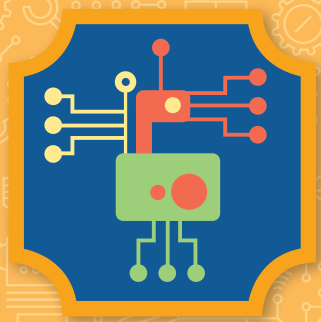
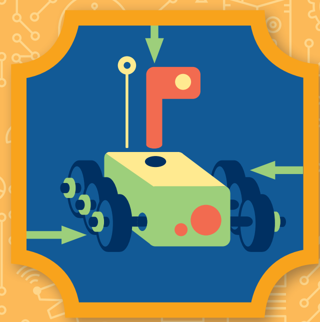



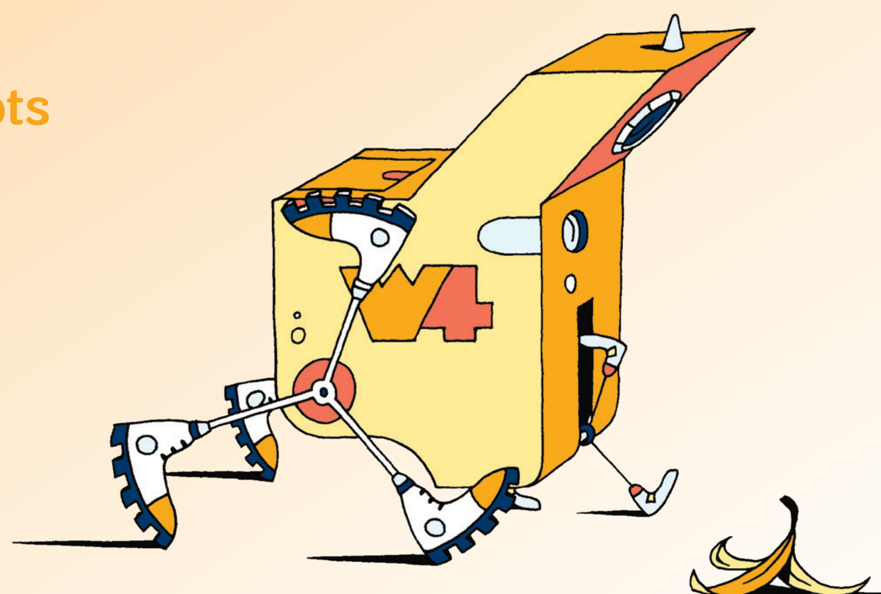

Ambassador Robotics

Develop your robotics skills by earning these three badges!

Badge 1:
Programming Robots

Badge 2:
Designing Robots

Badge 3:
Showcasing Robots



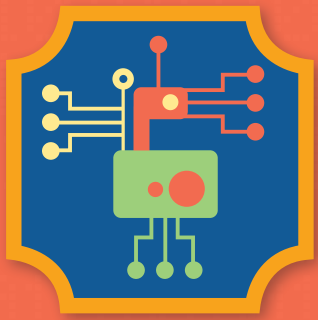
This Robotics badge booklet for girls provides the badge requirements, information, and fun facts about robotics for all three Ambassador robotics badges. It does not include all the information needed to complete the badges. Volunteers may access full meeting plans—including detailed activity instructions—on the Volunteer Toolkit (VTK) or by contacting their local council.

Welcome to the world of robots!

When you've earned these three badges, you'll know how robots are built and programmed. You'll get to design and build your own model robot. And you'll learn how to document your work so you can share it with others or present it to potential markets.

Why is robotics important? No matter what field you're interested in—transportation, construction, fashion, computers, health care, education, farming—chances are you'll be dealing with robotics in some form.

The more you know about how robots work, the better prepared you'll be to use them in the future. Who knows? You may even find yourself designing new robots for fields that don't even exist yet!



Badge 1: Programming Robots

Robots are machines that can detect what's going on around them and use that information to decide how they'll interact with the physical world.

To help you understand how robots work, learn about the parts that make up a robot. Get started by making a simple motorized robot to see how robot parts work together. Then practice coding robots, using important programming concepts, like functions and loops.

Steps

1. **Learn about robots**
2. **Build a robot model: motorized robot**
3. **Explore the way robotics systems work together**
4. **Learn about programming**
5. **Write a program for a robot**

Purpose

When I've earned this badge, I'll understand how robots work and how to control them.

Learn About the Parts of a Robot

- **Sensors,** such as cameras, microphones, and thermometers, send information about the environment to the robot's controller.
- **Controllers,** such as computers and microcontrollers, process information from the sensors and decide how the robot will react.
- **Housing** is the robot's body. It can be made out of all kinds of materials.
- **Actuators** are the power systems of the robot that make it move, such as an electric motor or hydraulic pump.
- **Effectors** are the parts of the robot that can move around, such as arms, grippers, legs, wheels, treads, fins, and propellers.

STEP

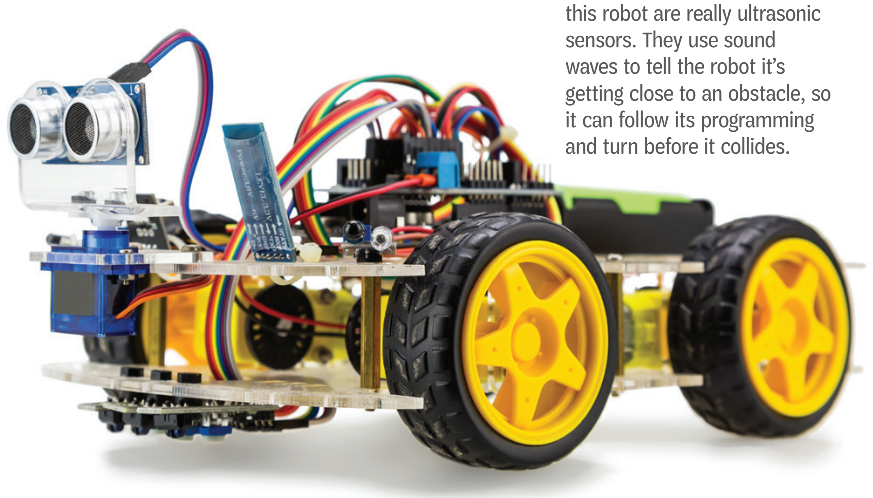
1 Learn about robots

Robots are all around us. But what makes a robot different from other kinds of electrical devices, like a toaster or a television? Many scientists use the Sense-Think-Act definition. It says that a robot can perform three functions that make it stand out from ordinary machines. They are:

Sense: A robot has sensors that give it information about the physical environment, the "real" world around it.

