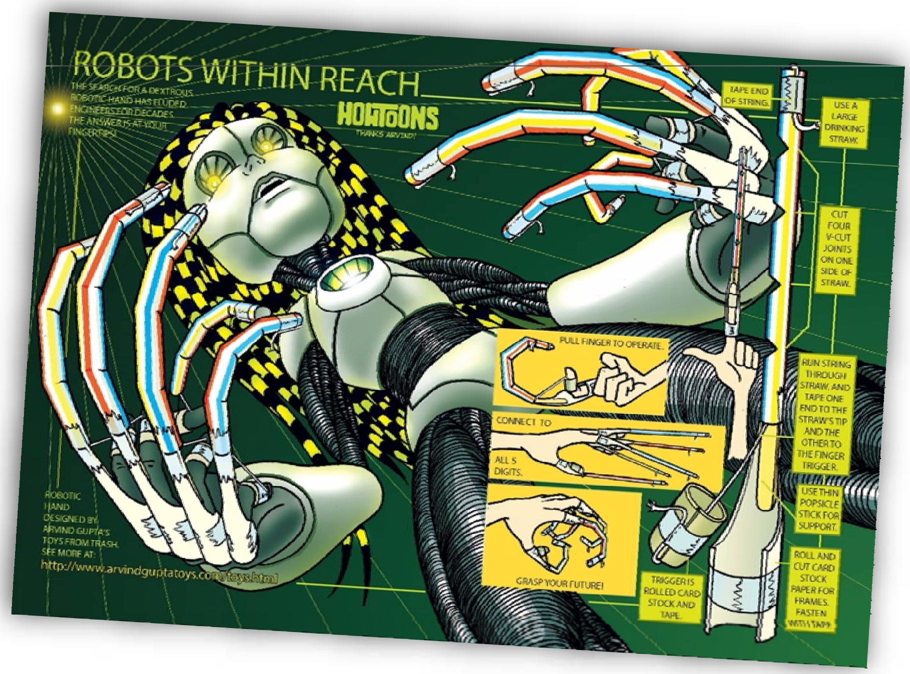
Small and simple things!

Tools of Mass Construction!

The popular image of robotics research involves big budgets, state-of-the-art technology and the latest materials. But in fact, a lot of cutting-edge research is done on the cheap, using things you probably have around the house. Coming up with ways to build simple, inexpensive prototypes makes it possible for researchers try lots of variations quickly and easily. Once perfected, these designs can be applied to more complex machines – although some researchers are looking into low-tech robots as an end in themselves!

Get a Grip!



Designing hands is one of the biggest challenges in robotics. Like your own hand, robotic hands need to be dexterous yet solid, sensitive yet tough; they must be capable of plucking a raw egg from a basket, picking up a coin and hoisting a heavy object across a room. The usual strategy when designing a robot hand is to try to replicate the human hand.

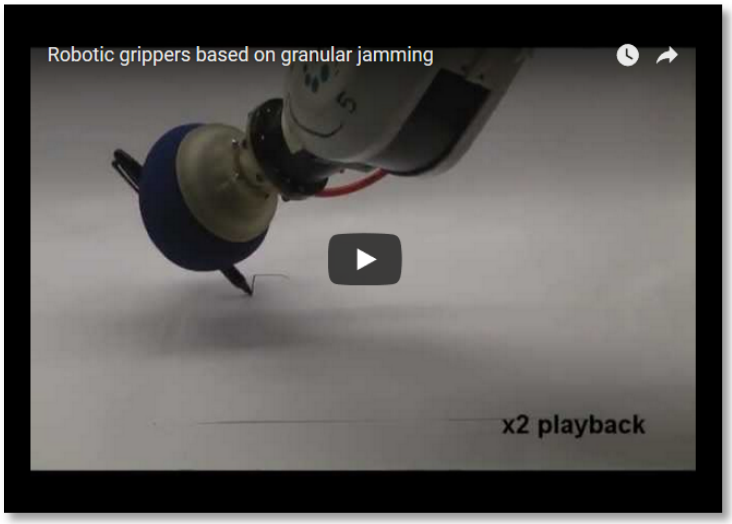
Rather like this robotic hand project from HowToons!

Have students give it a try. All you need are string, cardstock paper, tape, large drinking straws (or smoothie straws) and a pair of scissors!

Universal Robot Gripper

But does it have to look like a human hand to really get a grip on things? In 2010, researchers at Cornell University and the University of Chicago developed a unique approach: They created an amorphous gripper that can mold itself to the object to be picked up. It's very versatile and it's easy to build.

So, what is it? The most dexterous, most careful and most useful robotic gripper is not a claw or a hand with several fingers — it's a sack of coffee grounds. Researchers threw out hands altogether and opted for a mushy suction-ball instead. Here is [a video](#) from Cornell University that explains the process.



This gripper works because of a process called "jamming". When particles (like coffee grounds) are so densely packed that they can no longer slide past each other, they behave like a solid. When they're loosely packed, they behave like a liquid. As the pressure increases, so does the amount of friction between the individual grains. This effectively locks the grains in place.

