the signals mean. We can call it a **controller**, which reacts to what the sensor detects. Humans do this with their brain. When you eat something yucky your taste buds don't tell you to spit it out! It is your brain that tells your mouth to open, gag and spit (hopefully, in a trash can). In a robot the central processing unit, or CPU, holds the job of the brain or controller. A CPU uses a series of transistors and circuits that mimic the function of the brain, sort of like a computer. With a CPU, a robot can "think" and perform autonomously.

In order for a device to be a robot it must be able to do something. The part that can take action is called the **effector**. In other words, it needs something that will let it affect things in the outside world, such as a gripper, tool, laser beam, or display panel.

So, back to our first question: What is a robot? It seems to be a device consisting of sensors, a body and a CPU that together collect feedback and respond to it in an autonomous way (by themselves). Some summarize it as the "Sense-Think-Act" cycle, a cycle which dictates that a true robot senses (takes in information), thinks (processes info to determine what to do), and then acts (does something based on the info).

Of course, a robot can have way more than just three parts! They can have a drive system which is made up of wheels, legs, or other parts that make the robot move.. An actuator is another name for a robot's motor. There are many different types of actuators, but basically n actuator performs the same duty as a muscle in your body. They can have a computer for storing and working with information, or they might have a microcontroller, which works like a mini-computer.

Robot…Or Not?



A fun way to start this activity might be with the book *Robots, Robots Everywhere* by Sue Fliess which talks about different jobs robots might do.

Make a scavenger-hunt game of the following activity.

How can we tell whether a device meets the Sense-

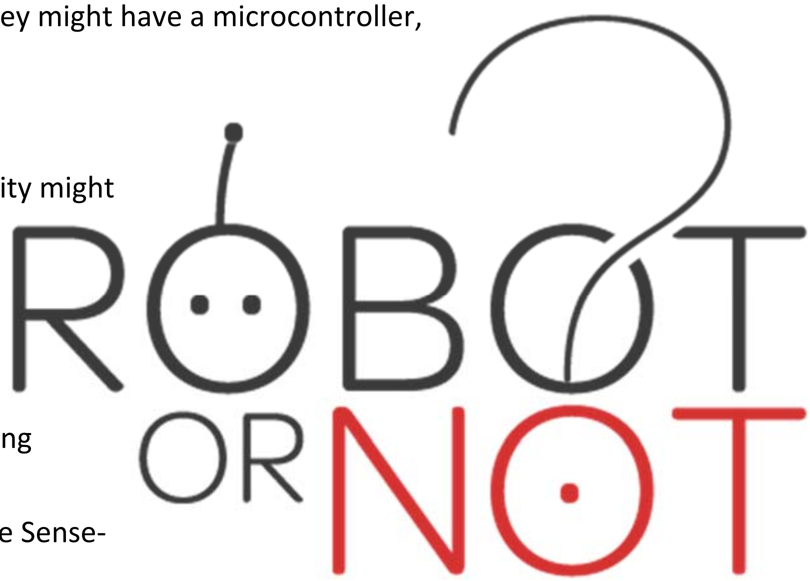


Image via: robot-or-not.com All Rights Reserved.

Think-Act definition of a robot? One way to test it is by going through the steps of a flowchart. Flowcharts are actually a big step in designing computer programs. Different shapes represent different types of action. An oval means 'Start' or 'End.' A diamond-shaped Decision Block contains a question that you have to answer. Arrows show you what order to go in. Red = you answered the question with no. Green = follow if you answered the question with yes

Have individuals, pairs, or teams take a sheet of paper and make a list with four columns. Label the columns, Device, Sensor, Controller, and Effector. **Or use the included worksheet (which contains samples).** In the Device column have the students list common machines that they find during the scavenger hunt that they think might qualify as robots, ex. television, calculator, clothes dryer, automatic garage door opener, automatic door at the store, electric toothbrush, smoke detector, automatic soap dispenser.

For the first device, go to the sensor column. Write down what kinds of sensors it has. If it doesn't have any, they can write 'none.' Have them do the same for controller and effector.

Continue down the list of devices, filling out the columns.

Sample:

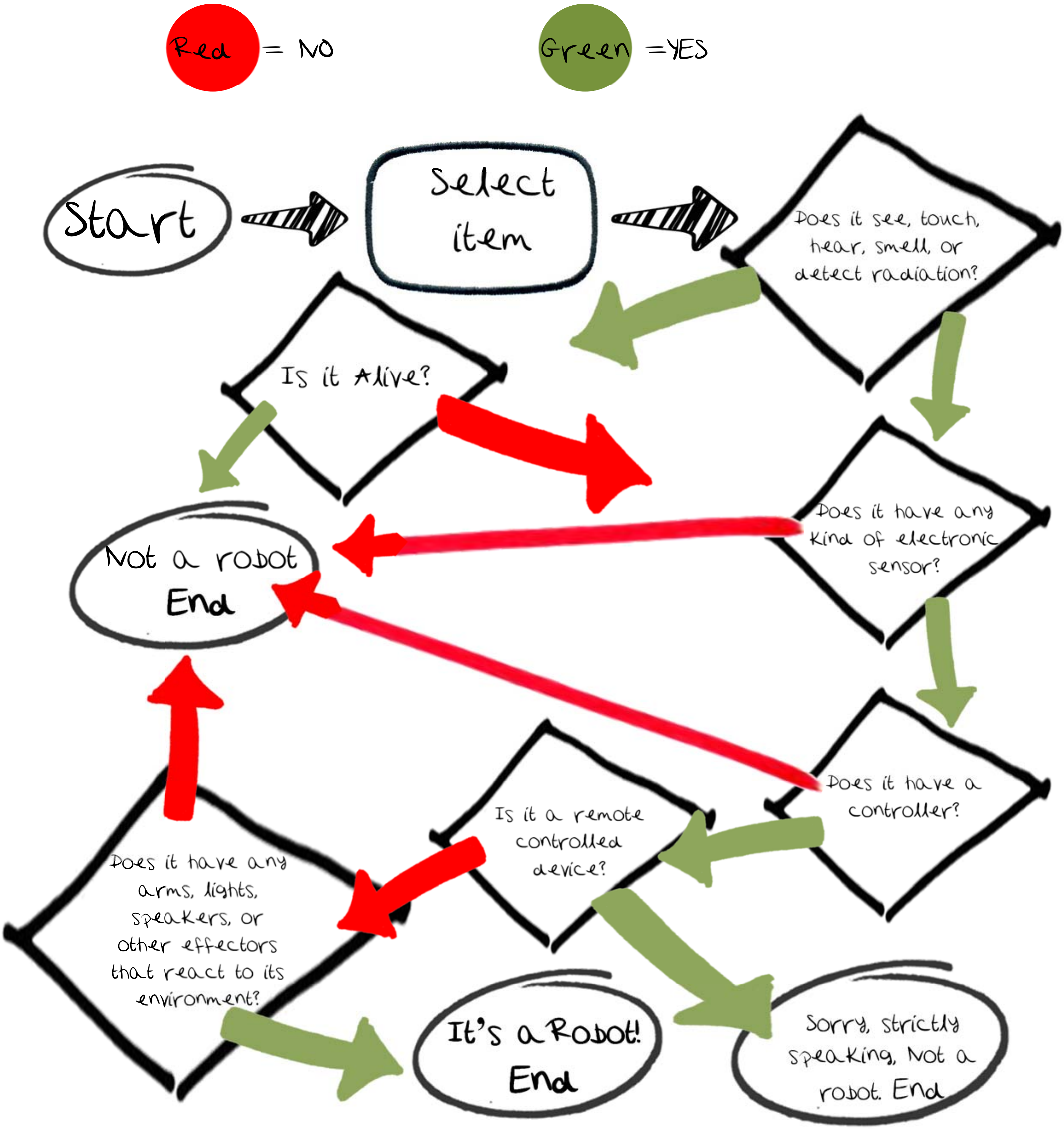
Device	Sensor	Controller	Effector
TV	Light sensor (to get signal from remote control)	Remote control	screen
Auto Soap dispenser	Motion sensor	nope	motor

As you think about each device ask yourself: Does it receive and respond to feedback? Does it have sensors? Does it have something like a "brain" or CPU? If you answered yes to these questions, list the device in the "robot" column. Put other devices in the "non-robot" column. Keep listing until they have the required amount, ex. ten items. After they get started, they may want to add a box at the bottom of their paper in which to put items they are not sure about.

Have groups compare answers. Do they agree with all of the other groups answers? It is ok if they don't, there are no real, "right" answers!

Have the groups defend their answers. Think about why they placed the devices in the column they did.

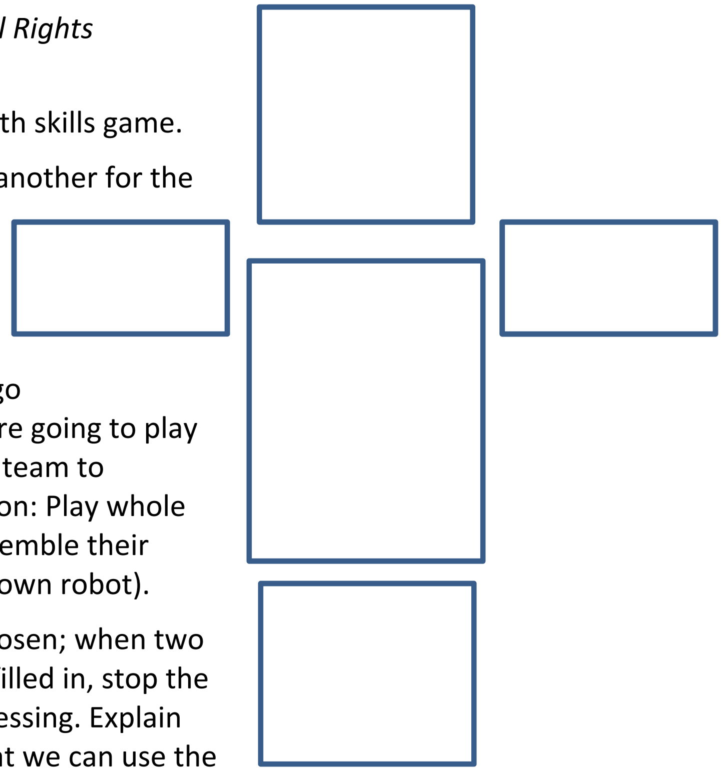
Here are some examples. The heating system in your classroom or home is robotic. It has a temperature sensor in the thermostat that indicates when the temperature rises or falls in the room and the furnace turns on or off. The thermostat on the wall is like the CPU or brain and the furnace is like the body that receives the message and then acts. Motion-activated lights are also robotic; they receive feedback from their motion sensors and turn the lights on. A remote controlled car that turns and stops as you move the joystick is not a robot. The car receives no feedback, only direct commands from you through the joystick. The car is not able to think or problem-solve when it encounters an obstacle. It will only do what you tell it to do. If you drive a remote control car into a brick wall, it will destroy itself before it will stop independently.


Red = NO
Green =YES
Start
Select item
Does it see, touch, hear, smell, or detect radiation?
Is it Alive?
Not a robot End
Does it have any kind of electronic sensor?
Does it have a controller?
Is it a remote controlled device?
Does it have any arms, lights, speakers, or other effectors that react to its environment?
It's a Robot! End
Sorry, strictly speaking, Not a robot. End

Device	Sensor	Controller	Effector
TV	Light sensor (to get signal from remote control)	Remote control	screen
Auto Soap dispenser	Motion sensor	nope	motor

Assemble: Robot Problem Solvers

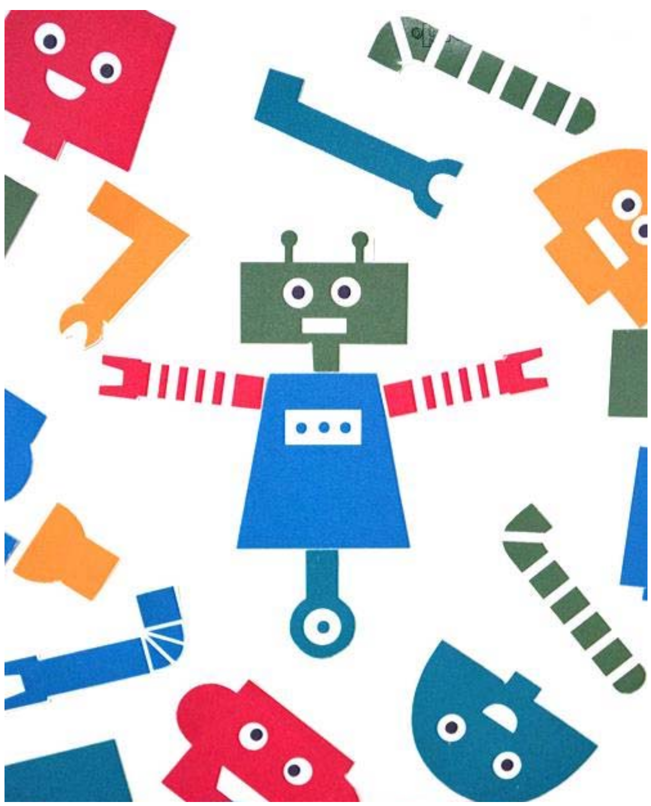
Students race to create their own robots in this fun math skills game.



Draw two robot boxes on the board [a box for a head, another for the body, one or two for the legs, and two for the arms] and below it, write a math problem, for example, _ + _ = _ _.

Explain that we've got a pile of parts at our factory for different robots and we've got to figure out how they go together and put them together as fast as we can. We're going to play 'Assemble' [aka Hangman] and compete to be the first team to assemble as many complete robots as possible (Variation: Play whole class vs. the teacher, where if they get it right, they assemble their robot, if they get it wrong the teacher assembles their own robot).

Pick kids to guess a number that's in the fact you've chosen; when two children have guessed correctly and two numbers are filled in, stop the guessing. Explain that we can use the numbers we know to figure out what we don't know. For example, if the board says 4 + _ = 11, you know that you're looking for a number that you can add four to in order to get eleven. Ask someone to solve the problem and say the last number.

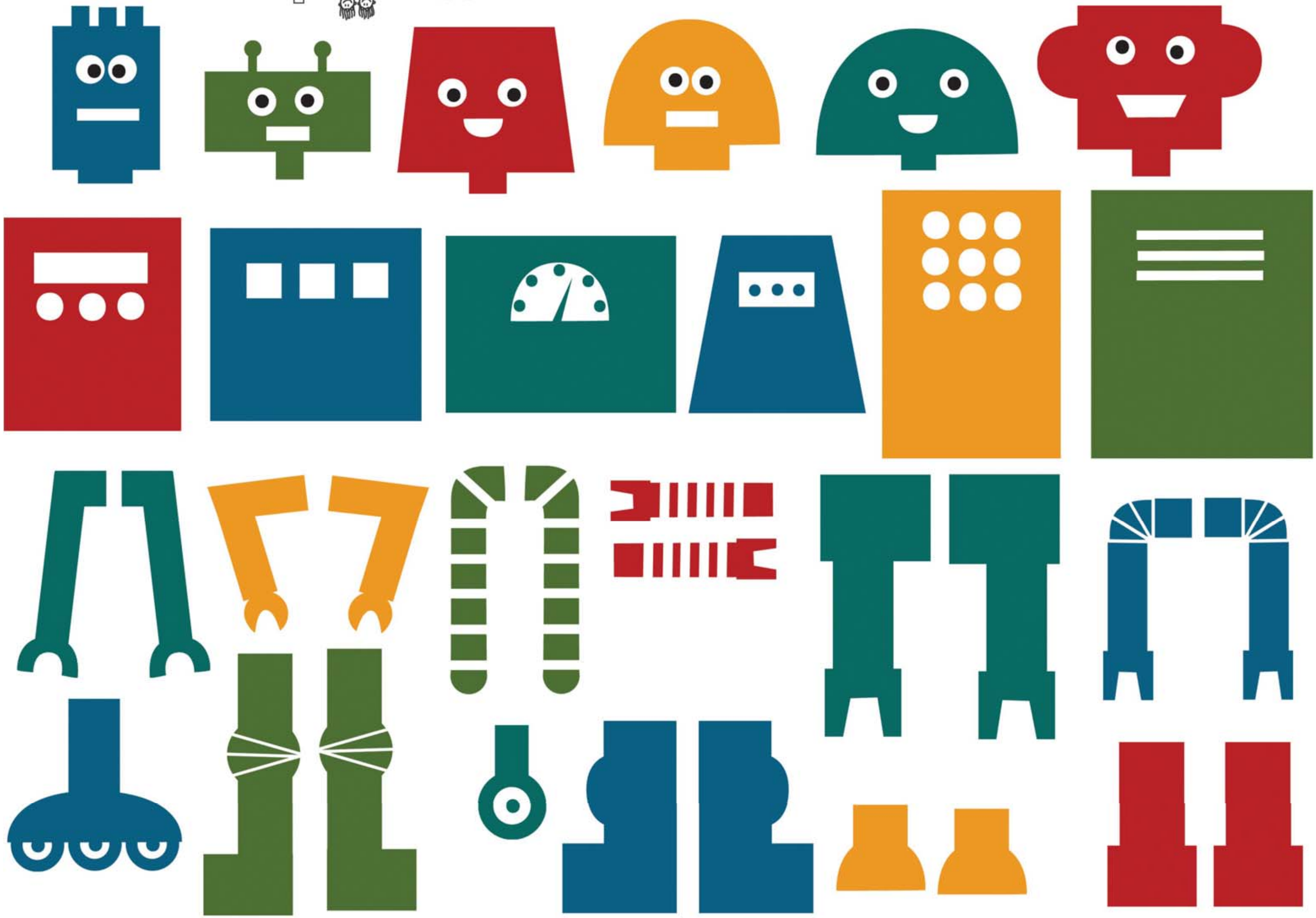


Pick a new math fact and have them guess again, but this time when you get to the answer, ask how they got that answer. Ask if anyone used a different strategy to get the answer. Make sure students are aware of the different strategies that can be used to solve this type of problem: subtracting or counting back four from eleven, guessing and checking, using memorized facts, etc. Choose a student to come up and think of a problem. Facilitate other students guessing and help the student fill in the numbers.

Students can only add a body part to their robot when they correctly guess a number. The team with the most completed robots by the end of the game wins.

Note: This game can also be used with subtraction, multiplication, and division problems, as well as equations, formulas, greater or less than, word problems, etc.

Build Your Own Robot!



Lesson Three K-8 Standards Alignment

K

7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.2.2 Use the senses to investigate and describe an object, ex. a variety of non-living materials

7.2.2 Know that people interact with their environment through their senses.

These standards will be met and reinforced as students participate in the 'Robot-Or-Not?' scavenger hunt and determine what they think might qualify as robot and why or why it doesn't fit under that category.

1

7.Inq.1 Use senses and simple tools to make observations.

7.2.3 Sort and classify a variety of living and non-living materials and objects based on their characteristics.

7.2.2 Record information about living or non-living objects in local environments.

These standards will be met and reinforced as students participate in the 'Robot-Or-Not?' scavenger hunt and determine what they think might qualify as robot and why or why it doesn't fit under that category.

2

7.Inq.1 Use senses and simple tools to make observations.

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3

7.T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.

7.T/E.1b Explain how different inventions and technologies impact people and other living organisms.

These standards will be met and reinforced as students participate in the 'Robot-Or-Not?' scavenger hunt and during our discussion of robots. We'll discuss how each 'robot' we find was invented to solve a problem (not always a 'serious' one, ex. what problem does a tv remote solve?) or answer a question, and we will identify the problem and purpose behind them. Students will be asked to determine if they think robots impact their lives and/or humanity before we go on our robot scavenger hunt to find out just how many robots we use every day. After the hunt we'll see if their opinion has changed or been reinforced.

4

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7.Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.

7.Inq.3 Interpret and translate data in a table, graph, or diagram.

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Mathematic Skill Alignment:

K

- K.CC.6. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group.
- K.CC.5. Count to answer "how many?" questions.
- K.OA.2. Solve addition and subtraction word problems, and add and subtract within 10
- K.OA.5. Fluently add and subtract within 5.

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

1st

- 1.OA.6. Add and subtract within 20, demonstrating fluency for addition and subtraction within 10.
- 1.OA.5. Relate counting to addition and subtraction (e.g., by counting on 2 to add 2).

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

2nd

- 2.OA.1. Use addition and subtraction within 100 to solve one- and two-step problems
- 2.OA.2. Fluently add and subtract within 20 using mental strategies.

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

3rd

- 3.OA.7.Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that $8 \times 5 = 40$, one knows $40 \div 5 = 8$)

- 3.OA.7.b) Fluently multiply and divide within 100, using strategies such as properties of operations.

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

4th

- 4.NBT.4. Fluently add and subtract multi-digit whole numbers
- 4.NBT.5.a Multiply a whole number of up to four digits by a one-digit whole number

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

5th

- 5.NBT.5. b Fluently multiply multi-digit whole numbers
- 5.NBT.5. a Perform operations (addition, subtraction, multiplication, division) with multi-digit whole numbers

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

6th

- 6.NS.2. Fluently divide multi-digit numbers
- 6.NS.3. Fluently add, subtract, multiply, and divide multi-digit numbers using the standard algorithm for each operation

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

7th

- 7.NS1.1 Apply and extend previous understandings of operations, ex. with fractions, to add, subtract, multiply, and divide rational numbers.
- 7.NS.3. Solve real-world and mathematical problems involving the four operations with rational numbers.

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

8th

- A-APR.1. Add, subtract, and multiply polynomials.
- A-APR.7. b Solve real-world and mathematical problems involving the four operations with rational numbers and/or rational expressions.

Students will practice these math skills, among others, through the selected math problem review game as we practice core math problem solving and mental math skills.

Lesson Four

Between the Greeks and the Geeks: Automatons

Robots that can sense, think, and act for themselves are pretty amazing, but they've only really been possible for about the last 50 years, after humans invented electronic computers. But didn't we say that robots (or at least the idea of them) had been around since the Ancient Greeks? Yep. And a lot happened between the Age of the Greeks and the Age of the Geeks.

As early as 200 BCE, a device that used air pipes and ropes pulled by hand to make mechanical musicians play flutes and stringed instruments entertained the emperor of China. Over 1,600 years later, when the famous Italian artist and inventor Leonardo da Vinci was only a 12 year old kid, he designed a mechanical knight. Dressed in a suit of armor, the knight could sit up and move its arms and head.

Then around 1555 CE an Italian clockmaker named Gianello Torriano built a wind-up model of a lady that could walk around in a circle while strumming a type of guitar called a lute. And if you visit a museum in Vienna Austria today you can still see her, over 460 years later.

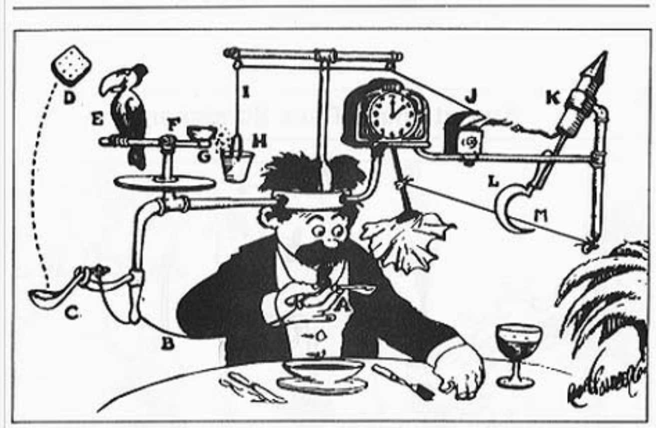
During the Middle Ages "automatons" became popular for entertaining and doing work for humans. They were fun machines that were able to do automatically only one or two things that they were programmed to do. These artful devices usually moved with clockwork technology and looked like animals or humans. Automatons were not able to think or react independently in their environment so th ey were not true robots, according to our modern dictionaries. However, they were the source of amazement to all who saw them and a huge step towards our modern day robots. Due to their entertainment value, automatons were a popular art form in eighteenth century Europe.

A modern version might be Animusic. 2001 there was a wildly popular CGI video created by Animusic called

FYI: A Rube Goldberg machine is a contraption, invention, device or apparatus that is deliberately over-engineered or overdone to perform a very simple task in a very complicated fashion, usually including a chain reaction. The expression is named after American cartoonist and inventor Rube Goldberg (1883–1970). In 1931, the Merriam–Webster dictionary adopted the word "Rube Goldberg" as an adjective defined as accomplishing something simple through complicated means.

Rube Goldberg's cartoons became well known for depicting complicated devices that performed simple tasks in indirect, convoluted ways. The example on the right is Goldberg's "Professor Butts and the Self-Operating Napkin", which was later reprinted in a few book collections, including the postcard book Rube Goldberg's Inventions! and the hardcoverRube Goldberg: Inventions, both compiled by Maynard Frank Wolfe from the Rube Goldberg Archives.[3] The "Self-Operating Napkin" is activated when soup spoon (A) is raised to mouth, pulling string (B) and thereby jerking ladle (C), which throws cracker (D) past parrot (E). Parrot jumps after cracker and perch (F) tilts, upsetting seeds (G) into pail (H). Extra weight in pail pulls cord (I), which opens and lights automatic cigar lighter (J), setting off skyrocket (K) which causes sickle (L) to cut string (M) and allow pendulum with attached napkin to swing back and forth, thereby wiping chin.

Self-Operating Napkin

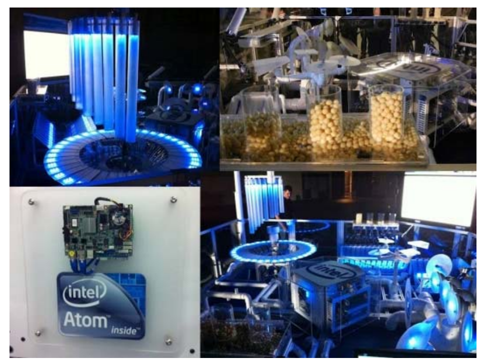


Professor Butts and the Self-Operating Napkin

Pipe Dream that featured an awesome Rube-Goldberg'esque music making machine. Their imaginary and virtual musical automatons became a smash hit, especially "Pipe Dream." [*Voted one of the 50 best 3D animation projects ever. Most of the other winners were big-budget movies (The Matrix, Toy Story, Star Wars) and a few video/computer games (Doom, Tomb Raider, Myst).] Watch here:* https://www.youtube.com/watch?v=hyClpKAIFyo

Virtual to Reality: Building Pipe Dreams [Computer Controlled Orchestra]

Intel was so inspired they built an equally as awesome real world version of it, check out this video to see it in action. https://www.youtube.com/watch?v=xAQX8W3D6Mg Inspired by the animated music video Pipe Dream by Animusic, Intel Embedded Computing engineers teamed up with Austin-based Sisu to turn that animation into a real computerized paint ball orchestra. The Intel Industrial Control in Concert piece was unveiled at the Intel Developer Forum in September 2011. Built with seven Intel Atom processors, running three different operating systems, security camera system, sensors, touchscreen and other technologies, the project was completed in just 90 days at a cost of about $160,000. So how do students think it compares to the original video? Not a bad CGI-to-reality conversion?

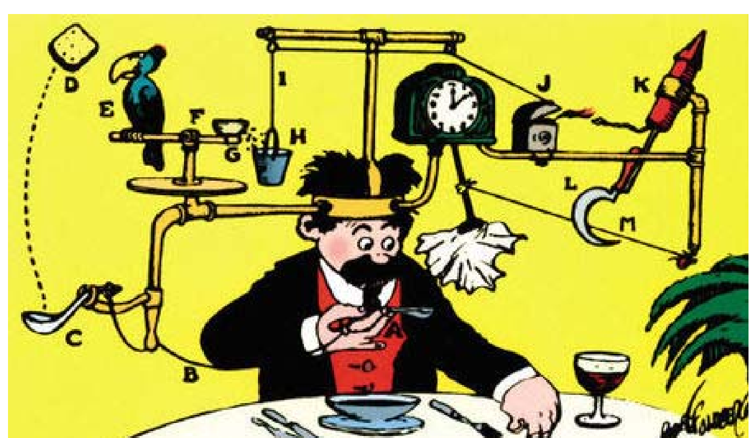


Chain Reaction: Rube Goldberg Project Creativity in Motion

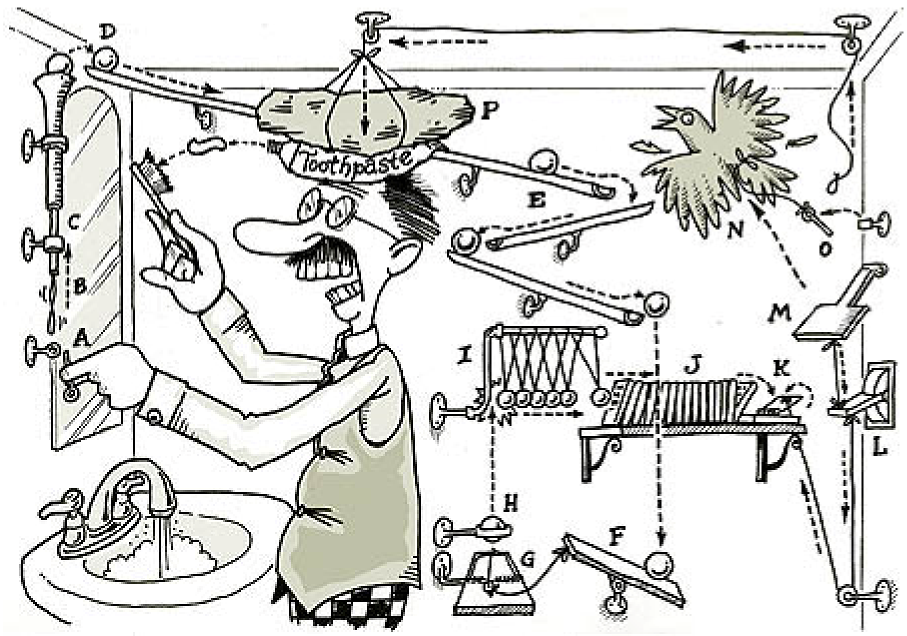
Rube Goldberg (rōōb gōld'berg), a comically involved, complicated invention, laboriously contrived to perform a simple operation – *Webster's New World Dictionary*

Rube Goldberg is the ® and © of Rube Goldberg, Inc.

These machines might not be practical, but they're definitely fun, creative, and educational! Building a Rube Goldberg machine is a great hands-on activity for all ages, plus it encourages children to flex their STEM muscles.

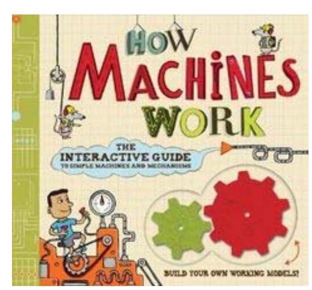


A Rube Goldberg Machine is an overly complex contraption, designed with humor and a narrative, to accomplish a simple task. Most inventions try to make difficult tasks easier. Rube Goldberg discovered ways to make simple tasks amazingly difficult. He had solutions for How To Get The Cotton Out Of An Aspirin Bottle, imagined a Self-Operating Napkin, and created a Simple Alarm Clock – to name just a few of his hilariously depicted drawings. One of his inventions used dozens of arms, wheels, gears, handles, cups, and rods that were moved by balls, canary cages, pails, boots, bathtubs, paddles, and animals, just to squeeze oranges for orange juice.



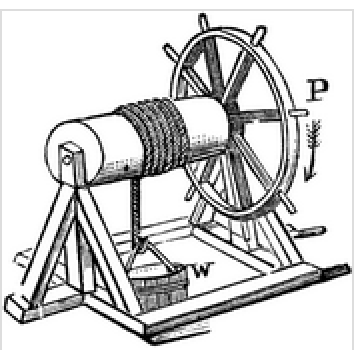
The promise and pitfalls of modern technology, including robotics, make Rube Goldberg's inventions even more relevant now than when they were originally created. From think-tanks in Silicon Valley, to the New York Times, to Sunday morning's Meet the Press, hardly a day goes by without the name "Rube Goldberg" being invoked. In fact, Rube Goldberg is an adjective in Webster's Dictionary. Rube did not build the machines he drew, but his cartoons have become an inspiration to aspiring engineers and scientists across the world.

Six Machines to Do It All Six Machines to Bind Them



A good introduction to this topic might be reading a book, such as: *How Machines Work: The Interactive Guide to Simple Machines and Mechanisms* by Nick Arnold, Allan Sanders or *Simple Machines: Wheels, Levers, and* Pulleys by David A. Adler

There are six simple machines that physicists use to redistribute forces. Rube Goldberg was famous for combining these in creative, complicated, and comical ways to perform a simple task.

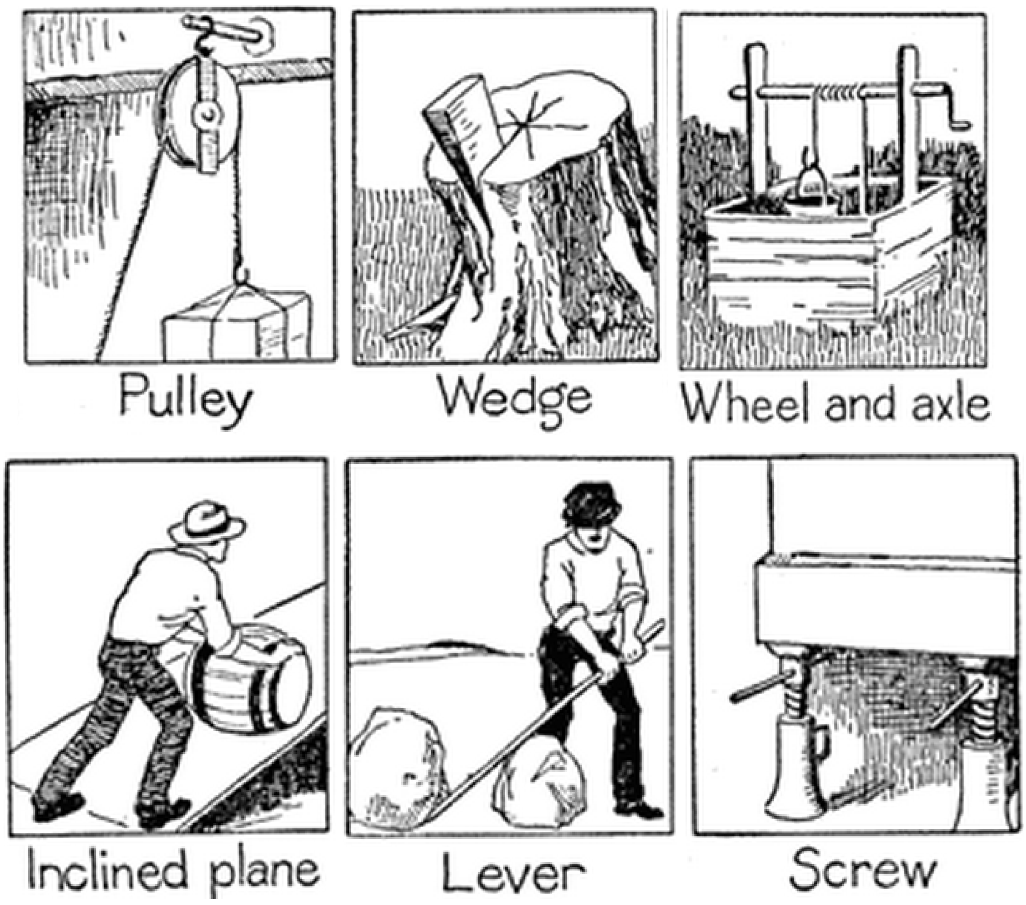


Wheel and axle

They are as follows: lever, wheel, pulley, incline plane, wedge and screw.

Theoretically, machines are devices that help make work easier for people. Most machines consist of a number of elements, such as gears and ball bearings that work together in a complex way. But no matter how complex they are, all machines are made of one or more of the six types of simple machinesthe lever, inclined plane, wedge, screw, pulley, and wheel and axle. Historically, simple machines were invented and used long before anyone ever classified them. We use simple machines every day without realizing it. Teeth are wedges and so are knives, forks, and thumbtacks. Many toys such as slides, which are inclined planes, and seesaws, which are levers, are also simple machines.

Simple machines can give you a mechanical advantage—in other words they allow you to spread the force you apply to move an object over a distance. This means you don't have to apply as much force at any given point in time. (ex. You can find screws (inclined planes wrapped around cylinders) on the tops of water bottles, what do they help you do?) Simple machines can make it possible for you to lift something or move something that would be too heavy otherwise. For example, consderd the difficulty in trying to lift a 200lb load up into the back of a truck. But placing a ten foot plank from the truck to the ground lets you slide the load up into the truck easily. This principle is used in conveyers as well.



Images via: http://questgarden.com/118/61/0/110208125606/task.htm

Something Is Screwy

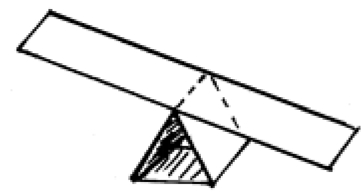
Names don't lie. Simple machines really do make our lives simpler. What's more, they make for some fun and simple learning experiences. Divide students into teams. Discuss with the students that each team will do the following for each simple machine:

- Make a model of it.
- As it is built, discuss geometric terms such as faces, vertices, planes, etc.
- Write the name of the simple machine on the model.
- Explain how it makes work easier for people.
- Create a list of examples of the simple machine.

Physical Challenge:

First, have students try to push something heavy across the floor. It could be a stack of books, a full laundry basket, or even a fellow student. Now, have her put the same load on wheels by stacking it on a wagon, cart, or ride-on toy or a big toy truck. Which is easier to push?

Lever Activity

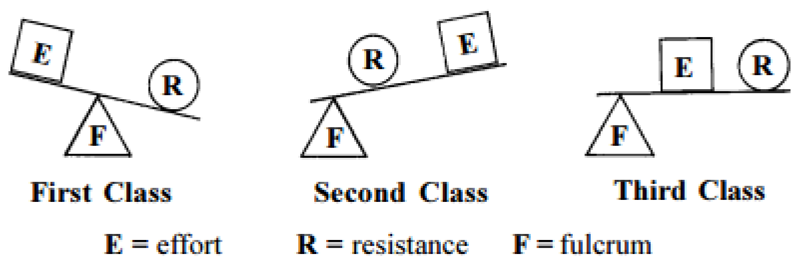


a. Cut out the lever pattern.

b. Fold and tape the base (fulcrum).

c. Set a small paper clip on one end of the lever and push the other end down. It should lift the paper clip up.

There are three classes of levers. The model is a first class lever.



Examples of levers include: see-saws and car jacks (first class), wheelbarrows and nutcrackers (second class), and shovels and brooms (third class). A lever has three parts: effort, fulcrum, and load or resistance. The fulcrum is the point on which the lever pivots. This allows the weight to be moved a short distance with a concentrated amount of force (effort).

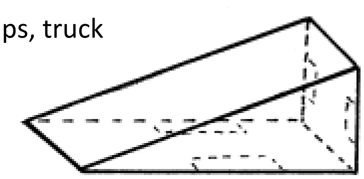
Inclined Plane Activity

a. Cut out the inclined plane patterns; fold and tape as shown.

b. Set the inclined plane on the table with one long side down.

c. Roll a pencil up and down the incline.

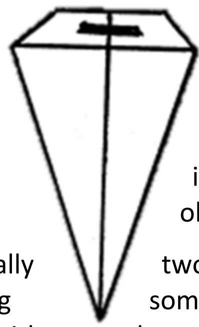
Examples of inclined planes include boat ramps, stairs, wheelchair ramps, truck loading ramps, and driveways, and grain elevators.



An inclined plane spreads the amount of work needed to move an object over a larger distance so that less force is needed at any particular instant.

Challenge: **The Difference is Plane to See.** Use different heights of inclined planes and a marble. Ask students to make predictions of distances the marble will travel on the different planes. Ask students to make estimations and to make actual measurements of distances traveled. Discuss potential and kinetic energy that will be utilized.

Wedge Activity



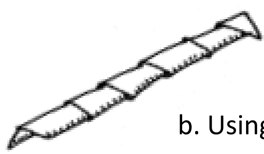
a. Cut out two wedge patterns.

b. Fold and tape them together.

Examples of wedges include axes, wedges, nails, ice picks, knives, plows, discs, treads on tires, and other objects that split things in two.

A wedge is theoretically two inclined planes attached together. A wedge makes work easier for people by splitting something perpendicular to the force that is applied. Wedges are often used in conjunction with levers.

Screw Activity

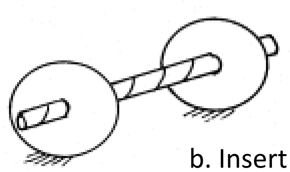


a. Cut out the triangle.

b. Using the arrows as a guide, roll the paper around a pencil and then tape in place.

Examples of screws include bolts, wood screws, jar lids, augers, and drill bits. A screw is an inclined plane rolled up. A screw concentrates the force applied on an object to a smaller area. It pushes a concentrated amount of force away from you.

Wheel and Axle Activity



a. Cut out the two circle patterns and punch or poke a hole in the center of each circle. The hole should be slightly smaller than the diameter of the straw.

b. Insert the straw through both holes.

c. Roll the wheel and axle across the desk. The circles are the wheels and the straw is the axle. If appropriate, have the students tape the wheels to the axle.

Examples of wheels and axles include tires, doorknobs, the crank shafts on bicycles, steering wheels, gears, and egg beaters. A wheel and axle reduces the amount of friction an object creates during its motion, because less surface is exposed to the stationary object, usually the ground, at any given time.

Pulley Activity

a. Cut a one-foot piece of string and thread it through the middle of a round wooden tinker toy, drapery pulley, thread spool, or bobbin.

b. Tape the two ends of the string on the edge of the desk so that the pulley hangs freely off the edge of the desk.

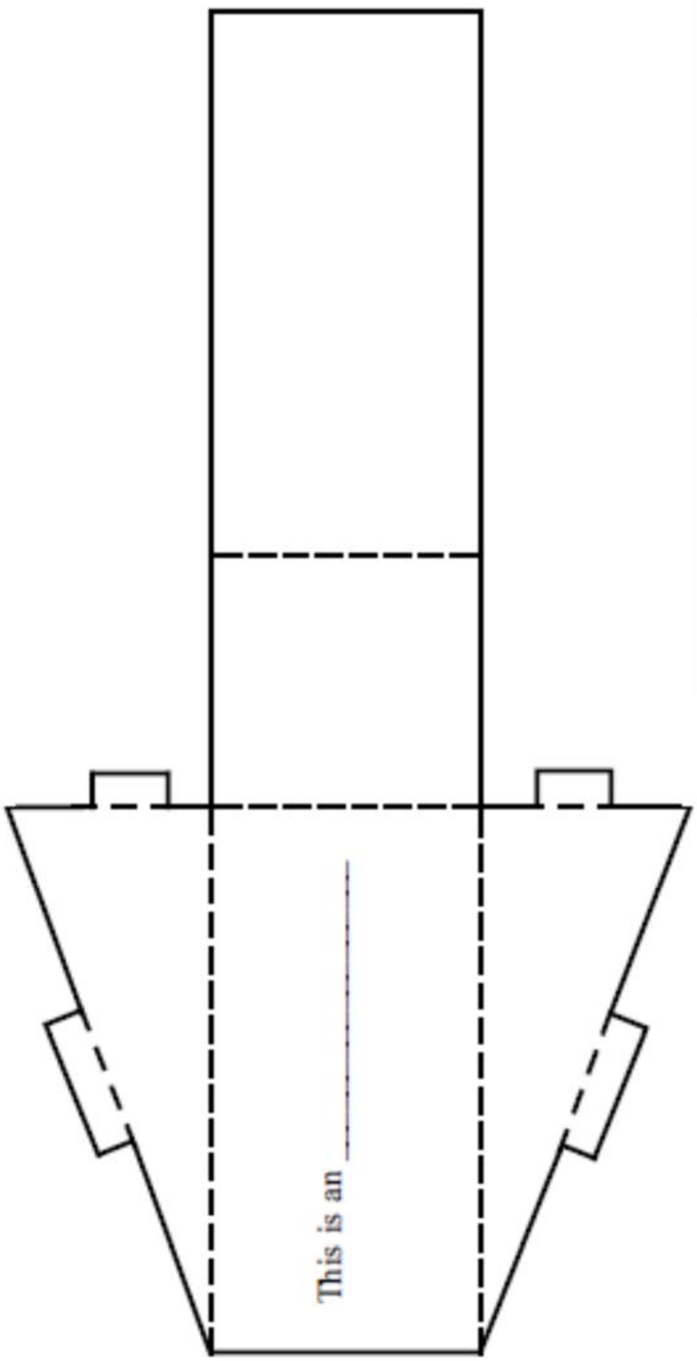
c. Thread the remaining piece of string around the top of the pulley so that it fits into the groove. Have students attach their pencils or other objects to one end of the string and provide time for students to experience how a pulley works.