Think: The input from the robot's sensors controls the robot's movement and actions. This control is usually carried out by electronic circuits or computer programming, either onboard or remotely. Sometimes it is built into the robot's physical design. This is called a "programmable body" or "smart body."

Act: A robot usually has some way to move or affect the world around it. This can include legs, wheels, helicopter rotors, fans, arms, grippers, lights, and speakers.



The "eyes" on the front of this robot are really ultrasonic sensors. They use sound waves to tell the robot it's getting close to an obstacle, so it can follow its programming and turn before it collides.

Words to Know

An **actuator** takes energy (from a battery or other source) and uses it to power a robot's movement. Examples include an electric motor or hydraulic pump.

An **algorithm** is a set of step-by-step instructions to carry out a task. A computer program is a type of algorithm.

Artificial intelligence or **AI** is a type of computer program that acts as if it can think like a human. For example, AI programs are used in devices that can answer questions and hold conversations with people in ordinary language.

Autonomous robots work some or all of the time without human control. They can make decisions based on their programming and input from the environment.

A **circuit** is a path for electricity to travel along. Most circuits are designed as loops with a switch that can open and close the circuit, like a drawbridge. A circuit must be closed for electricity to flow.

Robots Through the Ages

In 200 BCE,

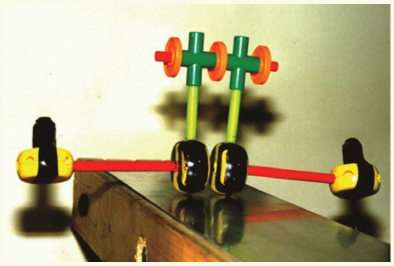
a group of mechanical musicians that played instruments on their own—ancient ancestors of today's robots—was presented to the Chinese emperor.

In 1921,

Czech author Karel Capek invented the word "robot," meaning "forced labor," in his play *R.U.R.* about artificially-created workers overthrowing their human masters.

In 1998,

Cornell University engineer Andy Ruina built a simple but lifelike set of gravity-powered robot legs using wooden Tinkertoys.



Michael Coleman and Andy Ruina, Cornell University

In 2002,

a company called iRobot began selling a robotic vacuum cleaner called the Roomba, launching the home robot industry.

In 2018,

Aibo, a robot puppy first introduced by Sony as a family plaything in 1999 and later discontinued, was reintroduced at the Consumer Electronics Show in 2018. The new Aibo is more lifelike and responds to human commands. It is part of a trend toward robots that can serve as a companion to the elderly as well as a toy for kids.

Binary is a way of presenting information using only two symbols. In math, a binary system consists of the numbers 0 and 1.

A **bug** is a problem in a computer program. To get rid of the problem, you **debug** the program.

Coding means writing a computer program, which is also known as code.

A **computer program** is a set of instructions that tells the machine what to do. Computer programs are written in code that can be understood by machines.

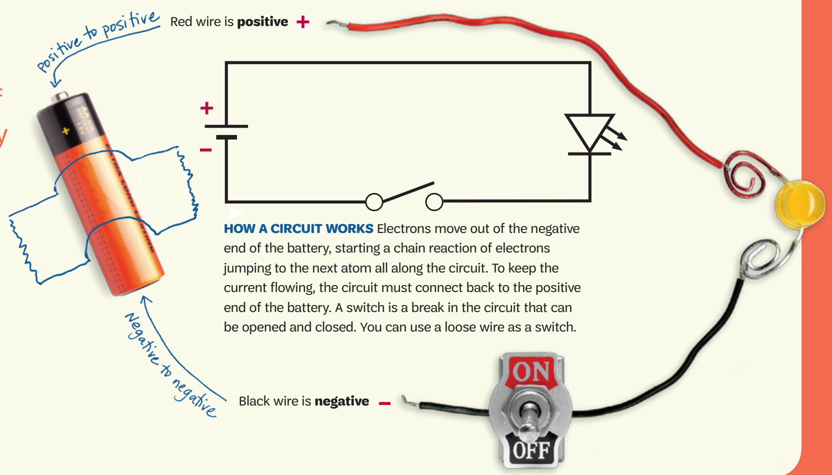
A **command** is one step in a computer program.

A **conditional statement** in a computer program tells the computer to make a choice between two or more actions. It is usually written in the form **IF-THEN-ELSE**. **IF** a certain condition is true, **THEN** the computer will take one action. If it is false, the computer will take the other action. For a loop, the statement might be **REPEAT UNTIL** a condition is true.

Conductive materials are substances that carry electricity easily, like metal.

HOW ELECTRICAL CIRCUITS WORK

- Electricity is the flow of electrons from one atom to another. When the energy from a chemical reaction or other source knocks an electron off an atom, **allowing it to jump to another atom**, electrical current begins to flow.
- **A circuit is a path for electricity to flow.** It is made of conductive material, a substance that carries electricity easily. It is surrounded by insulating material that doesn't carry electricity.
- **For electricity to flow in a circuit, there needs to be a place for it to go.** Usually a circuit is designed in a loop, so that the electrical energy flows around and around.
- **A power source, such as a battery, has a positive (+) end where the electricity comes out and a negative (-) end where it goes back in.** For electricity to flow, the circuit must be connected to both ends of the battery.
- **For electricity to flow, a circuit must be closed.** If a circuit is connected to both ends of a battery, but there is an opening anywhere in the circuit, nothing happens. This is called an open circuit.
- **A switch or sensor controls the flow of electricity by opening and closing the circuit.** It's like a drawbridge over the gap in the circuit. When the drawbridge is down, electricity can travel around the circuit. When it is up, or open, no electricity flows.
- **Some sensors can let higher or lower amounts of electricity flow, like the dimmer switch on a light.** The amount of electricity that is getting through is usually measured in units called volts. A robot's computer brain can be programmed to react differently depending on how much voltage is getting through.
- **A load is the component that is being powered by the circuit.** It can be a motor, a light, a buzzer, or anything that uses electricity to run.