You may have observed this phenomenon while handling bags of ground coffee or other vacuum sealed goods. A vacuum-packed bag of coffee is rock-hard as long as the seal remains intact. But as soon as the seal is broken, the coffee becomes soft and pliable and can be poured like a fluid. This process happens with many granular materials, such as rice, couscous, and even sand.[1]

Build the Hand

We're using this process to make an amorphous robot gripper. A balloon filled with coffee is attached to an air hose; when balloon is slightly pressurized the grounds are loose and easily rearranged. By pressing the balloon against an object, the grounds will move around it and take its shape. But when the air is sucked out of the balloon, the grounds are compressed and grip the object. The rubber surface of the balloon also helps to keep a hold on the object.

Materials:

- Coffee grounds

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[1] https://www.popsci.com/technology/article/2010-10/coffee-filled-balloon-makes-best-robotic-gripper

- Spoons
- Latex balloons
- Air hose
- Air pumps
- Objects to pick up
- Scissors/knife (adult use only!)
- Funnels
- For help check out the video from Make on YouTube
- Option: other materials to test, e.g., rice, couscous and even sand.

Filling the Balloon

1. The first thing you need to do is fill the balloon with coffee. To do this, attach the balloon to the end of a short tube or pipe, and insert the funnel into the other end.
2. Scoop about a tablespoon of dry, ground coffee into the funnel and it will pour down into the balloon.
3. Then remove the funnel and blow into the tube to partially inflate the balloon. This will allow all the coffee to fall to the bottom of the balloon.
4. As you slowly let the air back out, the coffee will remain trapped in the balloon.
5. Then insert the funnel back into the tube and repeat the process.
6. Continue adding coffee. Periodically, set the balloon inside the funnel to check its size. You want the balloon to stick out about one inch past the edge of the funnel. It might be about the size of a baseball.
7. Once you have enough coffee in the balloon, you can remove the balloon from the tube.

Adjusting the Funnel

Now we need to put the balloon in the funnel and insert the neck of the balloon through the narrow opening. Unfortunately, most kitchen funnels have a narrow section that is several inches long. This makes the process very difficult. So, to make it easier, the instructor should cut the narrow section of the funnel so that it is only 1/2 inch long. You can do this with any sharp knife. After cutting the funnel, try to smooth off any rough edges.

Attach the balloon to the funnel

Insert the neck of the balloon through the wide opening of the funnel and wrap it around the opening on the other side. To hold it in place, apply small strips of duct tape.

Keep the coffee in there!

1. We want the ground coffee to stay inside the balloon. To prevent it from falling out, attach a small piece of fabric to the opening, to act as a rough filter. You want to use a fabric that breathes easily so that the air pump will be able to quickly move air in and out of the balloon.
2. Tightly wrap the fabric around the opening of the funnel, then secure it in place with small strips of duct tape.

Adding the air(hose)

Now you need to attach the air hose to the funnel. The easiest way to do this is to hold the funnel up in the air hose and attach them together with several layers of duct tape. You want to make a (mostly) air tight seal, so feel free to use as much tape as you want.

Getting a Grip!

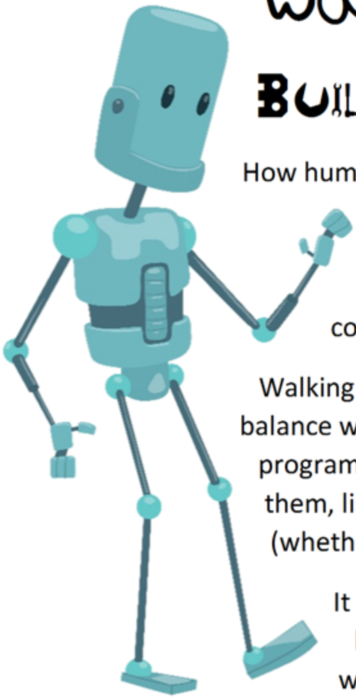
Now you are ready to use your universal gripper to pick up objects. Start by partially inflating the balloon. This will make the grains loose so that they will freely move around the object. Then gently press the balloon on top of the object. Now suck the air out of the balloon. Continue pressing down on the object as the balloon deflates. The balloon will shrink and the grounds will lock in place around the object.

When all the air is sucked out of the balloon, you should be able to pick up the object. As long as the vacuum is maintained, the universal gripper should continue to hold the object firmly. To release the object, simply break the seal and let some air back into the balloon; the object will then fall from the gripper. If you quickly blow air back into the balloon the gripper will forcefully eject the object. You can use this to shoot small objects across the room.

This kind of gripper is ideal for pneumatically powered robots; all you have to do is hook the gripper up to the robot's air line and you will be able to manipulate a wide variety of objects with ease.

Can students think of ways to improve the design? What other materials could they test?

Walk Like a Hu-uman?