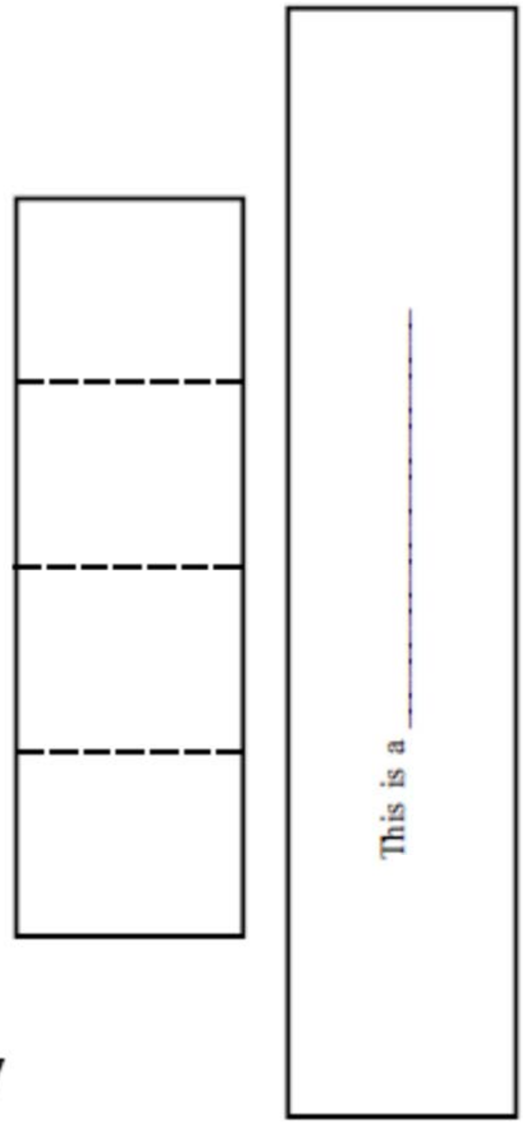
Items that contain pulleys include drape draws, elevators, flagpoles, sails on windsurfers and sailboats, scaffolding for window washers, engine hoists, and cranes. Pulleys make work easier by changing the direction of the force applied. With a pulley, when one pulls down, the object goes up.

Inclined Plane and Lever

Inclined Plane

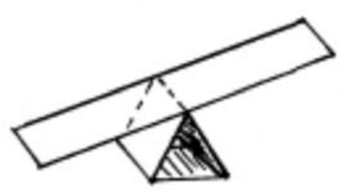
- Cut on solid lines.
- Fold on dotted lines.
- Use glue or tape to hold tabs in place.





Lever

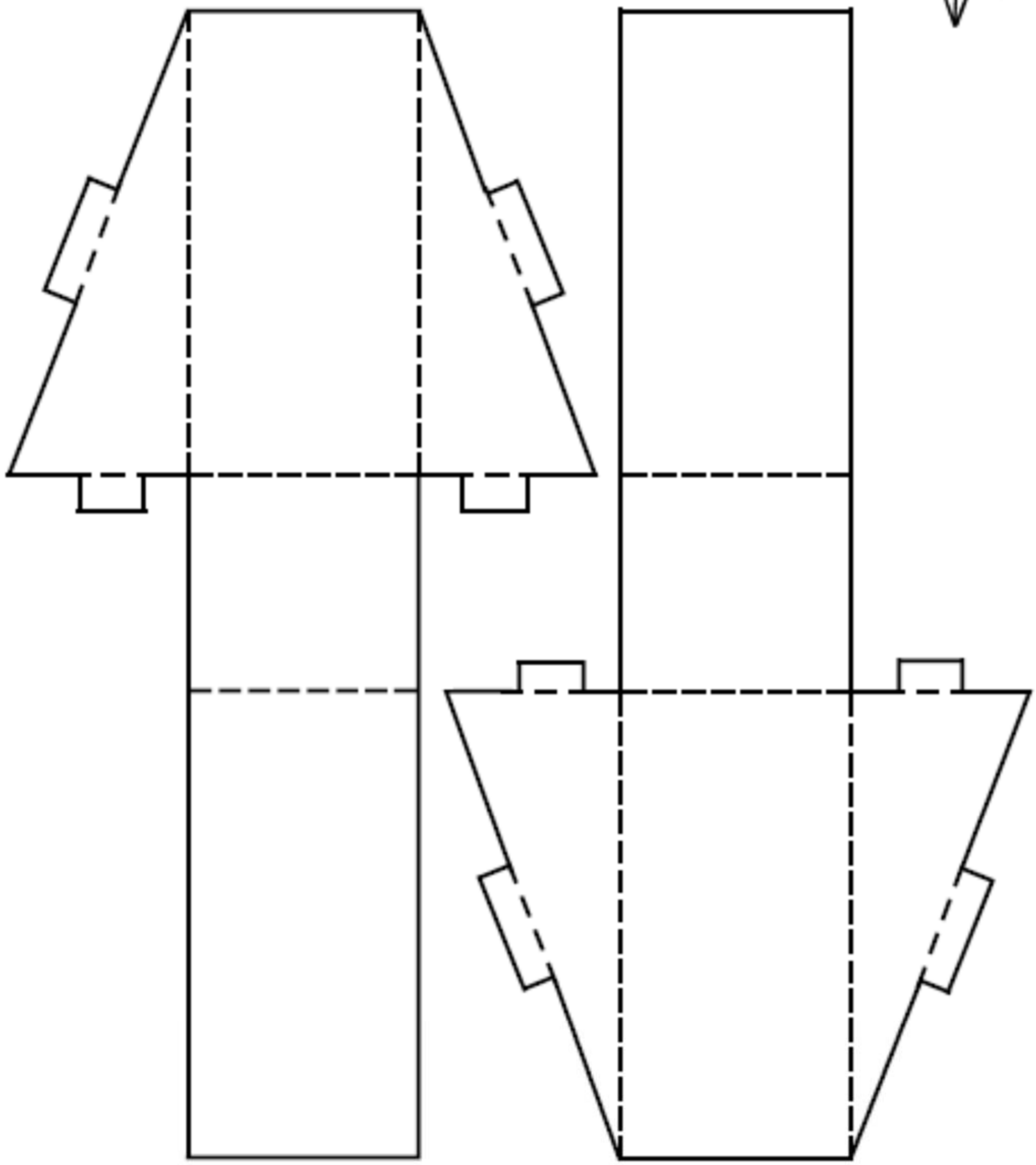
- Cut on solid lines.
- Fold on dotted lines.
- Tape to hold.



Wedge

Wedge

- Cut on solid lines.
- Fold on dotted lines.
- Glue or tape tabs in place.
- Glue or tape the two incline planes together.



Screw, Wheel and Axle

This is a ______________________________

Screw

- Cut on solid line.
- Roll in the direction of the arrows.
- Tape in place.

This is a

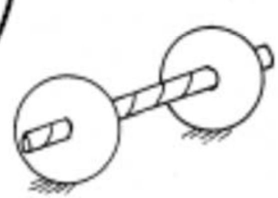
____

This is a

____

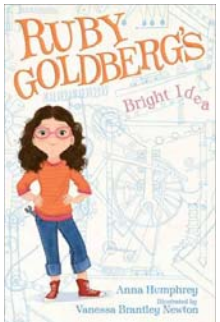
Wheel and Axle

- Cut the wheels out making the center holes just large enough to insert a straw.
- Insert a straw through both holes.
- Tape wheels to straw, if needed.



That s So Rube of You

Now that we know about simple machines, let's combine a few into something new, a complex machine (several simple machines working together)! For inspiration in building Rube Goldberg



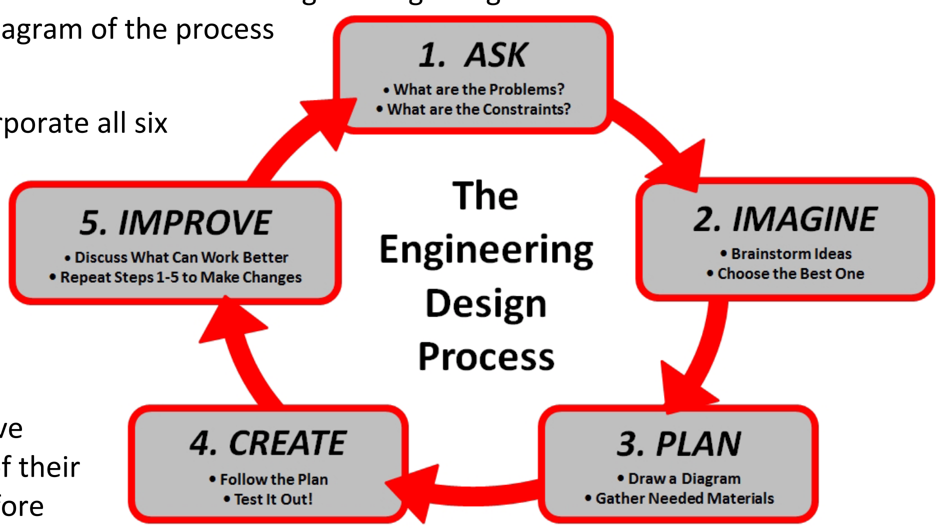
style machines find some interesting and fun videos such as:

Isaac Newton vs. Rube Goldberg https://vimeo.com/54913096 or Nat Geo's giant 4 ton machine http://www.wimp.com/videos/epicgiant/ (a massive machine with 38 triggers and 71 moving pieces, including a few staff members themselves and a car) and you may want to have students explore books such as *The Best of Rube Goldberg* by Reuben Lucius Goldberg or *Ruby Goldberg's Bright Idea* by Anna Humphrey.

Get students' creative juices flowing by having them watch clips from the following and seeing how and what others used to make their Rube Goldberg Inspired Machines:

- Rube Goldberg TV https://www.youtube.com/user/RubeGoldbergTV
- Sesame Street: Rube Goldberg Machines (which also does an excellent job of reinforcing concepts about simple machines and how they can all work together.) https://www.youtube.com/watch?v=pMpmit5YMcg
- 75 Rube Goldberg Ideas & Inventions https://www.youtube.com/watch?v=6FzUx2EFk8s [This video is split up into 3 sets of 25 ideas by 3 different youtubers. These short screen linked clips can help you with school projects or making your own chain reaction. This video is intended to help individuals obtain ideas and/or inspiration for building their own Rube Goldberg Machine. It is not meant to look like one actual machine. It is simply screenlinked to give more flow and continuity to the video.]
- Find videos and images at http://rubegoldberg.com/ , such as **A-Trak & Tommy Trash - Tuna Melt** [also at https://vimeo.com/62846755] and Tinkering with Monks [Tinkering with monks: Chain Reaction Contraption from The Tinkering Studio on Vimeo.

Give students the challenge for the contest! Discuss the Engineering Design Process and how it relates to this project and draw a diagram of the process up on the board.



Constraint: The machine must incorporate all six simple machines at least once.

Have students sketch their machine before building it. It can help each group choose the right materials and assemble a mechanism that works.

Don't wait until the end to test! Have students test and retest elements of their designs to make sure they work before they have built the whole thing. Take notes on which parts of the machine work and which ones do not. Does it achieve the task? If something doesn't work, what can you do to make it work next time?

Remember, the design process is cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way.

By making observations about the ways in which objects and simple machines behave in relationship to one another, new designs can be realized, constructed, and immediately tested. And, seeing common objects such as motors, ramps, toy parts, and kitchen utensils behave in surprising ways leads to unexpected experiments with, and new tests of these things. [Ex. Watch https://www.youtube.com/watch?v=k0B1hgP1tlE Pythagoras Switch - Japanese Rube Goldberg machine]

Chain reaction is an intuitively simple concept, but one that allows for an incredibly complex and deep investigation into something we experience every day: the relationship between cause and effect.

Testing Your Machine:

1. Once the machine is complete, test it to see if it works.
2. Take notes on which parts of the machine work and which ones do not. Does it achieve the task? If something doesn't work, what can you do to make it work next time?

Option: For mid to older level students, require that their Rube Goldberg machine incorporate all six simple machines.

Option: Large Scale Chain Reactions (Large-scale chain reactions allow for collaborative building and provide an opportunity for a dramatic conclusion.) Chain reaction can be done as a collective contraption: each participant/group is given a chunk of real estate on a table onto which to build a sequence of events. The only constraint is that it has to set off the contraption built by the next group: in the end this will result in a continuous chain reaction that goes from start to finish seamlessly, each section having been contributed by a different participant/group.

Did You Know?

The Rube Goldberg Machine Contest (RGMC) is an annual international competition that challenges teams of students from middle school to college age to compete in building the most elaborate and hilarious Rube Goldberg Machine.

Dating back over 60 years, the contest's namesake is the late American Pulitzer Prize-winning cartoonist, humorist and inventor, Reuben Lucius Goldberg, who specialized in drawing whimsical machines with every-day objects that performed a seemingly simple task.

Goldberg's legacy lives on through the contests -- as students nationwide build crazy machines that complete the annual task, all in the spirit of Rube's illustrations.

For example: the 2015 Task is: ERASE A CHALKBOARD.

Teams and their machines are judged on a range of criteria from absurd complexity, reliability, team chemistry, creativity, humor and story-telling -- along with the successful achievement of the task at hand.

Past Contests have included such challenges as:
2014 Zip A Zipper
2013 Hammer A Nail
2012 Inflate A Balloon and Pop It!
2011 Watering A Plant
2010 Dispense an Appropriate Amount of Hand Sanitizer into a Hand
2009 Replace an Incandescent Light Bulb with a More Energy Efficient Light Emitting Design
2008 Assemble a Hamburger
2007 Squeeze the Juice from an Orange
2006 Shred 5 Sheets of Paper
2005 Change Batteries and Turn on a 2-battery Flashlight
2004 Select, Mark and Cast an Election Ballot
2003 Select, Crush and Recycle and Empty Soft Drink Can
2002 Select, Raise and Wave a U.S. Flag
2001 Select, Clean and Peel an Apple
2000 Fill and Seal a Time Capsule with 20th Century Inventions
1999 Set a Golf Tee and Tee Up a Golf Ball
1998 Shut Off An Alarm Clock
1997 Insert and Then Play a CD Disc
1996 Put Coins in a Bank
1995 Turn on a Radio
1994 Make Cup of Coffee
1993 Screw a Light Bulb into a Socket
1992 Unlock a Combination Padlock
1991 Toast a Slice of Bread
1990 Put the Lid on a Ball Jar
1989 Sharpen a Pencil
1988 Adhere a Stamp to a Letter
1987 Put Toothpaste on a Toothbrush

Lesson Four K-8 Standards Alignment

K

7.T/E.2 Invent designs for simple products.

7.T/E.3 Use tools to measure materials and construct simple products.

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

These standards will be met and reinforced as students design, develop, and create a Rube Goldberg style machine to address the given problem/accomplish the assigned task. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem. As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a use for an 'everyday object,' and overcome challenges.

1

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2

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.

These standards will be met and reinforced as students design, develop, and create a Rube Goldberg style machine to address the given problem/accomplish the assigned task. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem. As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a use for an 'everyday object,' and overcome challenges.

3

7.T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

These standards will be met and reinforced as students design, develop, and create a Rube Goldberg style machine to address the given problem/accomplish the assigned task. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem. As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a use for an 'everyday object,' and overcome challenges. Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their designs.

4

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

7.T/E.5 Apply a creative design strategy to solve a particular problem

These standards will be met and reinforced as students design, develop, and create a Rube Goldberg style machine to address the given problem/accomplish the assigned task. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem. As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a use for an 'everyday object,' and overcome challenges. Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their designs.

5

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

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6

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

These standards will be met and reinforced as students design, develop, and create a Rube Goldberg style machine to address the given problem/accomplish the assigned task. As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their designs. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem.

7

7.11.1 Identify six types of simple machines.

7.11.1 Compare the six types of simple machines.

7.11.1 Differentiate between the six simple machines.

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

These standards will be met and reinforced as students learn about and build models of all six machine and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate those machines into their design for their Rube Goldberg style machine that they'll build to address the given problem/accomplish the assigned task.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their designs. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem.

8

1.1.19a Relate work and power to various simple machines.

1.1.19b. Recognize simple machines are combined to form compound machines

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

These standards will be met and reinforced as students learn about and build models of all six machine and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate those machines into their design for their Rube Goldberg style (complex) machine that they'll build to address the given problem/accomplish the assigned task.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine a uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their designs. They will have to demonstrate their invention and explain how it works to accomplish the task/solve the problem.

Robots [Weeks 1 & 2] Sample Academic Vocabulary Guide

K

- Picture Book
- Sort
- Shapes
- Computer
- Job
- Parts
- Observe
- Collect
- Position
- Senses
- Tools

1

- Past
- Present
- Future
- History
- Invent
- Sequence
- Technology
- Measure
- Property
- Push
- Pull

2

- History
- Decision
- Qualifications
- Main Idea
- Foot
- Inch
- Message
- Investigate
- Distance
- Discussion
- Outcome

3

- Tools
- Area
- Conclusion
- Opinion
- Organization
- Force
- Cause
- Effect
- Character
- Conjecture
- Setting
- Product

4

- Audience
- Compare
- Contrast
- Drawing conclusions
- Pattern
- Chance
- Friction
- Accuracy

5

- Point of view
- Personification
- Main ideas
- Theme
- Solution
- Data collection methods
- Bias
- History

6

- Sequential
- Personification
- Point of view
- Control
- Criteria
- Design constraint
- Cause and effect
- Myth

7

- Interaction with texts
- Viewpoint
- Function
- Property
- Simple machines
- Speed

8

- Human impact
- Sensory
- Reliability
- Family
- Product
- Variation
- Solution
- Function

Robots Lessons 1-4 Sample Supply List

Lesson One

- Chosen books
- Access to videos
- Large rope
- cones for boundaries (especially if you are playing outside)

Lesson Two

- Chosen books
- Watercolor paper
- Sketch paper
- Liquid or pan watercolors
- Paintbrushes
- Cups for water
- Pencils
- A problem & some imagination
- Optional: Salt
- Optional: Rubbing Alcohol
- Optional: Plastic Wrap
- Optional: Paper doilies
- Optional: Rice
- Optional: Crayons or oil pastels
- Optional: Glue

Lessons Three and Four:

- Printouts
- Tape or glue sticks
- Access to videos
- Chosen books
- A **WIDE** variety of materials for inventing with

Robots

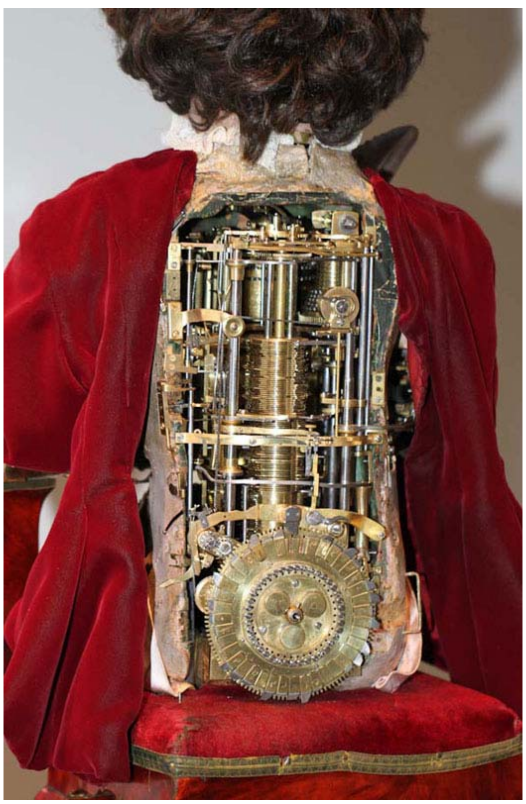
Part Two: The Illusion of Life

Lesson One

Keeps on Ticking

The oldest working automaton known today is the rooster atop the cathedral clock tower in Strasbourg, France. Built in 1352, the rooster flaps its wings, thrusts out its tongue and crows. Like the Strasbourg rooster, glockenspiels, German for "players of the bells", are run by the clockwork and move atop clock towers, chiming the hours. Glockenspiels can be quite elaborate and are often life-sized figures moving to the clock chimes in a choreographed dance.

By 1770, inventor/artist and watchmaker Pierre Jaquet-Droz became the first to create automatons that had all of the mechanisms built in the figures themselves. Droz's "Scribe" or 'Writer' was an adorable life-like boy who could dip his pen in ink and write whatever short message the operator selected. The almost 240-year-old automaton, which looks simply like a doll holding a quill and sitting on a pedestal, still works perfectly to this day. This fact is as amazing as the automaton itself, due to the complexity of it. The Writer is made from around 6000 parts, which have been miniaturized and designed to fit into the body of the doll. The Writer is considered his masterpiece. The doll can write any word or sentence up to 40 characters in length. As well

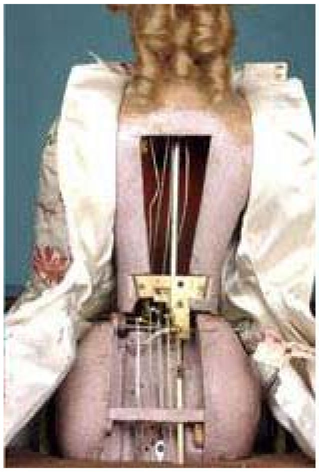


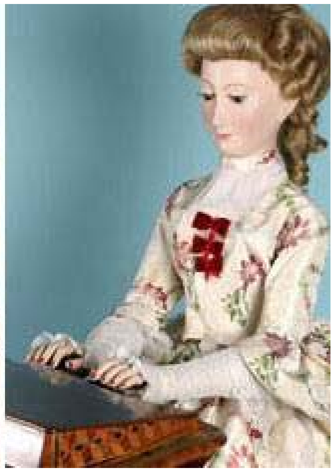
Where'd they Wind Up?

At the 1876 World's Fair in Paris, some of the last of the great performing automatons were on display. J. N. Maskelyne created a popular attraction for the fair that featured three musicians who played various tunes on brass instruments, "Zoe," a young girl who drew pictures and Psyco," a card playing gypsy.

as writing, the doll is able to control the pressure of the quill on the paper while writing and the eyes follow the writing on the paper as if it is actually following what it is writing.

"Musician" was a figure who played on a piano with all ten of her fingers. These figures can still





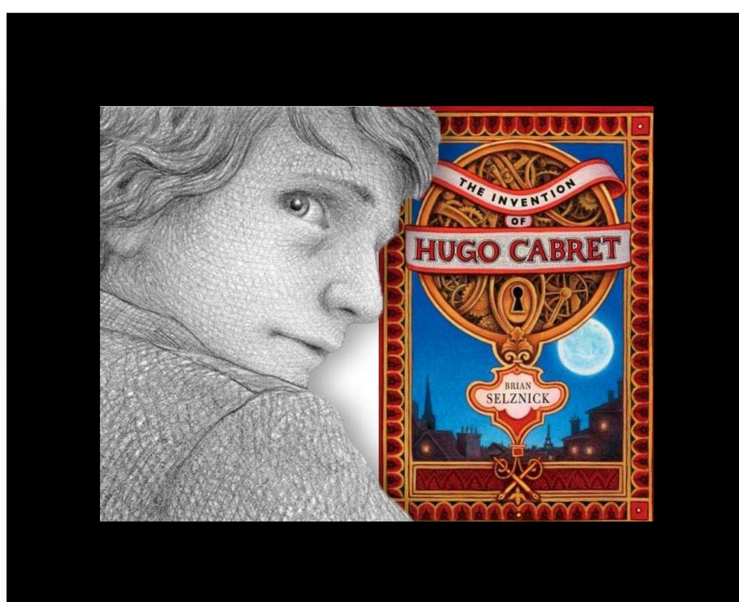
be seen operating in Neuchatel, Switzerland, more than 240 years after their construction.

Soon, inventors started putting automated machines to work to make their lives easier. A French silk cloth weaver built a loom in 1801 that automatically created patterns as it wove thread into cloth!

In 1822 English mathematician Charles Babbage used punch cards (a card with holes punched in it that gives directions to a machine or computer) in his Analytical Engine, one of the first mechanical calculators. His friend Lady Ada Lovelace designed a series of steps which would make Babbage's engine solve certain math problems. Her work is considered the world's first computer program. And in 1898 in New York, the electrical pioneer and inventor Nikola Tesla showed off the first remote-control device: a mechanical boat controlled by a radio transmitter.

The Illusion of Life

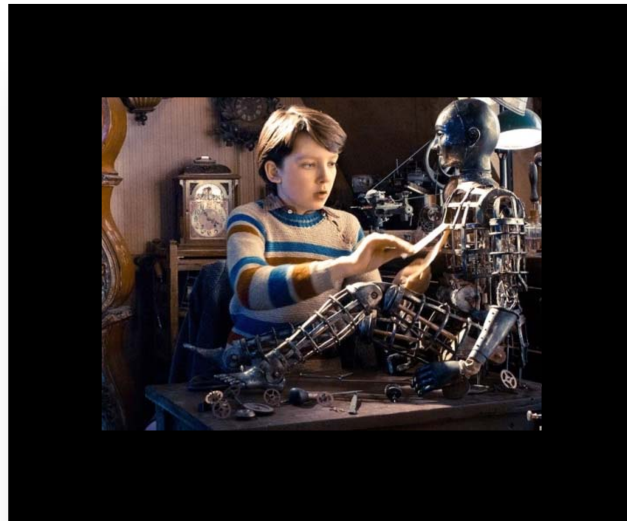
To illustrate this topic show sketches from the book *The Invention of Hugo Cabret* and watch short clips from the film version of *Hugo* – This was a beautifully designed film about old styles of film making and a very cute little boy who could make clockwork things and repairs an amazing automaton (mechanical man) that doesn't work without a special key. Maillardet's real-life automaton helped inspire the one in the movie.



Mr. Selznick was inspired, in large part, by the machine at the Franklin Institute. While working on the book he learned that Georges Méliès, the early French filmmaker who is central to the story, had a collection of automatons that was eventually thrown out.

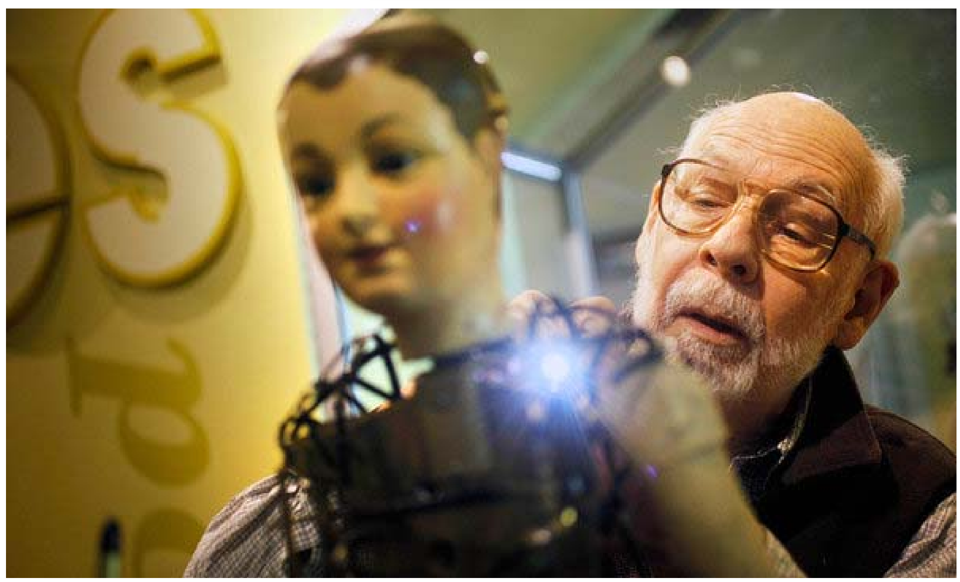
Mr. Selznick knew little about the machines. An Internet search turned up references to the Franklin Institute's automaton.

"When I called, that's when I was informed it had broken many years earlier," he said in an interview. "And that it was in the basement and out of view."



When Mr. Selznick visited, the Maillardet automaton's head was off, and it could not actually write or draw. But Mr. Penniman was able to wind it up and show him how things moved, and how all the gears and cams worked. "It feels like Charles has this very personal friendship with the automaton," Mr. Selznick said.

Mr. Selznick was also instrumental in getting the machine repaired, by Andrew Baron, a designer of pop-up books and restorer of vintage mechanisms in Santa Fe, N.M.



Charles F. Penniman, a retired museum employee, gently tended to the automaton.

Mr. Baron came to the museum for several weeks in 2007 and set to work. What makes an automaton tick? For the one on display at the Franklin Institute here, the answer is: a couple of hefty spring motors. The automaton, a mechanized doll built more than two centuries ago by the Swiss watchmaker Henri Maillardet, uses the power from the wind-up motors, carried through linkages to its right arm, to write and draw.

But it is what's between the motors and the arm that makes the two-foot-high Maillardet automaton seem like more than a machine. A stack of rotating brass cams precisely control the arm movements. As steel levers follow hills and valleys cut into the edges of the rotating disks, the arm moves smoothly along three axes — side to side, to and fro, up and down.

In essence, the disks are its read-only memory, giving the automaton a repertory of three poems — two in French and one in English — and four drawings, including one of a Chinese temple.

To repair it Mr. Baron took apart some elements of the mechanism, had a crucial replacement part produced by the museum's machinist, and oiled and adjusted the rest. The automaton, which sits, unclothed, in a glass display case as part of the museum's permanent "Amazing Machine" exhibition, is now in working order, although it is demonstrated only rarely.

INTRICATE Charles F. Penniman oversees the movement of the automaton's many cams, which function as its read-only memory.

When it is operated, museum staff treat it with kid gloves, using a block of aluminum to delicately set the hand and its pen (the original writing instrument is unknown; it was lost long ago) in the proper position over a small piece of paper. Once wound up and turned on, the machine whirs into action, producing a drawing or poem in about three minutes. Each requires multiple cams, and trouble can arise when the machine has to move the whole stack, by only an eighth of an inch, to shift cams. If all goes exceedingly well, it will automatically begin another drawing or poem shortly after finishing the first.

Automatons of this type were exhibited by makers of fine watches as advertising and public relations tools to build exposure to their wares. . Early-19th-century audiences would have been astonished by the lifelike movements.

No one knows exactly how they were made—trade secrets were common at the time—but the precision of the work is remarkable. The pieces that date from that period were the pinnacle of complexity. There was an extreme amount of hand labor that went into them.

It's hard to get a very lifelike, fluid motion of a simple arm movement or hand movement without becoming jerky but they did it brilliantly.

Mr. Penniman said he first understood how extraordinary the machine was when he studied the movements encoded by the cams. "I said, 'Oh, it did geometry—x, y and z axis,' " he recalled. But then he realized that it was not so simple: If Maillardet wanted the automaton to draw a straight diagonal line, for instance, he had to encode the cams to move the arm back while it was moving side to side — otherwise it would draw an arc.

“How do you think that through?” Mr. Penniman said. “Yes, you’re a clockmaker, and yes, you’ve had that experience. But this is a lot more complicated.”

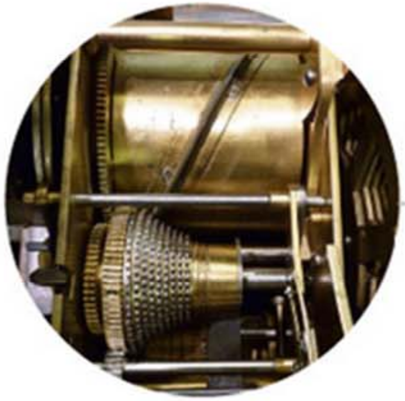
Even more remarkable for Mr. Baron, the restorer in New Mexico, were the movements of the head and eyes, which are controlled by a couple of simpler cams.

“Maillardet could have had the head in a fixed position, the eyes in a fixed position,” he said. Instead, when the automaton stops writing briefly as the cam stack shifts, the head comes up and the eyes turn up and gaze out for a few seconds, and then lower as the hand begins moving again.

“In this moment, he appears to his audience as if he’s thinking about what is going to do next,” Mr. Baron went on. “It’s performance art.” Maillardet “created an illusion of life,” he said. “That, to me, is the real magic.”

Mechanical Memory

The Maillardet automaton's motions are controlled by dozens of slowly rotating brass disks. These disks contain all the data necessary for its lifelike movement and drawings — in effect, they serve as a mechanical form of read-only memory. Related Article »



1. The writing hand is powered by two clockwork motors. One turns a set of brass disks — or cams — arranged in banks of three dedicated sets. The other (shown above) moves the cam assembly left and right.

3. The styluses in turn drive a series of rods, providing motion. There is a separate stylus for each direction: forward and back, side to side and up and down.

2. Each of the writing hand's 72 cams has a pattern cut into its edge corre- sponding to specific arm movements. As the cams rotate, metal styluses read the data.

4. The head, eyes and left arm are con- trolled by an integrated mechanism that takes its cues from a pair of cams. The cams are operated by the same rota- tional motor as the drawing cams.

Photos by Frank O'Connell (motor); Darryl Moran/Franklin Institute (automaton); Jessica Kourkounis for The New York Times

Send Feedback

Source: The Franklin Institute

Lesson One K-8 Standards Alignment

K

K.6.01 e. Explain the consequences of an individual's decisions and actions.

K.6.01 b. Know that individuals choose jobs that impact their lives, families and communities.

K.6.02 b. Understand that cooperation is necessary when working within large and small groups to complete tasks.

These standards will be met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later. And how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

1

1.6.01 Understand the impact of individual and group decisions on citizens and communities.

1.6.02 c. Recognize that cooperation is necessary in working with a group to complete a task.

1.5.02 Understand the place of historical events in the context of past, present, and future.

These standards will be met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later. And how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

2

2.06.01 a. Describe how groups and individuals work independently and cooperatively to accomplish goals.

2.6.01 Recognize the impact of individual and group decisions on citizens and communities.

2.5.02 Understand the place of historical events in the context of past, present, and future.

These standards will be met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later. And how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

3

3.6.01 a. Give examples of conflict, cooperation and interdependence among individuals, groups, and/or nations.

3.6.01 Recognize the impact of individual and group decisions on citizens and communities.

3.5.02 Understand the place of historical events in the context of past, present and future.

These standards will be met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later. And how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

4

4.6.01 Recognize the impact of individual and group decisions.

4.6.01. b. Understand how individuals and groups work independently and cooperatively to accomplish goals.

These standards will be met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later. And how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

5

5.6.01 b. b. Identify examples of institutions (ex. museum) and describe the interactions of people with institutions.

5.6.02 a. Give examples of the role of institutions (ex. museum) in furthering both continuity and change.

These standards will be met and reinforced during the discussion of how the Franklin Institute was able to both preserve the past (inventions, culture, etc) and affect the current/future and connect individuals in the past and present. Ex. When Mr. Selznick visited he was inspired by the work of Maillardet, wrote a book, which led to a movie, which millions of people saw. But it also inspired and enabled Selznick to connect with Penniman and then Baron to have the automaton repaired by all working together.

6

6.6.02 c. Analyze group and institutional influences on people, events, and elements of culture.

6.6.01 Understand the impact of individual and group decisions on citizens and communities.

These standards will be met and reinforced during the discussion of how the Franklin Institute was able to both preserve the past (inventions, culture, etc) and affect the current/future and connect individuals in the past and present. Ex. When Mr. Selznick visited he was inspired by the work of Maillardet, wrote a book, which led to a movie, which millions of people saw. But it also inspired and enabled Selznick to connect with Penniman and then Baron to have the automaton repaired by all working together.

Students will also learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later, ex. robots, machinery, and computer programming—we are still learning from what they created.

And students will explore how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret*. We will discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.*

7

7.6.01 Understand the impact of individual and group decisions on citizens and communities.

7.6.02 b. Demonstrate an understanding of concepts such as role when describing the interactions of individuals.

These standards will be also met and reinforced as students learn about inventors and engineers of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals (each taking on an individual role that was both necessary and different from the other) and the consequences of their actions and the effects they had/continue to have on lives over 240 years later (ex. computer coding, robotics engineering, sculpture, etc., we are still learning from what they created.) We will also discuss how Mr. Penniman, Mr. Selznick, Mr. Baron, and the Institute all had to work together (all having different skill sets and resources) to accomplish their goal of repairing and reconstructing the work that Henri Maillardet had done over 200 years before.

And students will explore how Henri Maillardet's work started a chain of effects and connections to and between Georges Méliès, Mr. Penniman, Mr. Selznick, Mr. Baron, the Franklin Institute, and all the readers and watchers of The Invention of Hugo Cabret *and the visitors to the Institute.*

8

8.1.04 a. Identify specific technological innovations and their uses.

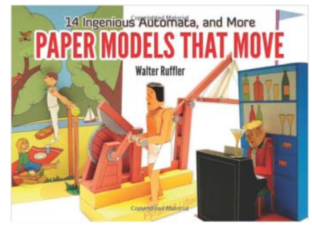
8.6.02 b. Describe the role of institutions (ex. museum) in furthering both continuity and change.

These standards will be also met and reinforced as students learn about inventors of the past, ex. Lady Ada Lovelace, Charles Babbage, and the work of inventor/artist and watchmaker Pierre Jaquet-Droz and Henri Maillardet. We will explore how Lovelace & Babbage worked together to accomplish their goals and the consequences of their actions and the effects they had/continue to have on lives over 240 years later (ex. computer coding, robotics engineering, sculpture, etc., we are still learning from what they created.)

These standards will be met and reinforced during the discussion of how the Franklin Institute was able to both preserve the past (inventions, culture, etc) and affect the current/future and connect individuals in the past and present. Ex. When Mr. Selznick visited he was inspired by the work of Maillardet, wrote a book, which led to a movie, which millions of people saw. But it also inspired and enabled Selznick to connect with Penniman and then Baron to have the automaton repaired by all working together. So the automata was both preserved and changed.

Lesson Two

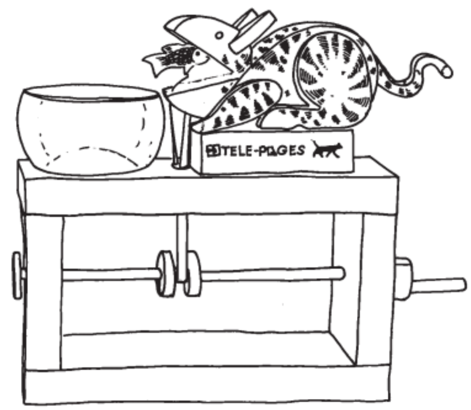
Cardboard Automata



For inspiration it may be helpful to look at and explore Karakuri and Automata books such as: *Making Simple Automata* by Robert Race, *Paper Models That Move: 14 Ingenious Automata, and More* by Walter Ruffler

An in-depth and fantastic resource is: *How To Design and Make Automata* by Robert Addams
http://www.smithstudents.com/New_Archive_MAKE_files/How_to_make_automata.pdf

Activity instructions and images via: Things to Try: Cardboard Automata PIE Institute: www.exploratorium.edu/PIE This material is based on work supported by the National Science Foundation under Grant No. ESI-04-52567.



Automata, or kinetic sculpture, is quite simply art and science that moves. Even the most complicated seeming ones are actually made up of very straightforward bits and pieces.

To get, and give students a view behind the scenes of creating automata, have them watch: Making the Don Quixote Automaton with Keith Newstead -- Smart TV at https://www.youtube.com/watch?v=mnb9vPOf-0k

Cardboard Automata are a playful way to explore simple machine elements such as cams, levers, and linkages, while creating a mechanical sculpture. This activity was inspired by the Cabaret Mechanical Theatre, a group of automata builders based in England. Artists like Paul Spooner, Keith Newstead, and Carlos Zapata build beautiful narrative pieces using elegant mechanisms based on cams, gears, springs, and linkages. Working with simple materials, this activity is easy to get started, and may become as complex as your students’ mechanical sculpture ideas. And as they tinker, they can learn (and actually see) just how many different solutions there are for the same problem as they build a physical representation of their line of thought and inquiry.

TIME TO TINKER

Tips and Suggestions:

*This activity was developed by staff at the Exploratorium and they have continued to 'tinker,' and come up with new designs and examples of how to create motion, changed some of the "common" motion models and added some new ideas to the mix. Each new example is directly the result of them spending time on the floor facilitating the activity. It is **highly** recommended you go to http://tinkering.exploratorium.edu/2014/08/20/automata-examples to see further examples.*

In order to work well, not only has the box to be sturdy and fairly square, but the axles on which the cams and followers are inserted need to be centered and at right angles with each other, and some helpful tips have been included.

Pay attention to the size of the boxes. Experiment on your own to find a size that works well with the rest of the materials, and you might want to keep the size between boxes fairly consistent. If you can get 6"x6" boxes, cut off the flaps to make other parts, and slice each flat box in half; this way, you get two automata for each box.

Another crucial component is the "foamie", foam sheet material has just the right amount of friction and rigidity to work very well as both a cam and a follower, yet is easy to cut and shape with just scissors or exacto knives. They come in thin and thick varieties, and you will want, if you can, to get both: the thick ones you'll use for the cams, and the thin ones as decoration materials.

With Cardboard Automata, providing clear and easy to follow examples of different types of motion is crucial; you might want to set up [five] different examples, made with the same materials that you will provide to the students, that move:

- round and round
- up and down, and around
- up and down, back and forth
- straight up and down
- side to side

Try to demonstrate the motions in a way that is clear and easy to understand but doesn't give visitors direct instructions on how to build and leaves the activity open to new ideas and personal challenges. Encourage students to try out all the different examples, get a feel for the motion, and then chose one to build. The first three are easier to build, and accomplish a remarkable range of motion with minimal variations in cam placement and setup, and therefore can be combined in a more elaborate automaton. The last two are more complicated to build.

In addition, if possible, it's very helpful to have a small selection of examples of completed automata, that span the range of complexity and "achievability" from completely achievable with the materials provided and within the time frame and skill level of the participants, to more ambitious and meant to serve as inspiration more than as a model to follow. So play around with the activity ahead of time, and keep the more inspiring fruits of your labors as examples; as you do this activity with kids, you might want to be on the lookout for particularly inspiring products, and ask the kids if you can keep them to let other people learn and be inspired from their example.

By building automata yourselves, you will encounter most of the frustrating points that students are likely to run into, and will know how to get them unstuck without giving them a pre-packaged answer to the problem in front of them. Pay particular attention to little tips and tricks like: using little foam bushings at the end of axles to keep the skewer from sliding out; adding weights to the cam follower to ensure a smooth motion; the perfect length of straw that will keep the vertical axle in place while still allowing for the full range of motion of the automata; ways of drawing perfect circles other than using a compass, like tracing round objects of various sizes that you might have around (yogurt cups, the inside and outside of masking tape rolls, etc.)

Once you have the "technical" side of construction down, you will probably find that quite often the most difficult thing to facilitate is the transition between the problem-solving oriented mindset involved in construction, and the creative and expressive mindset required for the next phase: what to make this automata do!

Here, a good selection of materials will prove very valuable: try to shy away from materials that are purely decorative – like crayons, markers, glitter, etc. – because they often end up disengaging kids from the construction aspect of the activity and plunge them into pre-existing play patterns like doodling, coloring, etc. Nothing wrong with that, but the value of this activity is in constructing a physical solution and expression to an idea you have in mind, and so keep your materials palette limited to things that you have to "do something to" in order to use them.

The first thing you'll want is a funny idea.

What makes an automata "good" is very subjective. We all like different things and we don't all find the same thing funny. As the saying goes " You can't please all of the people all of the time." So where do you start. The check list below gives some simple suggestions against which to test your ideas.

1) Is it visually exciting?

2) Is it funny?

3) Will it intrigue the viewer?

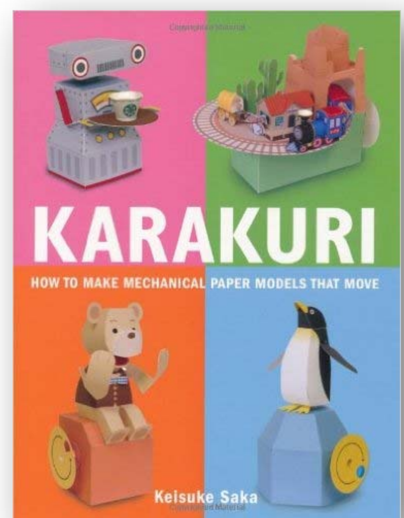
4) Will it hold the viewers attention for at least a minute?