HOW A CIRCUIT WORKS Electrons move out of the negative end of the battery, starting a chain reaction of electrons jumping to the next atom all along the circuit. To keep the current flowing, the circuit must connect back to the positive end of the battery. A switch is a break in the circuit that can be opened and closed. You can use a loose wire as a switch.

Words to Know continued

Data is information that a computer can understand.

Documentation means keeping a record as you create your design, from idea to completion. It can include written descriptions, drawings, photos, and videos. Documentation lets you create instructions to share with others or prove that you are the inventor of a new idea.

An **effector** is a part on a robot that can move around. Examples include robot arms or legs.

A **function** is like a mini-program within another program. It's a series of commands that is given a name. When you "call" the function's name in a program, those commands are carried out at that point.

Housing refers to a robot's body.

Input is data that is entered into a computer by a human operator or an electronic sensor.

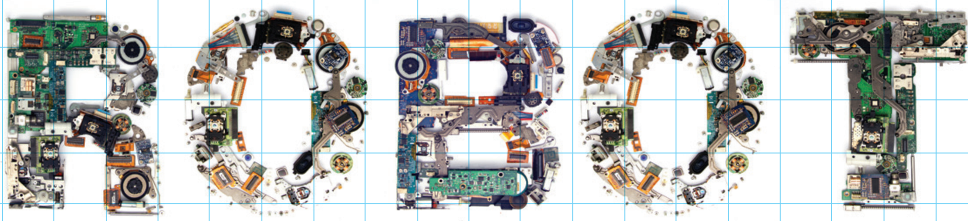
Insulating materials don't carry electricity easily. They are used to cover conductive materials and keep electricity from leaving the circuit.

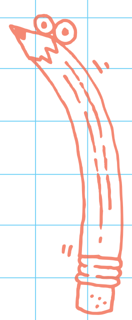
STEP

2 Build a robot model: motorized robot

Robot prototypes or test models are often made using recycled, repurposed, or spare parts. Learning to take devices apart to reuse the components is a handy skill!

To try it out, turn a fan or other device into a robot by giving it a body and figuring out how to use the motor to propel it.





Special Features

Think of a robot and a situation it must get itself through—for example, an underwater robot that must get to a coral reef while avoiding an aggressive shark. What systems would the robot need? How will it reach its destination? Robot designers use this type of planning to decide what features to include in the projects they are building.

Iterate means to repeat something over again.

The **left-hand-on-the-wall rule** is based on the idea that if you are walking through a maze and always keep the same hand on the wall, eventually you will end up at the exit. This method is often used for maze-solving robots.

Locomotion is the ability to move from one place to another.

A **load** is the component that is being powered by an electrical circuit. It can be a motor, a light, a buzzer, or anything that uses electricity to run.

A **loop** is a computer programming shortcut that tells the computer to go back and repeat a series of commands.

A **programmable body** is a way of controlling how a robot moves by changing its physical design.

Pseudocode means writing out a computer program in everyday language. It is used as a quick way to plan out a computer program without translating it into a programming language.

Robot Locomotion

The locomotion system of land-based robots depends on the environment they need to work in. The biggest challenge is to allow robots to get around on rough terrain or up and down stairs. Most robots tend to use either legs or wheels.

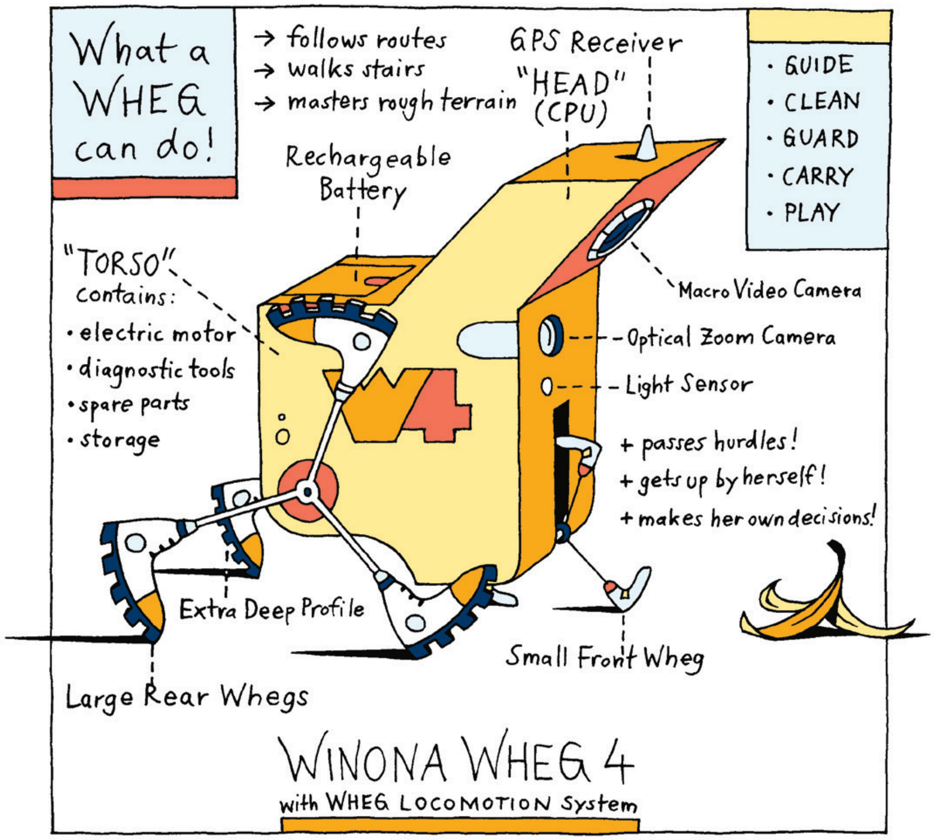
Some use a combination of wheels and legs known as "whegs"—legs that spin around an axle, like the spokes on a wagon wheel without the rim. Whegs can move quickly on smooth surfaces but can lift themselves over curbs and other obstacles. Other robots use treads, such as tanks that can roll up and over bumps and sharp edges.