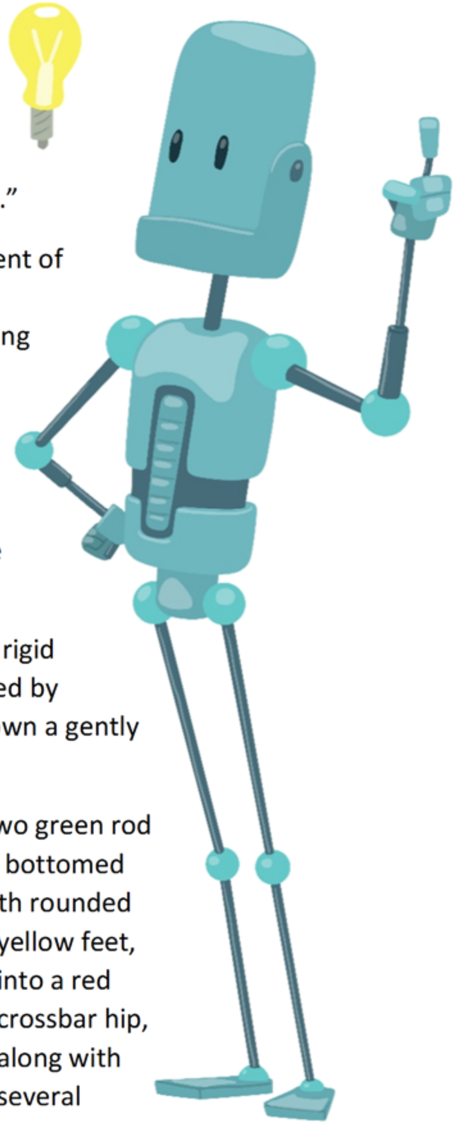
BUILDING A LEG TO STAND ON

How humans walk with their top-heavy, upright trunk atop two relatively spindly legs is not well understood. While some scientists believe that the human nervous system largely coordinates balance and locomotion, our research further suggests that the passive interaction of gravity, inertia and ground contact may also be very important in coordinating our locomotion.

Walking on two legs may be easy for some humans, but not for robots. 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.

It doesn't have a brain or a heart, and its walk is a little like the scarecrow's, but a little headless, armless, trunkless two-legged robot, developed at Cornell University, can walk, wobble, hobble, limp, stride and stagger. But it can't stand still in any position without falling over.

Michael J. Coleman, a lecturer in mechanical engineering at Cornell, says the little walker, by using gravity on a gentle slope "performs repeatable, chattering, human-like stable steps without falling over." Says Coleman, who earned his doctorate in February, "We believe this is the first two-legged, statically unstable 3-D passive-dynamic walker that can walk stably down a slope without any control system whatsoever."



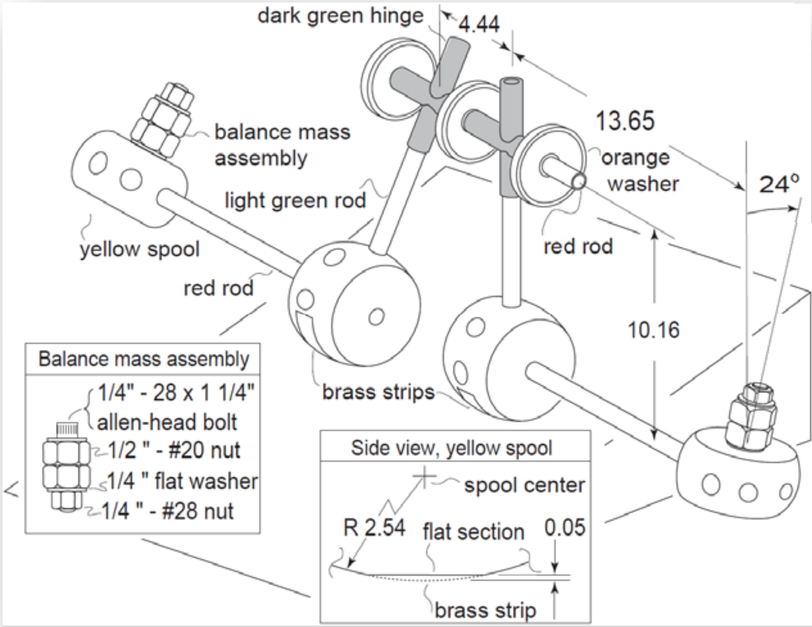
"Playing, with no hopes of success, we placed the toy on a ramp. Surprisingly, it took a few serendipitous, if not very steady or stable steps. After some nonquantifiable tinkering, we arrived at the functioning device."

Coleman and Ruina believe their work, which some liken to the development of airplanes from motorless gliders, will help provide key insights into the mechanics of walking. It could also have important implications for designing better powered and controlled biped robots, building better artificial legs and improving rehabilitation for neuromuscular problems.

Graduate student Mariano Garcia, along with Coleman,currently is exploring more complicated models to attempt to explain the observed motions of the Tinkertoy walker. The researchers hope to make the device more stable and sophisticated.

The design could hardly be simpler: two circular feet dangle from straight, rigid legs linked by an axle. Two balancing weights stick out to the sides, attached by spindles to the feet. Rocking from side to side, the model plods steadily down a gently sloping ramp. Motionless, it cannot stand.

Coleman originally constructed the Tinkertoy device as follows: He stuck two green rod legs, bottomed with rounded yellow feet, into a red crossbar hip, along with several orange washers and green hinges (which are now purple in the Tinkertoy King Size sets). To stabilize the toy, he added low-lying red and yellow outriggers weighed down with steel nuts off each foot to lower the centers of mass. Ruina helped fine-tune the toy by rounding out the flat spots of the Tinkertoy wheels with flexible brass

