4-H 509

ROBOTICS 1: NeXT Technology

THE OHIO STATE UNIVERSITY EXTENSION

18 U.S.C. 707

Name: ______________________________

Age (as of January 1 of the current year): ______________________________

County: ______________________________

Club Name: ______________________________

Advisor: ______________________________

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Robotics 1: NeXT Technology

Notes to the Project Helper

Congratulations! A 4-H member has asked you to serve as a project helper. You may be a parent, relative, project leader, friend, club advisor, or another individual who's important in the 4-H member's life. Your duties begin with helping the youth create and carry out a project plan, as outlined in the Member Project Guide. This is followed by helping the 4-H member focus on each activity; providing support and feedback; and determining what was done well, what could have been done differently, and where to go next.

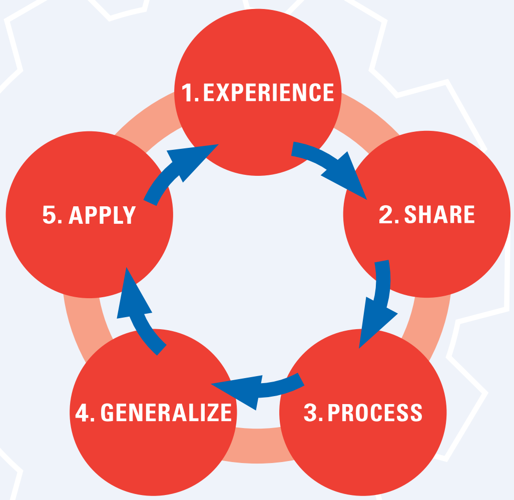
As a project helper, it is up to you to encourage, guide, and assist the 4-H member. How you choose to be involved helps shape the 4-H member's life skills and knowledge of robotics.

Your Role as Project Helper

- Guide the youth and provide support with goal-setting and project completion.
- Encourage the youth to apply knowledge from this project book to robotics.
- Serve as a resource person.
- Encourage the youth to go beyond the scope of this project book by learning more about robotics.

What You Should Know About Experiential Learning

The information and activities in this book are arranged in a unique, experiential fashion (see model). In this way, the youth is introduced to a particular practice, idea, or piece of information through an opening (1) **experience**. The results of the activity are then recorded in the accompanying pages. The youth then takes the opportunity to (2) **share** what he or she did with his or her project helper and (3) **process** the experience through a series of questions, allowing him or her to (4) **generalize** and (5) **apply** the new knowledge and skill.



Pfeiffer, J.W., & Jones, J.E.,
Reference Guide to Handbooks and Annuals.

What You Can Do

- Review the Learning Outcomes (Project Skill, Life Skill, Educational Standard, and Success Indicator) for each activity to understand the learning that is taking place. See page 47 for a summary of all Learning Outcomes.
- Become familiar with each activity and the related background information. Stay ahead of the youth by trying out activities beforehand.
- Begin the project by helping the youth establish a plan for the project. This is accomplished by reviewing and completing the Member Project Guide.
- After each activity, briefly talk with the learner so that she or he has an opportunity to share results and answers to the review questions. This important step improves understanding from an experiential learning perspective. Help the learner focus on the project and life skills being addressed.
- Help the youth celebrate what was done well and discover what could have been done differently. Allow the youth to become better at assessing his or her own work.
- In the Member Project Guide, date and initial the activities that have been completed.

Project Guidelines

Step 1: Complete **all twelve** project activities.

Step 2: Take part in **at least two** learning experiences.

Step 3: Become involved in **at least two** leadership/ citizenship activities.

Step 4: Complete a project review.

Member Project Guide

Welcome to the exciting world of robotics! In this project, you'll learn what a robot is, how to build one using a LEGO® MINDSTORMS® robotics kit, and how to program a LEGO® robot to interact with its environment. All activities are based on the LEGO® NXT system.

Robotics 1, which is appropriate for all age levels, is designed to be completed as an individual project, although many 4-H members decide to do this project in small groups. No previous knowledge of robotics is required, although younger members should take this project under the direction of a knowledgeable adult. The project can easily be completed in one year. Members who want to continue in robotics are encouraged to move on to *Robotics 2: NeXT Technology*.

Check your county's project guidelines (if any) for completion requirements in addition to the ones below, especially if you plan to participate in county project judging or plan to prepare an exhibit for the fair.

Step 1: Project Activities

Complete **all twelve activities.** The More Challenges activities are optional. When you begin an activity, jot down the date you start it. When you finish an activity, review your work with your project helper. Then ask your project helper to initial and date your accomplishment.