Two-legged robots that can walk as well as humans are particularly hard to design. But the four-legged robot dogs built by Boston Dynamics are so stable they can recover if you try to trip them. In one video, the company showed their robot dog the SpotMini slipping on a banana peel and getting back up on its own.

STEP 3 Explore the way robotics systems work together

For robots to meet the "Sense-Think-Act" definition, they need some way to respond to their environments. Even without an electronic controller, you can design a robot's body to affect the way it moves by changing the shape and weight distribution. This "programmable" body determines the way the robot reacts to conditions around it.

Now that you have a motorized robot, create a programmable body. Can you make your robot travel in circles? How could you design it to travel in a straight line?



Words to Know continued

A **robot** is a machine that can perform three kinds of tasks: sense, think, and act.

A **roboticist** is a scientist who works on robots and related technology.

Robotics is the branch of technology that deals with designing, building, and using robots.

A **sensor** is an electronic component that transmits information to the robot about its environment.

The **uncanny valley** is the point at which an artificial life form that looks almost real appears more threatening than friendly.

Syntax is the set of rules used by a language. It includes spelling, spacing, symbols, and punctuation.

A **vibrobot** is a motorized robot that moves by vibrating. It usually has little or no electronics.

Lori K. Sanders, Michael Wehner, and Ryan L. Truby, Harvard University

Soft Robotics

Robots are awesome, but a stiff, heavy robot body can't get around tight places as easily as living things made of flesh and blood. That's why roboticists have been working for some time on soft robots that can bend, twist, and shimmy like real critters.

One soft robot prototype that seems promising is the autonomous eight-armed Octobot. The Octobot was developed in 2016 at Harvard by roboticist Robert Wood and Jennifer A. Lewis, who specializes in biologically inspired engineering.

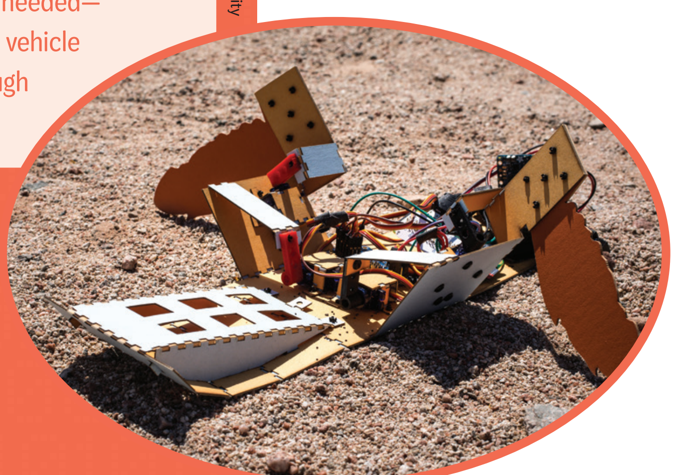
Based on the movement of real octopuses, the Octobot has no hard parts such as stiff circuit boards or motors. Instead, its rubbery body is controlled by a "microfluidic logic circuit." This liquid nervous system can inflate and deflate different arms at different times by sending gas through superthin tunnels throughout the robot's body. This is how the Octobot moves.

The Octobot was created to demonstrate that it can be easy to manufacture simple soft robots and to lay the foundation for more complex designs. Harvard shares its designs online through their Soft Robotics Toolkit. It also sponsors a soft robotics contest for hobbyists, researchers, professionals, and students in high school and college.

Robot Turtles

Inspired by sea turtles, a team of computer science, mechanical engineering, and biology researchers from Arizona State University created a low-cost, disposable robot that's smart enough to teach itself to crawl across sandy terrain. Made of laser-cut cardboard and 3D-printed plastic, the C-Turtle robot has a curved bottom shell and rounded flippers that pull it along.

Using an inexpensive minicomputer called a Raspberry Pi for a brain, the C-Turtle learned to repeat movements that helped it crawl forward and stop using those that didn't work as well. The researchers believe the C-Turtle is easy to make wherever it is needed—including on a vehicle traveling through space.



Charlie Leight / Arizona State University

STEP 4 Learn about programming

Computer programs are written in the form of an algorithm—a step-by-step set of instructions that tells the computer what to do. On many robots you'll find microcontrollers or onboard computers that are programmed to analyze incoming data and use it to carry out complicated instructions. To understand how algorithms work, write step-by-step instructions to help a line-following robot navigate its way through a maze.