5) Is it too complex?

6) Is the humor too obscure?

7) Will I enjoy making it?

This is just a general check list and is by no means a full proof system for producing the perfect automata, but it does help to weed out good ideas from the bad. As a general rule at the start, it may be a good idea to encourage students to base ideas on something that they are interested in such as a sport, a hobby, etc. Animals can provide a wonderful subject on which to base a theme for an automata.
As with any creative process, coming up with the idea is often the hardest part of the whole process. You may on the other hand be lucky and be brimming with ideas. But it's probable fair to say that most people have to work hard at the inspirational or ideas stage.



TRY IT! Collect these things:

- Cardboard boxes 15x15cm (6"x6")
- Scissors
- masking tape
- nail or screw,
- drinking straws
- hot melt glue
- glue gun
- skewer stick
- thick (6mm) craft foam
- nut or washer (optional)
- materials for decoration
- thin (2mm) craft foam
  markers/pens
- feathers
- pipe cleaners
- RobIves.com
- Printer Paper

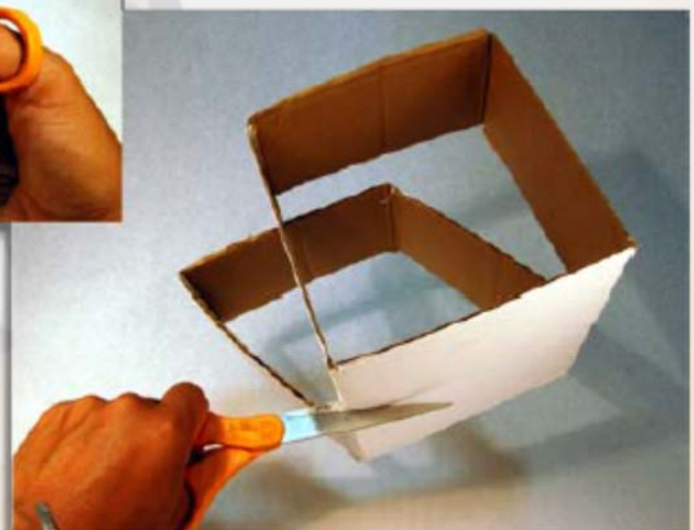
robives .com
Designing Paper Animations

- White Cardstock
- Books such as *Karakuri*
- Scissors
- Tape
- Craft/Tacky Glue

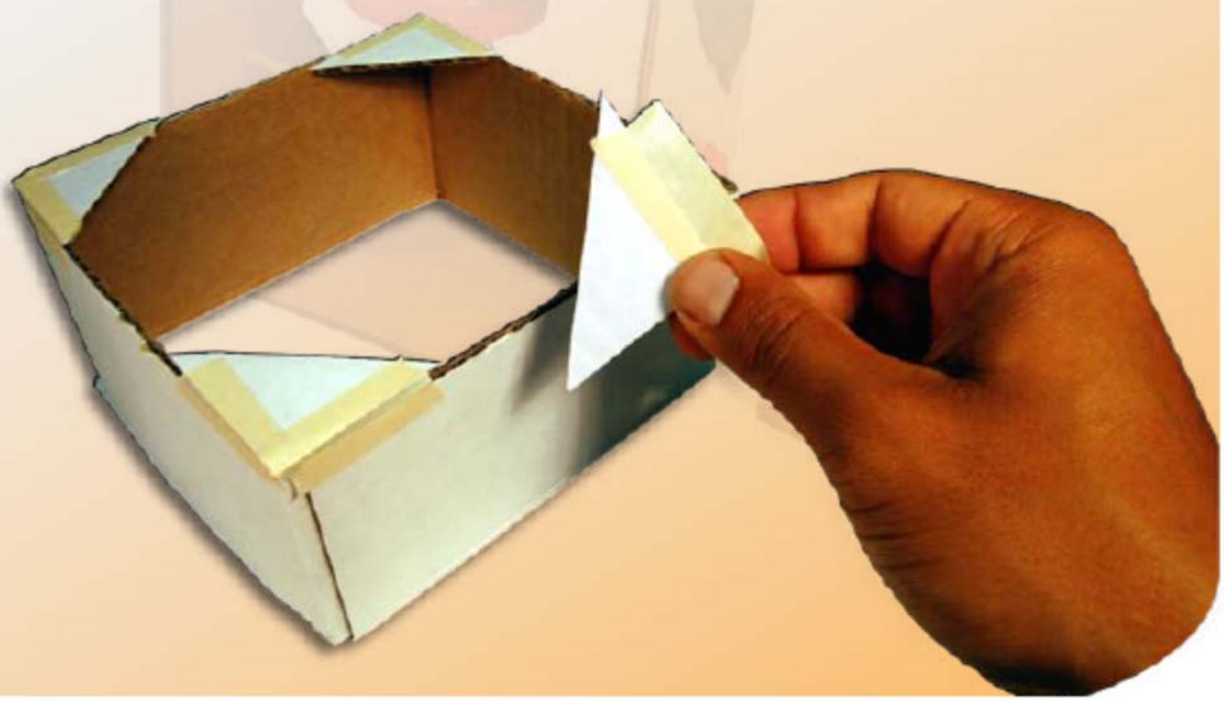
Real World Artist: Peter Markey is an artist who often makes whimsical automata out of wood, utilizing cams and cam followers as his main source of movement.
www.focsle.org.uk/first/markey & www.cabaret.co.uk/artists/markey/htm

MAKE A FRAME

Cut the flaps off the box,
then cut the box in two pieces
(you get two frames from each box)

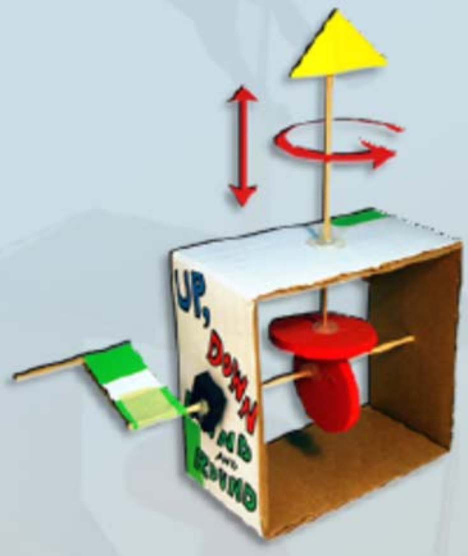


Cut triangles out of the flaps and tape them into each corner of the frame for support.

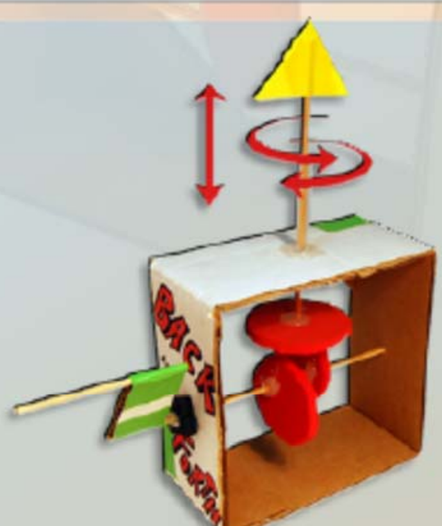


Choose a Motion

Round and Round

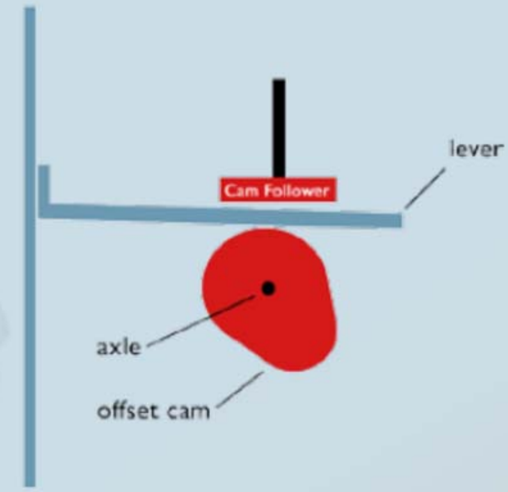


Up and Down,
Round and Round

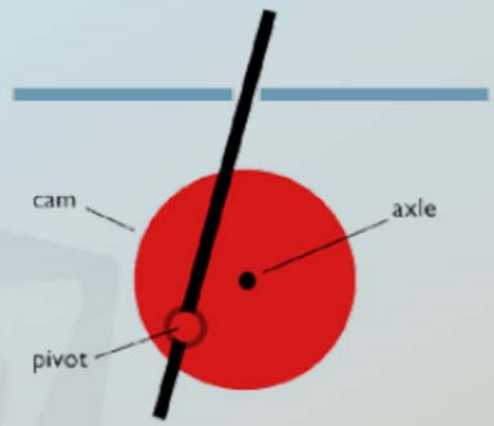


Up and Down,
Back and Forth

More Options

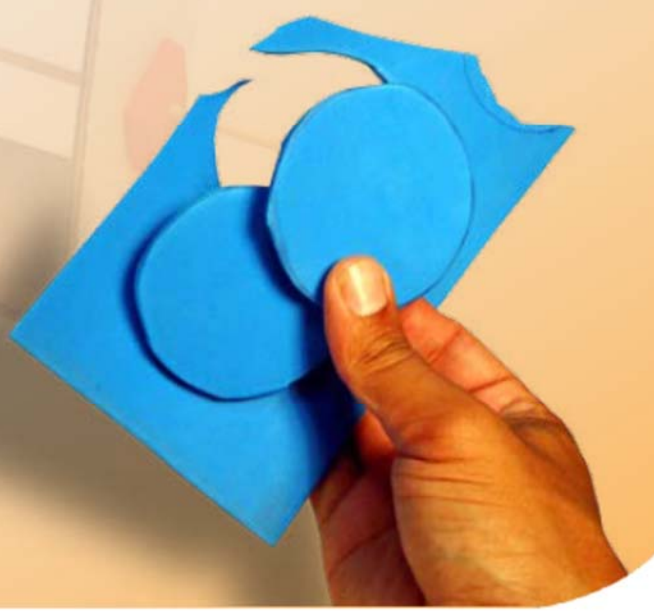


Up and Down



Side to Side

MAKE THE CAMS



Draw your cam and cam follower on the thick Foamie sheet, and cut them out.

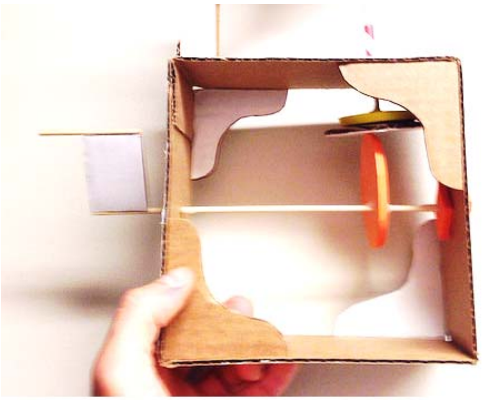
The cam should be about 2.5" (6cm) in diameter.

Tip: Cut the cams smoothly, and make sure the cam follower is a little bigger than the cam.

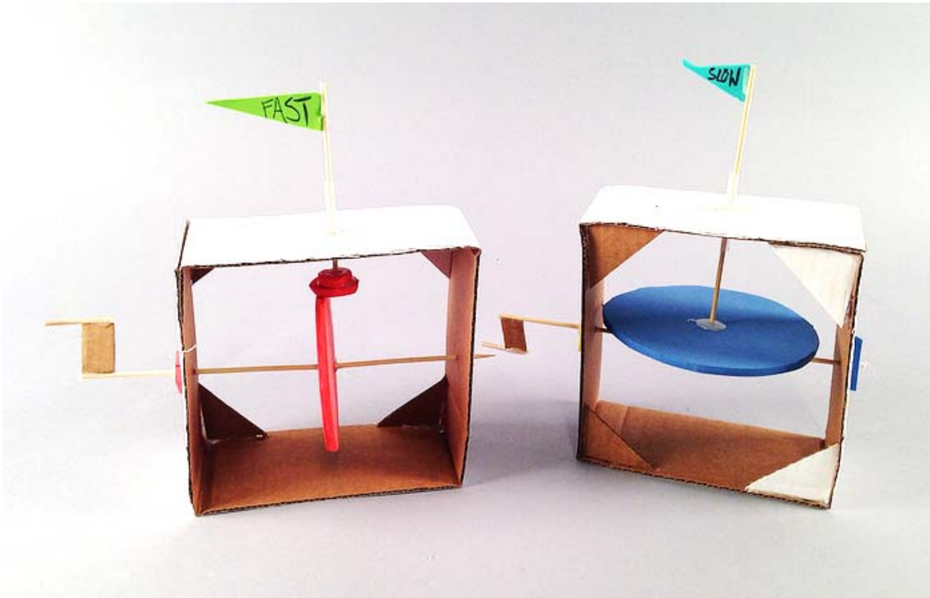
More Options

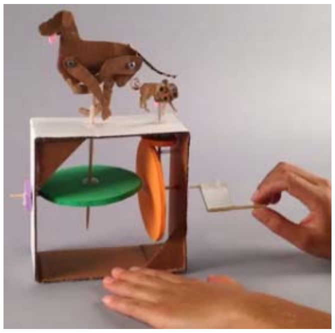
Right: A different version of the "up and down" mechanism using curved cardboard cam follower that moves up and down with the off-set cam but doesn't spin because of the flaps.

Below: A different method of removing the spin. A little cardboard circle keeps the cam follower touching the top piece but is not directly connected.



Another new addition to our set of examples explores how to make the motion of the automata fast or slow. By changing the relationship of the size of the cam to the size of the cam follower, you can adjust the speed at which the top piece spins. These examples are a little extreme but serve to demonstrate the principle.



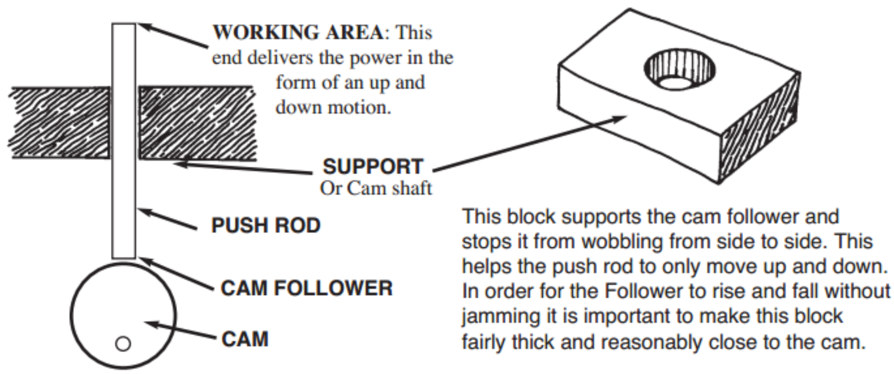


The Tinkering Studio ended up using the idea of the simple example to make this beautiful and funny automata with two dogs "chasing their tails" at different speeds. The addition of springs to the cam followers also really gives the dogs' motion a lot of personality. (Watch the video here: http://tinkering.exploratorium.edu/2014/08/20/automata-examples)

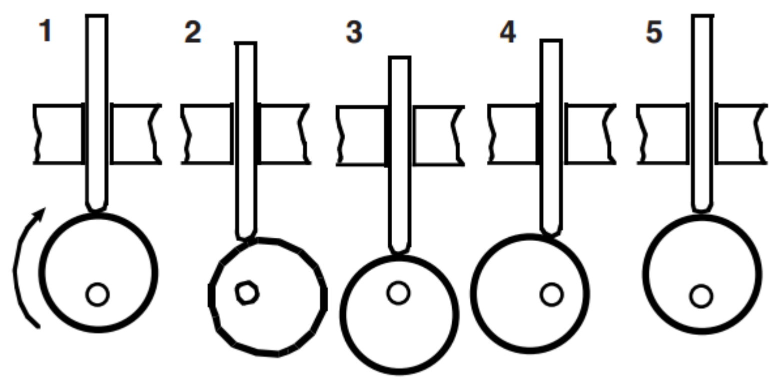
CAMS

Cams act like small computers, storing information that can be turned into movement. They can be very simple or complex and the only limitation is their size.

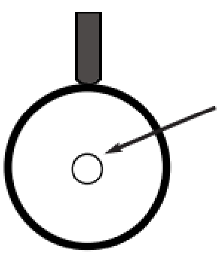
The basic principle of the Cam is to turn a circular motion into a linear one. This is referred to as reciprocating movement. In automata the cam is very useful, and is probably the most commonly used mechanical action. As you will see, the Cam is simple to make and very versatile.



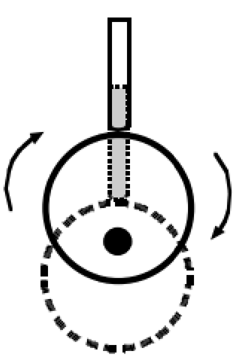
Cams normally work in conjunction with a "Cam Follower". As the name implies this follows the movement of the cam and transfers the movement to the working area. The cam follower is normally a rod made of rigid material such as wood or metal, which is supported by a shaft that limits the movement and direction. The cam follower is designed with a smooth end that can easily follow the cam's movement. This is a very important as the Cam and Follower will jam if not properly designed.



This cam is turning a circular motion into an up and down one. This is referred to as reciprocating motion. As you can see in stages 1-5, the cam follower steadily drops before rising up again. The whole process repeats as long as the cam keeps rotating clockwise.



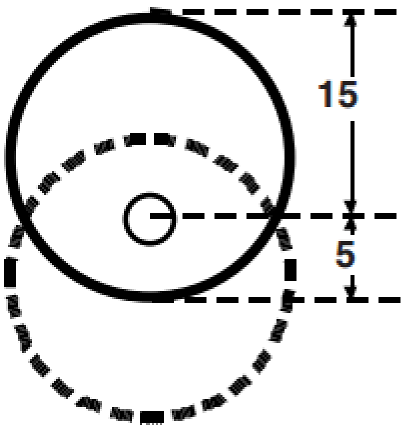
A circle with a shaft running through its centre will simply turn and produce no lift.



Offset the centre and you have made a cam.

The cam follower has lifted by this amount. So the more you off set the cam, the greater the amount of lift you produce.

In order to design a cam you need to know what you want it to do. It may have just one or several movements per revolution. Cams turn on a shaft and so need to be offset to create movement. If you have a circle with the shaft running through its centre then nothing happens. However, if you offset it you can create a mechanism that can lift. With this lift you can create many marvellous automata.



15 - 5 = 10

It is very simple to calculate the amount of lift by simply taking the measurement from the centre of the drive shaft to the lowest point of the cam and subtracting this from the measurement to the highest point from the centre of the shaft. This calculation will give the amount of lift the cam will produce.

This simple equation will enable you to work out how much lift a cam will give. Later on we will come back to this formula to accurately work out the lift of any given cam.

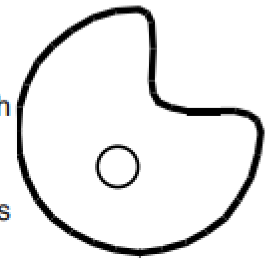
LOBED AND DROP CAMS

From the basic round cam you can increasethe diameter across one axis, to produce an egg-shaped, or “Lobed”, cam. Alternatively, you can create a recessed area that drops below the circumference of the circle, producing a “Drop” cam. You can, of course, combine these two elements in a cam, which is why they are so versatile.

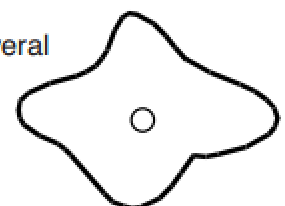
THE LOBED CAM

If you raise part of the circumference, you produce a lobe, hence the name lobed cam. This will lift the cam follower by the maximum height from the tip of the lobe to the circumference of the circle. When the cam follower returns to the circle it will pause and this is referred to as the dwell angle. You can produce a pause or dwell angle on top of the lobe if you design it properly

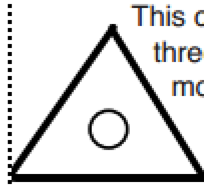
Different types of cam



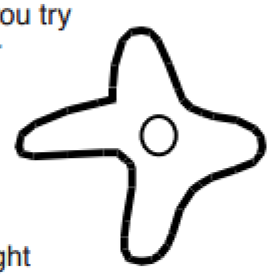
This cam produces a smooth uplift which suddenly drops down. It is often referred to as a snail cam because of its shape or contour. This cam can only work in one direction. If you turn it the other way the cam follower would jam. You need to bear this in mind when you are designing cams.



This cam produces several short up and down movements from one revolution.



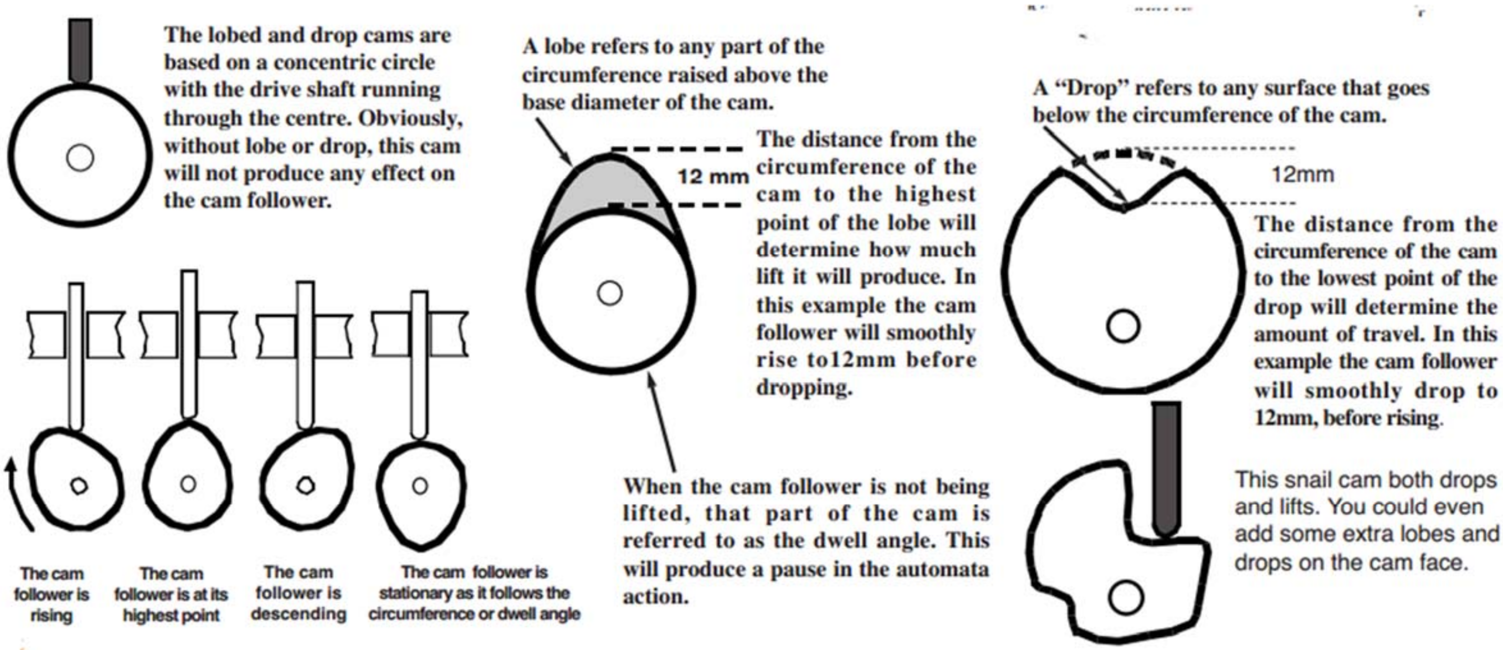
This cam produces three very distinct movements from one revolution.



You can combine as many movements as your cam will allow. Remember that the cam follower has to work smoothly. If you try to make it do too much or make the contours too steep such, as this one on the right, it will jam. The cam followers can only move on gentle curves. Make them too tight and you will have problems!

THE DROP CAM

If you dip below the circumference of the circle then the cam follower drops, hence the term drop cam. You can calculate the drop of the cam by measuring from the lowest point of the drop to the circumference. A very popular form of drop cam is called the snail cam. This has a sudden drop that slowly rises to the next drop point. This cam is used a lot in automata and is a blend of both drop and lobe cam.

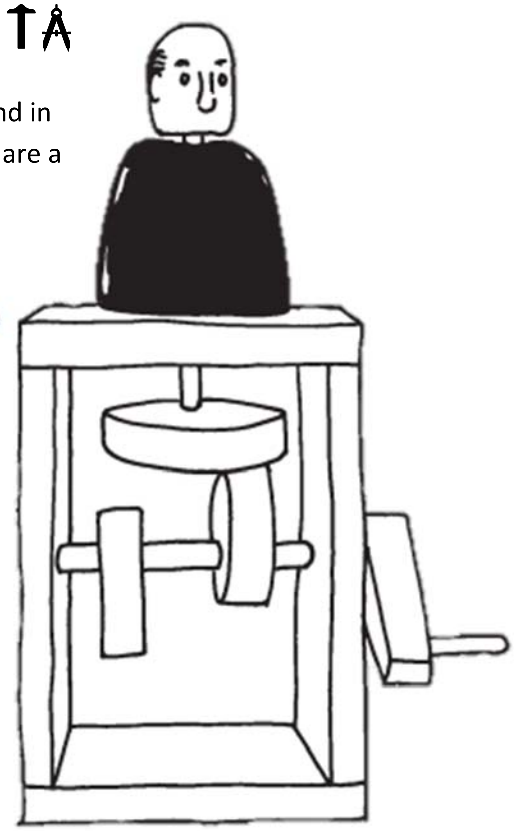


SPECIALITY CAMS FOR AUTOMATA

The cams covered so far are fairly simple. They are the sort that can be found in many everyday machines like car engines and washing machines, but there are a range of more unusual cams that can be used for added versatility or sophistication when making automata. They are, in themselves, very simple but may require more skill when making them.

For example, an offset cam not only moves things up and down but also in a circular motion. You must make sure that the cam contacts the cam shaft drive plate either side of the cam shaft.

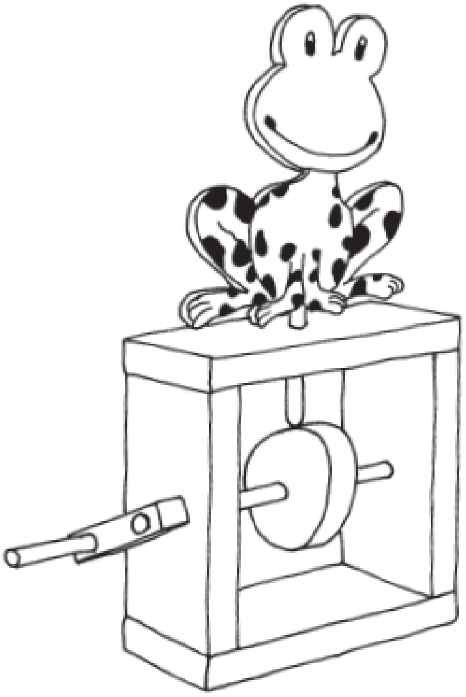
If it contacts directly underneath then it will only lift. Offsetting 2 cams either side produces movement in opposite directions. This then gives you both up and down as well as a side to side movement.



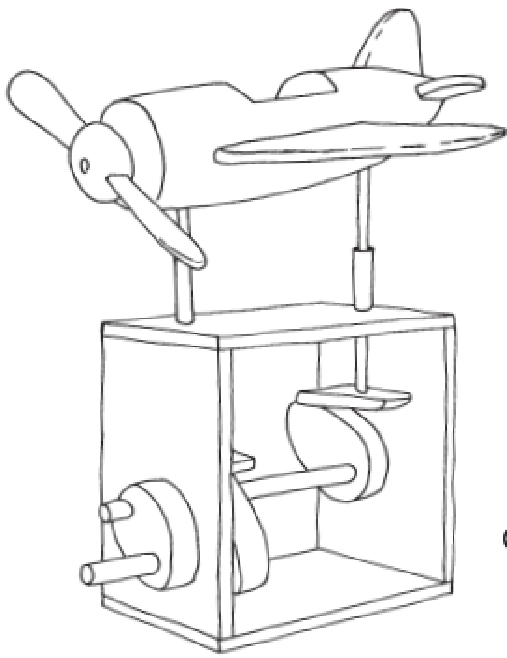
The man in this automata shakes his head from side to side. There is a small amount of lift but it is not really noticeable.

CAMS FOR AUTOMATA

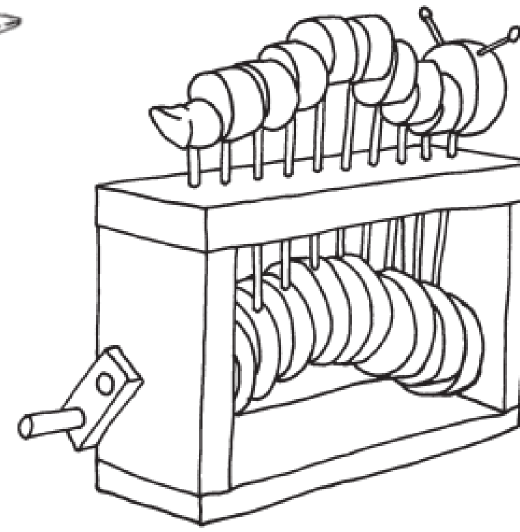
The examples below show how you can use the cam when it comes to making automata. The key point to make in mechanical terms is that it produces a linear movement from a rotating input and you can create an enormous amount of things with this. The illustrations below show a range of uses for simple one lobe cams.



FROG - USING A SINGLE LOBE CAM.
This will produce a single, smooth up and down movement.

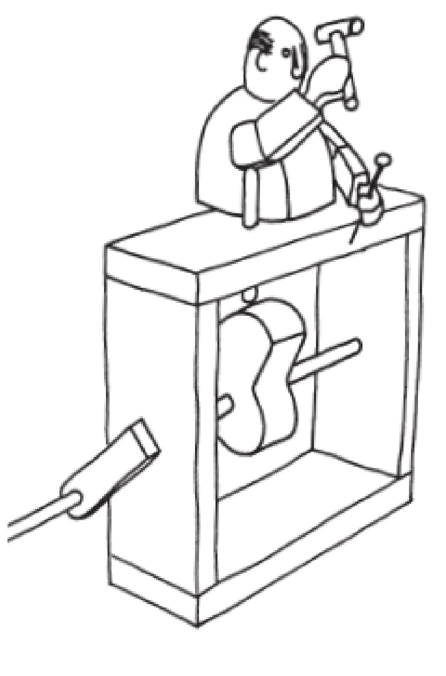


AEROPLANE - USING TWIN LOBE CAMS.
The two cams are at opposite ends and are set at 180° to each other. This causes the plane to dip up and down from nose to tail..

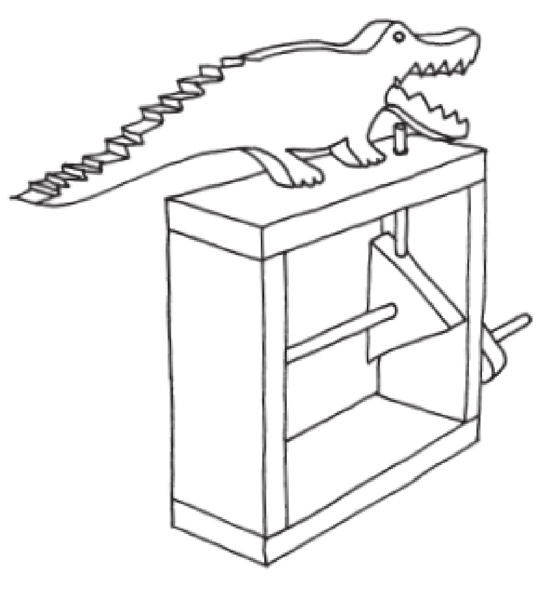


CATERPILLAR - USING MULTIPLE CONCENTRIC CAMS.
Each cam is slightly offset from the preceding one. This gives a smooth, wriggling motion.

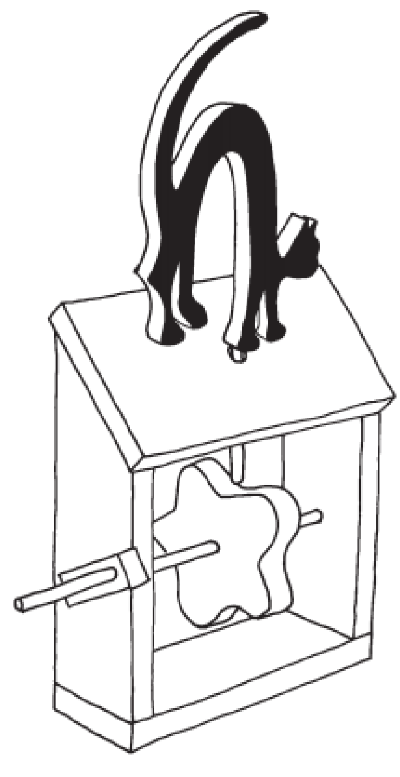
Cams can often have more than one lobe. Multiple lobe cams produce even more diverse and exciting movement.



This drop or snail cam allows the hammer to rise smoothly and then suddenly drop.



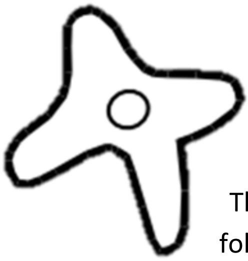
This pointed triangle will produce three equal sharp movements in one revolution, snapping the jaws open and shut.



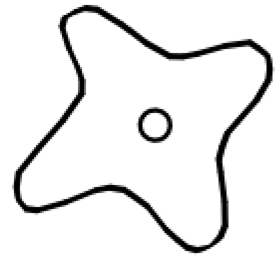
This cam has five lobes, one of which is higher than the rest. The cat will make four small jumps and then one big one.

DESIGN TIPS

When designing a cam, think about it creating a performance or event in one revolution. This can be simple or complex. Remember to use gentle curves to allow the cam follower to operate smoothly. If you design a cam that produces several events you may need to make it bigger.



The designer of this cam wanted to create 4 up and down movements per revolution. This design would probably jam and not function properly.

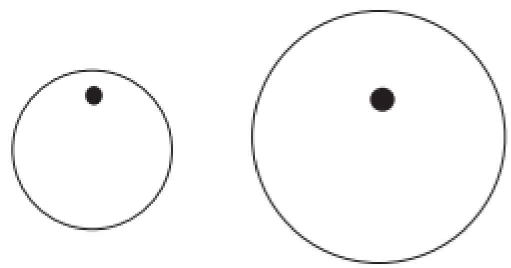


This bigger cam will do the same job, but now the cam follower is able to follow the contours as they are more gradual. It will still produce 4 varying up and down movements per revolution.

MAKING AND MEASURING

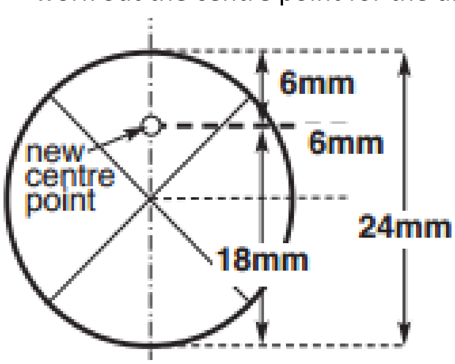
This final section on cams shows students how to use a simple mathematical formula to work out the lift for concentric cams.

The concentric cam, is a circle with an offset centre. By offsetting the centre we are able to produce the lift and the further you move away from the centre point the greater the amount of lift you produce. Do not overdo things, it is better to make a larger cam that rises gently than a small one that rises rapidly. They will both do the same job but the smaller cam is more likely to jam.



Both cams lift by the same amount but the larger circumference of the bigger cam will produce a much smoother lift. As a rough guide, try to make the biggest cam that will comfortably fit into your Automata.

When making Automata, we need to work things out fairly accurately. This applies to cams when you need to produce lift to a specific height. The following formula is very simple and shows you how to quickly and accurately work out the centre point for the drive shaft.

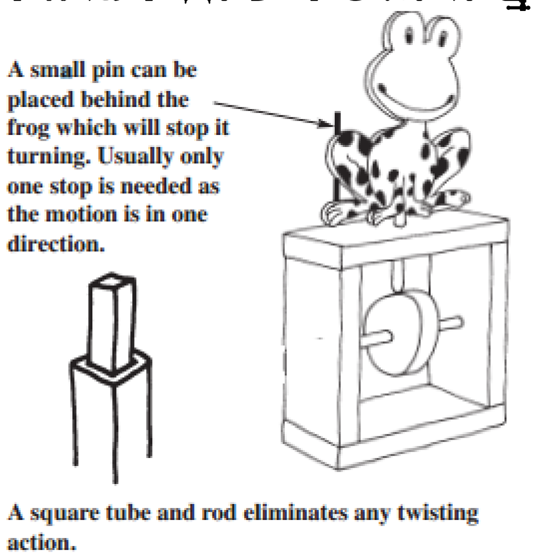


For every millimetre that you move away from the centre point, you must double this figure, in order to calculate the amount of lift generated by the cam.

In this example you can see that the centre point has been moved up by 6 mm which will produce a lift of 12mm. Students can confirm this by using the formula we looked at earlier by subtracting the two distances from the new centre point 18mm - 6mm = 12mm

It’s as simple as that. Remember you only have to accurately locate the centre point. The actual diameter of the drive shaft is not important.

TWIST AND TURNING



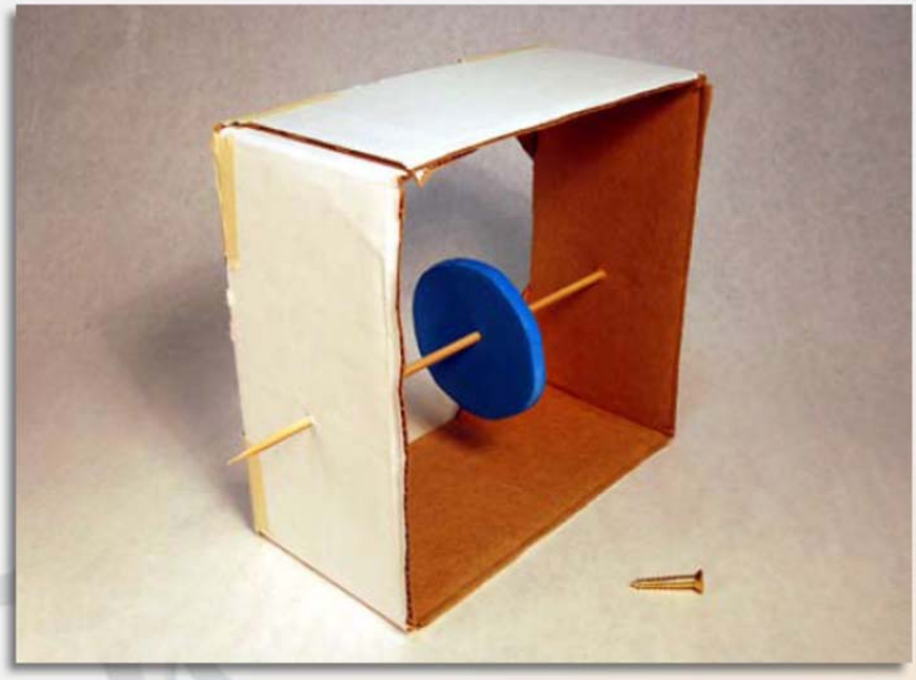
A rather annoying characteristic of the cam is that it produces a turning motion on the push rod. This may only be very slight but can cause problems. The leaping frog for instance slowly turns round as it moves up and down, which in some instances could be a problem.

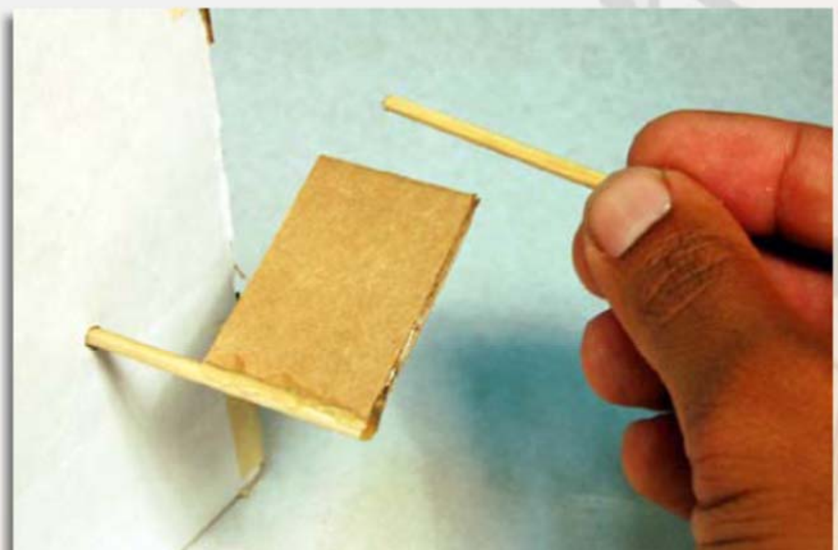
To eliminate the turning affect you can either build stops (ex. put a pin behind the frog) to prevent turning, (this can affect the overall look of your automata) or another method is to use square tube and rods. These hold the push rod firmly in place and eliminate any turning action.

Make the Axle

Put your cam on a skewer stick inside the frame.

Tip: Start the holes in the frame using a nail or screw, and make sure the cam clears the top and bottom of the frame.





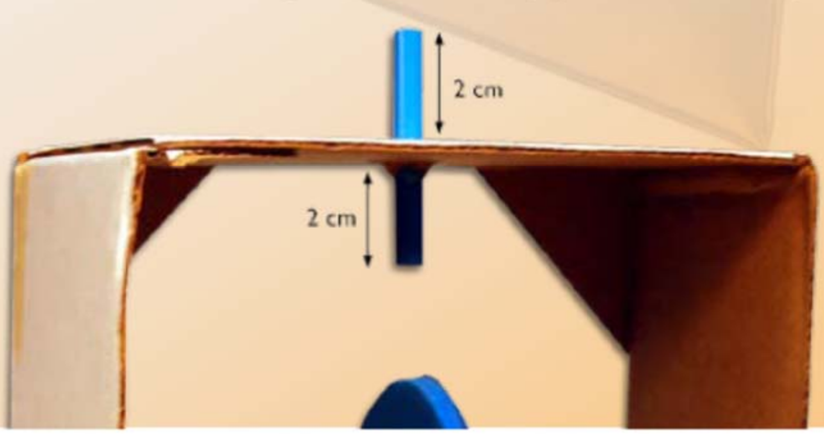
Make the Handle

Glue a small rectangle cut from the cardboard box flap to the skewer stick axle.

Glue a second piece of skewer stick to the end of the rectangle to make a handle.

Add the Cam Follower

Poke a hole in the top of the frame where you want your cam follower to be located, and insert a drinking straw. Carefully glue the drinking straw in place.



Tip: Use a pencil to make the hole large enough for the drinking straw.

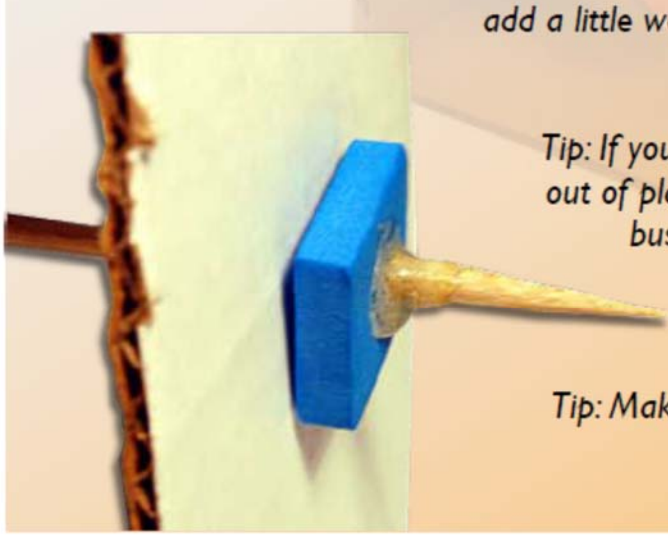
Glue your cam follower on the end of a skewer stick and put it through the straw.

Tip: The straw will keep the skewer stick from falling over.

Test it!

Adjust your cam under the cam follower until you get the motion you like, then GLUE the cam into place on the skewer stick axle.