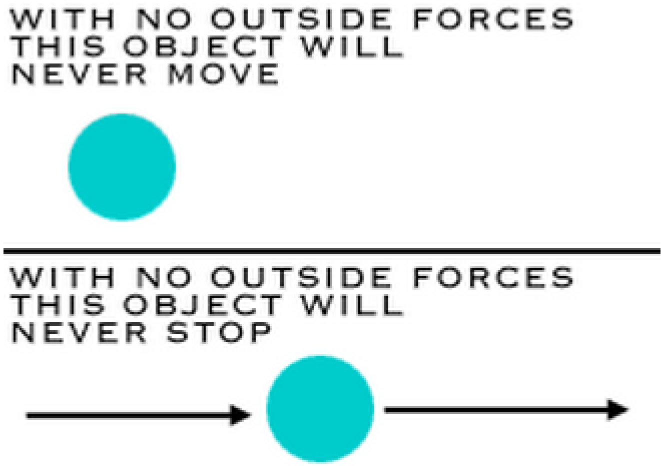


strips. Soon, the hand-sized gadget was tottering down a gentle slope, tilting from side to side but steadily walking on and on and on. But, it couldn't stand still. (Watch it here.)

The fact that this robot, made of plastic Tinkertoy parts and a few odds and ends, is stable in motion is giving mechanical engineers new thoughts about how humans walk.

Try It! Passive Dynamic Mini-Walkers

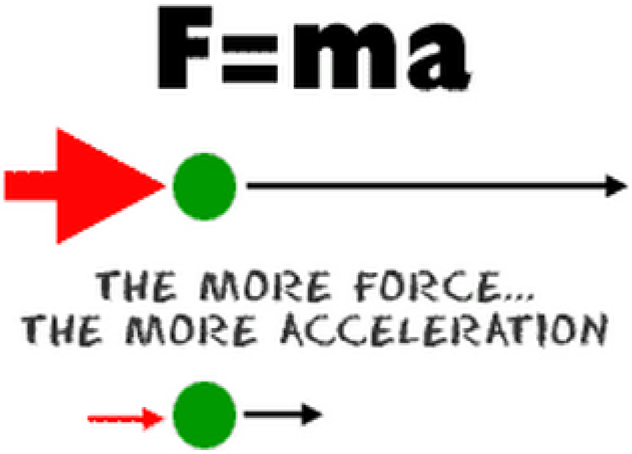
To get *us* started with the basics of robot walking, we'll build a passive dynamic walker based on models used to help roboticists figure out how to make robots move more naturally! Passive Dynamic means that a robot walker is powered by gravity. It doesn't need a motor or actuator of any kind. It's 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 walker moves down the slope.]

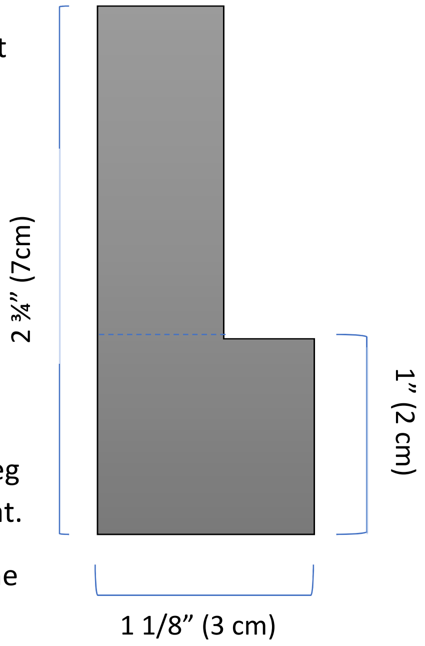
Have students experiment with different sizes and shapes, or use other materials that you have on hand. They can also expand the design and try four legs instead of two, give the walker knees, or attach swinging arms to add energy to each step.

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

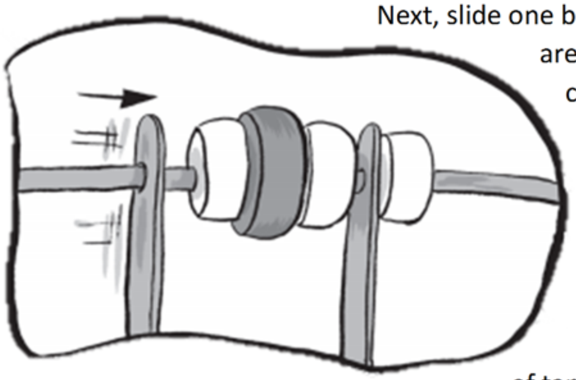
First, have students cut out two legs from the cardboard, 2 ¾ inches long (7 cm) and 1 ½ inches wide (3 cm). From one end of each rectangle measure 1 inch up (2 ½ cm) and make a ½ inch cut (1 cm). From there, trim up the cardboard so it forms an “L” shape, or a leg and a foot. With the pencil or nail, 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 one of 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.

Then, 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.