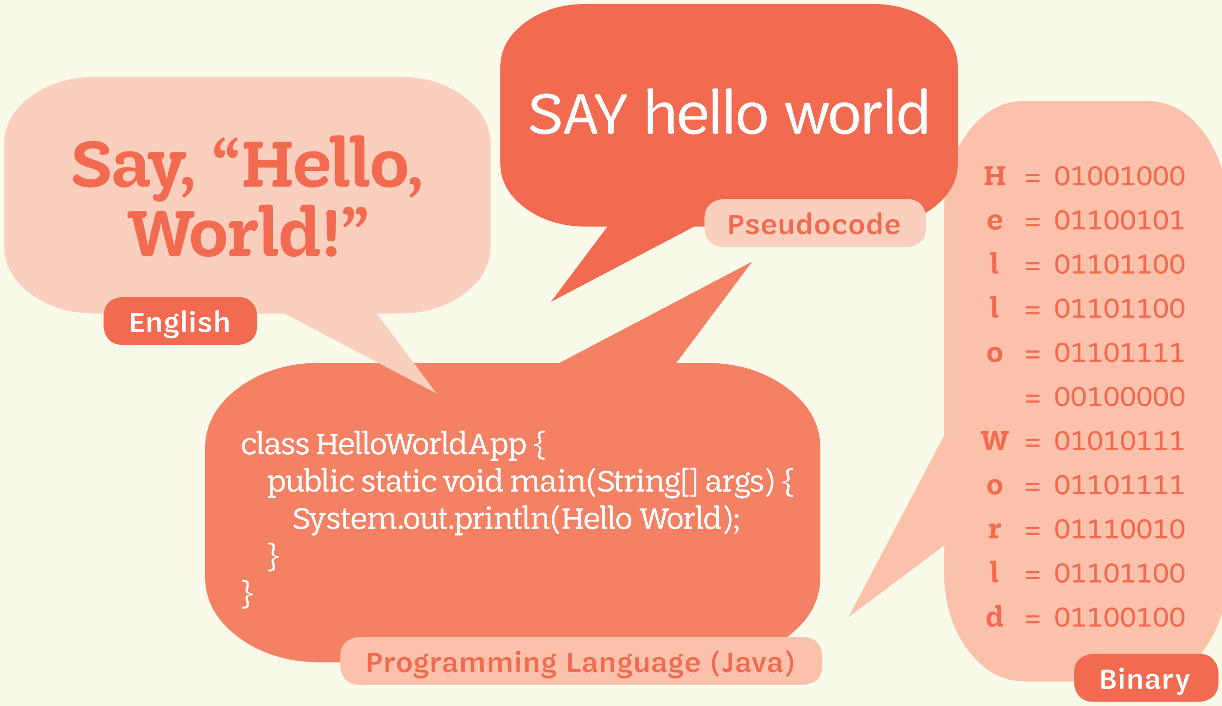
STEP 5 Write a program for a robot

Computer programs use commands to tell the machine what to do. A command is one step in a program.

But a computer program for a robot is not exactly like following a recipe. The robot's computer brain must also help it make decisions. To do this, it uses conditional **IF-THEN** statements. These statements test whether a certain condition is true or false. If the condition is true, it follows one command. If the condition is false, it does something else.

The conditions that a robot brain is looking for can be based on information it keeps track of itself, such as how many times the robot has repeated a certain action. It can also be based on data that the robot receives from its sensors, such as whether the robot is in a place that is light or dark.

Turn your instructions to solve a maze into a computer program using pseudocode. See if you can include conditional statements so your robot can make decisions on its own.



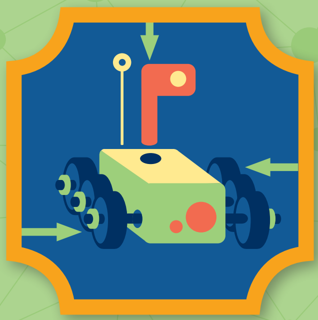
HOW TO TALK TO ROBOTS

- A computer contains millions of switches that can either be "on" or "off." In math terms, "on" is written as 1 and "off" is written as 0.
- Every command can be translated into a pattern of ones and zeroes that corresponds to switches that are "on" and "off." This is known as binary because there are only two choices.
- Computer languages take commands written in words and numbers and translate them into binary code (ones and zeroes) so the computer can understand them.
- To make it easier for people to talk to computers, programming languages translate commands from binary into a code which is more like human language. There are many different computer languages, but all of them use the same basic concepts. Learning about the logic behind computer languages can help you when it's time to learn a specific language.
- Some popular languages used in robotics research and education include Arduino, Java, Python, and C, C++, and C#. Beginners can also use visual languages like Scratch and MakeCode that let you drag-and-drop blocks on a computer screen instead of typing in words or abbreviations.
- There are many free resources for learning to code. You can find tutorials for many languages and programming environments at hourofcode.com.

Now that I've earned this badge, I can give service by:

- Discovering resources to learn more about programming and telling fellow Ambassadors about them.
- Sharing basics about programming with younger Girl Scouts.
- Finding problems that can be addressed with robotics and looking for ways to solve them.

I'm inspired to:



Badge 2: Designing Robots

Artificial intelligence, or AI, is a type of computer program designed to act like humans do and to learn new skills. Social robots use AI to make it easier for humans to interact with them. Every time they talk to a person, they learn what to say to sound more human. For this badge, design a social robot to help make life better for others.

Steps

1. **Pick a challenge**
2. **Explore possible solutions**
3. **Plan your prototype**
4. **Build a prototype**
5. **Get feedback on your robot**

Purpose

When I've earned this badge, I'll know how to design a robot and build a prototype.

Fictional Robot Assistants

In the movies, friendly robots think—and feel—a lot like humans.

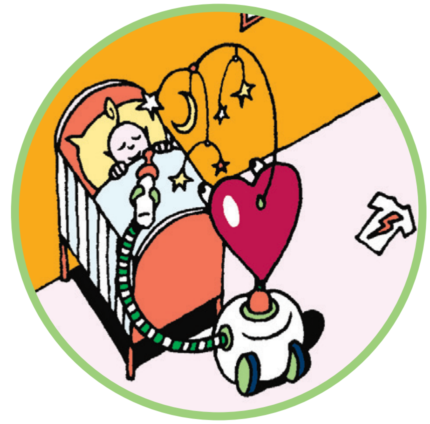
The main character in *Big Hero 6* is an oversized inflatable robot named Baymax, whose job is to be a "personal health care companion." He's got a kind and caring bedside manner.

The little droids R2D2 and BB-8 from *Star Wars* only speak in beeps and boops, but they're always ready to save their human friends.

And WALL-E is the last trash-collecting robot on Earth after everyone abandons the planet, but somehow collecting stuff people left behind—toys, movies, music—helps him to develop human emotions, including love.

So far, we don't have real-life robots who are quite so helpful or supportive—but these characters can offer inspiration to robotics designers of the future!

STEP 1 Pick a challenge



Robot assistants are being used more and more in homes and public places. They can help busy families stay organized or offer assistance to visitors who are lost.

For example:

- **Robotic home assistants** look like tabletop speakers.
- **Robotic pets** keep seniors company when they are not able to take care of living cats or dogs.
- **Robotic therapists** help children with autism practice communication and social skills, like making eye contact.
- **Robot guides** help customers and answer questions in multiple languages at airports or shopping malls.

Choose a challenge that a social robot might solve by brainstorming needs that robots might fill, such as drilling students on their multiplication tables.

STEP 2 Explore possible solutions

Research can help you save time and effort. It shows you what other people have found out about the problem you are interested in and different ways to address it.