Tip: If the cam follower does not fall on the cam, attach a washer or nut to add a little weight.



Tip: If your cam and axle move out of place, add a small bushing made from a scrap piece of a thick Foamie.

Tip: Make sure to glue the bushing to the axle and NOT to the frame.

Decorate your automata

Using cardboard, paper, pencils, foam, tape, glue, and whatever comes to hand…make your automata come to life!

Expanding this activity

If you offer this activity repeatedly, or over a long period of time, you may want to start expanding the materials palette, and add some other elements that deepen the experience. Here are some ideas to play with:

- Radically change the scale of the automata. Cardboard comes in great big sizes; what would it be like to make an automaton the size of a refrigerator box? This could be a great collaborative project for all the kids to work on together, figuring out how to make a box of that size stable, what materials to use for cams and followers, and how to operate the whole contraption. On the other end of the scale, could you make automata that are very tiny, for example fitting in a match box?

- Change the materials used for construction. Wood is a prime candidate for an alternative, but you can think even more laterally: what about scrounging for parts that can be adapted from the local dump, or recycling centers? Or you might decide to take apart a machine, like a typewriter, and make automata using parts salvaged from that. Or use food!
- Add technology. Perhaps the PicoCricket: a tiny programmable computer that can greatly expand the realm of possibilities by adding sensors, displays, and motors that can be programmed to respond to inputs and interact with each other. One initial project might be to make a coin operated automaton!

Lesson Two K-8 Standards Alignment

K

- 7.11.1a Explore different ways that objects move.
- 7.11.1b Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced as students participate in imagining, designing, building, testing, redesigning, and reconstructing their automata.

1

- 7.11.1 Use familiar objects to explore how the movement can be changed.
- 7.11.2 Investigate and explain how different surfaces affect the movement of an object.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, redesigning, reconstructing and then decorating their automata.

2

- 7.T/E.2 Invent designs for simple products.
- 7.T/E.3 Use tools to measure materials and construct simple products.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata.

3

7.T/E.3 Identify appropriate materials, tools, and machines that can extend or enhance the ability to solve a specified problem.

7.T/E.5 Apply a creative design strategy to solve a particular problem.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. As students encounter challenges to getting the motion or design they envisioned to work they will have to choose materials they feel would work best (test them) and redesign cams and other parts to meet their needs. They can get inspiration from those that have been designed by other inventors, branch off from them, or come up with a completely new design and test it out.

4

7.11.4 Demonstrate how friction affects the movement of an object.

7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. Different materials, shapes, and designs of cams, for example, will affect how their automata moves (ex. increase or decrease friction.) We will discuss how increasing and decreasing friction (through smoother/rougher surfaces, etc) will change their automata's motion in ways they may or may not like. As they build and test and watch the motion change they will have to determine what factors are causing the effects.

5

7.T/E.5 Apply a creative design strategy to solve a particular problem.

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. As students encounter challenges to getting the motion or design they envisioned to work they will have to choose materials they feel would work best (test them) and redesign cams and other parts to meet their needs. They can get inspiration from those that have been designed by other inventors, improve and branch off from them, or come up with a completely new design and test it out.

6

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. As students encounter challenges to getting the motion or design they envisioned to work they will have to choose materials they feel would work best (test them) and redesign cams and other parts to meet their needs. They can get inspiration from those that have been designed by other inventors, improve and branch off from them, or come up with a completely new design and test it out.

7

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. As students encounter challenges to getting the motion or design they envisioned to work they will have to choose materials they feel would work best (test them) and redesign cams and other parts to meet their needs. They can get inspiration from those that have been designed by other inventors, improve and branch off from them, or come up with a completely new design and test it out.

8

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in imagining, designing, building, testing, reconstructing and then decorating their automata. As students encounter challenges to getting the motion or design they envisioned to work they will have to choose materials they feel would work best (test them) and redesign cams and other parts to meet their needs. They can get inspiration from those that have been designed by other inventors, improve and branch off from them, or come up with a completely new design and test it out.

Sample Academic Vocabulary Guide

K

- Picture Book
- Sort
- Shapes
- Job
- Parts
- Observe
- Collect
- Position
- Senses
- Tools

1

- Past
- Present
- Future
- History
- Invent
- Sequence
- Technology
- Measure
- Property

- Push
- Pull

2

- History
- Decision
- Qualifications
- Main Idea
- Message
- Investigate
- Discussion
- Outcome

3

- Tools
- Area
- Conclusion
- Opinion
- Organization
- Force
- Cause
- Effect
- Character
- Conjecture
- Setting

4

- Audience
- Compare
- Contrast
- Drawing conclusions
- Pattern
- Chance
- Accuracy

5

- Point of view
- Personification
- Main ideas
- Solution
- History

6

- Sequential
- Personification
- Point of view
- Control
- Criteria
- Design constraint
- Cause and effect

7

- Interaction with texts
- Viewpoint
- Function
- Property
- Simple machines
- Speed

8

- Human impact
- Sensory
- Reliability
- Product
- Variation
- Solution
- Function

Sample Supply List for Robots Part Two, The Illusion of Life

Lesson One

- Access to videos & book
- Option: Printout of the Writer design [Mechanical Memory sheet]

Lesson Two

- Access to video links
- Karakuri book
- Rob Ives website
- Cardboard boxes, ex. 15x15cm (6”x6”) or cardboard that can be made into this size
- Scissors
- masking tape
- nail or screw,
- drinking straws
- hot melt glue
- glue gun
- skewer stick
- thick (6mm) craft foam
- nut or washer (optional)
- materials for decoration
- thin (2mm) craft foam markers/pens
- feathers
- pipe cleaners
- RobIves.com
- Printer Paper
- White Cardstock
- Scissors
- Tape
- Craft/Tacky Glue

ROBOTS

Lesson One

Part Three: Building Trust

What Is on Your Mind?

While *automatons* were busy entertaining the general population, and helping work get done other inventors were developing concepts and ideas that would help modern robots think and react. Research into the first computerized robots began after World War II. In 1948, mathematician Norbert Wiener wrote a book called *Cybernetics* in which he compared the way that people and machines worked or functioned. He found that people and machines have a few things in common. Namely, feedback (information about the result of an action that is sent back to the person or machine that did that action), communication (sharing information with another person or machine), and control to make decisions and take action.

In 1950, computer scientist Alan Turing came up with what he called, not surprisingly, the Turing test to see whether a machine was able to think like a human. It was a series of questions to test whether a computer can think like a human being.

> **Did You Know?**
>
> In 1959, the Massachusetts Institute of Technology [MIT] opened a laboratory to study artificial intelligence, which is the ability of a machine to act as if it thinks like a human. MIT is still a leader in robotics research today.

What was a passing grade? The computer had to fool people into thinking they were talking to a real live [human] person.

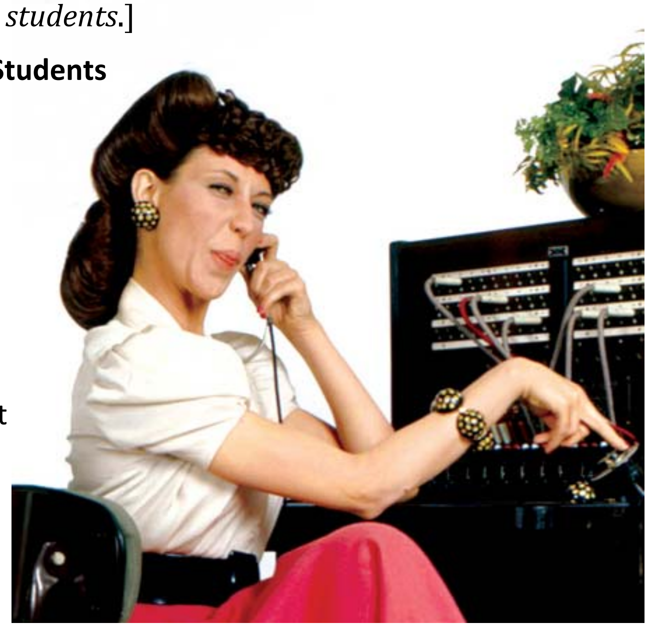
One Ringy Dingy! Pretending to be human?

[*Be sure to listen/watch to ALL video and audio clips before showing them to your students to make sure they are appropriate for your class and students*.]

Have students listen to the audio recordings…Do Students Think Samantha is Real?
http://newsfeed.time.com/2013/12/10/meet-the-robot-telemarketer-who-denies-shes-a-robot/

Option: Have students watch a news report about Samantha:
http://newday.blogs.cnn.com/2013/12/17/is-that-person-youre-talking-to-a-human-or-a-robot/

Watch: Artificially Intelligent Phone Operator. Meet Amelia.: http://motherboard.vice.com/blog/the-artificially-intelligent-call-center-operator



And just for fun, and comparison. Lily Tomlin as Ernestine the Telephone Operator, “One Ringy

Dingy!" Have I reached the party to whom I am speaking?"

- Good Afternoon Mr. Veedul! https://www.youtube.com/watch?v=SvesMBkduQo
- We Don't Care: https://www.youtube.com/watch?v=CHgUN_95UAw

Robot or human – who are you speaking to on that telemarketing call?

Meet Emily. Emily works for Bell Canada, answering phones for the customer service department. She's from the province of New Brunswick, got her degree from Carleton University and enjoys listening to music in her spare time. She's also a computer.

"Emily" is the name of Bell Canada's **interactive voice response (IVR)** system (her bio was provided by a press release.) When a customer calls with a question about their bill or to talk to a support specialist, they'll talk to Emily first. In a calm, pre-recorded voice, Emily guides them through the menu options, using speech-recognition software to understand the difference between "billing" and "support." If the customer wants to talk to a "real" customer service rep, he can always press zero. Emily won't be offended.

It's hard to think of a customer-oriented business that hasn't made the switch from live operators to IVR. When you call your credit card company, you can use the IVR to pay your balance or report a fraudulent charge. Airlines use extensive IVRs to book reservations and check the real-time status of flights. Pharmacies use IVRs for refilling prescriptions. And just about everybody uses IVRs to route calls to separate extensions or to access the company phone directory.

IVR software allows you to pre-record greetings and menu options that a caller can select using his telephone keypad. More advanced IVR systems include speech-recognition software that allows a caller to communicate with a computer using simple voice commands. Speech recognition software has become sophisticated enough to understand names and long strings of numbers -- perhaps a credit card or flight number.

On the other end of the phone call, an organization can employ text-to-speech (TTS) software to fully automate its outgoing messages. Instead of recording all of the possible responses to a customer query, the computer can generate customized text-like account balances or flight times and read it back to the customer using an automated voice.

A company or organization can choose to purchase all of this hardware and software and run it in-house, or it can subscribe to an IVR-hosting service. A hosting service charges a monthly fee to use its servers and IVR software. The hosting service helps the organization customize an IVR system that best fits its needs and provides technical support should anything go wrong.

But while companies suggest that this could free up human workers for more demanding tasks, some see this type of technology as yet another sign of the threat of robots to human employment.

The biggest advantage of IVR for small and large organizations is to save time and money. Answering phone calls takes a lot of time, and not every phone call deserves the attention of a trained employee. IVR systems can take care of most of the frequently asked questions that an organization receives (office hours, directions, phone directory, common tech support questions, et cetera) and allow customer service reps, salesmen and tech support specialists to concentrate on the harder stuff.

If a large company is able to shave even a second off the average length of each phone call with a live operator, it can save them hundreds of thousands or even millions of dollars a year.

IVR systems have the advantage of making callers and customers feel like they're being attended to, even if it's just by a machine. If you have a simple question, it's better to get a quick answer from a computerized operator than to wait ten minutes on hold before talking to a human being.

Another advantage is that IVR systems don't sleep. They don't take lunch breaks. They don't go on vacations to the Bahamas. An IVR system can be available 24 hours a day to field questions and help customers with simple tasks.

An IVR system can make a small company look bigger. Let's say you work from home as a consultant. By using a hosted IVR service to answer your phones, you already appear like a larger organization. You can get tricky by adding several menu options for different departments, all leading to separate voice mail boxes. Some IVR hosting plans even set you up with an 800 number to look more official.

Subscription IVR hosting plans make it easier for businesses and organizations to use these automated phone services. This is a big advantage of days past, when only large companies with big telecommunications and computing budgets could afford the hardware, software and staff to run in-house IVR systems.

The greatest disadvantage of IVR systems is that many people simply dislike talking to machines. Older adults may have a hard time following telephone menus and lengthy instructions. And younger callers get frustrated with the slowness of multiple phone menus.

The problem with IVR systems is that it's hard to design a good one and easy to design a bad one. If your script is too long, or you give people too many choices, or your 'voice' is hard to understand because you didn't hire a good voice actor or are using 'text to speech' technology, well, you might lose customers.

What do students think? Do they like talking to computers and robots? Or would they rather wait for a human being?

Building Trust

Option: Introduce this section with a video or book about the relationship between humans and robots, ex. Changing Batteries by Sunnyside Up Productions. http://www.bang-awards.com/en/movie/189-changing-batteries

This excellent short film tells the story of an old lady who lives alone who receives a robot one day as a gift from an absent son who cannot visit her due to work. We watch their relationship with one another grow as they develop a friendship that will not end when the batteries run out.

Remember how we talked about how nervous humans can be around robots? What's a way to convince humans that robots are safe? Well, you have to create the illusion of trust. The Victorians faked their mechanical marvels in many ways, and even today adding a layer of deception makes us feel more comfortable with our mechanical friends.

Magic creates the illusion of an impossible reality, and technology can do the same. Which is why we create the illusion that machines can think. Alan Turing, of the Turing Test, declared, "A computer would deserve to be called intelligent if it deceived a human into believing it was human." In other words, if we don't yet have the technological solutions to create computers indistinguishable from human life, would an illusion work as well? To create that robotic illusion humans devised a set of ethical rules that all robots must live by based upon a set of rules devised by the science fiction author Isaac Asimov.

The Three Laws are:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Asimov also added a fourth, or zeroth law, to precede the others:

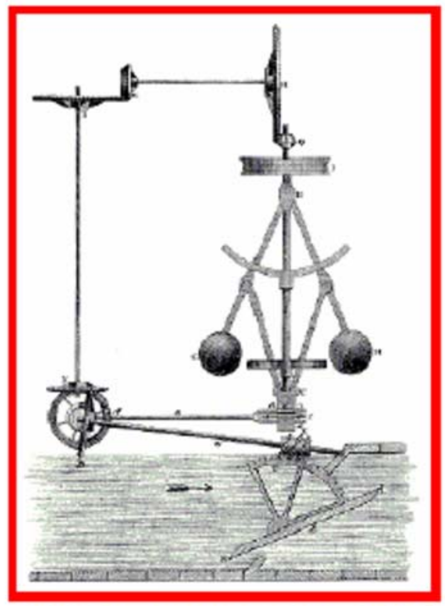
0. A robot may not harm humanity, or, by inaction, allow humanity to come to harm.

We anthropomorphize (to give a nonhuman thing a human form, human characteristics, or human behavior, or assume/assign human emotions) our machines, giving them friendly faces and reassuring voices. Most important we make them indicate that they are aware of our presence, that they are aware of our fragile bodies, move out of our way, and anticipate our unpredictable actions. So, under the spell of a technological illusion it becomes possible to ignore our fears and truly interact.

Modern automatons? ***Enhance the discussion using a video such as: Magic Robot - The Illusion of the Thinking Machine from Marco Tempest https://vimeo.com/87599583 Marco Tempest invites you to meet EDI, a deceptively charming robot who wants nothing more than to be your friend while we ponder the challenges and ramifications of creating an intelligent machine.***

FEEDBACK

For this activity students are going to use their body to illustrate the concept of feedback. Find a partner and choose one person to be the robot and the other will be a vision sensor. The robot/kid will put on a blindfold and the vision sensor/kid will attach to the robot's brain. The vision sensor will use their eyes to give feedback to the robot using verbal cues (talking). In this formation the two will move around the room. The robot will receive feedback from the vision sensor, which tells the robot how to behave in the environment. After a few minutes trade places.



"Flyball Govenor" invented by James Watts in 1770

- Can you think of a way the vision sensor can provide feedback to the robot without speaking?
- How do you think real sensors deliver feedback to robots?
- Which job is more difficult, being the robot/kid or the vision sensor/kid?
- How would you play this game if you changed the vision sensor/kid to a taste sensor?
- Did you notice that without vision, the robot/kid naturally put up its' "touch sensors?"

James Watts was another inventor who used the principle of feedback to make his invention better. Watts, who invented the steam engine in the 1770's, wanted to control the fluctuations in steam pressure so that the engine would run at a steady speed. Imagine how uncomfortable a train ride would be if it was constantly speeding up and slowing down. All the passengers would get motion sickness (throw up, barf)! Watts created a device called the flyball governor (shown in the diagram to the right), which automatically adjusted the throttle of the steam engine. If the engine ran too fast, the flyball governor would spin and automatically close the throttle and slightly slow the train.

The Principle of Feedback

The principle of *feedback* deals with changes in condition, and then self-correction. A machine that can sense changes in its environment and correct for them is using *feedback*. Your body uses the *feedback* principle to survive. For example, when you feel the room is too hot, what do you do? Ex. you open a window. And when you are too cold? Ex. you put on a coat. **Have students think about other ways their body uses *feedback*.** The idea of *feedback* for use with machines was developed in response to industrial needs.

In 1745, Edmund Lee, an English inventor, first used feedback to solve a problem he was experiencing at his lumber mill. At that time in history, logs were sawed into planks by harnessing the power of the wind. A huge windmill would point into the wind and turn a series of gears that were connected to a saw. As the wind blew, the saw turned and the logs would be cut. This system worked well as long as the wind blew in the same direction, but each time the wind changed the huge windmill had to be manually moved by the human workers.

Lee considered his problem with wind conditions. Using what he knew about the workings of the windmill, Lee developed a perfect feedback system. He mounted two smaller windmills on the back of the large one. If the wind changed direction, the small windmills moved and turned a series of gears attached to the axle of the large windmill.

The gears would turn the large windmill until it faced the wind and the small ones stopped. The machine automatically corrected for changes in condition (wind direction).

Catching the Wind

Build your own self-correcting windmill

In order to better understand the way Edmund Lee's principal of "***feedback***" works have students gather these materials and build their own self-correcting windmill.

-Three small straws and one large straw

-Three index cards, one 4 X 6 in. and two 3 X 5in.

-A small amount of modeling clay

-Three straight pins

Step 1: Fold index cards in half and cut to make two 3 X 3 squares and one 4 X 4 square.

Step 2: Cut diagonally from corners to center of each square.

Step 3: Poke straight pins through every other corner and then the center to make a pinwheel. Be certain that the two smaller pinwheels are mirror images of each other (see pictures below).

Step 4: Tape two of the smaller straws together, and cut the third one and tape it perpendicular to the others, in a cross shape. Place a pinch of clay in the end of each straw.

Step 5: Poke the pins, through the clay into each straw. Make certain that the larger pinwheel is facing the front and the smaller pinwheels are sticking out of the sides of the cross. Place small pinwheels as necessary to counter the motion of the large one.

Step 6: Slip the larger straw over the bottom straw so that the windmill can turn freely. For best results, hold onto the larger straw and position the larger pinwheel facing a blowing fan. Or blow on the pinwheels to observe how the countermotion of the small pinwheels keeps the larger pinwheel facing the wind.

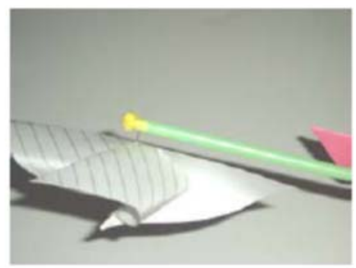
Step 1

Step 2

Step 3

Step 3

Step 4



Step 6

Lesson One K-8 Standards Alignment

K

7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.2.1 Recognize that some things are living and some are not.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies.

1

7.T/E.1a Explain how tools (ex. like robots), technology, and inventions are used to extend the senses, make life easier, and/or solve everyday problems.

7.T/E.1b Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

2

7.T/E.1a Explain how tools (ex. like robots), technology, and inventions are used to extend the senses, make life easier, and/or solve everyday problems.

7.T/E.1b Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

3

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

4

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

5

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

6

7.T/E.1 Explore how technology responds to social and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and *cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.*

7

7.T/E.1 Explore how technology responds to social, political, and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

8

7.T/E.1 Explore how technology responds to social, political, and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations. We'll explore the evolution of robot technology and we'll discuss the pros and cons of using robots for certain jobs (like answering and making calls) for both customers and companies and what problems they solve (and possibly create) for both sides.

Lesson Two

Biological Systems vs. Artificial Intelligence (A I.)

One vital aspect of robotics is the workings of the robot “brain” or CPU. In the 1950’s, early robot scientists saw a way to teach their mechanical devices to react to feedback. This ability distinguishes real robots from automatons. Today, there are two different ways robot scientists approach this difficult task. One way is to carefully study the way the human brain works and then figure out how it causes certain behaviors. Then scientists apply that knowledge to the intricate workings of a robot. This approach to robotics is called the study of Biological Systems. Robotisist who study neuromorphic engineering and biomorphic robotics focus on biological systems. The second approach to building robot “brains” looks at the behavior itself and figures out how to mechanically copy it. This method starts with a computer and focuses on how to use it to mimic human (or animal) behavior. The second approach is called Artificial Intelligence (A.I).

Scientists who study computer science or electrical engineering might tend to focus on A.I. There is no right answer to the ***Biological Systems*** vs. ***Artificial Intelligence*** debate. Both approaches have advantages and disadvantages. It seems that modern robot scientists combine aspects of both approaches to dream of, design, and then build robots.

Perhaps both approaches are necessary in order to unlock the complicated mystery of human thought.

Let’s look at an example. Imagine that you are a robot scientist. You have been given a mysterious toy made by aliens from the planet Xeon. The toy is called “Robota” and looks like a golden, robotic humanoid with lots of buttons and flashing lights. Robota comes with a book of instructions in English. Your job is to recreate the robot for mass production on the international toy market here on Earth. You can achieve this in one of two ways:

1.You can play with the toy, push all the buttons and study what Robota does. Then keep track of what you discover so that you may copy the behavior in the robots you mass-produce.

This way doesn’t work exactly, but while you are playing you accidentally discover that the robot can mow the lawn. (***Artificial Intelligence*** **or A.I.).**

2.You can read the instructions, follow the directions and teach Robota to do all the things she is able to do. Next, you open up the toy and study how her ***Central Processing Unit (CPU)*** or “brain” works to figure out how it causes certain behaviors. This takes years, but you discover a cure for cancer while you are at it**. (*Biological Systems*)**

← Which way is the most fun?

← Which way is the fastest?

← Which way is the most useful for the robot’s future?

← Which way do you think is the best?

The Claaaaw! It moves!

Working robots have come a long way from the first assembly-line operators—robots that could perform tasks such as welding and painting with a movable arm and a grasping hand, but were otherwise fixed in place on a factory floor. One of those was the first industrial robot, Unimate, which was just a giant arm. It worked in a General Motors plant in 1961.

And now it's time to build our own moving claw.

Materials:

Cardboard box (the harder the better, ex. a pizza box but you can used any type because we are going to reinforce it with the duct tape)

- Scotch Duct tape (metallic or silver is preferred for the most 'realistic' robot look)

- 3 machine screws 3 inches in size with nuts

- 2 machine screws 1 ¼ inches in size with nuts

- A flat and square piece of wood ideally 12 inches by 12 inches for the base to attach the robot

FOR THE HYDRAULIC SYSTEM:

- 8 syringes (the type that is used for cough medicine, or animals (no needles), often available at places like Famer's Co-ops, Tractor Supply and Walgreens)

- 6 feet of clear tubing ¼ "x .170" (ex. aquarium tubing)

- Water

TOOLS:

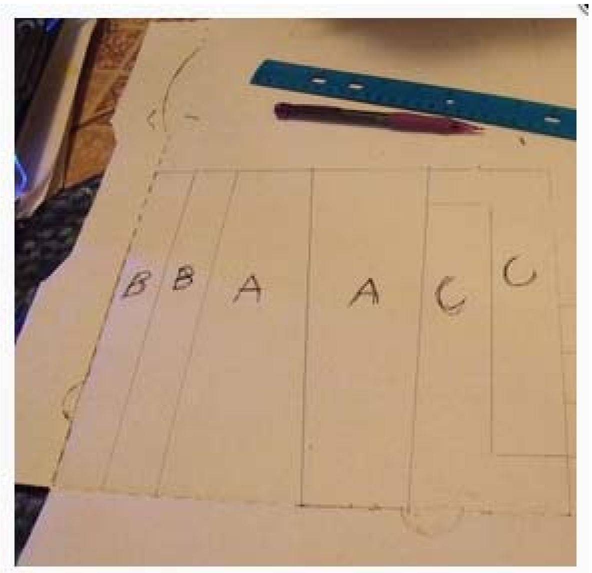
- Scissor

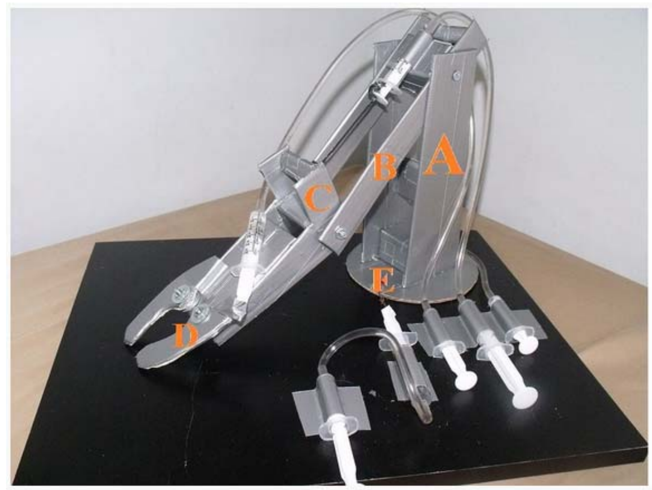
- Ruler

- Pen

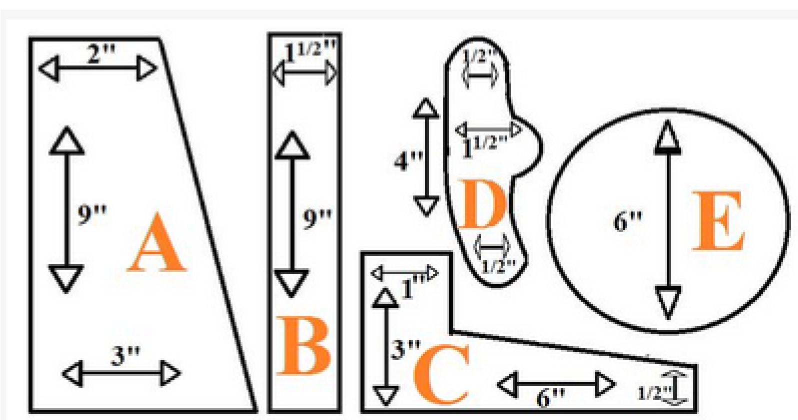
- Drill

Now draw the template on the cardboard, these are the measures used in the example but you can change them to make a smaller or bigger robot.



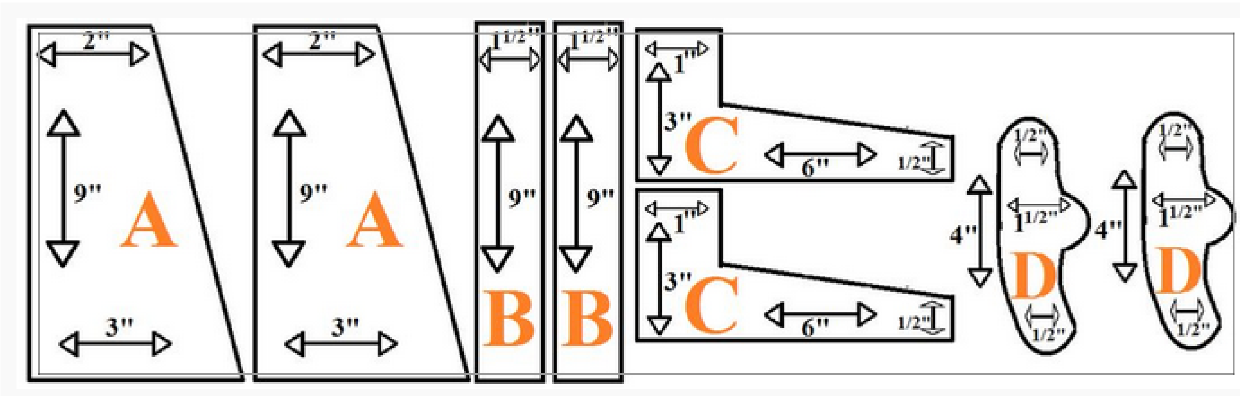


From the template cut out:
2 x A piece
2 X B piece
2 x C piece
2 x D piece
1 x E piece



These are the main parts of the body and the rest of the parts are going to be made as you go because they depend on the thickness of your cardboard and how many layers of duct tape you use. For example if you use thick cardboard, ex. sturdy pizza box, you only need one layer.

You should end up with the following parts:



Now that students have all their parts cut out they have to reinforce them. First cover one side of a piece with duct tape and the cut the extra tape, the cover the other side and cut the extra tape.

Repeat this for all the parts. If the cardboard is not strong enough repeat this step putting more layers of tape until you are satisfied with the strength and stability.

Now it's time to start putting our pieces together and see that your robot starting to take shape.

The next piece you have to make is a cube that is going to hold together the bottom of the 2 "A" pieces. The sample used a cube that is 3 inches wide by 1 inch sides (cube= 4 sides)

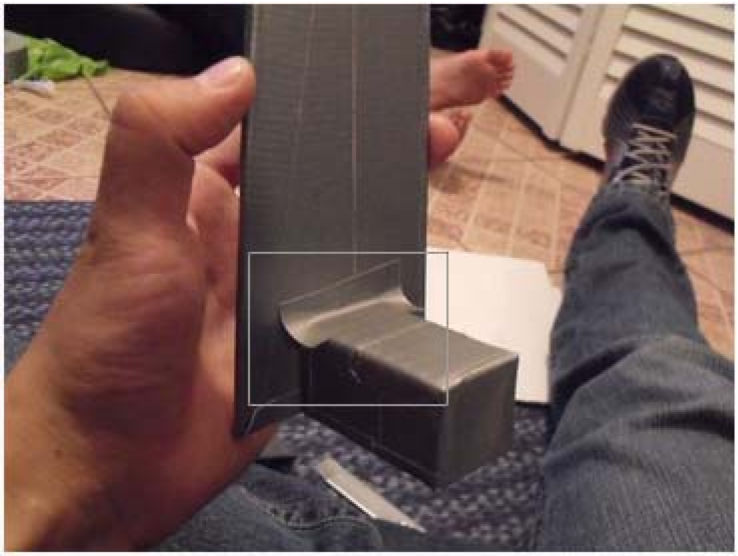
After you cut and fold the cube reinforce it with tape.

The reinforced cube needs to be attached to the bottom of the "A" piece (the bottom is the longer part 3")

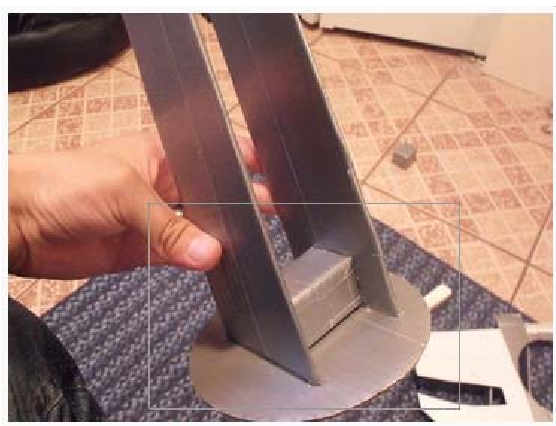
First attach it to one piece and then the other.

Put your piece in the floor to make sure the cube is level before taping.

The technique for taping is called L taping, which is not as fancy as it sounds. Just stick the tape to one side of one piece and the side on the other piece. If you are unsure how to do it, the photos may help.

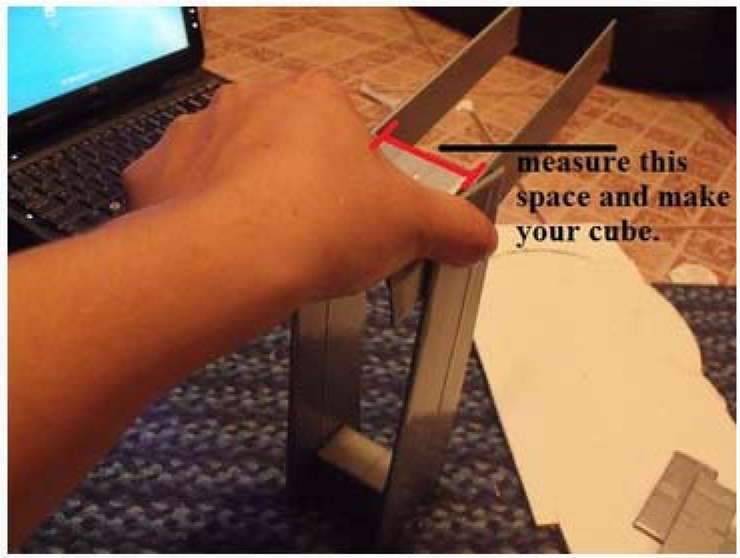


Next attach the "A+CUBE+A" piece to the 6" circle base using L taping (use as much tape as you think is necessary to get a strong hold and try to get it in the center.)

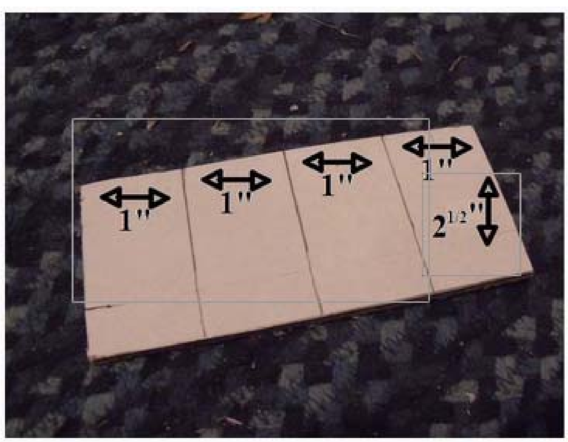


Now it’s time to make your next cube and holder for the first syringe.

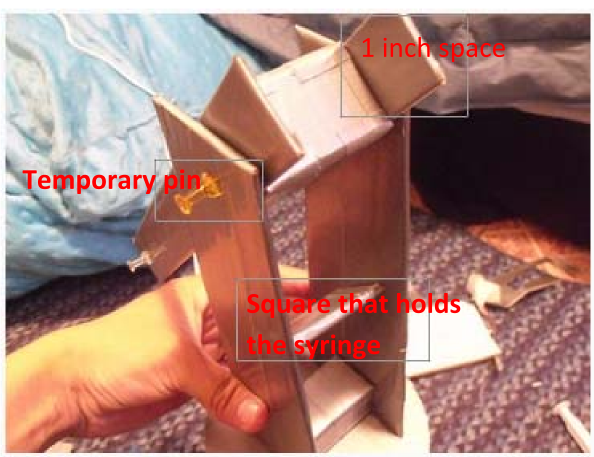
Hold your two “B” pieces on the inside of the “A+CUBE+A” piece and measure the space between them, that is how wide your cube needs to be.



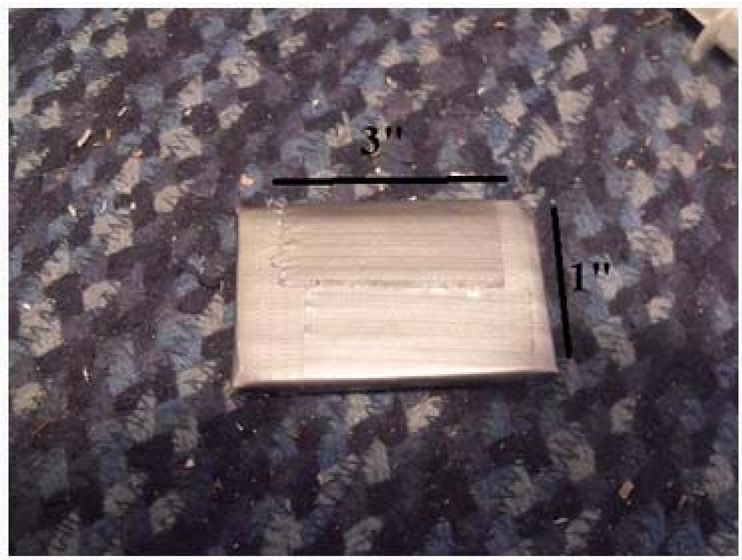
Now make your cube with your new size the same way as you made the first.
(in the sample, the new cube is 2 1/2" wide) and keep the 1 inch measure for the sides of the cube.



After making your cube attach it to the “B” piece leaving 1 inch space from the end.



Next depending on the thickness of your cardboard make 2 or more squares as wide as your first cube (in my case 3 inches) by 1 inch long and tape them together , this will be taped to the middle of the “A+CUBE+A” piece to hold the syringe.



Place the square vertical (straight up and down) and then give it just a little bit of an angle.

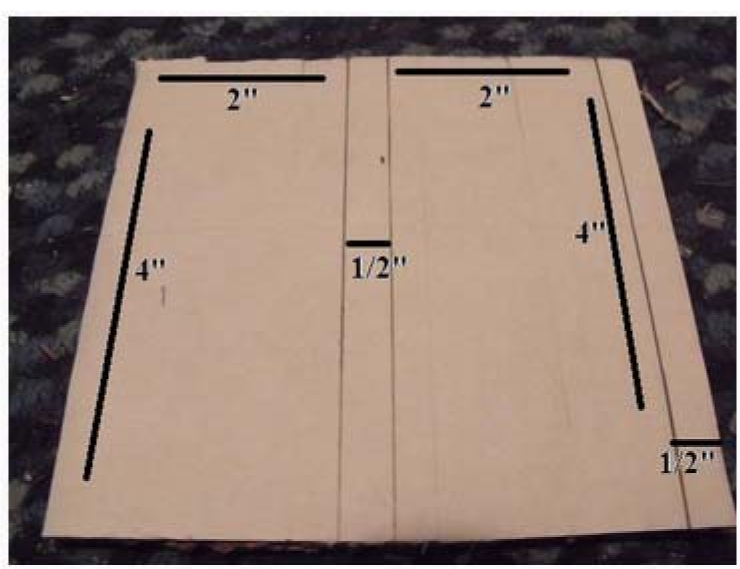
Repeat the beginning of what you just did but with the "C" pieces instead of the “A” pieces. Hold you “C” pieces on the inside of the of the “B+CUBE+B” piece and measure the space between them, that is how wide your cube needs to be (in the sample that is 2 inches wide) by 1 inch long for the sides.

Reinforce the cube and the attach it to the corner of the "C" pieces.

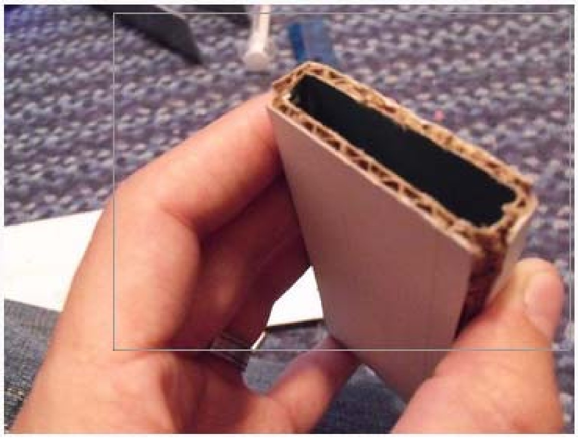
Now it’s time to get clawing!

First we have to make the holder for the claw that goes between the “C+CUBE+C” piece.

The holder is a “rectangular cube” that is 4 inches long and the sides are 2 inches by ½ inch.



To make our claw holder, we follow the same steps as we did in the very beginning (when we made our first cube),



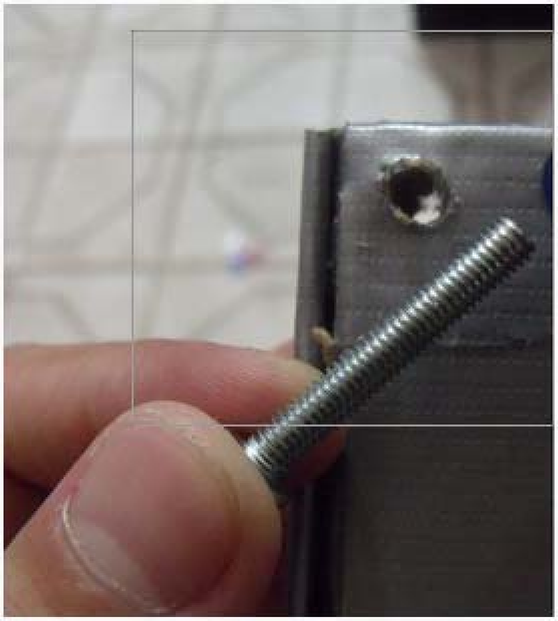
and attach it to the front of the "C+CUBE+C" piece flush with the front.

Note: The C piece in this photo looks different than the template because the designer had to go through the re-engineering process and found that the template design works better. The front *of the C piece and the front of the 'cube' should be flush.*

Now make the claw, the "D" piece. depending on the thickness of your cardboard you need to put as many layers of cardboard and tape as you want until you get a strong claw (in the sample 2 layers of cardboard and one of tape)

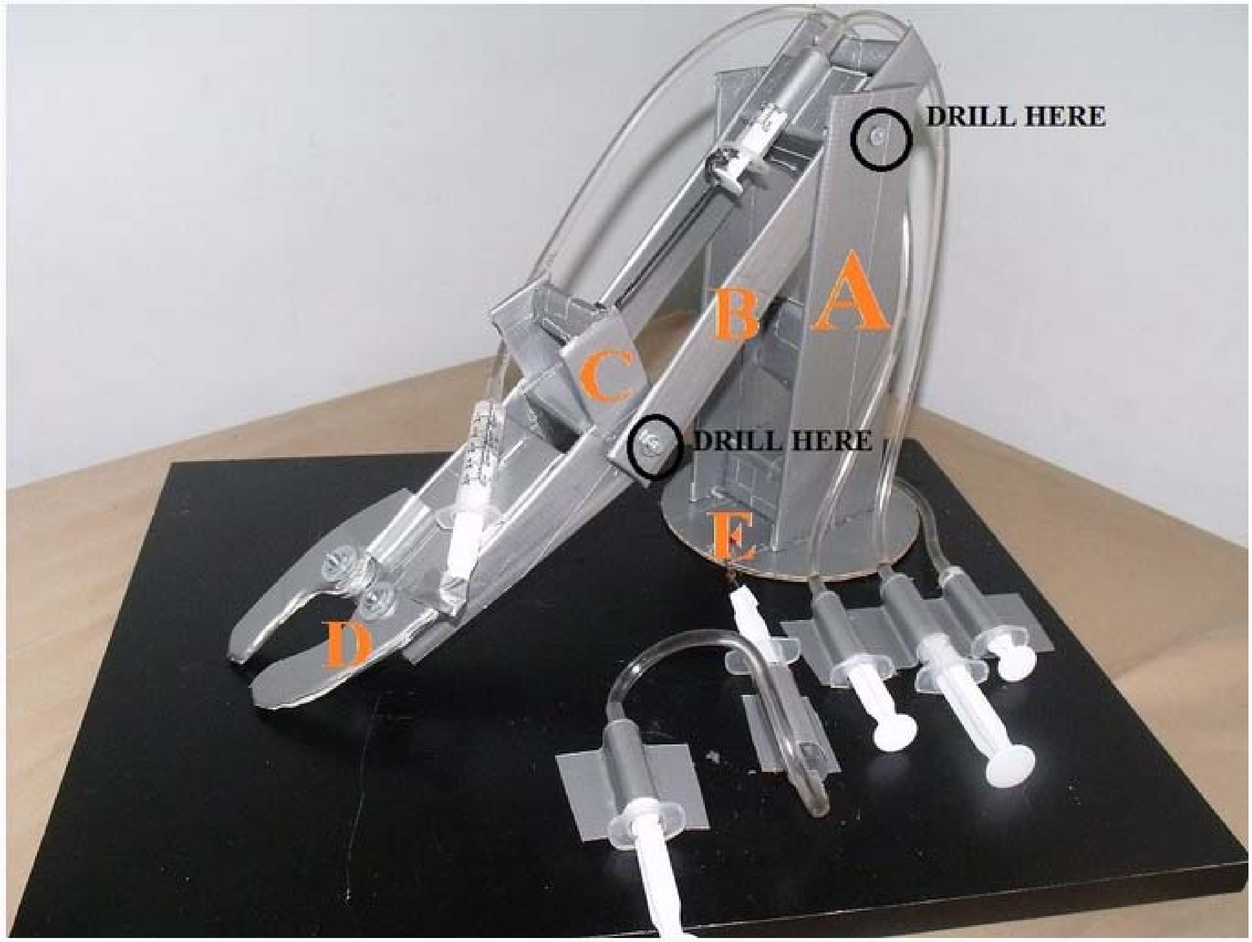
Make hole in both parts of the claw large enough for your 1 1/4" screw

Now make a hole in the front corner of the claw holder in the "C+CUBE+C" piece.