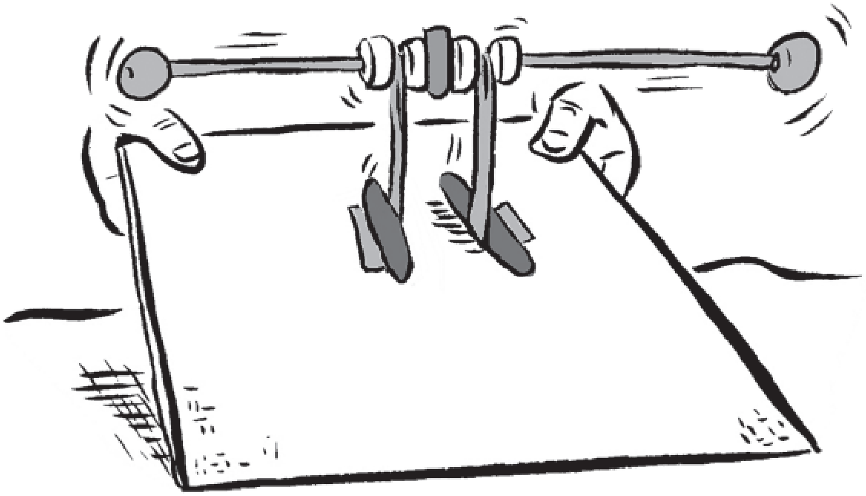


Next, slide one big bead or several small beads onto the skewer so that they are just touching the inside of the first leg. The bead(s) should cover about ½ inch of the skewer (1cm).

Now, 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 beads are 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 sure 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.

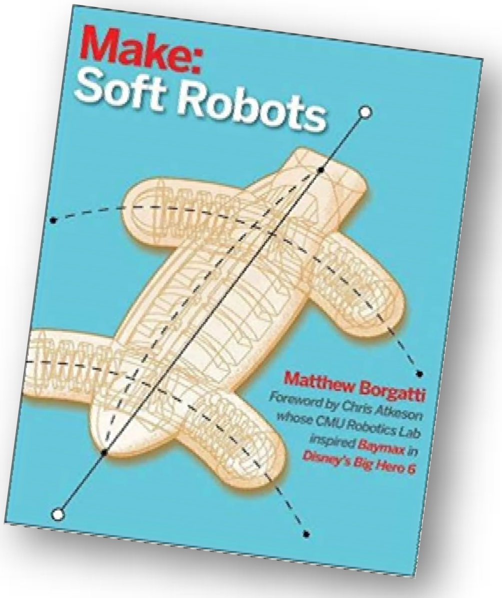


Make a test ramp with a long flat surface that you can tilt slightly, like a big book or a sheet of stiff cardboard or foam board. Foam core makes a nice walking surface.

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! Start with a robust, simple structure and expand! Can they lengthen the design? Add knees?

soft robots?



Resource: Look for the release of *Make: Soft Robots* by Matthew Borgattie and Kari Love in November 2018!

Walt Disney was a maker. Disney movies inhabit a world of fantasy and magic, but the man behind the mouse was also a roboticist and a futurist who built theme parks and automatons.

So, it's fitting that the a Disney hero is a maker and roboticist, too. Culled from the pages of a Marvel comic, Hiro Hamada, the teen at the center of Disney Animation's Big Hero 6, is a prototypical boy genius. His closest companion: an inflatable robot named Baymax.

Robotics has been done before, including by Disney. But Big Hero 6 tackled it a different way — with 3D printers and scanners, magnetics, chemistry, lasers, nanobots, makerspaces, and soft robotics. Big Hero 6 is celebrating the maker, and not by accident. In bringing maker tech to the big screen, Disney said a maker (engineer/designer/scientist) can be a superhero.[2]

Many students are informally familiar with soft robotics through the puffy robot Baymax from *Big Hero 6*. The students know that he's powered by air, which is a big departure from the design behind last famous cartoon robot, the eponymous WALL-E.

The inflatable robot of Big Hero 6 was based on real soft robotics research, like the ones being experimented with at startup Otherlab's *Pneubotics*. (Check out their YouTube channel for fascinating behind the scenes).

As with much of what Disney does, the maker tools in the story are re-envisioned with a sort of Disney panache, based in reality but moving slightly beyond it, an example of what could be coming next. Hiro himself assembles a nanobot swarm, like an advanced version of the shape-building Kilobots designed at Harvard. The 3D printers he uses in a school makerspace have multiple extruder arms, and print (much) faster than current printers, using better materials.

The ensuing adventures draw directly from research on core soft robotics ideas, including durability and (self) repair, and could even inform future robotics work — the crunchy-on-the-outside exoskeleton that Baymax uses, for example.[3]

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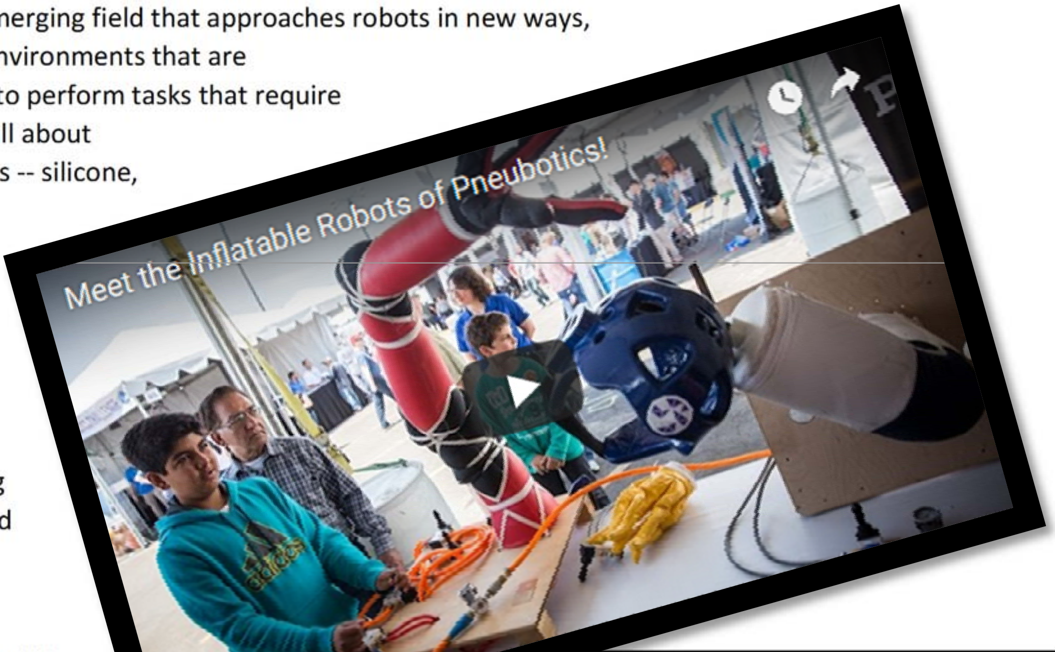
[2] https://makezine.com/2014/11/05/big-hero-6/
[3] https://makezine.com/2014/11/05/big-hero-6/