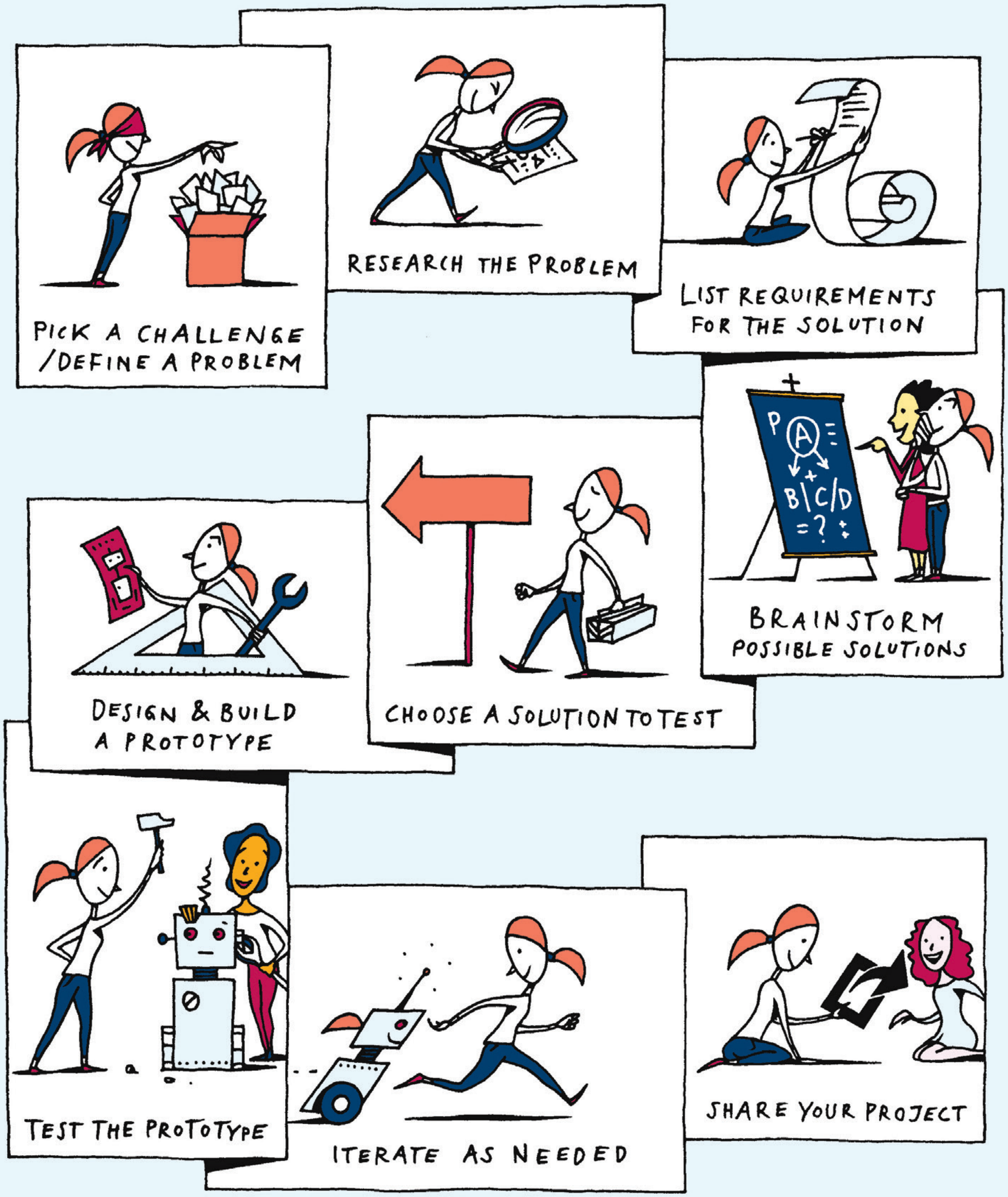
Write down any ideas you come up with for a robot that might help solve the problem. If you can, look at books, magazines, videos, or websites to find inspiration.

Some things to think about as you consider which solution to prototype:

- Where will the robot be used?
- What kinds of movement should it be able to make?
- How will it communicate?
- What will it look like?
- What protections will it need to be safe for humans and sturdy enough to be handled?
- What sensors does it need?
- How is the robot controlled? Does it require human controllers, is it completely autonomous, or does its design let it respond to its environment?

DESIGN THINKING PROCESS

The Design Thinking Process is a series of steps that help you to identify and work through problems as you develop your robot. Here is a typical series of steps in the Design Thinking Process:



Can Robots Replace Humans?

In 2017, the physicist Stephen Hawking told *WIRED* magazine that artificial intelligence will become a "new form of life that will outperform humans."

Many people automatically look up anything they don't know or can't remember on their phones—in a way, replacing their own memories with smart devices. Household robots that cook and clean for us, entertain and educate us, and care for our pets and the elderly are coming soon or are already here. And in more and more factories, warehouses, stores, and public places, robots are replacing human workers.

But experts point out that other leaps in technology—including the Industrial Revolution—eliminated many jobs before ultimately creating many more. In the end, they believe robots will make life better—for humans and machines alike.

STEP

3 Plan your prototype

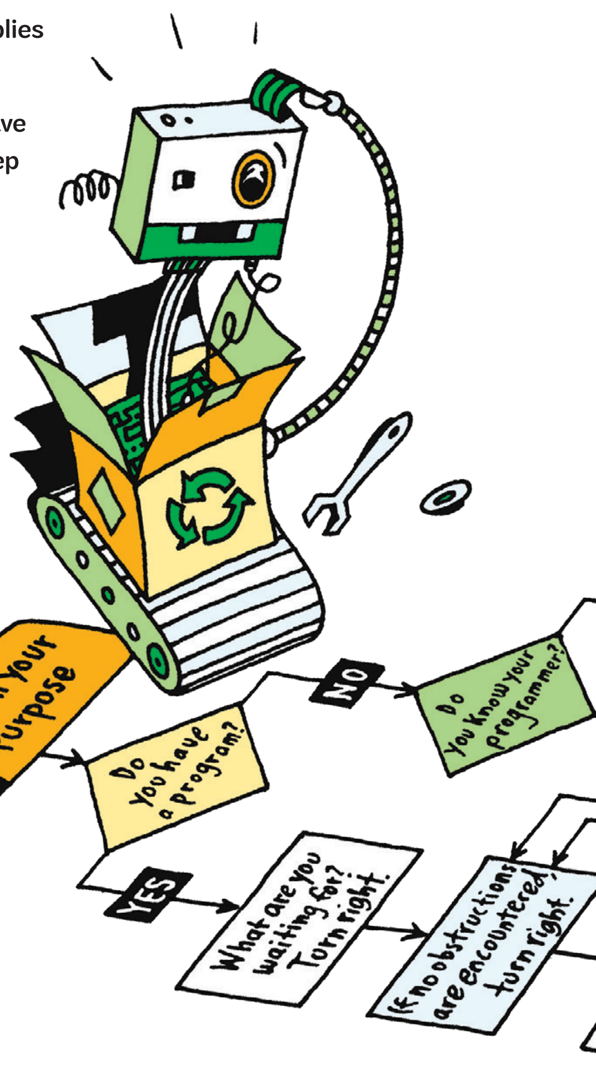
A prototype is a model that lets you design and test your robot idea (or some part of it) to see how well it works. When designing a robot, engineers will create several prototypes. They then take the information from the test about what works and what doesn't and use it to improve the robot.