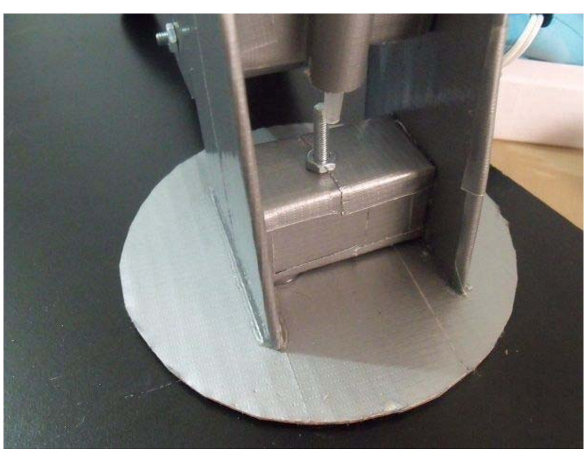
Use screws and attach the claw parts.

At this point you should be half way there, hold the parts in their place and drill in the joints of the robot across the inside of the cubes and place the screws.



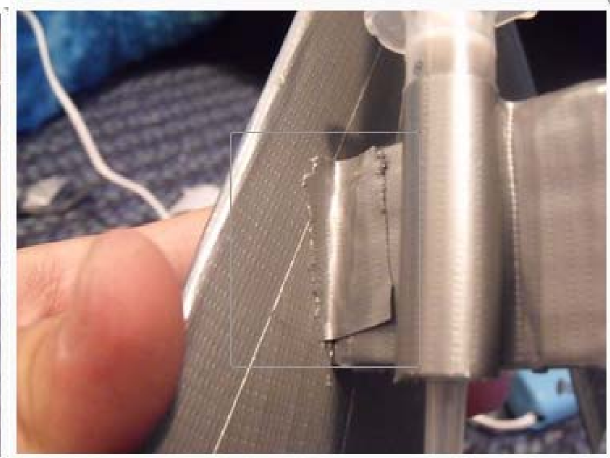
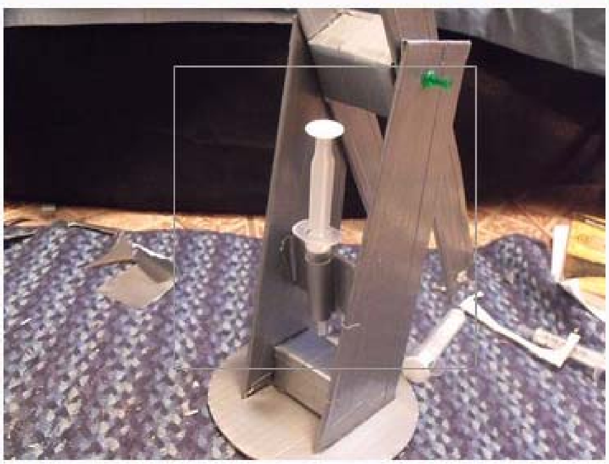
Attach to base and make hydraulic system 1st syringe

Now we're going to attach the robot to the base.
Drill in the middle of the cube at the bottom of the "A+CUBE+A" piece and on the wood for the base and put in your 3" screw.



Once we have it secured it's time to start with the Hydraulic system.

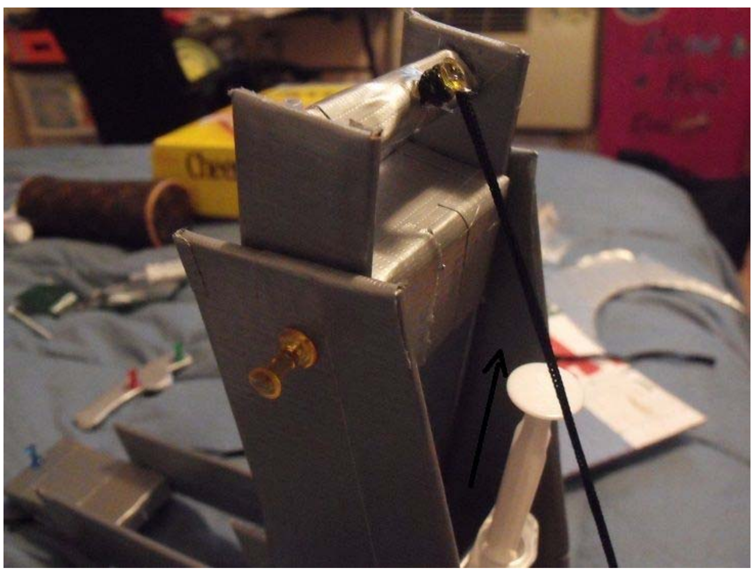
Attach the first syringe to the holder on the "A+CUBE+A" piece (just like the picture)

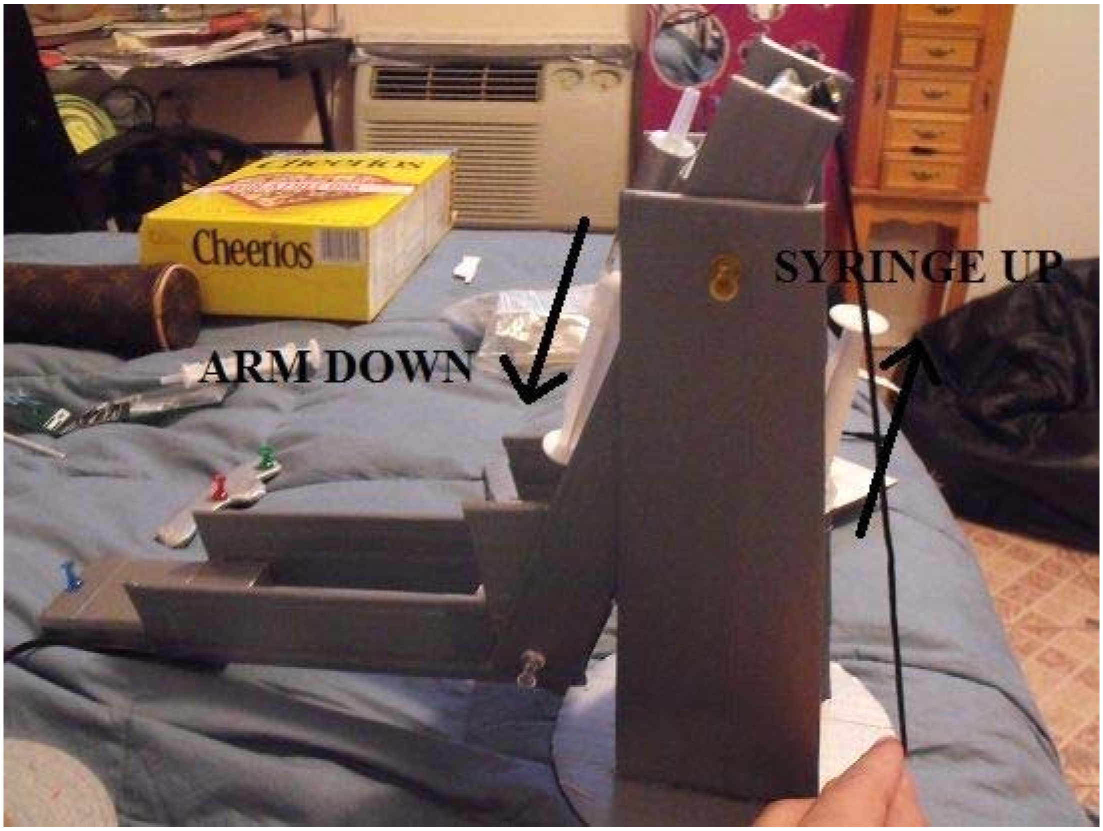




Now cut two pieces as wide as your second cube by a 1/2 inch. Tape them together and attach this to the 1 inch space you left in the "B+CUBE+B" piece (just like the picture)


Then put a pin in that new piece and tape around it.

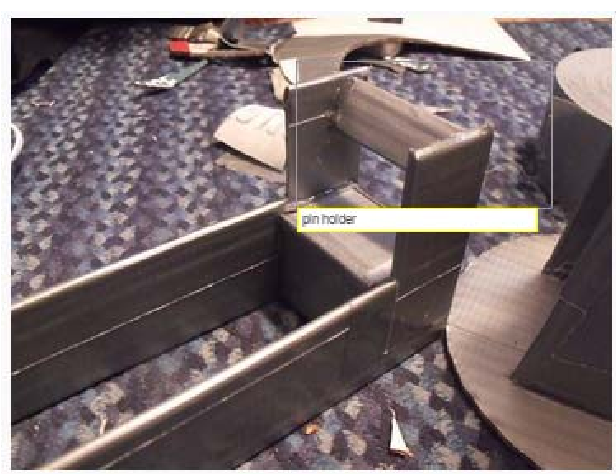
Now tie a piece of rope to the pin and from there to the syringe tight and cut, make sure the arm is down and the syringe is all the way out to get the right length of your rope (refer to picture for better understanding)

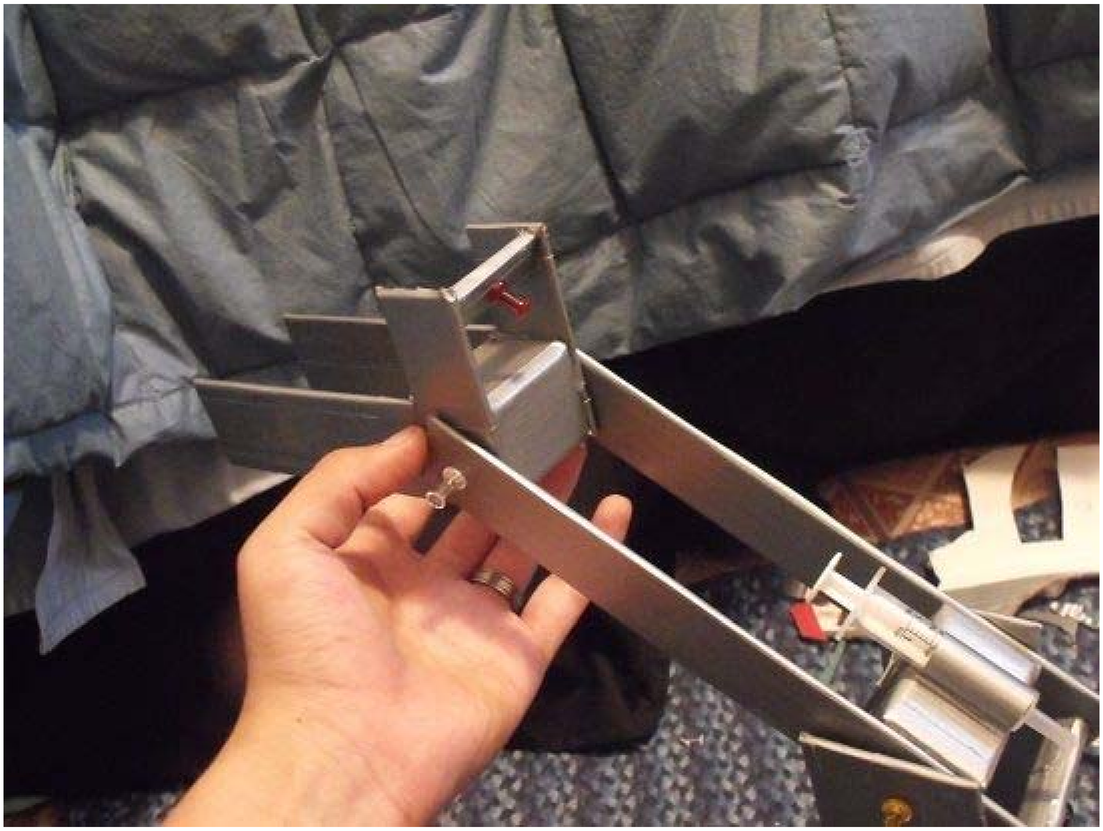




Now, for the second syringe

For the second syringe you need to make a holder in the top part of the "C+CUBE+C" piece. Use the same procedure as before, make sure the arm is down and the syringe out to get the right length for the rope.





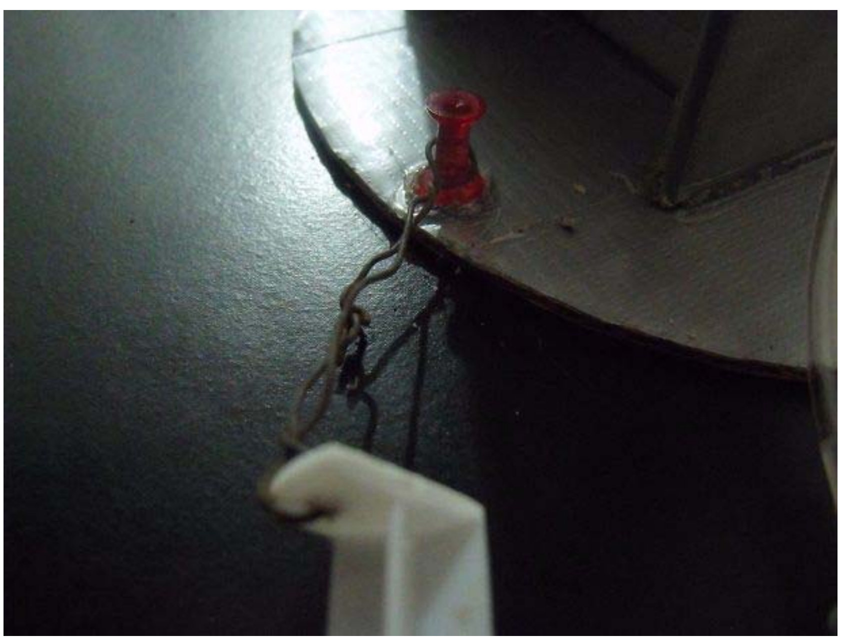
This is completely adjustable depending on how high or how low you want your arm to move, play around with the length of the rope to find out what works best for your robot.

Moving the Claw: Attaching a Syringe

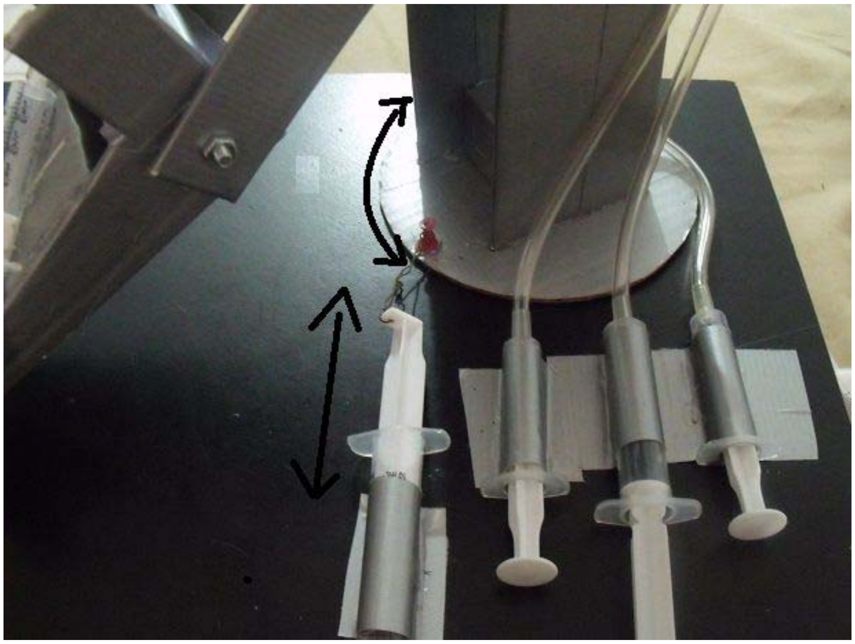
The syringe for the claw is going to be directly attached to the claw with duct tape. Tip: Make sure the duct tape is not too tight so the claw can move freely.

Syringe to turn the arm

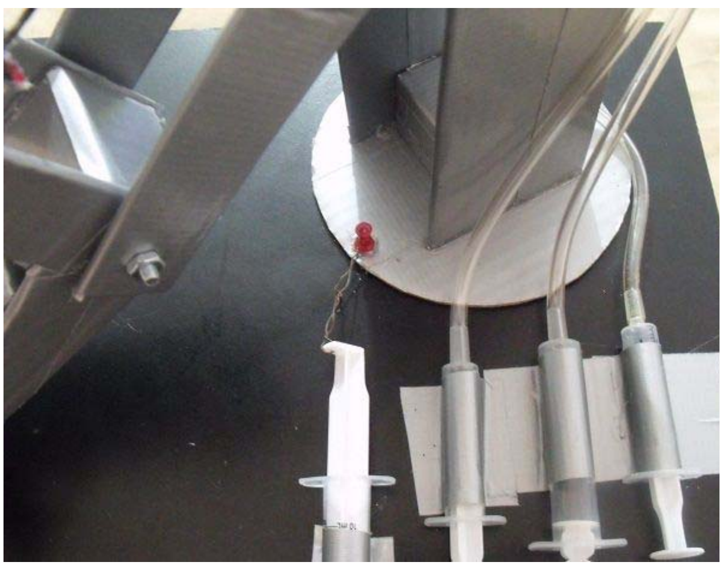
At the base of the robot attach the head of a pin (the sample used only the top part of the pin, the bottom part (needle) was removed and the use some hot glue) and then attach a syringe about 3 inches from the pin



Attach a wire from the pin to the syringe when the syringe moves makes the arm rotate left or right.



Now tape to the wood base 3 syringes next to each other, each of these are to be connected to the syringes in the arm.



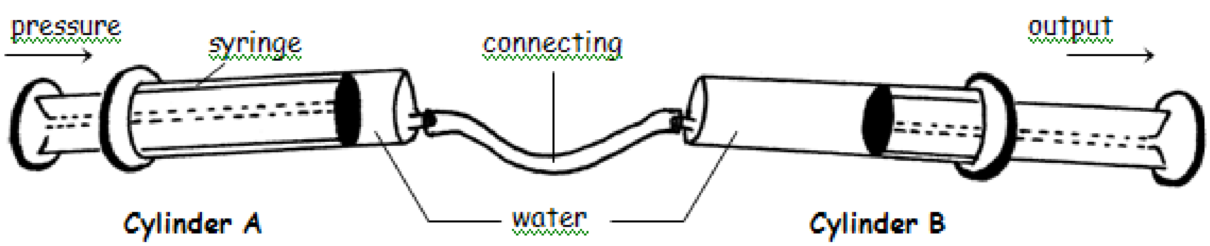
Run the tubing to all syringes

Run the tubing to all the syringes, fill with water.

This part can be a bit tricky for students. Although the process is fairly simple, it isn't easy to commit to memory by watching it done once or twice. You may want to outline these steps on a whiteboard:

1. Connect tubing to one syringe
2. Fill completely with water
3. Point the tip of the syringe up and push on the plunger. This expels all of the air and fills the tubing with water
4. Refill halfway and set aside
5. Submerge the tip of the second syringe and repeatedly pump the plunger to expel air. Fill halfway
6. Connect the syringes and try it out. If the total amount of water in either syringe exceeds the top mark (ex. 10ml) then there is too much water in the system. There should be little to no air bubbles, too.

Option: For extra fun, use food dye to color the water



Now test it. Does it need re-engineering or modifications? Watch the following video to see the project when completed. https://www.youtube.com/watch?v=njzjZBsjY-k

Ex. Variation on the style of claw

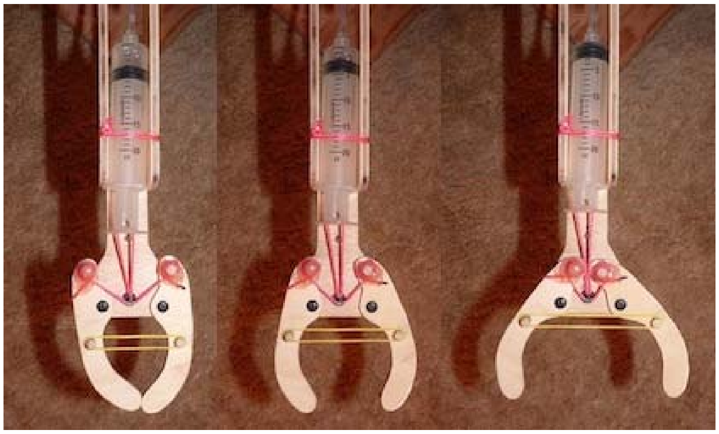


Image via: http://baconsize.blogspot.com/2013/04/hydraulic-arm.html

Lesson Two K-8 Standards Alignment

K

- 7.11.1a Explore different ways that objects move.
- 7.11.1b Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

1

- 7.T/E.3 Use tools to measure materials and construct simple products.
- 7.11.1 Investigate how forces (push, pull) can move an object or change its direction.
- 7.11.1b Use familiar objects to explore how the movement can be changed.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

2

- 7.T/E.3 Use tools to measure materials and construct simple products.
- 7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

3

- 7.11.1.b Identify how the direction of a moving object is changed by an applied force. (Any force could be considered to be an applied force, but applied force usually stands for a force applied by a person or an action which directly pushes or pulls on a system.)
- 7.11.1a Explore how the direction of a moving object is affected by unbalanced forces (Note: **Unbalanced forces** always cause a change in motion. They are not equal and opposite. Forces occur in pairs and can be either balanced or unbalanced. **Balanced forces** do not cause a change in motion. They are equal in size and opposite in direction so they cancel each other out and no motion happens. If motion is happening then there are unbalanced forces.)

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms. We will discuss the different *forces that are acting on the robotic arm (ex. gravity, fluid force with the hydraulics, friction, etc.) We will determine which ones are unbalanced and what the applied forces are.*

4

- 7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.
- 7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms. We will discuss the different forces that are acting on the robotic arm (ex. gravity, fluid force with the hydraulics, friction, etc.) and how they affect how and how fast the arm is able/unable to move.

5

7.12.2 Identify the force that causes objects to fall to the earth.

7.12.1 Explain and give examples of how forces can act at a distance.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms. We will discuss the different forces that are acting on the robotic arm (ex. gravity, fluid force with the hydraulics, friction, etc.) We'll look at how hydraulic forces and gravity can work at a distance to cause effects.

6

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

7

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

8

7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in building, testing, redesigning, and reconstructing their (group's) robotic arms.

Robots Part 3 Sample Academic Vocabulary Guide

K

- Shapes
- Air
- Job
- Parts
- Water
- Observe
- Collect
- Position
- Senses
- Tools

1

- Past
- Present
- Future
- History
- Invent
- Sequence
- Technology
- Measure
- Property
- Push
- Pull

2

- Economy
- Consumer
- Decision
- Qualifications
- Main Idea
- Message
- Investigate
- Discussion
- Wind vane
- Outcome

3

- Tools
- Conclusion
- Opinion
- Organization
- Force
- Cause
- Effect
- Character
- Conjecture
- Setting

4

- Mimicry
- Consumer
- Compare
- Contrast
-

- Friction
- Drawing conclusions
- Pattern

- Chance
- Accuracy

5

- Point of view
- Implied
- Gravity
- Edge

- Model
- Integration
- Personification
- Main ideas

- Solution
- History

6

- Sequential
- Personification
- Point of view

- Control
- Criteria
- Design constraint

- Cause and effect
- Energy transformation

7

- Interaction with texts
- Viewpoint

- Function
- Impact
- Property

- Repetition
- Simple machines
- Speed

8

- Human impact
- Sensory
- Interdependence

- Force
- Reliability
- Product

- Variation
- Solution
- Function

Sample Supply List for Robots Part Three, Building Trust

Lesson One

- Access to chosen videos
- Per windmill:
    - -Three small straws and one large straw
    - -Three index cards, one 4 X 6 in. and two 3 X 5in.
    - -A small amount of modeling clay
    - -Three straight pins

Lesson Two

PER ROBOT:

- Cardboard box (the harder the better, ex. a pizza box but you can used any type because we are going to reinforce it with the duct tape)
- Duct tape (metallic or silver is preferred for the most 'realistic' robot look)
- 3 machine screws 3 inches in size with nuts
- 2 machine screws 1 ¼ inches in size with nuts
- A flat and square piece of wood ideally 12 inches by 12 inches for the base to attach the robot (Or other equivalent base material)

FOR THE HYDRAULIC SYSTEM:

- 8 syringes (the type that is used for cough medicine, or animals (no needles), often available at places like Famer's Co-ops, Tractor Supply and Walgreens)
- 6 feet of clear tubing ¼ "x .170" (ex. aquarium tubing)
- Water

TOOLS:

- Scissor
- Ruler
- Pen
- Drill

Lesson One

Evolution

Today robots reach much farther than the factory floor. There are robots in homes, for example, the Roomba vacuum cleaner went on sale in 2002 (and lead to an internet sensation, Roomba Cats, aka videos of cats riding Roombas (sometimes in shark costumes) appeared on YouTube soon after, https://www.youtube.com/watch?v=KIblMtZ0EYk). It It was the first popular home robot (other home robots, like we mentioned earlier, are lawn mowers, floor washers, and swimming pool cleaners. Notice any similarities in what they do? Hmm, humans might not like cleaning!)

One interesting note, when the Roomba first came out, people, being curious, began hacking it to see if they could program it themselves. Ever willing to make money the company came out with Create, a version designed to be hacked (Built from remanufactured Roomba® platforms.) Now, for a starting price of $199 dollars (in January of 2015) hobbyists can program their Create robots to do stuff like play laser tag; sumo wrestle; draw on the floor with paintbrushes, pens, or markers; dance, and even be steered by a hamster in a ball attached to the top. https://www.youtube.com/watch?v=doQvWsJRCPs

See projects people have create here: http://www.irobot.com/hrd_right_rail/create_rr/create_fam/createFam_rr_projects.html

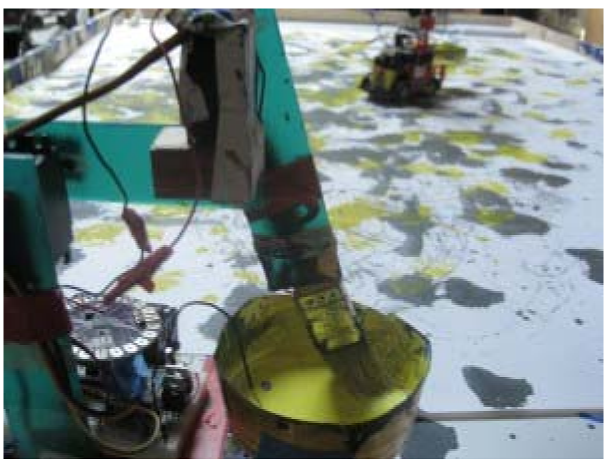
And others take it farther and in new directions all the time. A company called Zoobotics is working on a (classroom) kit where people build a programmable robot made from paper and grey cardboard. They're calling it their ZURI Paperbot system. Essentially, a DIY robot that you can put together yourself in a few (relatively) straightforward steps. The Zuri Robot can be fashioned together with the most rudimentary of tools i.e. glue, ruler and a razor blade and the kit comes with a control device that will permit you to make your Zuri follow your every command (provided your commands don't typically exceed 'walk around a bit, Zuri.'

Home Smart Home

It’s more than just clean floors these days. We have mobile webcams that let us see what is happening in homes or offices while we are away that can be controlled over the internet. Bill Gates, founder of Microsoft spent over $100 million dollars to build himself a smart home near Seattle Washington in the 1990s that could be programmed to turn on lights, adjust temperature, change wall colors, etc. Companies now offer to help everyday people turn their homes into smart homes, for a cost of course, to allow you to control your home's security features and appliances even when you're not there. Any device in your home that uses electricity can be put on your home network and at your command. Whether you give that command by voice, remote control, tablet or smartphone, the home reacts. Most applications relate to lighting, home security, home theater and entertainment, and thermostat regulation.

Robotics in Art

Artists use robots to create art, and as works of art themselves. Who needs fingers when you can paint with robots? There is the Drawbot, which draws, as well as the Jackoon Artbot (named after Jackson Pollock and Willem

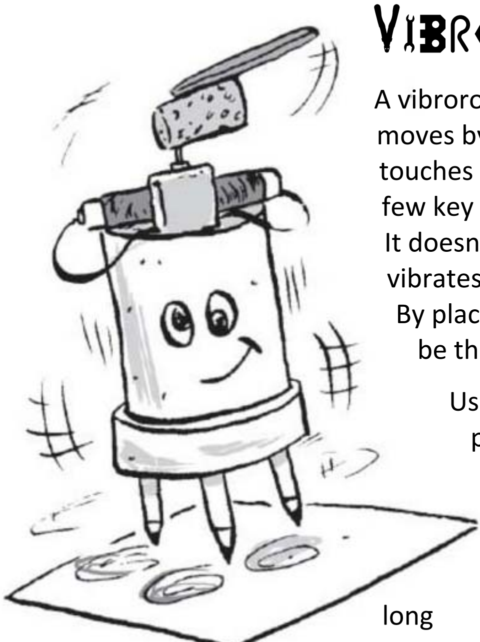


de Kooning-- You can see the similarities to those artists in the painting here called Lemon Wasp.) by Oscar D. Torres. Jackoon is a little robotic arm on wheels which scoots around dabbing a brush into a cup of paint and then on the paper [http://vimeo.com/4518641]

Although the paintings look random, the robot uses a camera mounted on the ceiling to help tell it where to paint. The paintings do not closely resemble the original, and must be modified by a human artist for the relationship to be recognizable. Greater precision is a goal for future models.

Musicians use robots too. The League of Electronical Musical Urban Robots (LEMUR) builds self-playing instruments. Their pieces feature robotic guitars, bells, gongs, and instruments made out of kitchen tools and hardwar. LEMUR's robotic instruments can respond to what they hear, which allows them to p lay with live musicians, including a fairly popular band named They Might Be Giants. LEMUR created the Orchestrion, a battalion of robotic musical instruments. Based on a childhood fascination with his grandfather's player piano, 19 time Grammy Award winner Pat Metheny, commissioned and built The Orchestrion, a mechanically controlled mini-orchestra capable of responding to his touch on the guitar. **Watch the trailer at** http://www.theorchestrionproject.com/

Even fashion designers are using robots for more than just inspiration. Imagine a skirt that sparkles with a rainbow of colors as you walk, dance, and twirl. The LilyPad Arduino, developed by Leah Buechely of the MIT Media Lab, is a programmable device that can be sewn into clothing. Fashion designer Shannon Henry of Polymath Design Lab used it to make a Skirt Full of Stars [and made an Instructable so others could have a glow-full skirt too.] The Lilypad makes different colored lights flash when a sensor shows that the skirt is in motion. And robots are bringing tech and fashion together! Watch the news report here: http://video.foxbusiness.com/v/3678082248001/robots-create-fashionable-dresses/#sp=show-clips '



Vibrobot: Artist in the Shaking

A vibrorobot isn't actually a real robot, but it acts like one. A vibrobot moves by, you guessed it, vibrating, shaking, or jiggling along. When it touches a wall, it turns and keeps on going. But a vibrobot is missing a few key parts it would need in order to fit into our definition of robot. It doesn't have a controller or a sensor to tell it what to do—it just vibrates away! A motor spins a weight to make the vibrorobot shake. By placing the weight a little bit off center, the whole vibrorobot will be thrown around enough to move.

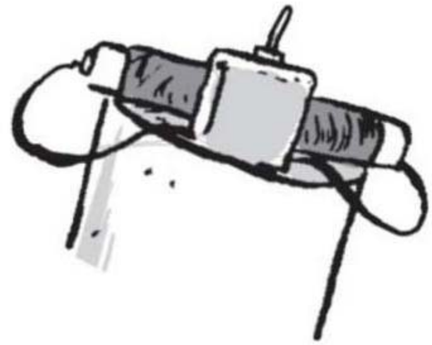
Using these principles, our Vibrorobot Artists will skitter across a piece of paper, drawing as it goes.

Materials (per robot):

- Small DC motor (1.5 volts)
- Insulated electrical wire, about 1 foot or 30 centimeters long
- Wire cutters
- Electrical tape
- 1 paper, plastic, or foam cup
- Foam mounting tape
- 2 AAA batteries
- Rubber Band
- Cork
- 3 Markers
- Cardboard box lid or box with low cut sides, about the size of a piece of 8.5 X 11 printer paper, ex. the lid of a box of printer paper
- Plain white paper

- Optional: Pipe cleaners, craft sticks, Styrofoam or wooden pieces, decorative glue-ons, googly eyes, glitter pens, quick-dry glue, or hot glue gun

1. If your motor doesn't have wires attached, use the wire cutters to cut two pieces of wire about 6 inches (15 centimeters) long. Remove about ½ inch of insulation from each end so that the metal inside is exposed (1 centimeter). Attach one wire to each of the metal terminals coming out of the motor so that the metal touches metal. Secure that with electrical tape. Test the motor by touching the other end of the wires to the ends of a battery. If you have done it correctly and have a good connection, the shaft of the motor will start to turn.



2. Turn the cup upside down. Attach the motor to the bottom of the cup with the foam tape so that the wires stick out either side and motor shaft is sticking up.
3. Line up the batteries so that the top (positive end) of one touches the bottom (negative end) of the other. Secure them together with electrical tape.
4. Put the rubber band around both batteries so that it covers the ends. Wrap more tape around this to secure if you need to. Use the foam tape to secure the batteries next to (alongside) the motor.
5. Stick the end of the wires under the rubber band so that the bare wire touches the ends of the batteries. The motor shaft should turn on. If not, move the wires around until it does. Turn the motor on and off by taking out one of the wires. You can tape the other wire in place.
6. Make an off balance weigh that will shake the cup by sticking a cork onto the motor shaft. You can hot glue a craft stick on the cork to make it even more off-balance.
7. Use the electrical tape to attach the markers as 'legs' on the cup. This is when the students can decorate their robots as desired.
8. To make an artist's arena for the 'bots', cover the inside of the box lid with a piece of paper. Take the caps off the markers, place the Vibrobot inside, and start your motor! The Vibrorobot will dance around and bounce off the walls, covering the paper with its own designs.
9. If the Vibrorobot doesn't work, or students are not happy with the way it's moving, there are a few things they can try.
    a. Make sure the weight on the motor isn't hitting anything on the robot.
    b. Try shifting the legs, the weight, or the decorations to chance the balance.
    c. If it's too heavy it may not move very well. Remove some decoration or use a 9V battery.
10. Just like with the Jackoon Artbot, some human artistry is needed with our Vibrorobot created skitter scatter art.

Skitter Scatter Art

Image Credit: http://imgkid.com/scribble-art.shtml.


Give students access to sets of water color paints, crayons, colored pencils, or other tools and instruct them to fill in each skitter art section of circle/space a different color.

Lesson One K-8 Standards Alignment

K

7.11.1 Explore different ways that objects move.

7.11.1 Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced as students build and test their vibrorobots artbots.

1

7.11.1 Use familiar objects to explore how the movement can be changed.

7.11.2 Investigate and explain how different surfaces affect the movement of an object.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how friction and force from different surfaces affects how their robot moves, as well as how weight, balance, and other forces affect the vibrobots movement and sound. As they understand and determine the effects of all the different factors they'll be able to work with them or adjust for them and change their vibrobots.

2

7.12.1 Determine that objects can move without being touched.

7.11.2 Describe the sounds produced by different types of vibrating objects.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the vibrobots movement and sound. As they understand and determine the effects of all the different factors they'll be able to work with them or adjust for them and change their vibrobots.

3

7.11.1 Plan an investigation to illustrate how changing the mass or weight affects a balanced system.

7.11.2 Demonstrate how changing the mass or weight affects a balanced system.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the vibrobots movement and sound. As they understand and determine the effects of all the different factors they'll be able to work with them or adjust for them and change their vibrobots.

4

7.11.2 Design a simple investigation to demonstrate how friction affects the movement of an object.

7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the vibrobots movement and sound. As they understand and determine the effects of all the different factors they'll be able to work with them or adjust for them and change their vibrobots.

5

7.10.5 Demonstrate different ways that energy can be transferred from one object to another.

7.10.2 Conduct experiments on the transfer of energy.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They'll put together the circuitry with the motor, electrical wire, and battery and learn how a circuit works, providing energy from the battery to the motor through the wires, causing spin and movement, etc.

6

7.12.1.b Identify how simple circuits are associated with the transfer of electrical energy when heat, light, motion, sound, and/or chemical changes are produced.

7.12.1 Describe how simple circuits are associated with the transfer of electrical energy.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They'll put together the circuitry with the motor, electrical wire, and battery and learn how a circuit works, providing energy from the battery to the motor through the wires, causing spin and movement, etc.

7

7.T/E.5 Develop an adaptive design and test its effectiveness.

7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the vibrobots movement and sound. As they understand and determine the effects of all the different factors they'll be able to work with them or adjust for them and change their vibrobots.

8

7.12.7 Explain how the motion of objects is affected by gravity.

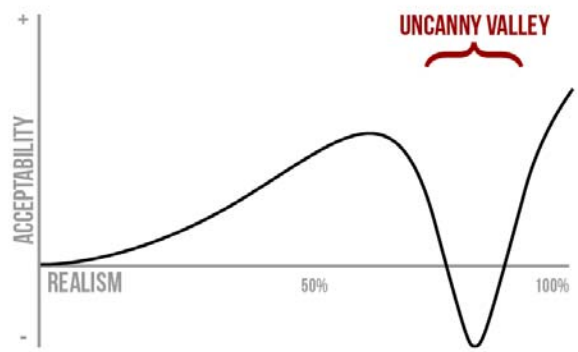
7.T/E.5 Develop an adaptive design and test its effectiveness.

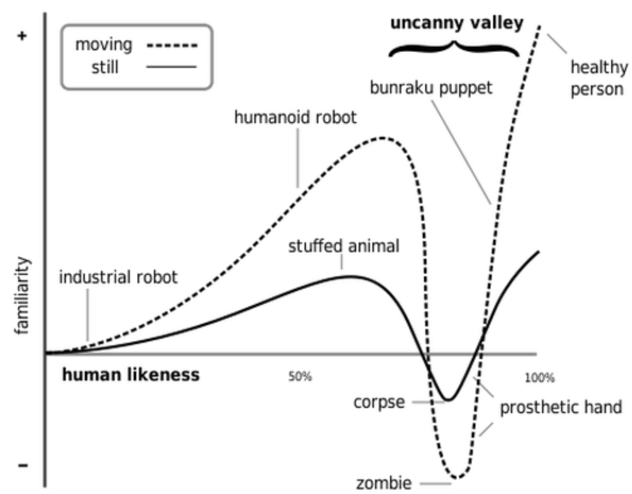
These standards will be met and reinforced as students build and test their vibrorobots artbots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the vibrobots movement and sound.

Lesson Two

Robot Skin

Robots come in every shape and size imaginable! They range from microscopic research bots to giant space rovers. And they can be made out of almost any kind of material, from stretchy fabric to the toughest metals or plastic. Many industrial, military, and exploration robots look like everyday tools or vehicles. Robot toys and social robots often look like animals, cute friendly monsters or imaginary creatures. Some look like blisteringly fast jet planes, whirling miniature helicopters, or tiny insects. A ‘humanoid’ robot is one that often has a face, two arms, and two legs. It can look like what everyone thinks of as a robot, an old-fashioned mechanical man. But if its covering is made soft and squishy, like skin, it can look so real it can scare people.





The uncanny valley as envisioned by the roboticist Masahiro Mori in 1970.
Credit: Creative Commons | SmurrayinchesterView full size image

Have you ever noticed that some of the most realistic robots are also the, well, creepiest?

A century ago, psychologists identified "the uncanny" as an experience that seems familiar yet foreign at the same time, causing some sort of brain confusion and, ultimately, a feeling of fear or repulsion. Originally no more than a scientific curiosity, this psychological effect has gradually emerged as a profound problem in the fields of robotics and computer animation.

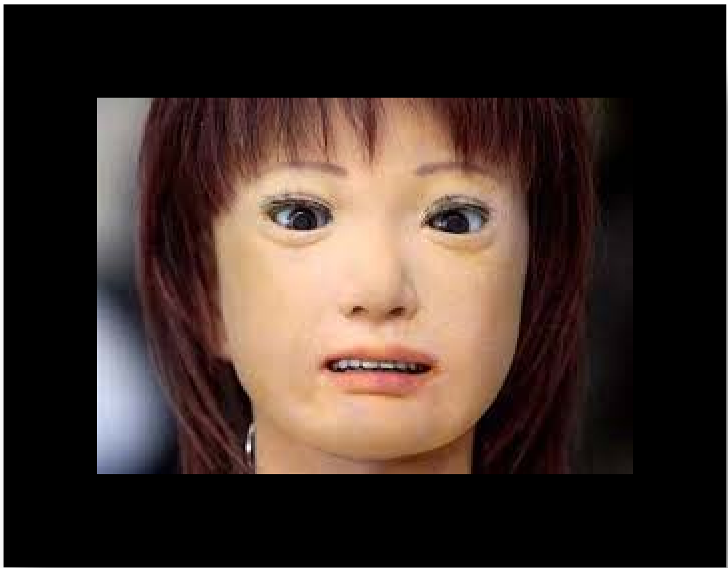
According to scientists, there’s a place right between believable and not-quite-believable that gives humans the willies. Scientists call it the ‘Uncanny Valley.’ The term comes from a graph created by Japanese roboticist Masahiro Mori that plots human empathy against the anthropomorphism of robots. On the graph, as robots become more realistic and we feel more and more empathy for them, the line trends upward. But as the robots' humanism approaches that of actual humans, our empathy for them — and the line on the graph — suddenly plummets. The resemblance between human and robot goes from remarkable to repulsive, and this precipitous drop became known as the "uncanny valley."

The Uncanny Valley is the idea that there's a curve related to an object's level of realism and how acceptable we perceive it to be. If something is somewhat realistic but stylized (like a stuffed animal), we're going to like it. The more realistic it is, the more we like it—to a certain point. A cute doll or human-like robot might bring us joy. However, once we cross a critical point in realism, our opinion of it plummets into the valley. Think about "realistic" video games or animated movies (Polar Express, perhaps) where the characters just feel… off. It's possible to get out of that valley, but only if the realism is cranked up enough to be truly indistinguishable from reality.

For example, which of the images below seems off, or "uncanny"? The animated and slightly cartoonish Anna from Frozen, the realistic girl from Polar Express, or the hyper-realistic painting (yes, painting!) of Morgan Freeman?

Researchers still don't know why it happens.

The original hypothesis states that as the appearance of a robot is made more human, some observers' emotional response to the robot will become increasingly positive and emotional, until a point is reached beyond which the response quickly becomes that of strong revulsion. However, as the robot's appearance continues to become less distinguishable from that of a being, the emotional response becomes positive once again and approaches human-to-human empathy levels.



In experiments even monkeys that were show pictures of almost-real monkeys turned away in fright.

Whatever the psychological root of the problem, there's a lot to be gained from figuring out how to get around it. Many computer animation studios, including industry leader Pixar, shy away from characters that might get lost in the uncanny valley, preferring cartoon stylization instead. They've watched braver studios fail. For example, ImageMovers Digital, a computer animation firm headed by producer Robert Zemeckis, produced a series of critical and commercial flops because of negative audience reactions to their eerie characters— starting with "The Polar Express" in 2004 and including "A Christmas Carol" and "Mars Needs Moms." You can't make much money on a robot, video game, or a film or whose uncanny protagonist doesn't garner empathy from consumers.

Rubbery Frubbery Robot Skin

Make new friends, but keep the old. One is silver, and the other gold!

Making a robot skin that's tough, soft, and sensitive is another challenge for scientists.

David Hanson of Hanson Robotics makes almost-real robot heads that can talk, smile, make jokes, interact with humans in a relatively natural, conversational way and recognize facial expressions around it and can respond accordingly. The key is a special artificial skin he invented called Frubber. It makes robot faces bend and crinkle in a lifelike way. (But videos of the Einstein head mounted on a shiny plastic robot body give many people the chills. The company will have to work hard to keep its fantastic machines from falling into the uncanny valley!)