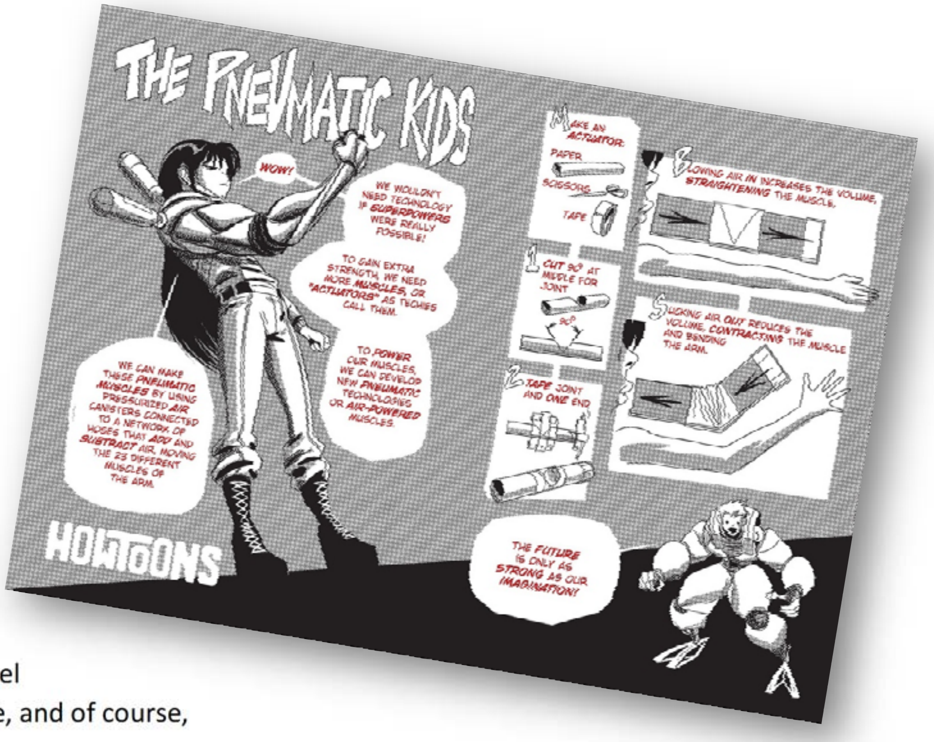
Soft robotics is a real-world emerging field that approaches robots in new ways, enabling them to operate in environments that are unstructured or unstable and to perform tasks that require delicacy and malleability. It's all about engineering with soft materials -- silicone, cloth, balloons, flexible plastics -- and combining them in different ways to come up with novel, approachable, and surprising solutions to interesting problems. And powering them with surprising things like air (pneumatics) and water!



- Watch the MIT 'soft robotic cube' jump bounce and roll!
- Watch: Meet the Inflatable Robots of Pneubotics! and learn how robots can be designed and built with lightweight and flexible skins that have impressive dexterity and structural strength.
- Watch the growing vine like robot from Stanford University

"If you're going to have robots essentially interacting with people, they need to be soft and safe, and our vision of that is inflatable robots. Not only are inflatables cheaper than metal robots, they're light and safe and appropriate for personal care. To take care of people, robots will have to touch them, he explains. "You'll have to dress [people], you have to comb their hair, you've got to brush their teeth. You're not going to do that with a bulldozer. It's just too dangerous." -Chris Atkeson, Robotics Professor, Carnegie Mellon

What are actuators?



An actuator converts energy into motion whether it's in a human or a robot. The muscles in our body are the actuators that help us move! In robots motors and hydraulics and pneumatic pistons are the things we might think of as actuators, but there are even more kinds! In soft robotics they use air and water too.

Try this fun project from HowToons and build air-powered actuators! All you need are paper towel rolls or cardstock/paper, scissors, tape, and of course, air!

Inspired by Origami?

"The delicate art of paper folding is playing a crucial role in designing robotic artificial muscles that are startlingly strong. In fact, the researchers say they can lift objects 1,000 times their own weight.

The researchers say the muscles are soft, so they're safer compared to traditional metal robots in environments where they would interact with humans or delicate objects, and they can be made out of extremely low-cost materials such as plastic bags and card stock.

Because it is able to lift heavy payloads, the design, overcomes a core paradox of the field of soft robotics: "You're typically giving up strength because you're using soft materials.""