Sometimes that means going back to the drawing board and changing major parts of the design. Other times, the design will just need minor tweaking.

Each new version of a prototype is called an iteration. Learning to iterate is one of the most valuable skills an engineer can have. Each time they tweak their idea, their prototype will be a little better and a little closer to the final product.

Think about what you can build that will demonstrate how your robot works, or some part of it. As you're planning, keep these thing in mind:

- **Tools and materials—**What supplies do you have access to?
- **Deadline—**How much time do have to produce a working model? Keep track of time and materials and make sure all the parts come together on schedule.
- **Documentation—**How will you make a record of your project? You can take notes, make drawings, or shoot photos and videos.
- **Packaging—**Make your robot look appealing to the people who will be using it.



STEP 4 Build a prototype

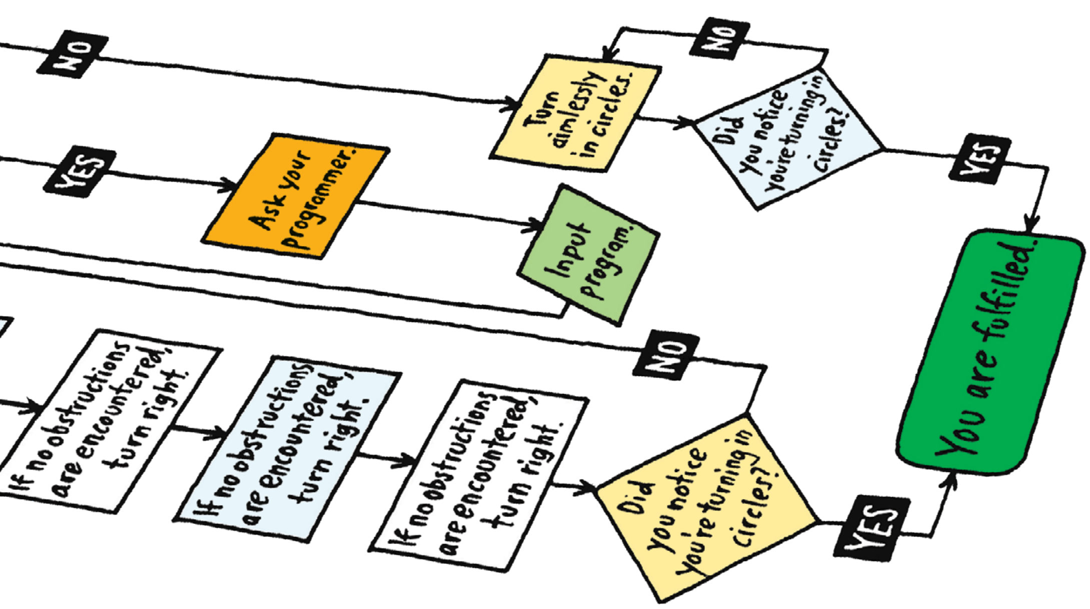
A prototype lets you visualize and test your design. But that doesn't mean it has to look like the real thing. It can be made from simple materials as long as it lets you demonstrate or test some aspect of the robot's design. A prototype that is quick and inexpensive to build is best, since it makes it easier to build new versions.

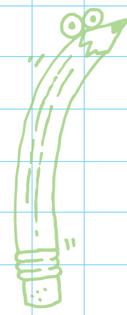
Make a prototype or model that shows how your robot works using the resources available to you. If you don't include features like motors, electronic sensors, or controllers, you can show where they will go in future iterations.

STEP 5 Get feedback on your robot

Getting feedback on your project is an important part of the Design Thinking Process. As a designer, your first testers will probably be the people you work with. And they may ask you to give them feedback as well. So engineers must learn to ask useful questions and give helpful advice. When you listen and give feedback on others' presentations, it's important to keep it constructive. Point out things you like as well as make suggestions for improvements.

When your prototype is ready, share it for feedback and use what you learn to improve your design.





NOTES

Now that I've earned this badge, I can give service by:

- Researching and volunteering for programs that test social robots.
- Advocating for social robots as companions for seniors at local nursing homes.
- Designing a social robot experiment that will show people how to treat each other with more kindness.

I'm inspired to:

Badge 3: Showcasing Robots

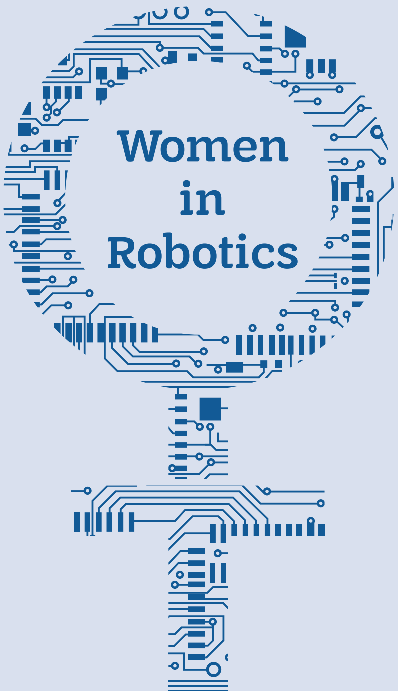
After engineers build their robots, they share their work with others through challenges, competitions, or marketing campaigns. Now that you've built your robot prototype, it's time to share your design with others and explore your future with robotics.