Einstein Robot - UCSD Machine Perception Laboratory
https://www.youtube.com/watch?v=pkpWCu1k0ZI

In 2011, at Stanford University in California chemist Zhenan Bao demonstrated a rubbery film that can 'feel'. The material contains microscopic springs that stretch when pressed, even if the pressure is very light. The springs send an electrical signal to the robot's brain, telling it how much pressure has been applied. Based on the amount of pressure the robot can detect something as light as a fly or as heavy as an elephant.

Einstein Robot - UCSD Machine Perception Laboratory

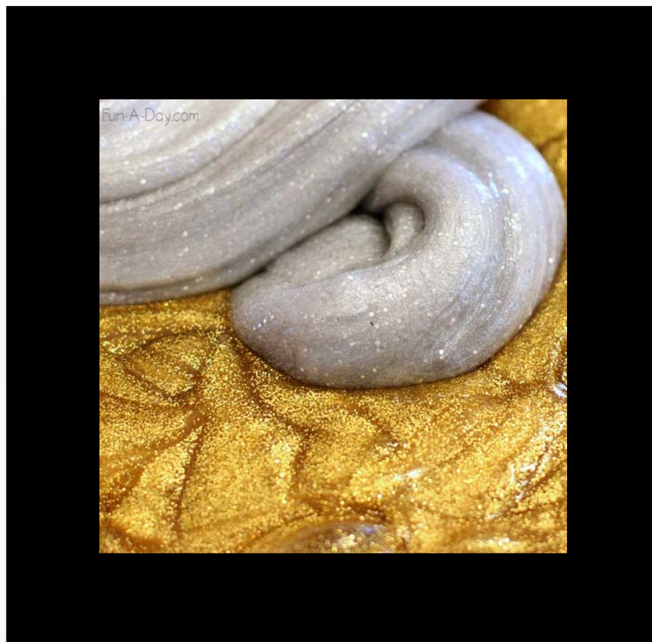
She, Zhenan Bao, is working on adapting the skin to absorb solar energy and to detect other things like chemicals or microscopic life in its surroundings. Some day, the robotic skin may be sued to help people feel through their artificial limbs or make touch screens even more sensitive.

Roboticists turn to chemistry when they want to create lifelike skin for humanoid robots. Here's how to make up some silver and gold skin for your new robot friends.

Have students experiment with the ingredients to change the thickness, stickiness, and stretchiness. They should make notes as they try different formulas so the group can determine which one they like best.

IMPORTANT: Be careful not to get their concoctions ground into furniture or clothes and don't pour it down the drain, or it will clog up the plumbing.

Silver Skin Slime



Recipe, images, and instructions from http://fun-a-day.com/silver-gold-homemade-slime-new-year/ . All Rights Reserved.

Tips: *Always shake your* liquid starch *container a bit to make sure that it is well-mixed.*

Materials (per batch):

- 5 oz. bottle Clear Elmer's glue (Colorations clear glue also works well)
- Silver metallic liquid watercolor, ex. Colorations brand or Sax, etc.
- Sta-Flo liquid starch
- Option: Silver glitter

Directions

1. Pour the bottle of clear glue into a bowl.
2. Add 2 tablespoons of silver liquid watercolor to the glue. Mix well.
3. (Optional) For extra sparkle, carefully add several tablespoons of silver glitter and mix well.
4. Add 4 tablespoons of liquid starch. Mix well.
5. Add another 2 tablespoons of liquid starch. Mix well.
6. Add 2 more tablespoons of liquid starch and knead (just like you would with bread dough). At this point, you should have added a total of 8 tablespoons of liquid starch to the mixture.

Gold Skin Slime

Materials:

- 5 oz. bottle of Elmer's Clear School Glue
- 2 TB [ex. Colorations] Gold Liquid Watercolor
- 1/2 cup (4 oz. or 8 TB) of Sta-Flo Liquid Starch
- Option: Gold Glitter

Directions

1. Place all of the clear glue into a bowl or cup.

2. Add the gold watercolor to the glue. Be sure to stir it in completely before the next step.

3. **Shake the liquid starch bottle** to make sure nothing's settled to the bottom.

4. Pour HALF (about 1/4 cup) of the liquid starch into the glue, then stir very well.

5. Add half of the remaining liquid starch (about 1/8 cup) to the mixture and stir well.

6. Add the remaining liquid starch and keep on mixin'.

7. Knead the mixture using hands. It will feel like thick pudding at first. As kneading progresses, it will transform! After kneading for a minute, check the stickiness and stretchiness of the slime. Knead for another minute if necessary, but don't over-knead.

8. If need be, add another tablespoon of liquid starch to the slime and knead for another minute or two.

Be sure to add the liquid starch in small increments or it'll become a clumpy mess! If you run into any problems with the process, check out Fun at Home with Kids' how to fix slime post [http://www.funathomewithkids.com/2014/06/how-to-fix-slime-that-didnt-work-out.html]. She has a different glittery, gold slime recipe you might want to check out while you're there.

Troubleshooting:

Let's look at the two ways this slime can go wrong.

First way: Not enough liquid starch. How do you know if this is your issue? Your slime will be stringy - it will stick to your fingers a ton. As you stir, you'll see little strings of glue grabbing your spoon. If you grab a section of your slime, it won't lift out in a glob - just a small stringy portion will stretch up.

Remedy? Add more liquid starch, approximately one Tablespoon at a time. Stir well to mix in between each addition of liquid starch. You'll know you've added enough when you no longer see those strings of glue grabbing your spoon as you stir, and you'll be able to lift all or most of the slime out if you grab a section of it. After a few minutes of kneading it will be beeeautiful and not sticky.

Second way things can go wrong: Too much liquid starch. A slime that's had too much liquid starch added will be stringy, but NOT sticky. It won't stick to your fingers - it will slide right off. It won't stick to a spoon or even to itself. It's just gross looking clumps of goo.

You can see strands of floating slime, and there will be standing liquid starch. How do you fix it? First, pour off any standing liquid starch. Then add clear glue, approximately 1/4 cup at a time, and stir. Once the slime starts holding together, you will need to knead it by hand. After adding glue and kneading for 2-3 minutes, it will be just like new! It will gel even more if left overnight in a sealed bag.

So what does perfect slime look like? It holds together and doesn't have any strings of glue or standing liquid starch. If you grab it, it moves as one cohesive unit. Kneading it for a minute or two will make it gel into a smoother and more uniform slime.

Store it in an airtight container or Ziploc bag when you aren't using it. It will keep for several weeks.

And don't worry if it bubbles. That's normal.

Final tip: Vinegar will dissolve this slime - just in case you get any on your carpet or clothing!

Lesson Two K-8 Standards Alignment

K

7.9.1 Describe an object by its observable properties.

7.9.2 Identify objects and materials as solids or liquids.

These standards will be met and reinforced as students make and describe batches of 'robot skin' slime and relate them to the robot skin created by scientists.

1

7.9.3 b Predict the changes that may occur when different materials are mixed.

7.9.3c Investigate and describe the results of mixing different substances.

These standards will be met and reinforced as students predict what will happen when we mix the ingredients, then make and describe batches of 'robot skin' slime and relate them to the robot skin created by scientists.

2

7.9.1 Use tools to observe the physical properties of objects and materials.

7.9.2 Describe what happens when a material changes, ex. from a solid to a liquid.

These standards will be met and reinforced as students predict what will happen when we mix the ingredients, then make and describe batches of 'robot skin' slime and relate them to the robot skin created by scientists.

3

7.9.1 Describe a substance in terms of its physical properties.

7.9.4 Classify combinations of materials according to whether they have retained or lost their individual properties.

These standards will be met and reinforced as students predict what will happen when we mix the ingredients, then make and describe batches of 'robot skin' slime (determining whether the ingredients have stayed the same, like when you mix sand and water or salt and pepper, (they are still recognizably themselves), or if they have changed. We relate our batches of slime o the robot skin created by scientists.

4

7.9.1 Use appropriate tools to measure and compare the physical properties of various solids and liquids.

7.9.2 Compare the causes and effects of various physical changes in matter, mixtures, and materials.

These standards will be met and reinforced as students participate in discussions about robot skins, their characteristics, and why scientists create them. Students will predict what will happen when we mix the ingredients, measure out the amounts for test batches, then make, adjust, and describe batches of 'robot skin' slime. As we troubleshoot our batches of slime students will hypothesize what caused the problem and a solution, ex. if the slime is too sticky…what was the cause and what effect will adding more starch or glue have?

5

7.T/E.1 Explain how different inventions and technologies impact people and other living (and non-living) organisms.

7.T/E.1c Study a tool, technology, or invention that was used to solve a human problem.

These standards will be met and reinforced as students participate in discussions about robots, robot skins, their characteristics, and why scientists create them and what problems they were designed to solve and what problems they have inadvertently caused. Ex. the uncanny valley. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

6

7.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as students participate in discussions about robots, robot skins, their characteristics, and why scientists create them and what problems they were designed to solve and what problems they have inadvertently caused. Ex. the uncanny valley. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

7

7.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as students participate in discussions about robots, robot skins, their characteristics, and why scientists create them and what problems they were designed to solve and what problems they have inadvertently caused. Ex. the uncanny valley. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

8

7.9.7 Describe how the characteristics of a mixture are different than the characteristics of their component parts.

7.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced as students predict what will happen when we mix the ingredients, then make and describe batches of 'robot skin' slime (determining whether the ingredients have stayed the same, like when you mix sand and water or salt and pepper, (they are still recognizably themselves), or if they have changed. We relate our batches of slime o the robot skin created by scientists.

Students will also participate in discussions about robots, robot skins, their characteristics, and why scientists create them and what problems they were designed to solve and what problems they have inadvertently caused. Ex. the uncanny valley. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

Lesson Three

How to train your robot

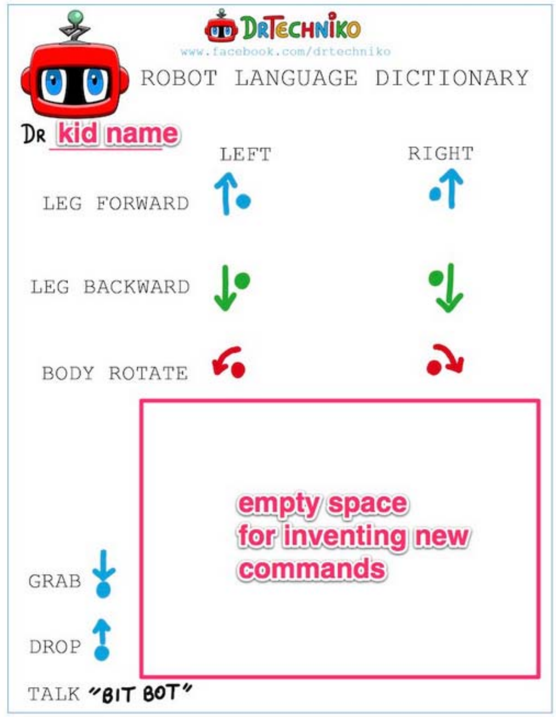
Learning how to program is going to be one of the most useful new skills we can teach our kids today. More than ever our lives depend on how smart we are when we instruct computers. They hold our personal data and they make decisions for us. They communicate for us and they are gradually becoming an extension of our brains. The time to begin to learn programming is now.

The goal of this game is for the 'robots' to go through an obstacle course, pick up a ball and bring it back. The kids have to write a program that will tell the robot how to do all that. Every time they write a program, they hand it to their robot and the robot executes it. To do that, give each kid a pen and paper where they copy symbols from the dictionary to write their programs and off their robots go!

The fun part begins when each robot retrieves the ball. After the initial run [aka test program] let kids invent their own moves and symbols that they add to their dictionary and then teach their robots. There is no limit to what the kids come up with.

This game teaches some very basic principles of computer science and programming:

- Programming languages are just another way to communicate to an entity (via programs).
- Programs are recipes for automating stuff



Important programming elements students also often quickly figure out:

- Program Parametrization: Instead of putting a forward step ten times, put a 10 in front of the "step" symbol.
- Composition: Grouping of a set of moves ("move left leg forward, then move right leg forward and do this combo 10 times")
- Abstraction: "Run in a circle, then say "I'm dizzy!" , then call this the "Run Dizzy" program and do it 100 times. (For some reason, kids love making their partners repeat stuff 100 times over.)
- Unit testing: Write a test program to get the partner moving a few steps, have their partner run it, then fix it and run it again, and then add a few more steps until they reach the goal.

Materials:

- Printouts of the Robot Dictionary
- Pens/pencils
- Materials for an obstacle course
- Ball for each partnership

Set up an obstacle course

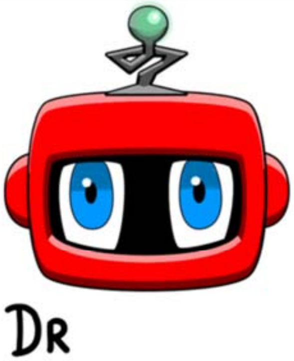
Divide students into pairs

Introduce the game:

So now that we've learned a bit how robots work, you will get to train your own robot! But, wait. Do you guys see any robots around here? Well, I do. Your partner! Let's turn your partner into your own personal robot. Imagine you are on the planet Mars and you cannot go out of your station. There is a very precious element called B-Rainium that you want to retrieve.

Your mission is to write a program that will send your robot around these obstacles retrieve the ball of B-Rainium and bring it back to the station.

But your robot doesn't understand a human language. It only understands the Robot Language. Here is the Robot Language Dictionary. Let's all practice the moves and then you can use these moves to tell your robot what to do!



DRTECHNIKO

www.facebook.com/drtechniko

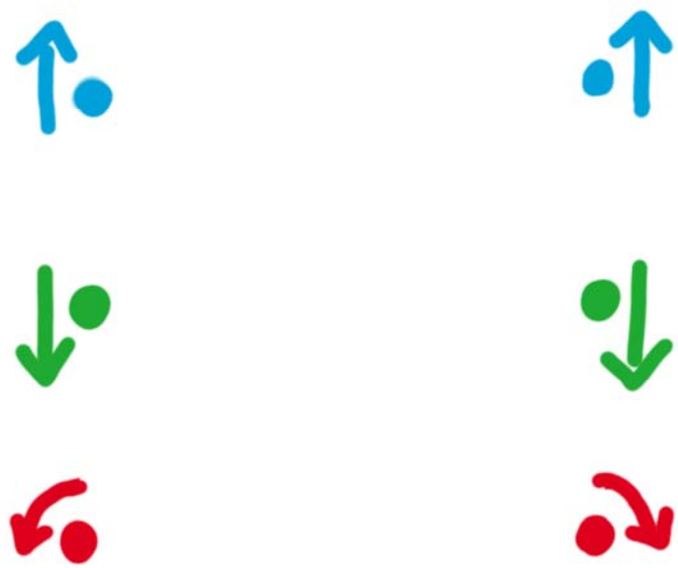
ROBOT LANGUAGE DICTIONARY

LEFT RIGHT

LEG FORWARD

LEG BACKWARD

BODY ROTATE



GRAB 

DROP 

TALK "BIT BOT"

Lesson Three K-8 Standards Alignment

K

RF.K.3. Know and apply word analysis skills in decoding words.

L.K.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

1

RF.1.3. Know and apply word analysis skills in decoding words.

L.1.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

2

RF.2.3. Know and apply grade-level word analysis skills in decoding words.

L.2.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

3

RF.3.3. Know and apply grade-level word analysis skills in decoding words.

L.3.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

4

RF.4.3. Know and apply grade-level word analysis skills in decoding words.

L.4.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

5

RF.5.3. Know and apply grade-level word analysis skills in decoding words.

L.5.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

6

RL.6.4. Determine the meaning of words and phrases as they are used, ex. in a text.

L.6.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

7

RL.7.4. Determine the meaning of words and phrases as they are used, ex. in a text.

L.7.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

8

RL.8.4. Determine the meaning of words and phrases as they are used, ex. in a text.

L.8.3 Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend concepts and texts more fully.

These standards will be met and reinforced as students participate in creating the codes and while playing the computer coding and code reading/computer code execution game using the robot language.

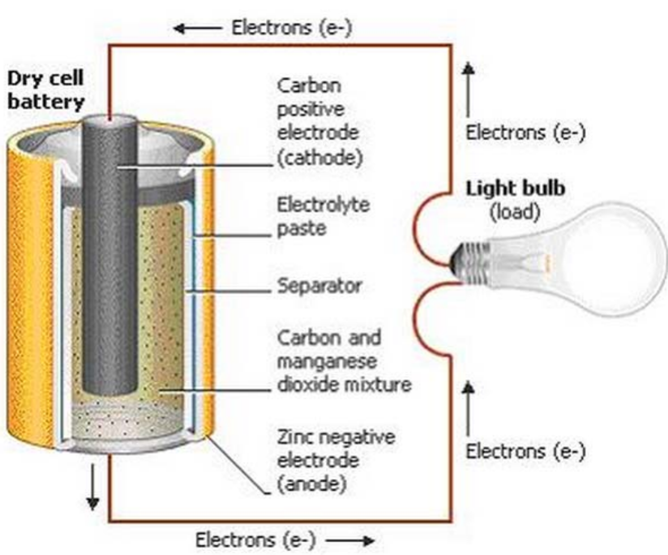
Lesson Four

We Like to Move it Move it!

Just like humans and other living things, robots need energy to move and "think." Even the earliest automata that moved by themselves were powered by humans. People raised the weights, turned the cranks, and wound up the springs that made them move. Humans were their power source. But the power source for most modern robots is a battery. The kinds of batteries used in robots range in tiny disks like watch batteries to big heavy batteries like you'd see in a car, often bigger than a cinder block. Batteries are portable power plants that use a **chemical** reaction (chemical energy) to produce electricity.

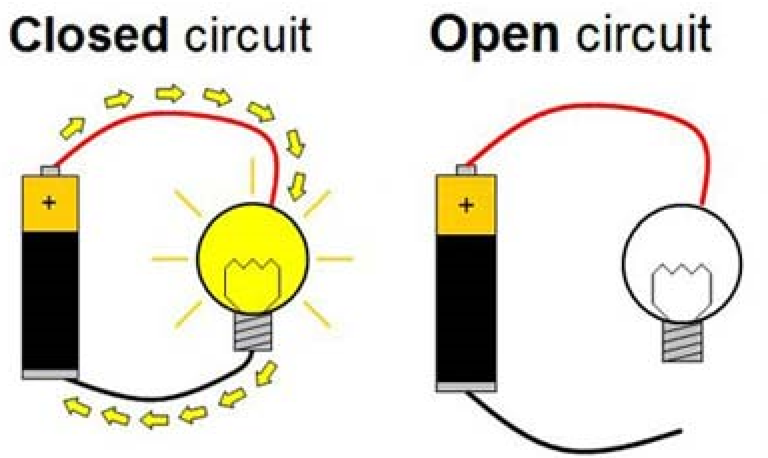
How does a battery produce electricity

Energy cannot be created or destroyed, but it can be saved in various forms. One way to store it



is in the form of chemical energy in a battery. When connected in a circuit, a battery can produce electricity. A battery is a portable power plant that uses a chemical reaction to make electricity. In a battery two metals made of different kinds of atoms are placed near each other in a container that's filled with a special acidic solution. All atoms contain electrons, which have a negative charge. Negative charges repel or push away other negative charges. Opposites attract though. So negative electrons don't like to be near other negative particles, but are attracted to positive charges, and vice versa.

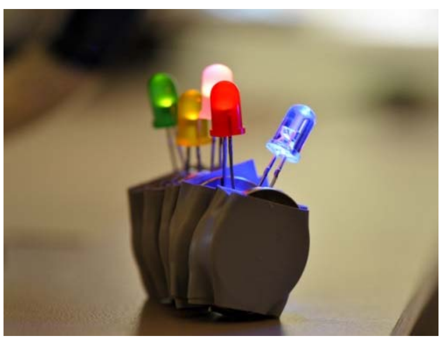
In the battery, one metal has a slight positive charge, while the other metal has a slight positive charge. So the electrons from the negatively charged metal are attracted to the positively charged metal. The electrons travel through the chemical inside the container from one metal to the other. This movement creates a flowing negative charge, which we call electricity.

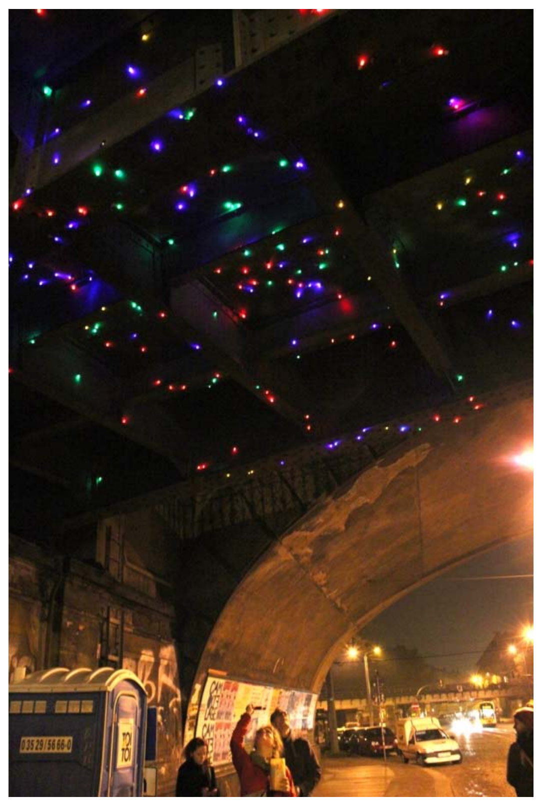


If a circuit (a path that lets electricity flow when it's closed in a loop), is hooked up to the battery, the negative charge will flow out of the positive end, or terminal (the point where electricity flows in or out), of the battery, through the wires and components, and back into the battery through the negative terminal. The circuit has a switch that opens and closes like a drawbridge. When the switch is opened, no electricity can travel over the circuit. But when it is closed, the circuit is complete and the power? It starts humming!

LED Throwies

http://makezine.com/projects/extreme-led-throwies/





The more you make, the cooler they look!

The LED throwie was first invented around 2005 or 2006 as a kind of non-destructive electric graffiti. Guerilla graffiti artists incorporated LEDs to produce temporary pieces in public places.

Artists use them by throwing individual LEDs onto metallic objects, like public sculpture or road infrastructure. By throwing LEDs onto an object, the object itself acts as a canvas.

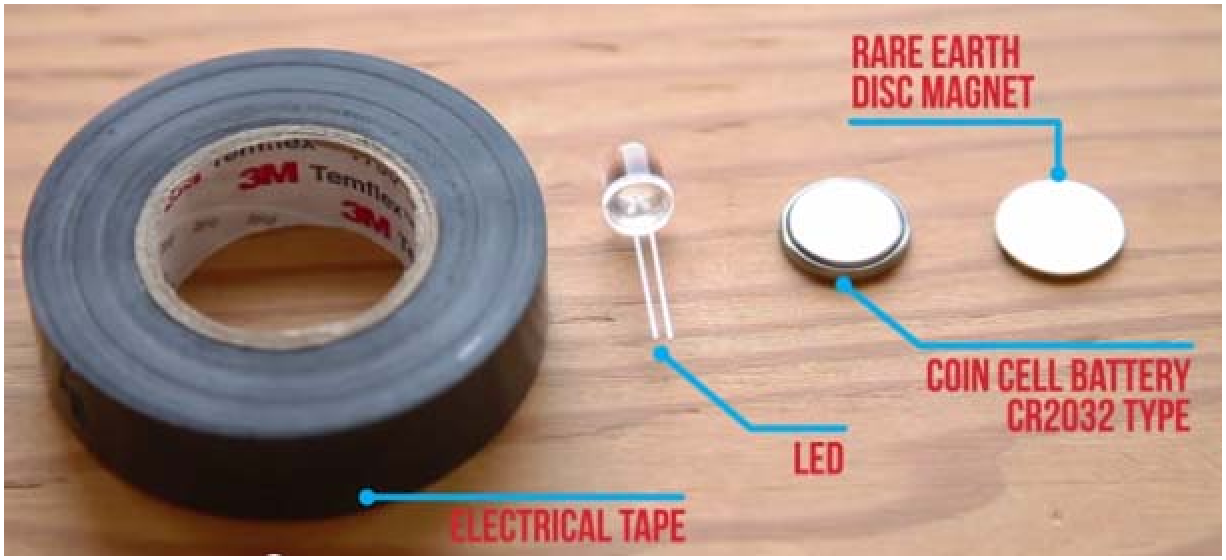
Note: LED throwies were invented in 2006 by the artists

Evan Roth and James Powderly the founder of Graffiti Research Lab at Eyebeam Atelier open lab NYC. After Graffiti Research Lab posted the instructions how to make a throwie on Instructables LED throwies went viral on the Internet and could be found in advertising, were for sale as DIY kits or further developed by other artists and hackers worldwide. You'll also find them in those little keychain flashlights– open one up and there's just a battery and an LED.

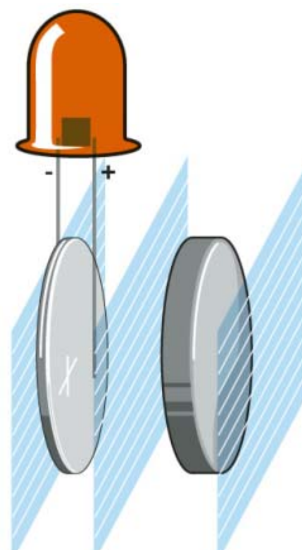
LED throwies are cheery glow-dots (a.k.a. magnetic, closed circuits that stay lit for weeks!) students can make in seconds from simple components and they stick to any ferro-magnetic surface. But that's just the beginning. First we'll make a basic LED throwie, and chain them up into big throwie "bugs." Then we'll learn to hack the throwie circuit with an On-Off tab (made of paper) so we can switch it on, or off, whenever we want (the beauty of circuits!) *Also we can make up games, ex. throwie darts, while kids learn about the properties of currents, circuits, and electricity.* **Warning:** DON'T use a whiteboard that someone cares deeply about, ex. another teacher's, to play throwie dart review. The board will get a bit pockmarked by the end, so a cheap and portable one (especially one that can be permanently dedicated to the game) is perfect.

There's a very helpful and informative video that takes you step by step through the throwie construction process here: http://makezine.com/projects/extreme-led-throwies/

Materials:



- First you'll need **LEDs**. You can buy them from any electronics supplier.
- Some electrical tape
- Coin Cell batteries and
- You'll also need small **magnets**. Ex. 12mm×2mm neodymium-boron magnets
- Paper
- And maybe some scissors for the tape



Tips: A throwie will shine for 1-2 weeks, depending on the weather and the LED color. To get one off a ferro-magnetic surface, don't pull it, or it might come apart. Instead, slide the magnet sideways while lifting it with a fingernail or tool.

Let's get started:

1. Pinch the LED's leads to the sides of the battery, with the longer lead (the anode, or positive leg) touching the battery's positive (+) terminal, and the shorter lead (cathode, negative leg) touching negative (–).

It should light up. If not, you probably just have the battery the upside down, so flip it over.

2. Cut a 7" length of strapping tape or electrical tape, and wrap the leads tightly to the battery so the LED does not flicker. Wrap once around both sides of the battery.

3. Place the magnet on the positive side of the battery and continue wrapping tightly.


4. The battery's positive contact surface extends around the edges of the battery, so don't let the short lead (cathode) touch it or you'll short the circuit.
5. That's it! You've got an LED throwie (and a complete circuit) You're ready to throw it and watch it stick to any ferro-magnetic surface.


Throwie Bugs

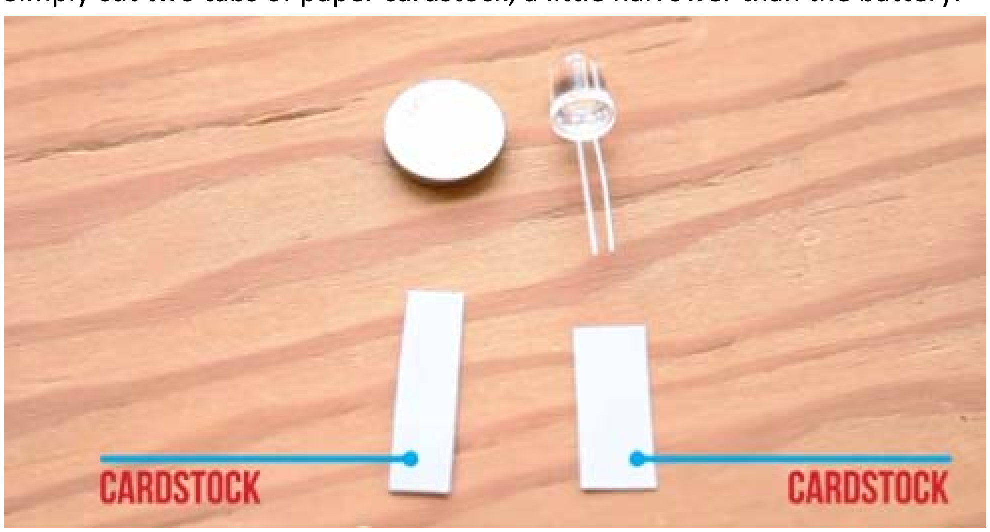
Throwies will naturally stick together because of the magnets, so they can be chained together in giant 'throwie bugs' to really light things up.

On Off Switch

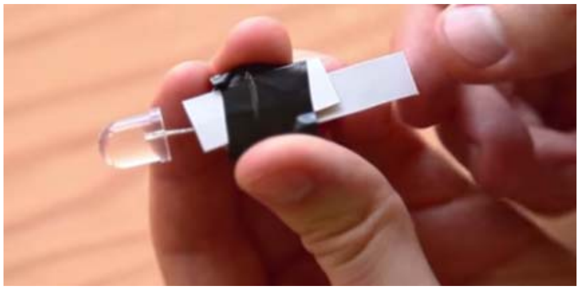
Once we make a basic throwie it stays lit, until it uses up the whole battery. To modify it so that we can turn it on and off whenever we want, we need a circuit breaker.

Materials:

Simply cut two tabs of paper cardstock, a little narrower than the battery.



Then sandwich the LED's longer lead between these two pieces of cardstock before you tape up the throwie. One tab will stick to the tape, the other will slip in and out making and breaking contact, so we can switch throwies on and off whenever we want.



Lesson Four K-8 Standards Alignment

K

7.1.3 Take apart an object and describe how the parts work together.

7.1.2 Use building materials to create a whole from the parts.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies.' We'll discuss what each part does and how they work together as a whole.

1

7.12.1 Identify and classify objects in the classroom as magnetic or non-magnetic.

7.12.2 Make predictions about how various objects will be affected by a magnet.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies.' We'll determine what the magnet does for the throwie and what they think it will stick to and how the magnet helps hold the throwie in place.

2

7.12.2 Realize that things fall toward the ground unless something holds them up.

7.12.1 Explain how two magnets interact.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies.' We'll determine what the magnet does for the throwie and what they think it will stick to and how the magnet helps hold the throwie in place. We'll predict what will happen when we join two of them together and then test our theories.

3

7.10.1 Use an illustration or model to identify various sources of energy, ex. heat, light, chemical

7.12.2 Determine that only certain types of objects are attracted to magnets.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies.' We'll determine what the magnet does for the throwie and what they think it will stick to and how the magnet helps hold the throwie in place.

We'll determine what the energy source is for the throwie and discuss how the chemical energy in the battery gets changed into the light and heat energy in the bulb.

4

7.12.3 Describe how electricity passes through a simple circuit that includes a battery, wire, switch, and bulb.

7.12.3c Determine the path of an electrical current in a simple circuit.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies' and discuss and discover how they work. We'll find out what happens when the circuit is complete (light) and when it's broken (light shuts off) or the energy source is drained (light shuts off), what the battery does, and how the switch works to interrupt the flow of electricity.

5

7.10.5 Demonstrate different ways that energy can be transferred from one object to another.

7.10.2 Conduct experiments on the transfer of energy.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies' and discuss and discover how they work. We'll find out what happens when the circuit is complete (light) and when it's broken (light shuts off) or the energy source is drained (light shuts off), what the battery does, and how the switch works to interrupt the flow of electricity.

6

7.12.1.b Identify how simple circuits are associated with the transfer of electrical energy when heat, light, motion, sound, and/or chemical changes are produced.

7.12.2 Describe how simple circuits are associated with the transfer of electrical energy.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies' and discuss and discover how they work. We'll find out what happens when the circuit is complete (light) and when it's broken (light shuts off) or the energy source is drained (light shuts off), what the battery does, and how the switch works to interrupt the flow of electricity.

7

7.T/E.5 Develop an adaptive design and test its effectiveness.

7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies' and come up with their own designs, modifying ones that have been created by previous inventors. Students will demonstrate their understanding of simple circuitry by building simple circuits and testing them and explaining why their design works or why it does not.

8

1.5.6 Build circuits to demonstrate how they function.

7.12.1 Investigate the relationship between magnetism and electricity.

These standards will be met and reinforced as students participate in constructing and deconstructing 'throwies.' We'll determine what the magnet does for the throwie and how electrical and magnetic forces are similar, different, and/or work together. And as they participate in constructing and deconstructing 'throwies' and come up with their own designs, modifying ones that have been created by previous inventors, students will demonstrate their understanding of simple circuitry by building simple circuits and testing them and explaining why their design works or why it does not.

Robots Part Four Sample Academic Vocabulary Alignment

K

- Change
- Shape
- Observe
- Parts
- color

1

- Property
- Texture
- Living
- Non-living
- Magnet
- Matter

- Light
- Mixed
- Invent

2

- Energy
- Transform
- Type
- Observe
- Compare
- Contrast
- Similarities
- Differences
- Sound
- Vibration

3

- Tools
- Mixture
- Borders
- Conductor
- Force
- Area
- Conclusion
- Rotation

4

- Chemical energy
- Friction
- Electricity
- Camouflage

5

- Energy
- Matter
- Properties
- Irregular
- Model

6

- Simple circuits
- electrical conductor
- energy transformation
- conductivity
- cause
- effect

7

- Phenomenon
- Impact
- Synthesize
- Tissue
- Property
- Function

8

- Magnetic
- Variation
- Product
- Human impact
- Debate

Robots Part Four Sample Supply List

Lesson One:

Access to videos

Materials (per robot):

- Small DC motor (1.5 volts)
- Insulated electrical wire, about 1 foot or 30 centimeters long
- Wire cutters
- Electrical tape
- 1 paper, plastic, or foam cup
- Foam mounting tape
- 2 AAA batteries
- Rubber Band
- Cork
- 3 Markers
- Cardboard box lid or box with low cut sides, about the size of a piece of 8.5 X 11 printer paper, ex. the lid of a box of printer paper
- Plain white paper
- Optional: Pipe cleaners, craft sticks, Styrofoam or wooden pieces, decorative glue-ons, googly eyes, glitter pens, quick-dry glue, or hot glue gun
- Art supplies: sets of water color paints, crayons, colored pencils, or other tools and instruct them to fill in each skitter art section of circle/space a different color.

Lesson Two

Access to videos

Silver Slime Materials (per batch):

- 5 oz. bottle Clear Elmer's glue (Colorations clear glue also works well)
- Silver metallic liquid watercolor, ex. Colorations brand or Sax, etc.
- Sta-Flo liquid starch
- Option: Silver glitter

Gold Slime

- 5 oz. bottle of Elmer's Clear School Glue
- 2 TB [ex. Colorations] Gold Liquid Watercolor
- 1/2 cup (4 oz. or 8 TB) of Sta-Flo Liquid Starch
- Option: Gold Glitter

Lesson Three

- Printouts of the Robot Dictionary
- Pens/pencils
- Materials for an obstacle course
- Ball for each partnership

Lesson Four

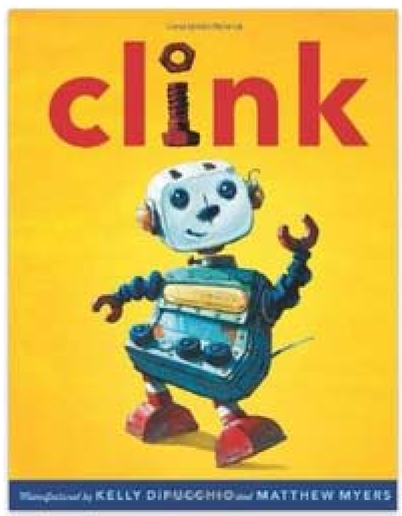
- First you'll need **LEDs.** You can buy them from any electronics supplier.
- Some electrical tape
- Coin Cell batteries and
- You'll also need small **magnets.** Ex. 12mm×2mm neodymium-boron magnets
- Paper
- And maybe some scissors for the tape

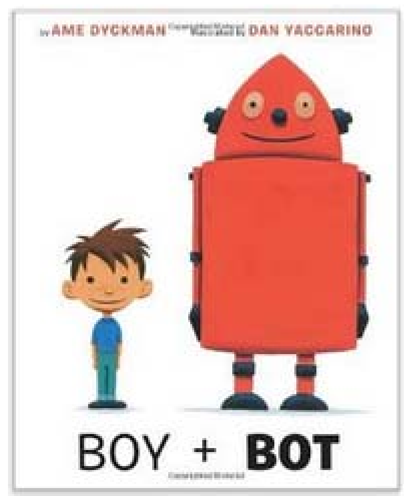
ROBOTS

Part Five: We Like to Move it Move it

1 Image via, all rights reserved: http://s733.photobucket.com/user/19nikkivelez89/media/robot_dancing.png.html

Lesson One





Access Prior Knowledge encourage discussion, and introduce the theme by reading a book about robots, such as the sweet and fun *Clink* by Kelly DiPuccio and/or the excellent and humorous *Boy and Bot* by Ame Dyckman. *The Robot Book by Heather Brown*, *The Robot and the Bluebird* by David Lucas, or *Robot Zot!* by Jon Scieszka and David Shannon.

Energized by the Sun

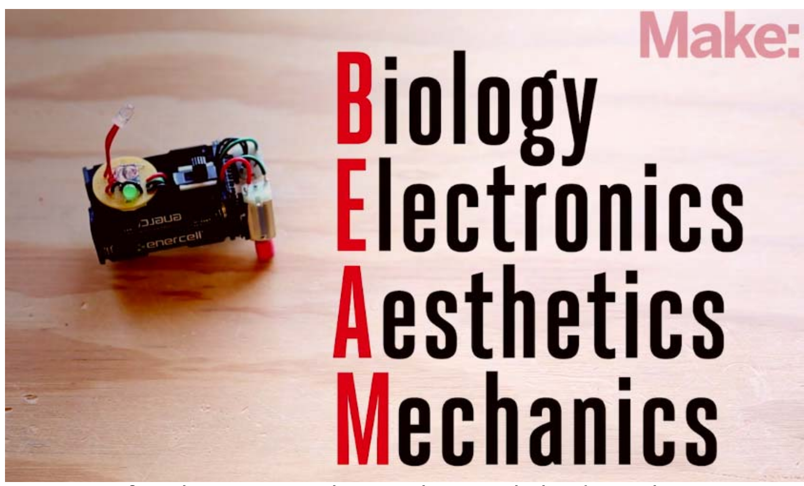
Another source of energy or electricity for robots is the sun. A solar cell works kind of like a battery, but it uses light rays from the sun. NASA uses solar energy to keep the batteries in its Mars rover charged. **(Why might they choose to use solar energy? How hard would it be to change the batteries on the Mars rover?)**

BEAMing You Up

A BEAM robot is a type of solar-powered machine that is popular with robotics hobbyists. A physicist by the name of Mark Rilden first came up with idea in 1989. He wondered what early robots would have looked like if robots had evolved (evolve: a change in a species of living thing in response to the world around it) like living things. The letters in BEAM stand for:

Biology: BEAM robots take inspiration from nature, especially "simple" organisms like plants, worms, and insects. They are often classified by their primary sensor system: *audiotropes* respond to sound, *thermotropes* respond to heat, *radiotropes* respond to radio sources, etc. They can be further subdivided by their type of movement or positioning mechanism: sitters, squirmers, jumpers, fliers, rollers, walkers, and so forth.

Electronics: BEAM robotics requires clever circuit design. BEAM robots use analog circuits, which are more subtle than digital circuits. Designing digital circuits is more like computer programming, while designing analog circuits is more like plumbing.



Aesthetics (which means artistic, or the appearance): BEAM robotics is as much art as science. That a design "look cool" is not always a priority for engineers, but the BEAM approach emphasizes the importance of looks, though not just for their own sake. Rather, polished aesthetics are a test that mature BEAM designs should pass. A good-looking robot has been designed and constructed with close attention to detail. Its form is a refined, efficient, natural, logical reflection of its function. People who see it will recognize its beauty and want to preserve it, so aesthetics becomes a "survival" function, as well.

Mechanics (or how it works): Sometimes a mechanical solution is cheaper, easier, or more robust than an electronic one. For example, rather than complicate a circuit with electronic motor controls, BEAM designs often adopt simple mechanical "hacks" (like steeply tilting the motors or using small-diameter wheels) to regulate motor speed.

From a design perspective, BEAM robotics is about getting the most complex and interesting behaviors using the simplest circuits, actuators, and components. Therein lies the challenge.

Although BEAM robots use only simple circuitry instead of computers, their unexpected movements make them act as if they are alive. Their secret is a capacitor, the electronic component that stores electricity like a battery.

The energy made by the solar cell is stored in what's called a capacitor until there is enough to make the robot's motor move. The time it takes to store enough energy depends on how much sunshine there is. When it's ready, the capacitor sends its "juice" into the motor all at once and the robot jumps. To move again, the BEAM robot has to wait until its capacitor is recharged, so you have to look out! You never know when a BEAM robot will come to life.

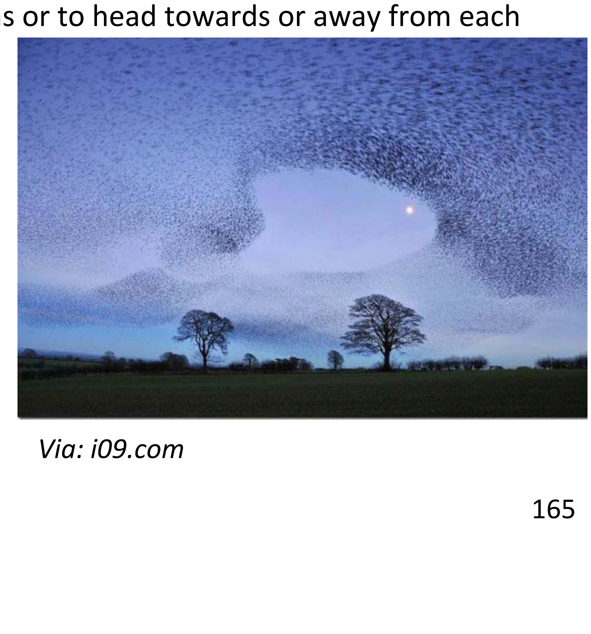
Swarming Vibrobots

Vibrating robots behaving in lifelike ways without any electronic control through a combinations of random movements and mechanical programming due to their shape and distribution of weight.

Where it came from

Probably the most famous example of a vibrating robot is the Bristlebot—the Throwie of the robot world. First appearing on the Evil Mad Scientist Laboratories website in 2007, the Bristlebot is made of the head snipped off a toothbrush, a tiny vibrating motor like those used in pagers and cell phones, and a disc battery. The bristles direct the bot in roughly forward direction, with just enough unpredictability to make it fun and give it character. Hexbug's popular Nano robots are basically fancier Bristlebots with added decorations and sometimes sensors. Another version is the Artbot we made earlier.

However, not all vibrobots are "dumb." Kilobots are tiny vibrating robots created at Harvard. They can be programmed to move in preset patterns or to head towards or away from each other. About the size of a quarter, each Kilobot consists of a circuit board, battery, two vibrating motors, and infraredsensors on three toothpick style legs. Infrared signals (like the signals a remote sends to a TV) tell the Kilobots what to do and can program dozens or even hundreds of them simultaneously.



Via: i09.com

How it Works

Via: i09.com

In 2013, Italkian researcher Luca Giomi used custom-designed Bristlebots to show that collective behaviours like swarming can arise simply by letting self-propelled devices interact in a confined space. They found that when a crowd of Bristlebots (walkers or spinners) reached critical mass, they started to move in sync, like a school of fish, or a flock of birds. The finding suggests that to some extent the swarming of birds, fish, bees, etc may be the result of the size of the group, as opposed to voluntary individual decisions.