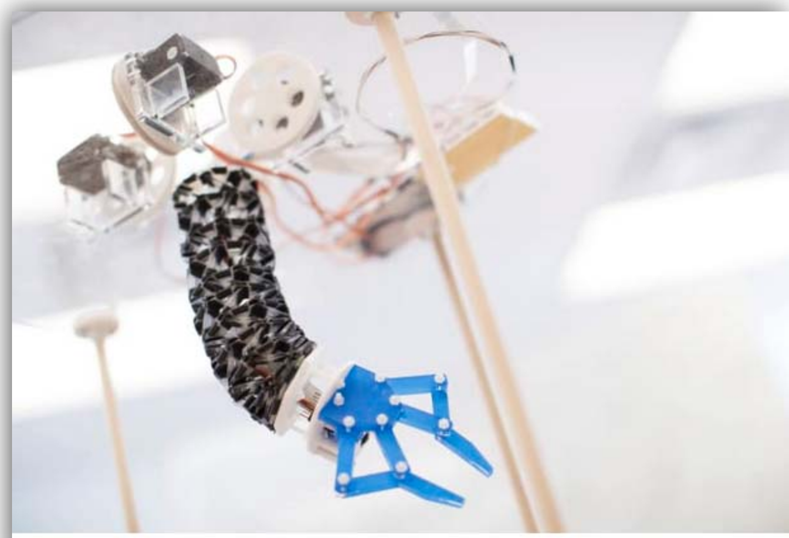
Remember those simple machines we studied? The devices are so strong because their design amplifies force much like a pulley or a lever does. As the origami structure inside contracts, and the outer plastic skin pulls in, it converts "the fluid pressure to a large tension force on the skin." Based on their models, the researchers believe a 1-kilogram artificial muscle could lift 1,000 kilograms.

The researchers say the way that the origami skeleton is folded determines the motion that the artificial muscles will make as they expand or contract. They can be programmed, or folded, to move along multiple axes and to bend and rotate.

Researchers see these models working well in environments like homes or hospitals, where they might interact with humans. They're strong so they can manipulate large heavy objects yet be safe to operate around. Someday they could be used as wearable robots, such as artificial muscles helping people who use wheelchairs to stand.

An upcoming challenge for the design team is to mimic a prime example from nature of power and softness: they want to design a robotic elephant using these artificial muscles, capable of lifting heavy loads with soft materials.[4]

Soft and Safe!



TWISTER, an origami-inspired soft robot. (Image courtesy of Russell Lee.)

And it's not just one team that's turning paper into robots! An engineer has turned the origami she enjoyed as a child into a patent-pending soft robot that may one day be used on an assembly line, in surgery or even outer space.

Kiju Lee, an assistant professor of mechanical and aerospace engineering at Case Western Reserve University, and her lab have moved from paper robots to 3-D-printed models that bend, contract, extend and twist. This novel mechanism is called TWISTER (TWISted TowEr Robot).

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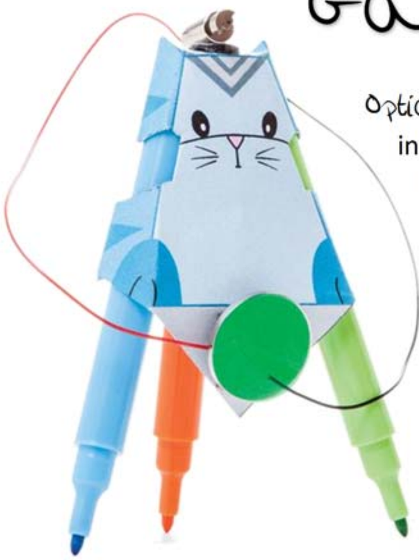
[4] Merrit Kennedy, "Robot Muscles Inspired By Origami Lift 1000 Times Their Weight" *NPR* https://www.npr.org/sections/thetwo-way/2017/11/28/567014007/robot-muscles-inspired-by-origami-lift-1000-times-their-weight

TWISTER was inspired by an origami twisted tower originally designed by Japanese artist Mihoko Tachibana, which uses multiple origami segments to form a tower structure. This origami design was then reinvented for various potential applications in robotics and manufacturing.[5]

Gami-bots!



Option: The Gami-Bot kit includes supplies to create four different origami robot bodies, four vibrational motors to power the bots, and five batteries, plus our Howtoons comic and other supplemental supplies.

This project teaches kids about origami, circuits, motors and vibration, and why scientists are using origami principles to create innovative technologies.

- all the materials to build 4 different origami robots (Battle-bug, Rattle-cat, Horsepower, and Skitter'n Scorpion)
- 4 motors, 5 batteries, mounting tape, scissors
- battle arena
- paper for the Rattle-cat drawing bot
- bonus hexaflexagon project
- Magazine that includes an 8 page comic, instructions to build the origami robots, education on simple circuits and origami, an interview with Kevin Albert (Roboticist), and extra DIY project toons

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[5] "New Soft Robot Design Inspired by Origami" *Engineering.com* https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/15725/New-Soft-Robot-Design-Inspired-by-Origami.aspx

Small and Simple Things Activities Supply List:

Get a Grip!