Steps

1. **Learn about robotics events**
2. **Hold a mini robotics event**
3. **Give a presentation about your robotics activities**
4. **Find out about robotics career opportunities**
5. **See robot makers and robots in action**

Purpose

When I've earned this badge, I'll know how to share my robot designs with the world.



In 2015, the percentage of women in the areas of physics and computer science, including fields like robotics, was only 15 to 20 percent. However, experts believe that number will grow as more girls become involved with robotics kits, teams, and events.

Many schools and organizations are working to encourage more women to enter robotics and related fields. To learn more about who they are and how they got there, check out the list published every year by the group Women in Robotics of 25 women who are making names for themselves in the field.

STEP

1 Learn about robotics events

You can see and participate in robotics events around the country.

Here are some places to check out:

- **Middle, high school, and college robotics competitions—**In robotics competitions, teams build robots according to official regulations and face off against robots from other teams as they complete a series of tasks while preventing their opponents from finishing first. Other kinds of science competitions accept robotics projects as well. Many are held by nationwide organizations at local, regional, and national levels for a variety of ages. For example, you might have heard of FIRST or VEX robotics competitions.
- **Maker Faires, maker expos, and state and county fairs—**Maker Faires and other kinds of maker expos are free to exhibitors and often feature robotics areas. They are frequently hosted at schools, libraries, and museums. Although they are noncompetitive, some events award ribbons to exhibitors in different categories. State and county fairs sometimes feature robotics among other maker, engineering, and handicraft exhibits.
- **Science festivals—**Science festivals are locally produced events that may include engineering and robotics. There are also major national events like the USA Science Festival in Washington, DC, and the World Science Festival in New York City.

Girl Scouts at a robotics competition

STEP 2 Hold a mini robotics event

Now's your chance to design your own mini robotics event. Brainstorm your event design and ready your robot before you hold your event!

Things to consider:

- What is the goal of your event? If you're holding a competition, what are the rules?
- What do you want the robots to do?
- What will the event look like? Do you need a competition field?
- Do you need to redesign your robot for the event?

STEP 3 Give a presentation about your robotics activities

Many student robotics competitions require participants to make short presentations about their projects. Being able to describe your project and discuss the details with others is just as important as building it. It's part of sharing your invention with the world. Create a presentation that you could use to showcase your robot.

You might include important information like:

- The robot's name
- The kind of environment is it designed to operate in
- What it is designed to do
- How it senses, thinks, and acts
- What makes this robot special or unique

Roboticist Carol Reiley

Carol Reiley has worked on many different kinds of robots over the years, including underwater, industrial, and surgical robots. Her PhD work at Johns Hopkins University focused on robotics and computer vision. With that experience, Reiley turned to work on using robotics to make it easier for self-driving cars to communicate with pedestrians.

Reiley believes that a driverless car is a kind of social robot that needs to learn how to interact with people around it. Her company, Drive.ai, is working on a roof kit that flashes text and emoji-like symbols. Pedestrians can read the sign on the car to know when it's safe to cross in front of it—the same way a human driver might wave and point.

drive.ai

STEP 4 Find out about robotics career opportunities

People involved in developing and using robots come from a wide range of backgrounds. There are a few universities that offer undergraduate (bachelor's) degrees in robotics. In most cases, however, students earn their undergraduate degrees in another area, such as computer science. Then they go on to study robotics in graduate school. And sometimes people work in the field of robotics after studying subjects that seem totally unrelated.

Research how robotics might be incorporated into professions you're interested in. Look for people in your region, or at universities you are interested in, who are working with robotics. Find out if you can contact them to talk or visit. Ask them about their backgrounds and how they recommend getting into robotics.

STEP 5 See robot makers and robots in action

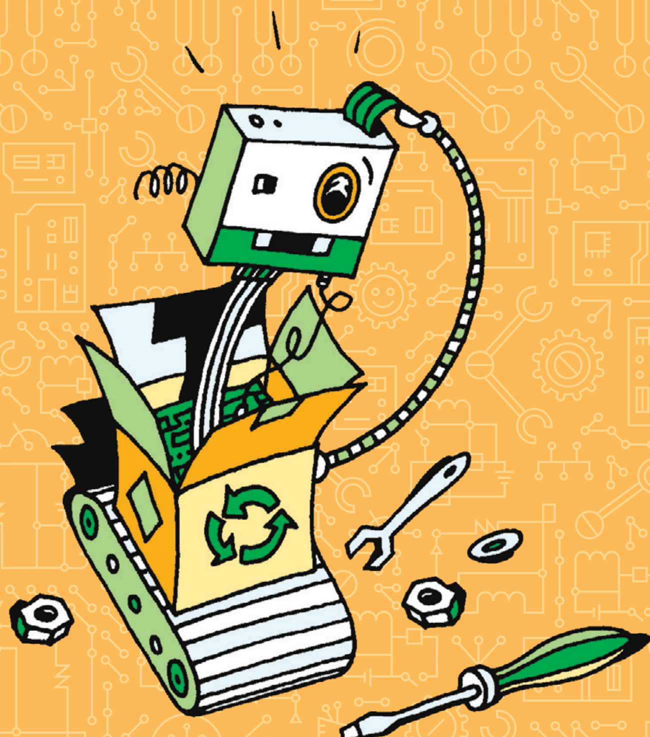
There may be robots used in places around your community or nearby. Some of the places you can observe robots and meet robot builders and technicians include:

- Hospitals and surgery centers
- College and university robotics, engineering, or computer science departments
- Factories and warehouses using industrial robots
- Robotics and engineering companies
- Farms using milking robots and drones
- Science museums
- Science education companies and camps
- Maker spaces
- Robot hobby clubs or organizations
- Robotics events

Now that I've earned this badge, I can give service by:

- Making videos of interviews with one or more roboticists and sharing them with others.
- Organizing a field trip to a maker festival for younger girls so they can see robots in action.
- Researching exciting new developments in robotics and giving a presentation about them at an elementary or middle school.

I'm inspired to:



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