See an interesting short explanatory video of the tendency and project: https://www.youtube.com/watch?v=0uqsRGFLM20

View fascinating images and some gorgeous footage of birds exhibiting swarming behavior here: http://io9.com/you-wont-believe-the-patterns-created-by-flocks-of-bir-1469575403 "When birds travel in flocks, their behavior takes on emergent properties. Out of the chaos of flight, gorgeous, geometric patterns coalesce. When photographers capture these patterns at exactly the right time, it's like seeing mathematical abstractions written across the sky. Here are some of the most stunning images of flocking patterns we've ever seen."

Rock Paper Scissors Swarm

All the players find a partner and play rock paper scissors. Whoever loses must put their hands on the shoulders of the winner, forming the start of a 'swarm,' and must act as an enthusiastic cheerer/chearleader for that player.

The front person of that train leads their 'swarm' to another 'swarm' and the undefeated front people of each swarm play against each other. Each time a team wins, it collects the other team's players, and they line up behind the unbeaten leader, enthusiastically cheering their new leader. At the end, there will be two large teams, led by the unbeaten leader in front. After the final match, the celebration begins and only one swarm remains!

Traditional rules of Rock, Paper, Scissors...

Two players face each other and simultaneously throw out one of the following hand signals: rock, paper, or scissors.

Rock is formed by making a fist. Rock "beats" Scissors, by breaking them. Rock is beaten by the signal for Paper, as Paper covers Rock.

Scissors is formed by horizontally extending your middle and index fingers (a sideways peace sign). Scissors "beats" Paper by cutting it. Scissors are beaten by Rock, as Rock smashes Scissors.

Paper is formed by holding your hand out straight, with palm facing down. Paper "beats" Rock by covering it. Paper is beaten by Scissors, as Scissors cut Paper.

Generally, each player holds one hand out in front of their bodies and they simultaneously chant, "One, Two, Three, shoot" and on "shoot," both players display their signal. The player whose signal beats the other wins.

Lesson One K-8 Standards Alignment

K

K.G.1. Describe objects a) in the environment using names of shapes,

K.G.1. b) describe the relative positions of objects using terms such as above, below, beside, in front of, behind, and next to.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and see if they see any shapes within the patterns and describe the motion that they see.

1

7.Inq.2 Communicate interest in simple phenomena and plan for simple investigations.

7.11.1 Investigate how forces (push, pull) can move an object or change its direction.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other) and we'll discuss how we're going to make our own vibrobots (the following day) and whether or not students think we can get them to 'swarm' and why they will or will not.

2

7.Inq.2 Communicate interest in simple phenomena and plan for simple investigations.

7.2.2 Investigate living things found in different places.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other) and we'll discuss how we're going to make our own vibrobots (the following day) and whether or not students think we can get them to 'swarm' or form patterns and why they will or will not.

3

3.OA.9. Identify patterns and explain them.

7.11.1 Identify how/why the direction of a moving object is changed, ex. by an applied force.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other.)

4

4.OA.5 Generate and/or analyze patterns.

7.6.1 Analyze patterns, relative movements, and relationships among the objects under investigation.

7.11.1 Recognize that the position of an object can be described relative to other objects or a background.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other) and we'll discuss how we're going to make our own vibrobots (the following day) and whether or not students think we can get them to 'swarm' or form patterns and why they will or will not.

5

5.OA.3 Analyze patterns and relationships.

7.Inq.4 Analyze and communicate findings from multiple investigations of similar phenomena to reach a conclusion.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and patterns and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other) and we'll discuss how we're going to make our own vibrobots (the following day) and whether or not students think we can get them to 'swarm' or form patterns and why they will or will not.

6

6.SP.5.b) Describe the nature of the attribute under investigation as well as describing any overall pattern and any striking deviations from the overall pattern.

7.Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and their motions and make their own hypotheses about what causes these *patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other, gravity, friction, airflow, etc.)*

7

7.11.4 Recognize how a net force impacts an object's motion.

7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other, gravity, friction, etc.)

8

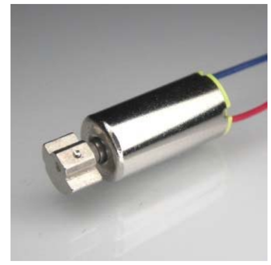
7.Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.

7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

These standards will be met and reinforced as students participate in the discussion, view and analyze images, and watch videos from around the world about collective behaviors such swarming patterns in both living and non-living creatures. Students will look for similarities in the swarms and make their own hypotheses about what causes these patterns to occur (ex. they might think it's because the creatures push each other/want to stay away/or want to be near each other, gravity, friction, etc.)

Lesson Two

Making the Bots



Materials:

- Small vibrating motors, often called pager motors, available from most electronics dealers, or recycle them from old cell phones, pagers, or Oral B Pulsar disposable electric toothbrushes. Ex. http://shop.evilmadscientist.com/productsmenu/partsmenu/131-pagermotor or http://www.goldmine-elec-products.com/products.asp?dept=1107
- Three or more small coin cell batteries (1.5 to 3 volts)
- Foam tape
- Three or more 2-inch (5cm) acorn-shaped plastic gumball machine capsules (the kind used to dispense toys)
- Smooth test surfaces, ex. large piece of posterboard and/or cardboard box top for a confined test area.

First, list out the goals of the project for students. Ex. The goal is to assemble quick and easy Gliding Vibrorobots that travel in large loops. As the number of little bots grows, so will the patterns we are likely to see. The more, the merrier!

Plan the project together. Putting the pieces together for this project is really easy. The challenge comes in positioning them just right, to achieve the kind of movement we're hoping for. While the plastic gumball machine capsules look great without any decorations, students can add personality and change the behavior of their bots with added decorations. Have them keep in mind that this project has no on/off switch. Keep a few extra batteries on hand, since they will burn through them as they test (and play with) their Vibrobots.

Have students keep track of directional movements and emerging/existing patterns by drawing diagrams.

Tip: check out the original bristlebot how-to on the Evil Mad Scientist website for inspiration and building tips. http://www.evilmadscientist.com/2007/bristlebot-a-tiny-directional-vibrobot/ The ingredients? One toothbrush, a battery, and a pager motor. The result? Serious fun. [make a bunch of them to race them competitively.]

Now, build your prototype:

1. If you're repurposing an old vibrating motor, make sure each of its wires have a little metal exposed at the end. If not, strip off about ¼ inch (3mm) of insulation with a wire stripper (or carefully with a scissor or wire cutter.)
2. Cut a piece of foam tape about 2 inches (5cm) long. Stick the motor onto the tape, with the weight on the shaft hanging off the end of the foam tape. It needs to be able to spin freely.
3. Press one wire down along the tape. If the wire is more than an inch (2.5 cm) logn or so, curve it ab it so that the metal end is closer to the bottom of the motor. Then press the disk battery on top of the metal end of the wire to hold it in place. When you're ready to turn the Vibrobot on, secure the other wire to the top of the battery with more tape.
4. Take off the clear plastic lid of the gumball capsule and set it aside. Stick a square of foam tape inside the bottom (colored flat part) of the capsule. Make sure it is a little off center.
5. Attach the foam tape holding the motor and battery onto this piece of tape. You will have to fiddle with it a bit to get the vibrobot to move forward and not spin in place. One configuration that works is to put the battery up against the side (for ballast) and the weight on the motor shaft almost touching the side as well.

Make several more the same way. Start each vibrobot moving by attaching the top wire to the top of the battery with foam tape. Snap on the clear lid and you're ready to test, test, test!

Give them a clear space to move around in. A long piece of posterboard makes a nice smooth surface or the lid of a copy paper box makes a great confined space.

Turn them on, set them down, and observe how they move.

Adjust the position of the motors and the batteries as needed to get the kind of motion you'd like.

Troubleshoot and Refine

Make sure the vibrating motor is firmly attached to the inside of the bot at all times. If it just sits and spins, try moving the parts around until it moves forward(ish).

Adaptations & Extensions

Decorate! Stick on some googly eyes, ballpoint pen springs for antennae, or add mini craft-stick skis to the bottom. You can even create flying saucer style landing gear by sticking some long straight pins with plastic ball ends through the bottom of the plastic gumball capsule and hotgluing them in place. For advanced makers and older students, trying adding some popular upgrades like two flat vibrating motors and a light sensing circuit that tells the bot to turn towards or a way from the light.

Lesson Two K-8 Standards Alignment

K

- 7.11.1 Explore different ways that objects move.
- 7.11.1b Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion of single vibrobots, then small groups, then large groups to see what kind of motion patterns emerge, what causes changes to the motion, etc.

1

- 7.11.1 Use familiar objects to explore how the movement can be changed.
- 7.11.2 Investigate and explain how different surfaces affect the movement of an object.
- 7.11.1a Investigate how forces (push, pull) can move an object or change its direction.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion of single vibrobots, then small groups, then large groups to see what kind of motion patterns emerge, what causes changes to the motion ex. the vibrobots pushing against each other, etc. We will test the vibrobots on different surfaces and in different styles of confined space to see if those variables affect the motion and action in any way or cause any patterns to emerge.

2

- 7.11.1 Use a variety of objects that vibrate to demonstrate how sounds are produced [and motion is created.]
- 7.11.2 Describe the sounds [and motion] produced by different types of vibrating objects.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion and sounds created by single vibrobots, then small groups, then large groups to see what kind of sound and motion patterns emerge, what causes changes to the motion ex. the vibrobots pushing against each other, etc. We will test the vibrobots on different surfaces and in different styles of confined space to see if those variables affect the motion and action in any way or cause any patterns of sound or motion to emerge.

3

- 7.11.1b Identify how the direction of a moving object is changed by an applied force. (Any force could be considered to be an applied force, but applied force usually stands for a force applied by a person or an action which directly pushes or pulls on a system.)
- 7.11.2 Recognize the relationship between the mass of an object and the force needed to move it.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. As students add elements we will determine if the increased weight under the same amount of power affects the motion and speed of the vibrobot, or not. We will determine what applied forces are present and interacting with the vibrobots (ex. other vibrobots, the walls, the floor, gravity, friction, etc)

4

- 7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.
- 7.11.4 Demonstrate how friction affects the movement of an object.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. As students add elements we will determine if the increased weight under the same amount of power affects the motion and speed of the vibrobot, or not. We will determine what applied forces are present and interacting with the vibrobots (ex. other vibrobots, the walls, the floor, gravity, friction, etc)

5

7.11.1 Explain the relationship that exist among mass (size, or weight), force, and distance traveled.

7.11.3 Design and conduct experiments using a simple experimental design to demonstrate the relationship among mass (size, weight, etc), force, and distance traveled.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. As students add elements we will determine if the increased weight under the same amount of power affects the motion and speed of the vibrobot, or not. We will compare and contrast the movement of a bare basic vibrobot to those students have modified, keeping other variables (ex. surface, number of bots, area, etc) the same. We will see if increased mass, size, weight and surface area affect the speed, maneuverability, or motion of the bots by themselves and in groups.

6

7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

7.Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion of single vibrobots on a surface, then pairs, then small groups, then large groups to see what kind of motion patterns emerge, what causes changes to the motion ex. the number of vibrobots, the surface, vibrobots pushing against each other, etc. We will test the vibrobots on different surfaces and in different styles of confined space to see if those variables affect the motion and action in any way or cause any patterns to emerge.

Students will track motion and formulate hypotheses, which we will then test. Each group and the class as a whole diagram any patterns, ex. swarming, that emerge and keep track of direction, length of time it took, how many vibrobots it took, etc, to see if there are any consistencies or formulas we can come up with to pinpoint causes and predict effects.

7

7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

7.Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.

7.11.4 Recognize how a net force impacts an object's motion.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion of single vibrobots on a surface, then pairs, then small groups, then large groups to see what kind of motion patterns emerge, what causes changes to the motion ex. the number of vibrobots, the surface, vibrobots pushing against each other, etc. We will test the vibrobots on different surfaces and in different styles of confined space to see if those variables affect the motion and action in any way or cause any patterns to emerge.

Students will track motion and formulate hypotheses, which we will then test. Each group and the class as a whole diagram any patterns, ex. swarming, that emerge and keep track of direction, length of time it took, how many vibrobots it took, etc, to see if there are any consistencies or formulas we can come up with to pinpoint causes and predict effects.

8

7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

7.Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.

These standards will be met and reinforced as students follow the instructions to build and test the original vibrobot prototype design and then work to troubleshoot and refine their designs. We will study the motion of single vibrobots on a surface, then pairs, then small groups, then large groups to see what kind of motion patterns emerge, what causes changes to the motion ex. the number of vibrobots, the surface, vibrobots pushing against each other, etc. We will test the vibrobots on different surfaces and in different styles of confined space to see if those variables affect the motion and action in any way or cause any patterns to emerge.

Students will track motion and formulate hypotheses, which we will then test. Each group and the class as a whole diagram any patterns, ex. swarming, that emerge and keep track of direction, length of time it took, how many vibrobots it took, etc, to see if there are any consistencies or formulas we can come up with to pinpoint causes and predict effects.

Lesson Three

BEAM Type Solar Wobblebot

This very primitive BEAM-type robot has no "brain," but it does react unpredictably to intense light by wobbling around on its one foot. It uses a solar panel to directly power a motor that makes the robot move in unpredictable ways. https://www.youtube.com/watch?v=GH8-A7wNZrI

Instructions and images via: Kathy Ceceri at http://www.instructables.com/id/Solar-WobbleBot/#step1 See a video of one in action:. https://www.youtube.com/watch?v=GH8-A7wNZrI

Note: This project requires some hot glue gun work, this should be completed by/with the assistance of the teacher.

Materials:

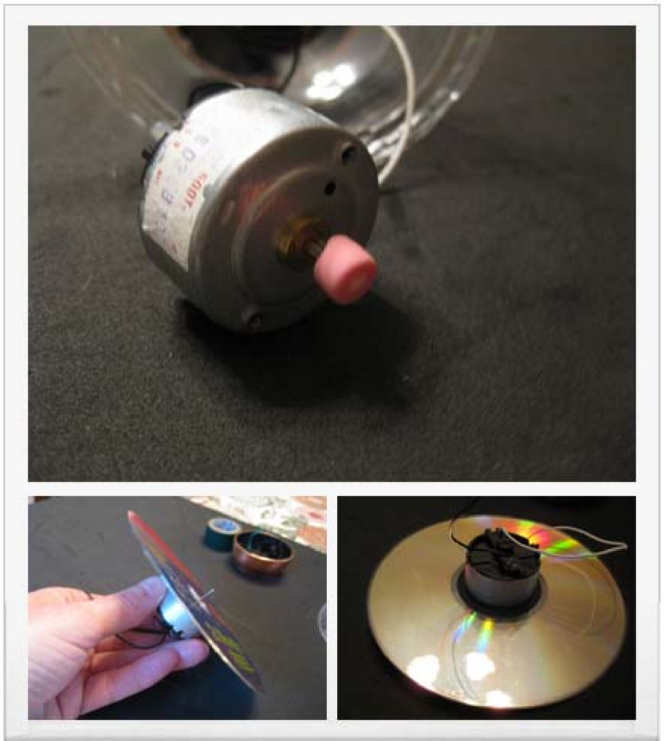
- pencil with an eraser
- 1.5 volt, low-inertia/low-speed DC motor with wires attached (or take one out of an old Walkman or DVD player)
- solar panel (can be recycled from a solar garden light)
- wire strippers
- electrical tape
- scissors
- recycled CD or DVD
- hot glue gun or glue dots
- recycled clear dome from drink cup

Step 2: Prepare the Solar Light and Test the Solar Panel

If reusing a solar panel from a garden light, open up the back and remove any batteries or capacitors. You will see two wires connecting it to a circuit board. Cut away the circuit board, leaving as much wire connected to the solar panel as possible.

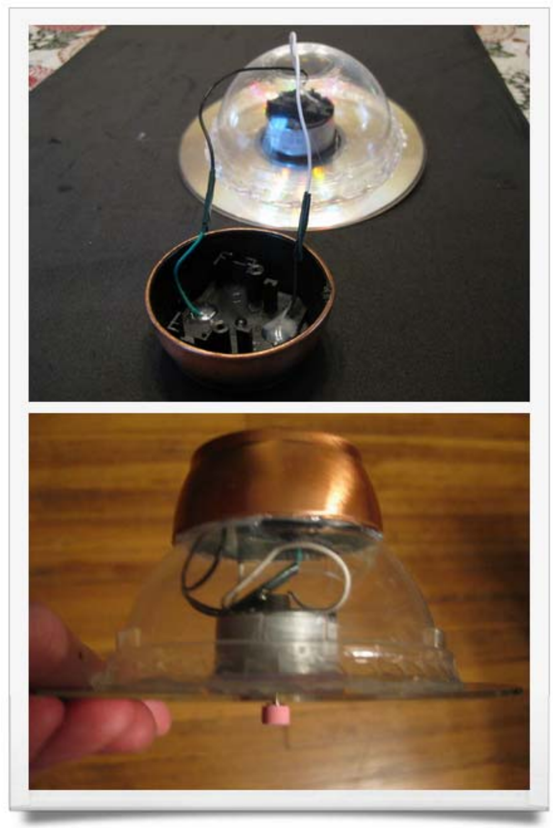
Before going further, make sure the solar panel produces enough power to run the motor by temporarily connecting the wires with small pieces of electrical tape. Also put a little "flag" of electrical tape on the shaft. Take it out in bright sunlight or hold the panel up to a very bright indoor light, such as a halogen light or shop light. If the motor doesn't turn, try a different motor or a more powerful solar panel. Once everything works, carefully take off the tape and separate the wires.

Step 3: Attach the Motor



If your motor has a short shaft, you may want to attach a rubber "foot" to give it a little more traction. Break the eraser off the pencil. Use the point of the pencil to make a hole in the middle of the broken-off side. Push the eraser up onto the shaft of the motor. It will probably hold on well enough without glue.

Now insert the shaft of the motor into the hole in the CD. Use hot glue or glue dots to attach the motor to the disc. Be careful not to get any glue into the motor or on the moving parts. Add some electrical tape if needed for extra security



Step 4: Connect the Solar Cell to the Motor

Place the clear dome top over the other end of the motor. Pull the motor wires through the hole at the top, where the straw would go. Attach the bottom of the dome to the CD. If you use Glue Dots, you can make adjustments before attaching it permanently.

Attach the motor wires to the solar panel wires and tape them together securely. Then push the wires back inside the dome and glue the solar panel on top.

Step 5: Testing Your Solar WobbleBot

Use your bright indoor light or take the Solar WobbleBot outside in bright sunlight to test it. Put the bot with the disc-side down and the solar panel facing up (it will be just a little bit tilted), on a very smooth, flat surface. The motor shaft should spin and make the bot dance and skip around!

Troubleshooting Tips: If your bot doesn't spin, check to see that the wires are connected. If it still doesn't run, try a different surface (the glossy cover of a coffeetable book works well). Sometimes giving the shaft a little turn to get it started before putting it down on the test surface helps too. Be careful not to leave your bot out in bright sun for too long -- it can overheat!

Step 6…: Brainstorm a Better Robot

This WobbleBot works great under ideal conditions, but it's just a start/prototype. What improvements can students add to make it more rugged or more reliable? Robot hobbyists and scientists are always sharing ideas for making better designs! So what can students come up with together?

Lesson Three K-8 Standards Alignment

K

7.10.1 Identify the sun as the source of heat and light.

7.10.2 Investigate the effect of the sun on [a variety of] materials.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

1

7.10.1 Investigate the effect of the sun on land, water, and/or air and other materials and objects.

7.6.2 Realize that the sun can only be seen during the day.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

2

7.10.1 Identify and explain how the sun affects objects on the surface of the earth.

7.10.2 Investigate how the sun affects various objects and materials.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

3

7.10.1 Identify various sources of energy.

7.10.2 Classify materials according to their ability to conduct energy.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions, identifying the purpose for each of the parts (including those that bring/convert energy (from the solar panel to the wires and motor) and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

4

7.10.1 Identify different forms of energy, such as heat, light, and/or chemical.

7.10.2 Determine that/which surfaces reflect, refract, or absorb light.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions, identifying the purpose for each of the parts (including those that absorb, transfer, or convert energy (from the solar panel to the wires and motor) and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

5

7.10.5 Demonstrate different ways that energy can be transferred from one object to another.

7.10.2 Use data from an investigation to determine the method by which [heat, chemical, light, electrical] energy is transferred from one object or material to another.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions, identifying the purpose for each of the parts (including those that absorb, transfer, or convert energy (from the solar panel to the wires and motor) and then testing it in the sun, in the shade, indoors, out of doors, and possibly with sunscreen over the solar panel.

6

7.10.3 Recognize that energy can be transformed from one type to another.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions, identifying the purpose for each of the parts (including those that absorb, transfer, or convert energy (from the solar panel to the wires and motor) and then testing it in the sun, in the shade, indoors, out of doors, and possibly with different levels of sunscreen over the solar panel.

7

7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications.

7.T/E.2a Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

These standards will be met and reinforced as students discuss the power sources related to our solar wobblebot and other solar based robots on earth and in space. Then we will demonstrate our understanding while building the wobblebot according to the instructions, identifying the purpose for each of the parts (including those that absorb, transfer, or convert energy (from the solar panel to the wires and motor) and then testing it in the sun, in the shade, indoors, out of doors, and possibly with different levels of sunscreen over the solar panel.

8

7.T/E.2bApply the engineering design process to construct a prototype that meets certain specifications.

7.T/E.2a Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

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Lesson Four

Invisible Power

Then there's nuclear power. For space robots traveling farther than the planet Mars, well, solar power just isn't good enough. While we think of the sun being all powerful, it would actually be too far away to provide the amount of energy needed to keep the batteries charged. So NASA pulled out the nuclear generators. These use the energy that releases when the center part of an atom, called its nucleus, splits apart. NASA launched the nuclear powered rover Curiosity in November 2011. Its fuel was designed to last a Martian year (aka two Earth years) and will also give it more power than previous rovers had, which means it can travel faster and climb over bigger obstacles.

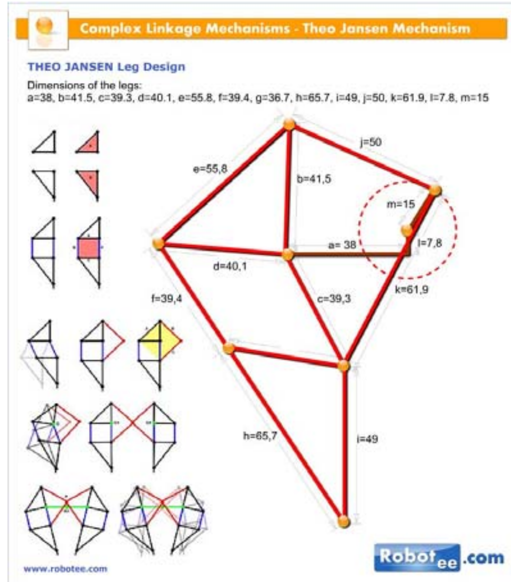
Animari: A New Form of Life?

One of the most interesting ways, or perhaps strangest ways, to power a robot is with the wind. Dutch artist Theo Jansen (pronounced: Tay-oh Yawn-sen) builds autonomous wind-powered walking machines he calls Strendbeests or "beach animals."

> Since 1990 I have been occupied creating **new forms of life.**
>
> Not pollen or seeds but **plastic yellow tubes** are used as the basic material of this new nature. I make skeletons that are able to **walk on the wind,** so they don't have to eat.
>
> Over time, these skeletons have become increasingly better at **surviving the elements** such as storm and water and eventually I want to put these animals out in herds on the beaches, so they will **live their own lives.**

For well over a decade Theo Jansen has rigorously experimented 'with the making of a new nature. Not pollen or seeds but plastic yellow tubes are used as the basic material of this new nature.' He talked about how protein acts as the key element in the structure and functioning of all living cells and that he wanted to use his own protein (plastic tubes) to act as the building block for his very own creations.

They're made of multiple pairs of legs made out of plastic tubes (yellow tubing that is readily available in his native Holland) that step sideways across the sand. Propellers or sails collect the wind, which is stored in recycled lemonade bottles in the Strandbeest's belly. When the air pressure in the bottles is released, it powers the legs. The graceful creatures evolve over time as Theo adapts their designs to harness the wind more efficiently. Watch the incredible video Theo Jansen's Strandbeests - Wallace & Gromit's World of Invention Episode 1 Preview - BBC One here: https://www.youtube.com/watch?v=HSKyHmjyrkA

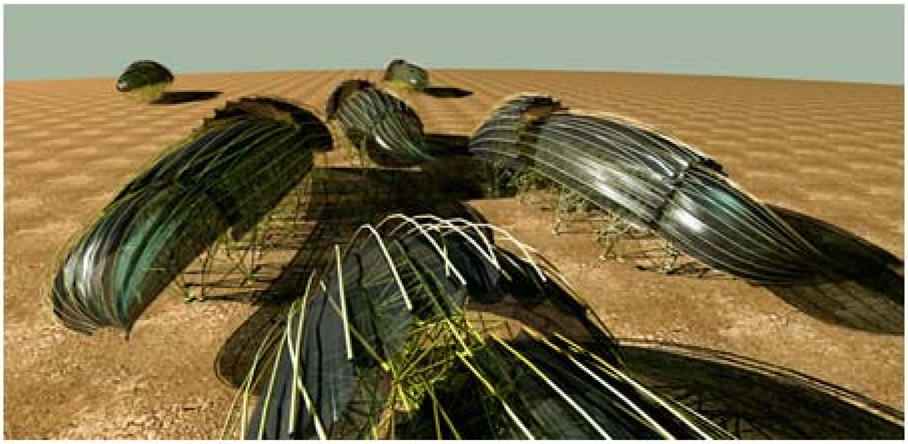


A narrow tube that Jansen calls a "feeler" drags the ground and sucks in water when the Strendbeest gets too near the sea. This resets the machine's "brain" and makes it back up, towards land. Jansen's incredible invents take very simple ideas and put them together in complex ways that make his Strandbeests appear shockingly lifelike. His creations are now able to make decisions on their environment and avoid hazardous environments much like evolving species learn to do.

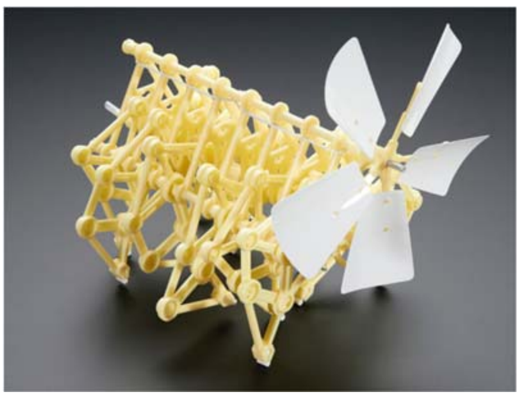
He in fact calls them a 'new form of life.' His creatures are designed to move — and even survive — on their own. He has started using more advanced air systems which he hopes the creatures will be able to use to collect air themselves and compress it to power pressurized pneumatic devices. What's most exciting is that he has devised a system of valves that act as yes/no logic gates for the pressurized air which could eventually be built up to process simple logic and develop a primitive form of intelligence. In all seriousness he suggests that eventually he wants these creatures to be able to think for themselves and reproduce.

And 5,000 years after the creation of the wheel he has created 'a new invention…better than the wheel.' Watch his TED talk here. http://www.ted.com/talks/theo_jansen_creates_new_creatures?language=en Explore more (shockingly lifelike) video, photos, and history at http://www.strandbeest.com/ and https://www.youtube.com/watch?v=MYGJ9jrbpvg

Some might assume that these ideas are verging on the side of crazy but his passion for dreaming the impossible and seemingly managing to progress towards it with every new mutation in his species development is amazing. Jansen says: "The walls between art and engineering exist only in our minds."



A Render of one of his future visions

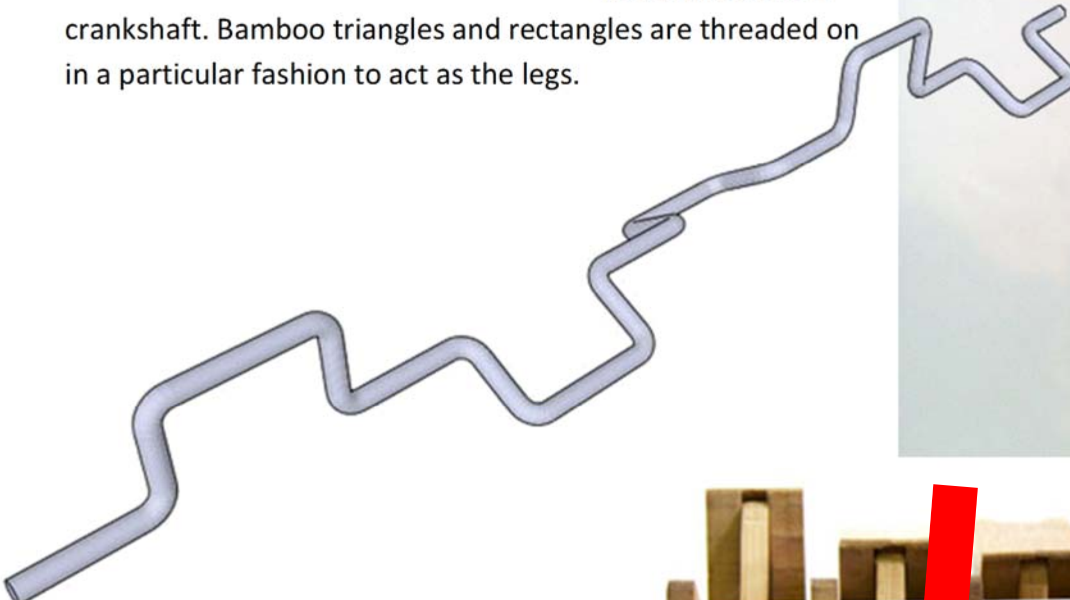


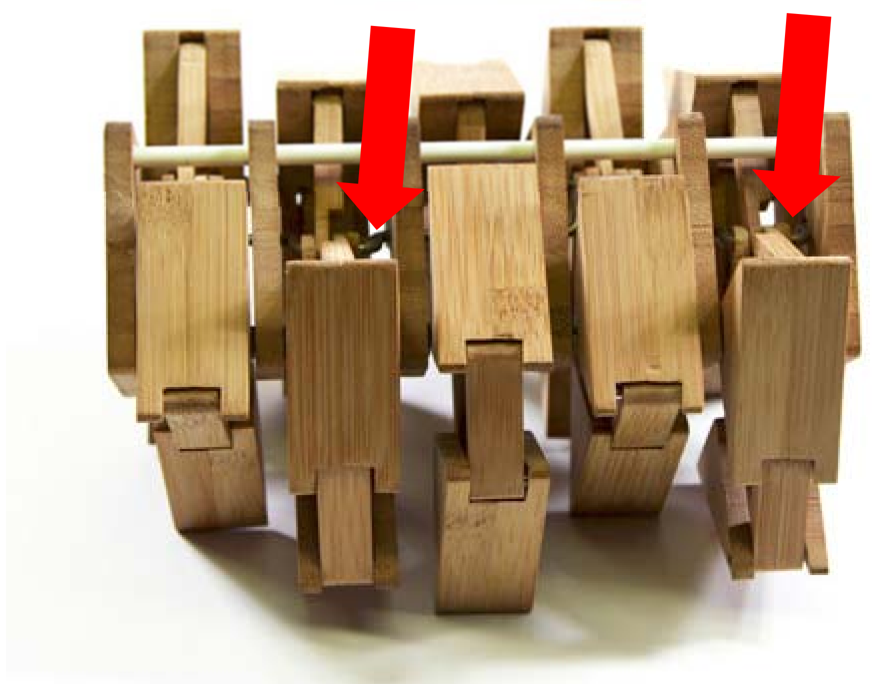
There are miniature kits available so people can build 'strandbeest larvae' at home. **Aw, it's a baby!**

Kinetic Creatures

In the way of the internet, and inventors and engineers throughout time, someone has an idea and someone else takes it and adapts it. SmallWonder toys made the 'Humble Velocipede' out of bamboo. (Play with one online here: http://smallwondertoy.co/)

The mechanism that drives the entire toy is a single bent steel rod that acts as a crankshaft. Bamboo triangles and rectangles are threaded on in a particular fashion to act as the legs.





Giraffes Can Dance! Or At Least Walk…

As a collaboration between Alyssa Hamel- a Visual Arts Teacher and Artist and Lucas Aimsworth- an Industrial Designer made Kinetic Creatures. Kinetic Creatures takes a complex mechanical linkage,

popularized in Theo Jansen's Strandbeest, and made it accessible through an easy assembly and friendly cardboard form.

Kinetic Creatures are a set of three walking cardboard animal sculptures. The Creatures, Elly the Elephant, Rory the Rhino, and Geno the Giraffe, are each made up of cardboard pieces that you assemble using tabs-and-slots. By turning the wire handle, you make the creatures come alive with a simple mechanical motion.

How big are they?

Bigger than a bread box. Here are the dimensions:

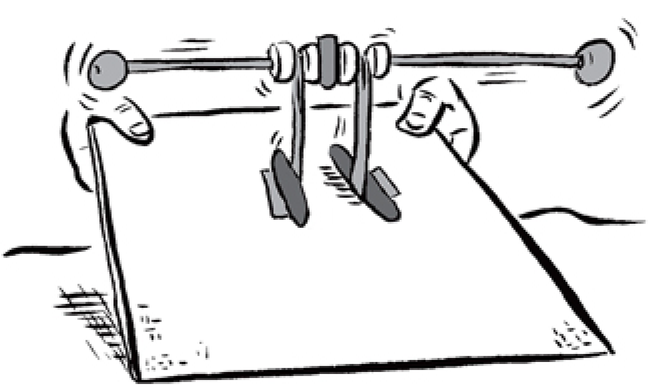
Elly the Elephant is 11.5" tall x 15" long

Rory the Rhino is 9.5" tall x 15.5" long

Geno the Giraffe is 21.5" tall x 18" long

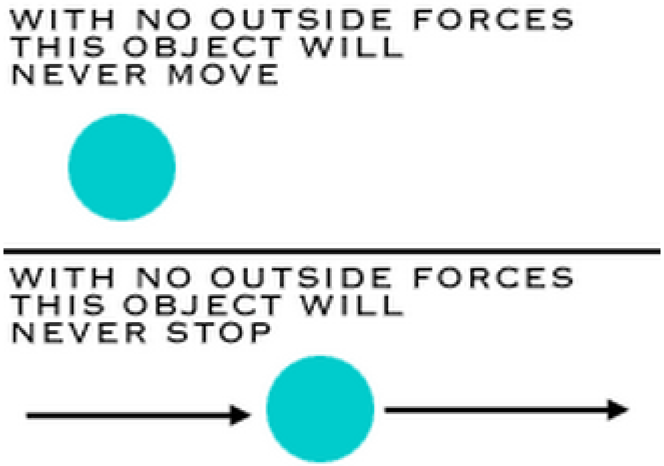
Can they walk on their own?

Why yes, they can! All the kits come with a wire turn handle for manual power, but adding a Kinetic Creature Motor Kit allows the animals to walk on their own with a small electric motor and laser-cut wooden gears. The creatures can also be powered by Lego motors!



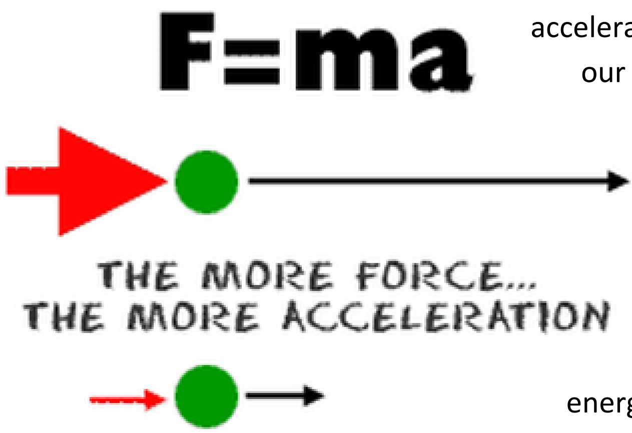
Passive Dynamic Mini-Walkers

To get *us* started with the basics of robot walking, we'll build a passive dynamic walker based on models used to help roboticists figure out how to make robots move more naturally! Passive Dynamic means that a robot walker is powered by gravity. It doesn't need a motor or actuator of any kind. It's only power is the force of gravity! Also called a ramp waler, this system of walking works best on a slightly downward tilted surface. Give it a little push (an outside force-you) and gravity (and a gradual conversion of potential energy into kinetic energy as the walker moves down the slope) will pull it downhill the rest of the way.



As, like Newton's laws tell us, once it is in motion, it wants to stay in motion until and outside force works on it Remember, the first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed. Motion (or lack of motion) cannot change without an unbalanced force acting.

In this case the unbalanced force down the slope results in an acceleration of the walker down the slope. Friction also works to slow down our walker, etc.



Second law says with more force, the more acceleration…hmm, so if we change our angle, or raise our ramp and increase the gravitational force…does your walker move faster? At what point does it go faster or does it simply fall over? **Compare and contrast two walkers made the same way on two differently angled ramps.**

This method of walking doesn't just save energy (it takes less energy to move downhill, as gravity helps instead of fights), it looks more natural too. [Note: The energy lost due to friction and collisions when the swing leg returns to the ground are balanced by the gradual conversion of potential energy into kinetic energy as the walker moves down the slope.]

Here is one way of making a small-scale passive dynamic walker. Watch it walk here: https://www.youtube.com/watch?v=bwrrzOBtpTc Instructions & images via: http://nomadpress.net/wordpress/wp-content/uploads/2014/04/NP_ActivityPrintOut_Mini-Walker-Robotics.pdf

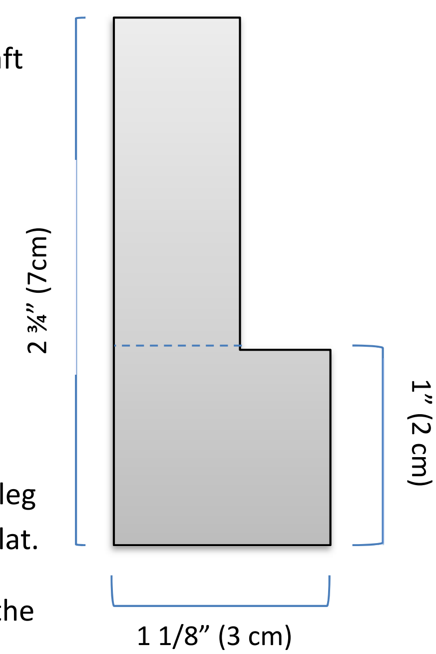
Walking on two legs may be easy for humans, but not for robots. In humans the brain automatically adjusts our bodies every time we move to keep us from falling over. To get a robot to balance while standing, walking, running, or going up stairs takes a lot of complicated programming. That's why some robots are built to stay in place and have work brought to them, like those in factories, and the most common way for robots to get around is on wheels (whether it's one, two, three, four, or even more), and others have treads, just like tanks.

One of the most well-known walking humanoid robots is ASIMO (Advanced-Step-In-Innovative-Mobility, in other words, new ways to get around). Honda (the car company), first made ASIMO in 2000 and has been working to make it ever better ever since. The latest one can catch itself when it loses balance by quickly moving its feet. That makes it possible for it to travel over uneven ground, walk, run forwards, run backwards, and even hop. Scientsists are also working on creating robots that can climb…hmm, sticky feet might come in handy for those robots!

Have students experiment with different sizes and shapes, or use other materials that you have on hand. They can also expand the design and try four legs instead of two, give the walker knees, or attach swinging arms to add energy to each step.

Materials:

- Cardboard
- Scissors
- Sharp pencil or a large nail about as wide around as a skewer
- Small sheets of craft foam, felt, or thin cork (sticky-back/peel-and-stick is best)
- Glue sticks
- Bamboo skewers about 10 inches long (25 cm)
- Wooden or plastic beads
- Mini craft sticks about 2 ½ inches (6 ½ cm) long, or regular craft sticks or coffee stirrers cut to size
- Optional: Clear tape or rubber bands (2 per robot)
- Optional: Large sheet of foam core
- Optional: masking tape

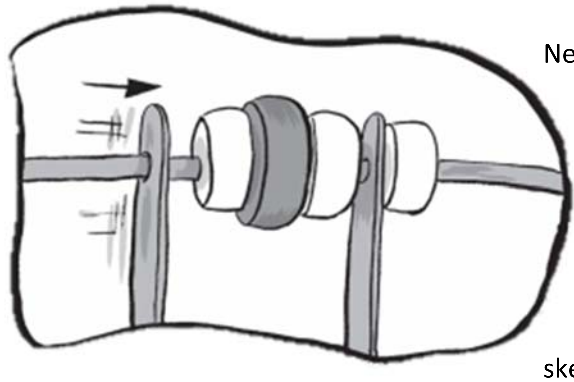


First, have students cut out two legs from the cardboard, 2 ¾ inches long (7 cm) and 1 ½ inches wide (3 cm). From one end of each rectangle measure 1 inch up (2 ½ cm) and make a ½ inch cut (1 cm). From there, trim up the cardboard so it forms an "L" shape, or a leg and a foot. With the pencil or nail, poke a hole at the top of each leg in the center. Fold the cardboard at the "ankle" so that the foot sits flat.

Then, cut out two pieces of craft foam, felt, or cork the same size as the foot. Glue it onto the bottom of each foot for padding and traction.

After that, slip oneo f the beads onto the skewer a little past the middle. Try to use a bead that is a little tight on the skewer. If it’s loose enough to slide around have them just keep it in place with their finger for now.

Fourth, slide one of the legs onto the skewer through the hole so that the foot faces the end of the skewer with the bead. The leg and the bead should be almost touching.



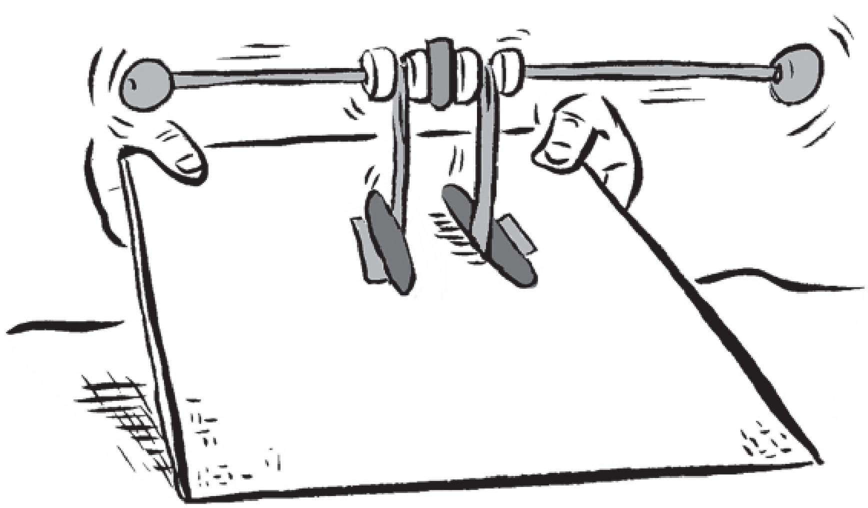
Next, slide one big bead or several small beads onto the skewer so that they are just touching the inside of the first leg. The bead(s) should cover about ½ inch of the skewer (1cm).

Subsequently, slide on the second leg so that the front of the food is pointing in the same direction as the first foot. Slip another bead onto the the skewer to thold the legs in place, making sure there is just enough space for the legs to swing back and for the easily. If the outside beadsa re not staying in place, wrap a rubber band or a little piece of tape around the skewer to keep them from sliding around.

Stick a bead on each end of the skewer. It should be tight enough to stay on. If not, attach with tape. You can glue the beads on, but first make srue the legs are in the center of the skewer and your mini-walker is balanced. Avoid getting any glue on the legs.

Stand the walker on its feet. Glue a mini craft stick onto each foot, right next to the leg.

Make a test ramp with a long flat surface that you can tilt slightly, like a big book or a sheet of stiff cardboard or foam board. Foam core makes a nice walking surface.



For added traction put some strips of masking tape down the length of the ramp. To test each walker, set it at the top of the ramp and gently tap one end of the skewer. The walker should tip from side to side as it makes its way downhill.

Now, try other designs!