- 2 large rolls of cotton string
- 1 sheet of cardstock per student
- 5 rolls of tape
- large drinking straws (or smoothie straws), 5 per student
- scissors, one per student

Universal Robot Gripper

- Coffee grounds
- Spoons
- Latex balloons, 2 per student/group
- Air hose, 1 per student/group
- Air pumps, for testing
- Objects to pick up
- Scissors/knife (adult use only!)
- Funnels, one per student or small group
- For help check out the video from Make on YouTube
- Option: other materials to test, e.g., rice, couscous and even sand.

Passive-Dynamic Walkers

- Cardboard (one large box should provide plenty for a classroom)
- Scissors, one per student
- Sharp pencil or a large nail about as wide around as a skewer, one per student
- Small sheets of craft foam, felt, or thin cork (sticky-back/peel-and-stick is best), ½ sheet per student
- 10 Glue sticks, can be shared among students
- Bamboo skewers about 10 inches long (25 cm), 1 per student
- Wooden or plastic beads, 4-6 per student
- Mini craft sticks about 2 ½ inches (6 ½ cm) long, or regular craft, Sticks or coffee stirrers cut to size
- Clear tape or rubber bands (2 per robot)
- 3 large sheets of foam core, can be shared between groups
- 3 rolls of masking tape
- Optional: TinkerToy King Size sets

Air-Powered Actuator Muscles

- paper towel rolls or cardstock/paper, one per student
- scissors, one per student
- 3-5 rolls of tape, to be shared among students
- Air

Gami-Bots

- 5 Gami-bot kit(s) from HowToons (option these can be shared among students/groups)
- Copier

Samples of Academic Standards that can be reinforced during 'Small and Simple Things' activities

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, e.g. what works best for a human hand isn't the best for a robot hand!. We'll discuss the pros and cons of using robots for certain jobs (like working with medical patients) for both customers and companies. We'll discuss what kinds of robots students would prefer to work with themselves. Ex. Would they like it if their doctor was like Baymax?

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 gami-bots.

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 'gami-bots.' We'll discuss what each part does and how they work together as a whole.

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.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, e.g. what works best for a human hand isn't the best for a robot hand!. We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

7.11.1 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 gami-bots. 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 gami-bots 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 gami-bots.

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 'gami-bots.' We'll determine what the magnet does for the gami-bot.

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.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, e.g. what works best for a human hand isn't the best for a robot hand!. We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel *about the various 'solutions' scientists have come up with and what they think are the most effective ones.*

7.12.1 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 gami-bots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the gami-bots/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 gami-bots.

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.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, e.g. what works best for a human hand isn't the best for a robot hand!. We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

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

7.10.1 Use an illustration or model to identify various sources of energy, ex. heat, light, or chemical

These standards will be met and reinforced as students participate in constructing and deconstructing 'gami-bots. We'll see what happens if we change the design or add or subtract weight as we construct them.' We'll determine what the energy source is for the gami-bots and discuss how the chemical energy in the battery gets changed into the motion energy. We'll find out what happens when the circuit is complete (motion) and when it's broken (motion stops) or the energy source is drained (motion stops), what the battery does, etc.

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.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, e.g. what works best for a human hand isn't the best for a robot hand! We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

7.11.2 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.

7.12.3 Describe how electricity passes through a simple circuit that includes a battery, wire, switch, and motor.

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 gami-bots and discuss and discover how they work. 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. We'll find out what happens when the circuit is complete (motion) and when it's broken (motion stops) or the energy source is drained (motion stops), what the battery does, etc.

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.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 (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 we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations, e.g. what works best for a human hand isn't the best for a robot hand! We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

7.10.5 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 gami-bots and discuss and discover how they work. 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. We'll find out what happens when the circuit is complete (motion) and when it's broken (motion stops) or the energy source is drained (motion stops), what the battery does, etc.

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.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.

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 we discuss the relationships and similarities and differences between humans and robots, and their uses and purposes as well as limitations, e.g. what works best for a human hand isn't the best for a robot hand! We'll explore the evolution of robot technology (e.g., soft robotics) and we'll discuss the pros and cons of using robots for certain jobs (working with medical patients, for example) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

7.12.1.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 participate in constructing and deconstructing gami-bots and discuss and discover how they work. 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. We'll find out what happens when the circuit is complete (motion) and when it's broken (motion stops) or the energy source is drained (motion stops), what the battery does, etc.

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.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.

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

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, e.g. what works best for a human hand isn't the best for a robot hand! We'll explore the evolution of robot technology (into soft robotics, etc.) and we'll discuss the pros and cons of using robots for *certain jobs (like working with medical patients) for both customers and companies and what problems they solve (and possibly create) for both sides.*

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.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 gami-bots 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.

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.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, e.g. what works best for a human hand isn't the best for a robot hand! We'll explore the evolution of robot technology (into soft robotics, etc.) and we'll discuss the pros and cons of using robots for certain jobs (like working with medical patients) for both customers and companies and what problems they solve (and possibly create) for both sides. We'll discuss how students feel about the various 'solutions' scientists have come up with and what they think are the most effective ones.

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

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

1.5.6 Build circuits to demonstrate how they function.

These standards will be met and reinforced as students build and test different varieties of gami-bots. They will modify and test their designs, seeing how gravity, friction, weight, balance, and other forces affect the gami-bots movement and sound.

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.

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.5 Develop an adaptive design and test its effectiveness.

These standards will be met and reinforced when students discuss, build, and test the passive dynamic walkers.