Lesson Four K-8 Standards Alignment

K

- 7.11.1 Explore different ways that objects move.
- 7.11.1 Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

1

- 7.11.1 Investigate how forces (push, pull) can move an object or change its direction.
- 7.11.1 Use familiar objects to explore how the movement can be changed.
- 7.11.2 Investigate and explain how different surfaces affect the movement of an object.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

2

- 7.12.2 Realize that things fall toward the ground unless something holds them up.
- 7.12.2 Describe what happens when an object is dropped/let go and record the observations

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

3

- 7.11.1a Explore how the direction of a moving object is affected by unbalanced forces. (Note: **Unbalanced forces** always cause a change in motion. They are not equal and opposite. Forces occur in pairs and can be either balanced or unbalanced. **Balanced forces** do not cause a change in motion. They are equal in size and opposite in direction so they cancel each other out and no motion happens. If motion is happening then there are unbalanced forces.)
- 7.11.1b Identify how the direction of a moving object is changed by an applied force. (Any force could be considered to be an applied force, but applied force usually stands for a force applied by a person or an action which directly pushes or pulls on a system.)

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

4

- 7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.
- 7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

5

- 7.12.2 Identify the force that causes objects to fall to the earth.
- 7.12.1 Explain and give examples of how forces can act at a distance.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

6

- 7.10.2 Analyze various types of energy transformations.
- 7.10.3 Recognize that energy can be transformed from one type to another.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

7

- 7.11.4 Recognize how a net force [the overall force acting on an object] impacts an object's motion.
- 7.11.4 Investigate how Newton's laws of motion explain an object's movement.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

8

- 7.12.5 Recognize that gravity is a force that controls the motion of objects.
- 7.12.7 Explain how the motion of objects is affected by gravity.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.

Robots Part Five Sample Vocabulary Guide

K

- Shapes
- Air
- Job
- Parts
- Observe
- Pattern
- Collect
- Position
- Senses
- Tools

1

- Past
- Present
- Future
- History
- Invent
- Sequence
- Technology
- Measure
- Property
- Push
- Pull

2

- Economy
- Consumer
- Decision
- Qualifications
- Main Idea
- Message
- Investigate
- Discussion
- Outcome

3

- Tools
- Conclusion
- Opinion
- Organization
- Force
- Cause
- Effect
- Character
- Conjecture
- Setting

4

- Mimic
- Consumer
- Compare
- Contrast
- Friction
- Drawing conclusions
- Pattern
- Chance
- Accuracy

5

- Point of view
- Implied
- Gravity
- Edge
- Model
- Integration
- Personification
- Main ideas
- Solution
- History

6

- Sequential
- Personification
- Point of view

- Control
- Criteria
- Design constraint
- Cause and effect
- Energy transformation

7

- Viewpoint
- Function
- Impact
- Property
- Repetition
- Simple machines
- Speed

8

- Human impact
- Sensory
- Interdependence
- Force
- Reliability
- Product
- Variation
- Solution
- Function

Robots Part Five Samply Supply List

Lesson One

- Access to Videos & Books

Lesson Two

- Small vibrating motors, often called pager motors, available from most electronics dealers, or recycle them from old cell phones, pagers, or Oral B Pulsar disposable electric toothbrushes. Ex. http://shop.evilmadscientist.com/productsmenu/partsmenu/131-pagermotor or http://www.goldmine-elec-products.com/products.asp?dept=1107
- Three or more small coin cell batteries (1.5 to 3 volts)
- Foam tape
- Three or more 2-inch (5cm) acorn-shaped plastic gumball machine capsules (the kind used to dispense toys)
- Smooth test surfaces, ex. large piece of posterboard and/or cardboard box top for a confined test area.

Lesson Three

- Access to videos & books
- pencil with an eraser
- 1.5 volt, low-inertia/low-speed DC motor with wires attached (or take one out of an old Walkman or DVD player)
- solar panel (can be recycled from a solar garden light)
- wire strippers
- electrical tape
- scissors
- recycled CD or DVD
- hot glue gun or glue dots
- recycled clear dome from drink cup

Lesson Four

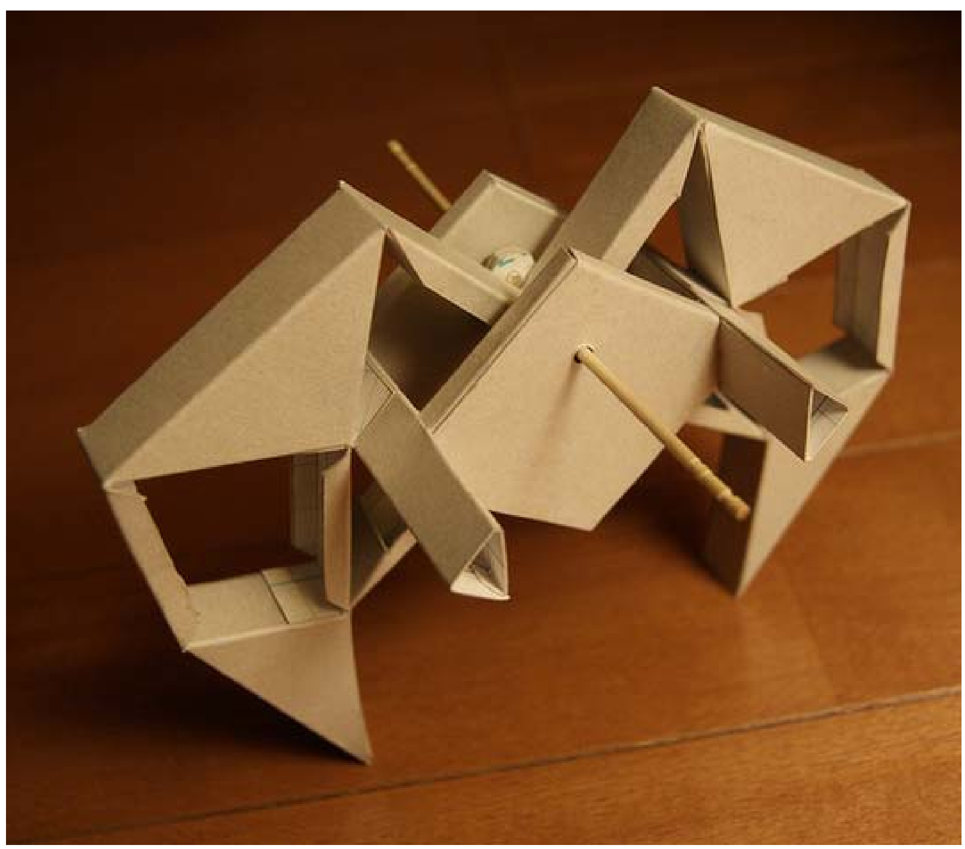
- Access to videos & books
- Cardboard
- Scissors
- Sharp pencil or a large nail about as wide around as a skewer
- Small sheets of craft foam, felt, or thin cork (sticky-back/peel-and-stick is best)
- Glue sticks
- Bamboo skewers about 10 inches long (25 cm)
- Wooden or plastic beads
- Mini craft sticks about 2 ½ inches (6 ½ cm) long, or regular craft sticks or coffee stirrers cut to size
- Optional: Clear tape or rubber bands (2 per robot)
- Optional: Large sheet of foam core
- Optional: masking tape

ROBOTS

Part five B: We Like to Move it Move it

Challenge!

Part FIVE: Week Two



Students STEM Challenge: Put It In Motion

Have students work to design their own version of the Strandbeests. They can come up with their own version, or using the supplies, templates, and instructions--take those basics and expand upon them.

Materials:

Materials that you will want to have available during this project.

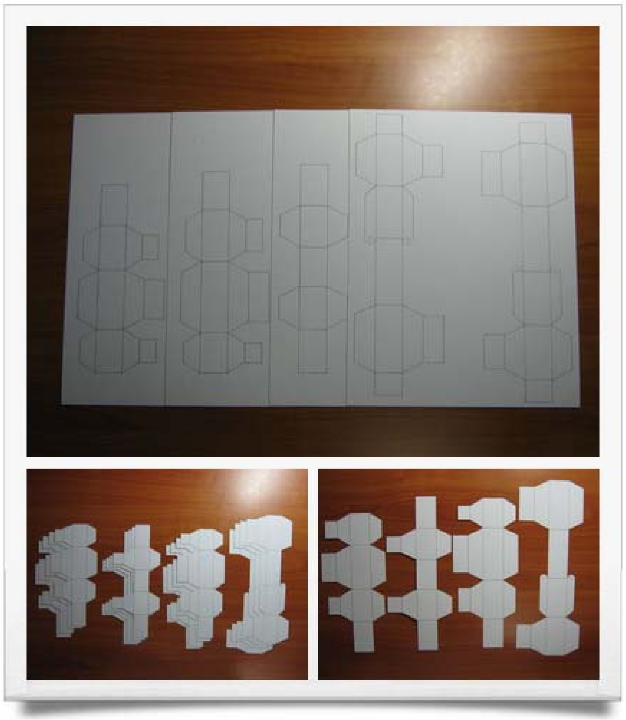
- Card Stock (ex. 110lb heavyweight) or thin, lightweight card, ex. like that from from breakfast cereal packaging or craft shop. Bends and cut easily with scissors.
- Standard printer paper
- Foam core or cardboard .012 inches/3 mm thick (for comparison, it needs to be about the thickness of 12 sheets of card stock stacked up or a bamboo skewer)
- Cutting mat or surface (like thick cardboard)

- Hobby knife (to be used only by instructor)
- Scissors
- Pencils
- Protractor
- Metal rulers and/or plastic rulers
- Masking tape
- Scotch tape
- Super glue
- Bottle of all purpose white glue
- Tooth picks
- Wooden skewers
- Drinking straws
- Printouts of leg templates (Each page will need to be printed 4 times in total for each walker].

Instructions and images for legs and crankshaft disks via: by CreativLiMade http://www.instructables.com/id/Paper-Motorized-Walking-Machine-Sculpture/?ALLSTEPS Go there to be able to see the following pictures enlarged and for complete instructions of his model.

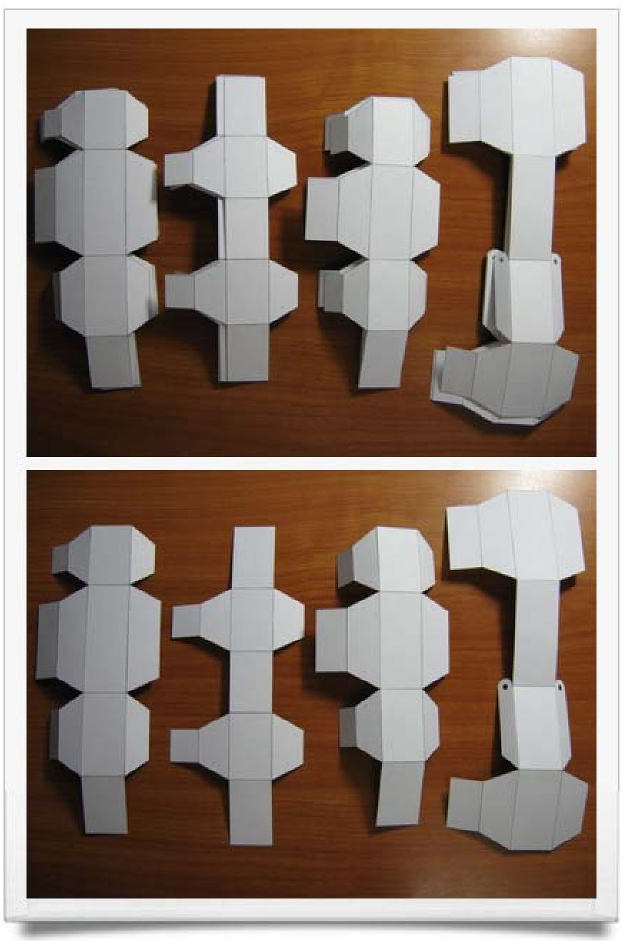
Legs: Step 1

Starting off, print all the pieces out and cut them out.



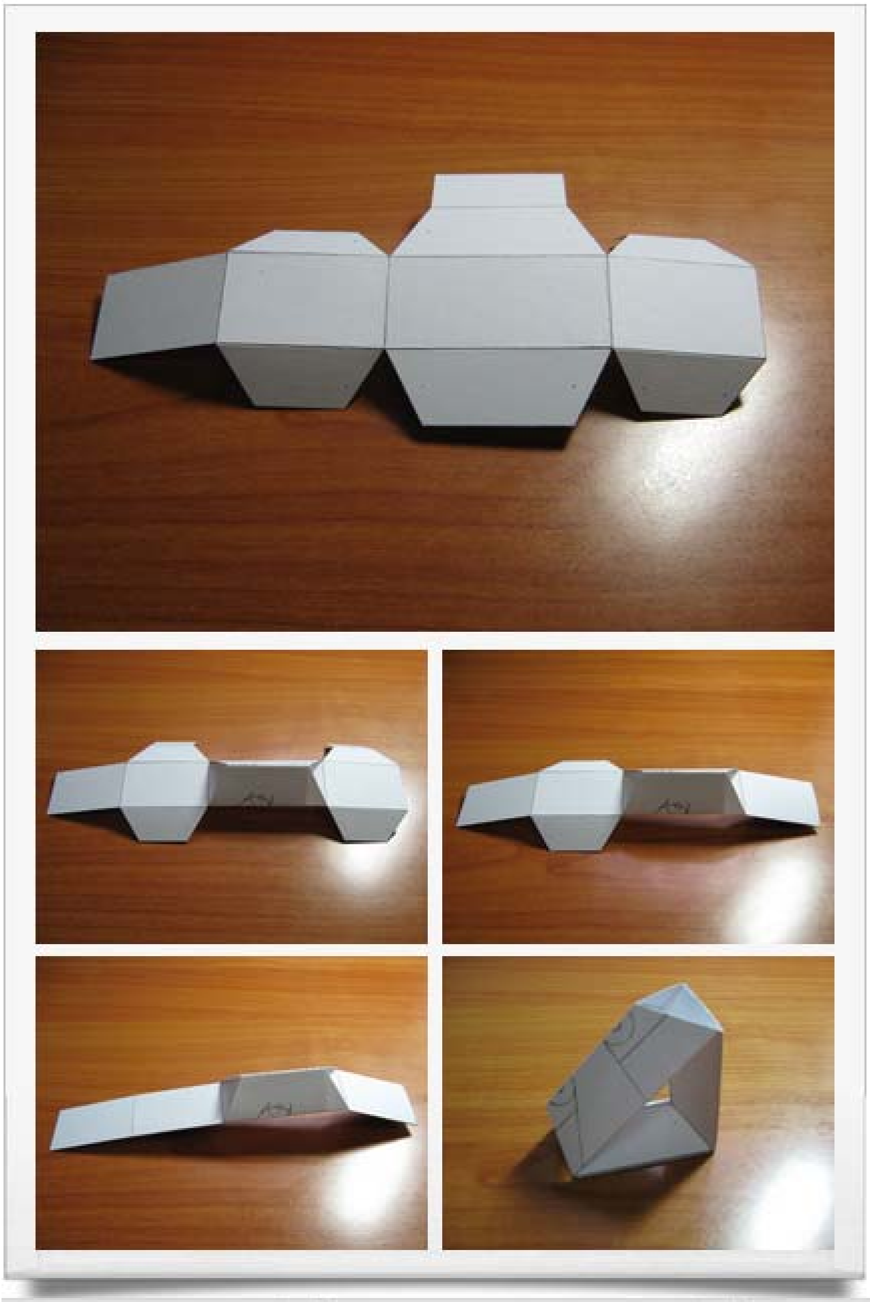
Legs: Step 2

Crease all the places where they need to be folded.



Legs: Step 3

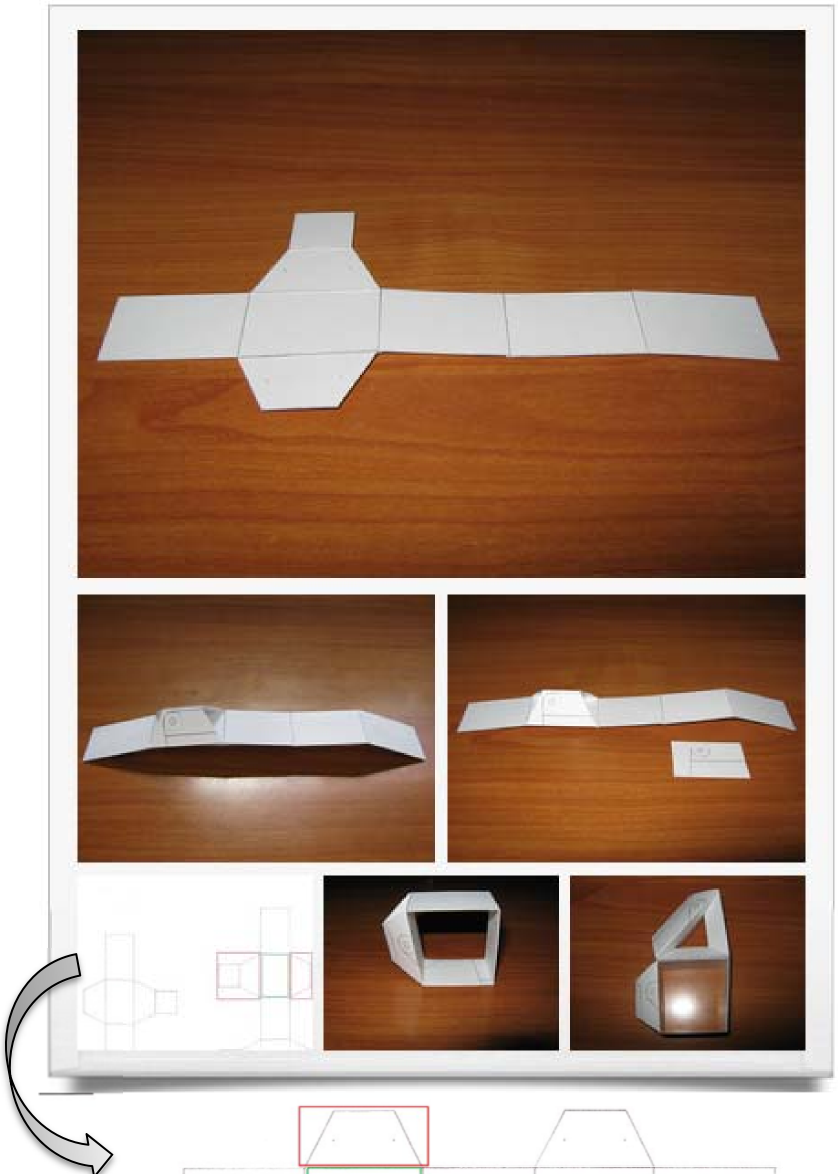
Take the top most part of a leg and super glue it together.

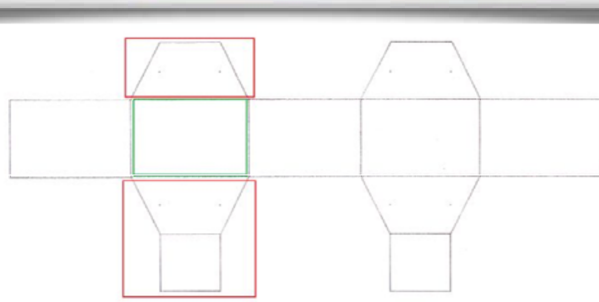


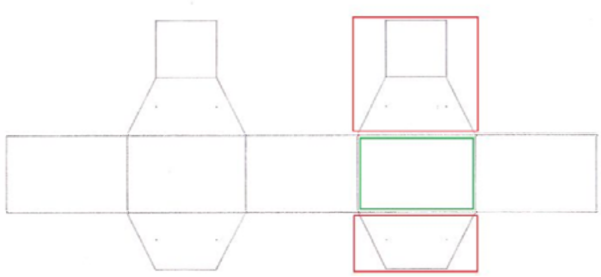
Legs: Step 4

Then take the mid section of one leg and glue it together. Glue an extra piece of card stock onto the right side seen in image 5 in order to make it stronger (or you can also see where to place the extra piece in image 4 which would be the green rectangle).

After this combine the two pieces you've made.

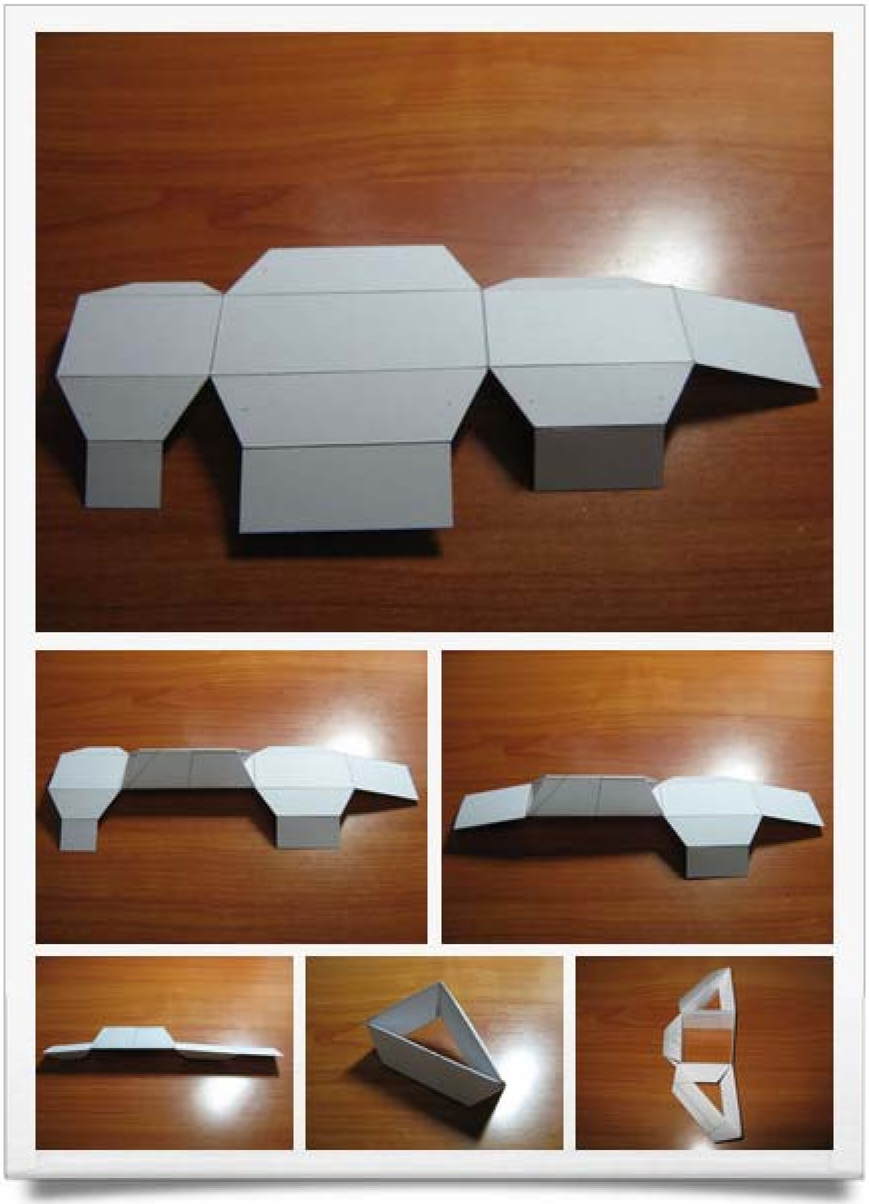




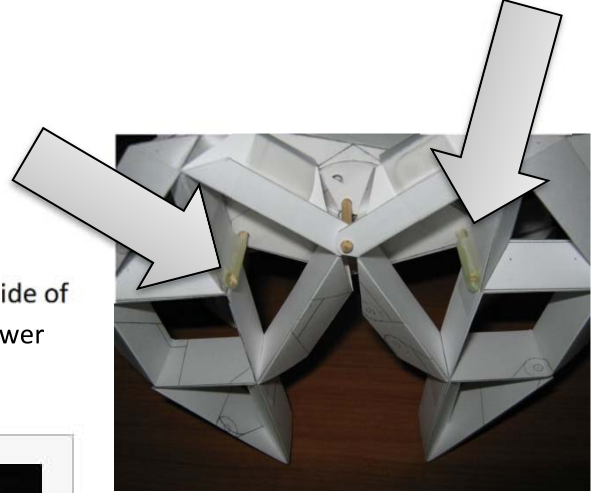


Legs: Step 5

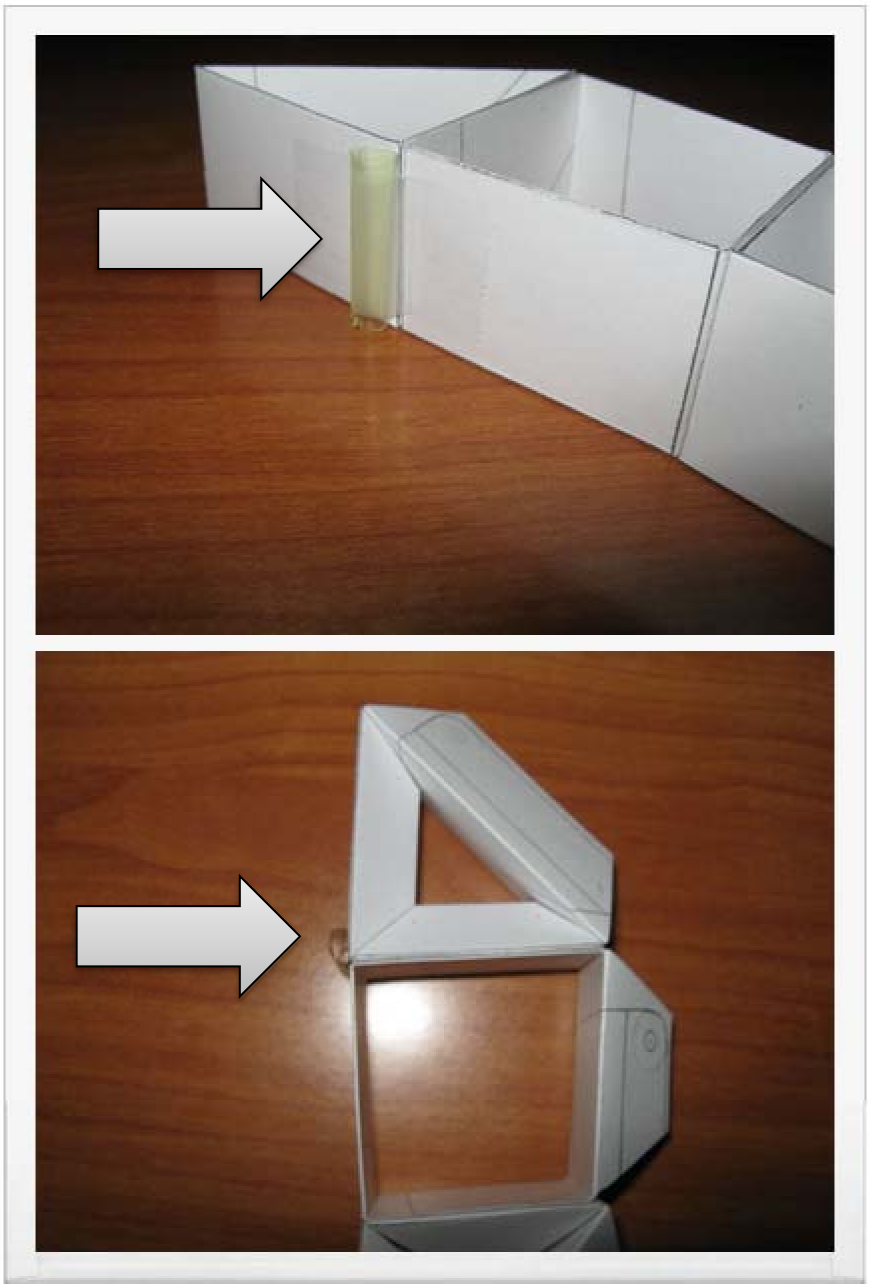
Next, assemble the lower part of the leg and combine it with the rest of the leg assembly.



Legs: Step 6

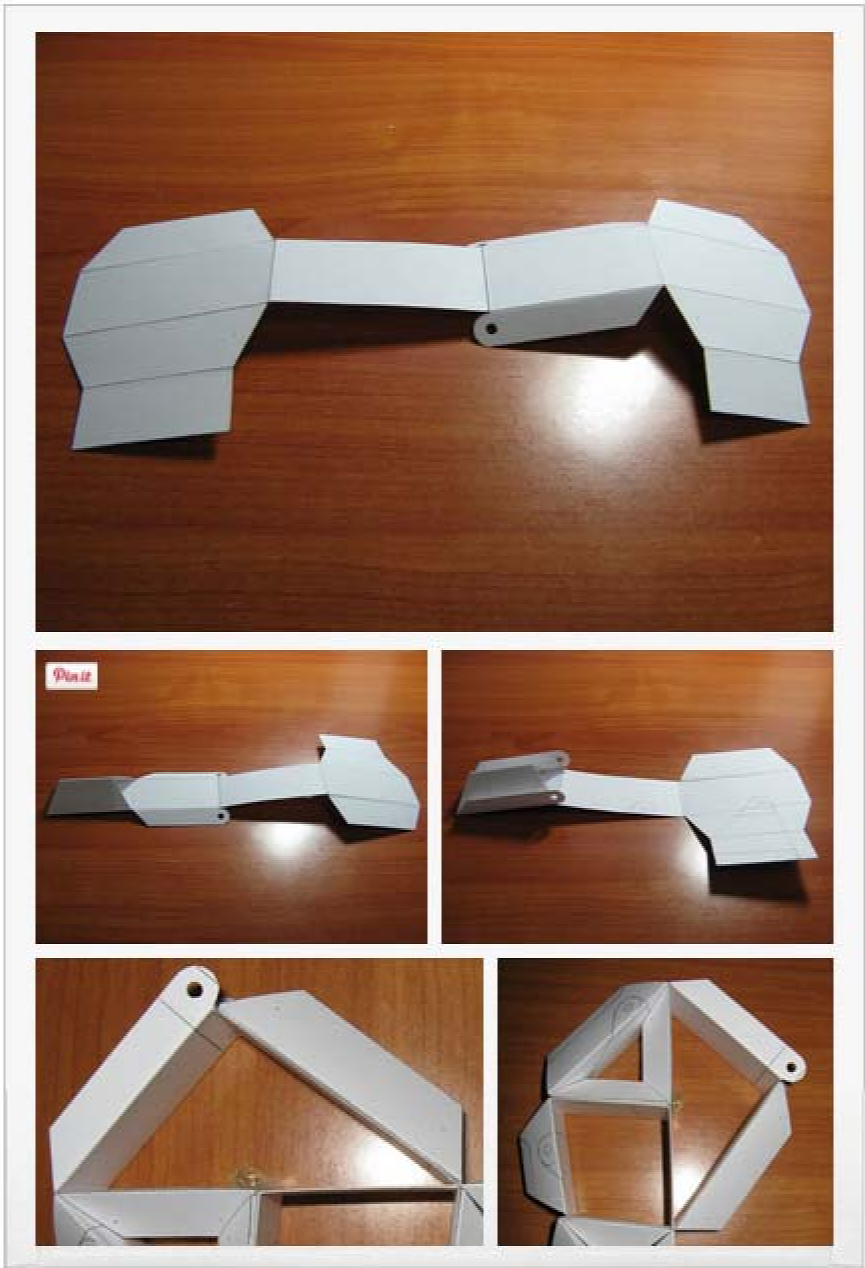


Then take a piece of a plastic straw and glue it to the bottom backside of the upper leg. Cover the straw with tape as an extra support. A skewer will go through the straw later.



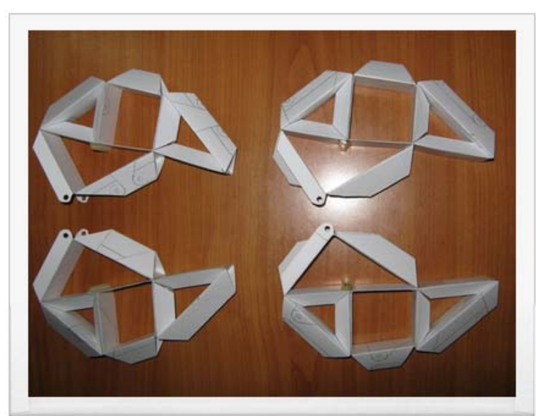
Legs: Step 7

The final part of the leg also attaches to the crank disc. Assemble it in this step.



Legs: Step 8

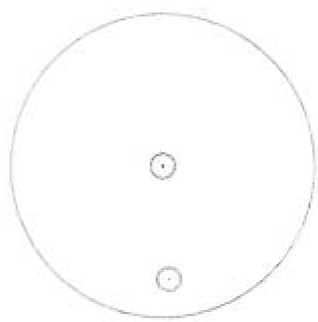
Do the same thing another three (or more) times to get all the legs done.



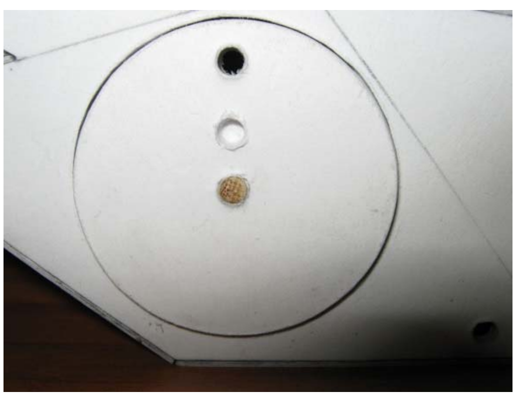
Crank Shaft Discs

These help make the legs move and provide stability and guidance for the skewers. Have students test different materials to determine what works best, ex. cardboard, craft foam, foam board, etc.

Each disc should be .012 inches/3 mm thick (for comparison, it needs to be about the thickness of 12 sheets of card stock stacked up or a bamboo skewer.)



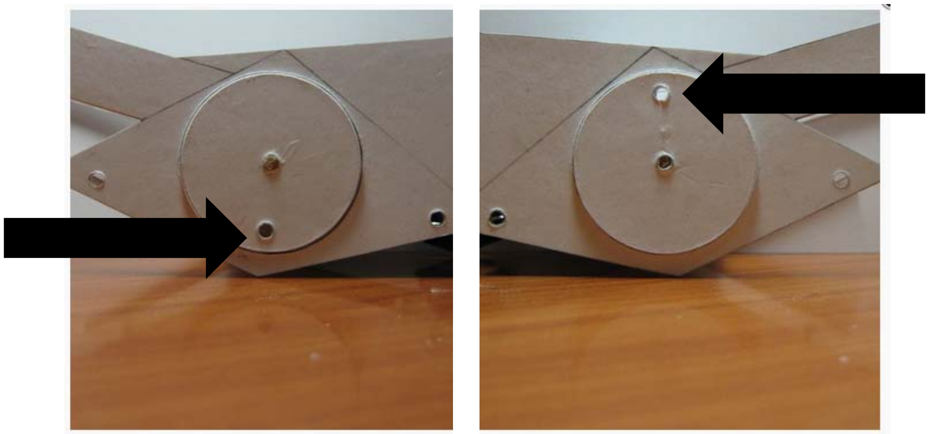
The image is a bit faint but they can be made easily. The diameter of the circle is 4cm and the distance from the center to the outer hole is 1.5cm. Disclaimer from the designer, "I had to change the distance of the holes from the centre of the disc. The distance is now 1/4 of an inch from the centre."



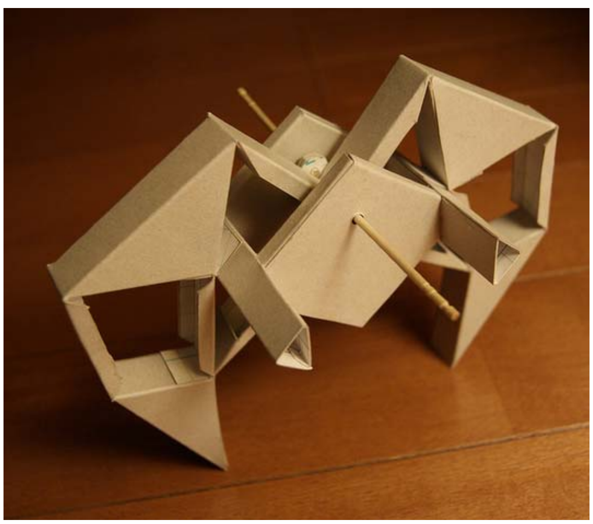
Have students figure out what placement of holes works best for their design.

Trim the drive shaft first to the appropriate length before attaching the disks.

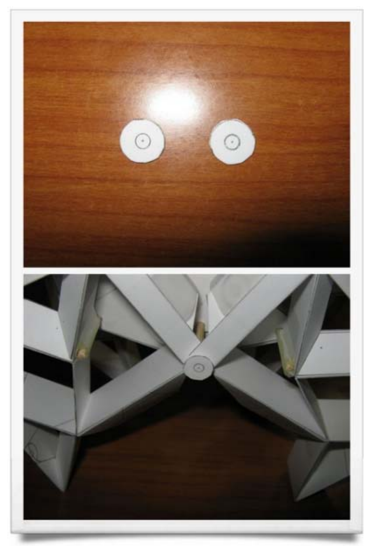
Next, I take the two crank shaft disks and super glue them to the drive shaft on the motor housing. Note that when attaching the disk, make sure that the holes near the outer edges are opposite of each other (the left sides hole would be in the reverse position on the right side—see image below, note that these discs are attached to the body of his design—instructions for the body are at the Instructables site or have students create their own design).

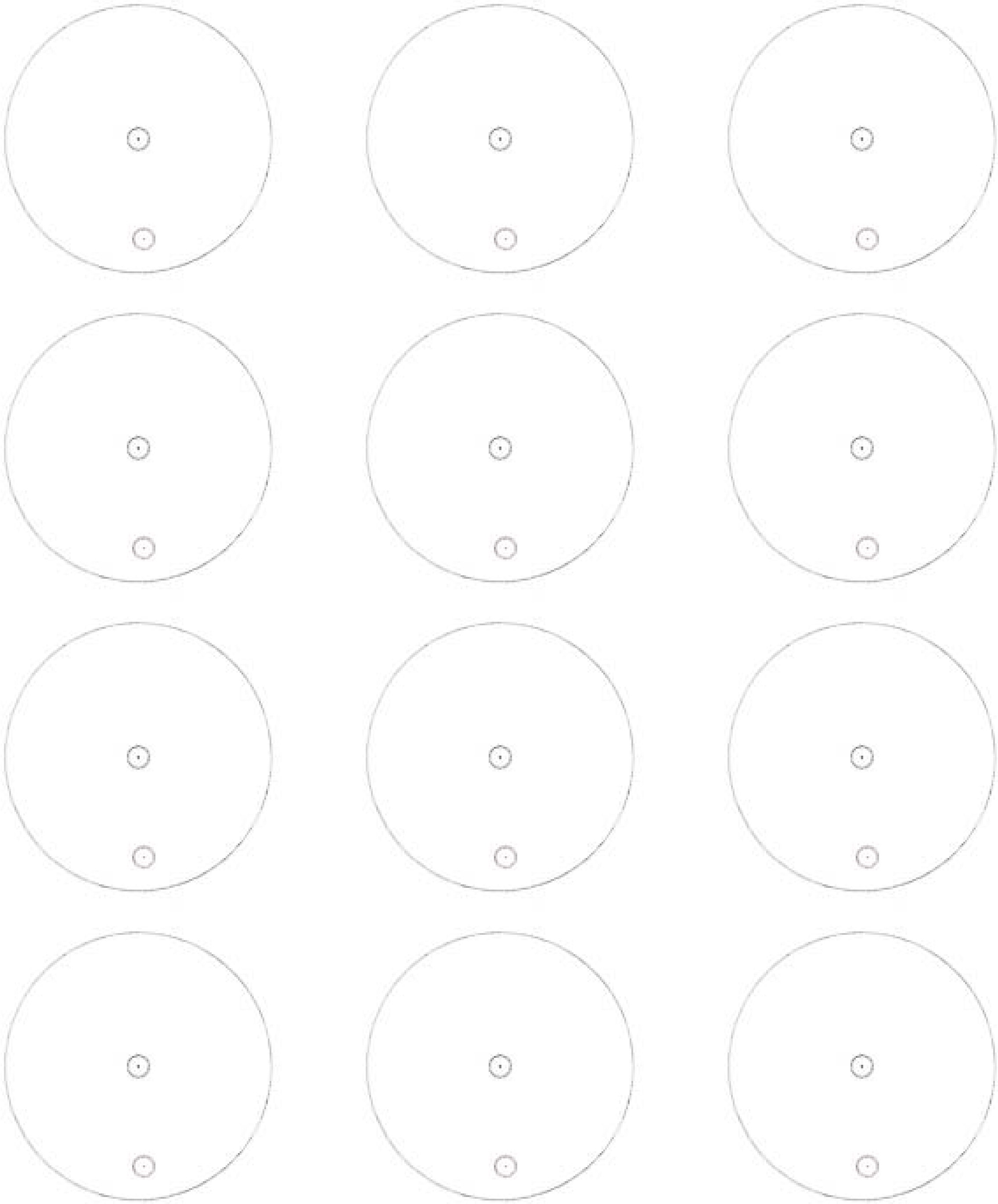


Take each pair of legs and attach them to the skewer and discs (and/or body) *Another designer uses a similar skewer strategy, see below.*



Tip: To make sure that the legs do not fall off the crank shaft discs or the skewers take two small circular pieces of card stock (two layers each) and glue them to the tips of the skewers attached to the crank shaft discs.





Days One through Four K-8 Standards Alignment

K

- 7.11.1 Explore different ways that objects move.
- 7.11.1 Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

1

- 7.11.1 Investigate how forces (push, pull) can move an object or change its direction.
- 7.11.1 Use familiar objects to explore how the movement can be changed.
- 7.11.2 Investigate and explain how different surfaces affect the movement of an object.
- 7.T/E.3 Use tools to measure materials and construct simple products.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

2

- 7.12.2 Realize that things fall toward the ground unless something holds them up.
- 7.12.2 Describe what happens when an object is dropped/let go and record the observations
- 7.T/E.3 Use tools to measure materials and construct simple products.
- 7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

3

- 7.11.1a Explore how the direction of a moving object is affected by unbalanced forces. (Note: **Unbalanced forces** <u>always</u> cause a change in motion. They are not equal and opposite. Forces occur in pairs and can be either balanced or unbalanced. **Balanced forces** <u>do not</u> cause a change in motion. They are equal in size and opposite in direction so they cancel each other out and no motion happens. If motion is happening then there are unbalanced forces.)
- 7.11.1b Identify how the direction of a moving object is changed by an applied force. (Any force could be considered to be an applied force, but applied force usually

stands for a force applied by a person or an action which directly pushes or pulls on a system.)

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4

- 7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.
- 7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

5

- 7.12.2 Identify the force that causes objects to fall to the earth.
- 7.12.1 Explain and give examples of how forces can act at a distance.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

6

- 7.10.2 Analyze various types of energy transformations (gravitational potential, kinetic, etc).
- 7.10.3 Recognize that energy can be transformed from one type to another.
- 7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.
- 7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications
- 7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

7

- 7.11.4 Recognize how a net force [the overall force acting on an object] impacts an object's motion.
- 7.11.4 Investigate how Newton's laws of motion explain an object's movement.

- 7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.
- 7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications
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These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

8

- 7.12.5 Recognize that gravity is a force that controls the motion of objects.
- 7.12.7 Explain how the motion of objects is affected by gravity.
- 7.T/E.2 a. Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.
- 7.T/E.2b Apply the engineering design process to construct a prototype that meets certain specifications
- 7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

These standards will be met and reinforced as students participate in designing, building, testing, redesigning, and reconstructing their own passive dynamic walkers.

K

- Shapes
- Air
- Job
- Parts
- Observe
- Pattern
- Collect
- Position
- Senses
- Tools

1

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3

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- Conclusion
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- Force
- Cause
- Effect
- Character
- Conjecture
- Setting

4

- Mimic
- Consumer
- Compare
- Contrast
- Friction
- Drawing conclusions
- Pattern
- Chance
- Accuracy

5

- Point of view
- Implied
- Gravity
- Edge
- Model
- Integration
- Personification
- Main ideas
- Solution
- History

6

- Sequential
- Personification
- Point of view
- Control
- Criteria
- Design constraint
- Cause and effect
- Energy transformation

7

- Viewpoint
- Function
- Impact
- Property
- Repetition
- Simple machines
- Speed

8

- Sensory
- Force
- Reliability
- Product
- Variation
- Solution
- Function

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