Activities	Date Started	Date Completed	Project Helper Initials
The Basics			
1: What Is a Robot?			
2: Introduction to LEGO® NXT			
3: The Intelligent Brick			
Building Your First Robot			
4: Start with Something Simple			
5: Giving Your Robot a "Brain"			
6: One Step at a Time			
Sensors			
7: Seeing, Feeling, and Hearing			
8: Avoiding Obstacles			
9: Sounds Like a Plan			

10: Seeing Is Believing			
11: Ultra Robotics			
What Do You Want Your Robot to Do?			
12: Small Tasks, Big Accomplishments			

Step 2: Learning Experiences

Learning experiences are meant to complement project activities, providing the opportunity for you to do more in subject areas that interest you. What are some learning experiences you could do to show the interesting things you are learning about? Here are some ideas:

- Attend a clinic, workshop, demonstration, or speech on a topic related to engineering or robotics.
- Prepare an announcement for school, radio, television, or the Internet on an event related to engineering or robotics.
- Help organize a club meeting based on this project.
- Go on a related field trip or tour.
- Host a workshop to share tips and tricks about working on robots and other science, technology, engineering, and math projects.
- Prepare your own demonstration, illustrated talk, or project exhibit.
- Participate in county judging.

Once you have a few ideas, record them in the table below. Complete **at least two** learning experiences. Then, describe what you did in more detail, and ask your project helper to date and initial in the appropriate spaces.

Plan to Do	What I Did	Date Completed	Project Helper Initials
Demonstration	*Showed club members the tools and supplies needed to assemble a robot*	*5/5/YR*	*T.D.*

Step 3: Leadership/Citizenship Activities

Choose **at least two** leadership/citizenship activities from the list below (or create your own), and write them in the table below. Record your progress by asking your project helper to initial next to the date each one is completed. You may add to or change these activities at any time. Here are some examples of leadership/citizenship activities:

- Teach someone about programming a robot.
- Help another member prepare for his or her project judging.
- Help organize a club field trip to a science museum or to a manufacturing plant that has robots.
- Organize a science, engineering, or technology event in your area.
- Encourage someone to take a science, engineering, or technology project.
- Arrange for someone from a local manufacturing firm to speak to your club about robotics.
- Plan your own leadership/citizenship activity.

Leadership/Citizenship Activity	Date Completed	Project Helper Initials
Organized a club field trip to the Just Gaming hobby store	*5/5/YR*	*T.D.*

Step 4: Project Review

Before your project review, use this space to write a brief summary of your project experience. Be sure to include a statement about the skills you have learned and how they may be valuable to you in the future.

Arrange for a project review with your project helper, club advisor, or another knowledgeable adult. Completing a project review helps you evaluate what you have learned and assess your personal growth. Your review can be part of a club evaluation or it can be part of your county's project judging.

Glossary

Words in **red** throughout this book are defined in the Glossary on page 44.

Activity 1: What Is a Robot?

The words **robot** and **robotics** are used to describe many things, some of which are actually robots and some of which aren't. To successfully use robots, you need a clear understanding of what they are and what they can do.

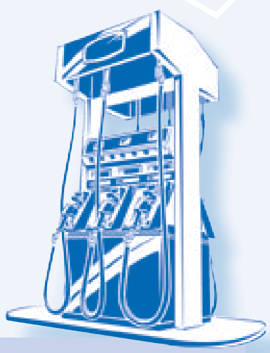
What to Do

Robots are much more than mere machines. But what, exactly, are they? The following list serves as a good, basic definition.

A robot must . . .

- be programmable. A robot must have some type of instructions that can be changed by the operator.
- be able to work without a person controlling it.
- be a multi-use machine. A robot must be able to do different jobs either by changing the program or by changing the parts.
- sense its surroundings. A robot must have **sensors** that are used to collect information about its environment.

Use the checklist next to each item below and on the top of the next page to determine whether it is a robot.



Gas Pump

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?

○ Yes ○ No

Car

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?

○ Yes ○ No

Blender

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?

○ Yes ○ No

Learning Outcomes

Project Skill: Understanding what a robot is

Life Skill: Thinking critically

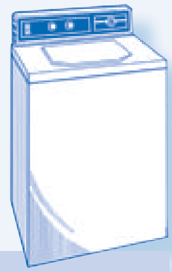
Educational Standard: National Science Education Content Standard F: Science in Personal and Social Perspectives (Grades 5–8), Science and Technology in Society; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology

Success Indicator: Identifies robots in everyday life

Computer

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?
○ Yes ○ No



Washing Machine

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?
○ Yes ○ No

Light Switch

○ Programmable
○ Automatic
○ Multi-use
○ Senses surroundings

Is it a robot?
○ Yes ○ No

Answers are on page 46.

Talking It Over

SHARE Using your own words, define the word *robot*. ____________________

____

____

REFLECT Why is defining a robot so difficult? ____________________

____

____

GENERALIZE Provide at least three specific examples of machines that are NOT robots. What are three examples of machines that ARE robots?

____

____

____

APPLY What kind of robot would be the most helpful to humans? Describe it here. ____________________

____

____

More Challenges

- Name some toys that are based on robotics. Explain to your project leader or to other club members how they meet the definition of *robot*.
- Create a time line of the history of robots. Use it for your project display at the fair.

Background Information

"I can't define a robot, I just know when I see one."

—Joseph Engelberger,
the "Father of Robotics"

Pay special attention to the tools and machines you hear about and use every day. Can you relate to the quote above? Defining what a robot is can be a challenge, and scientists and engineers have been debating the topic for decades. A very important part of the definition is that a robot must sense its surroundings.

SENSE
Robots must use sensors to gather data from their surroundings.

PLAN
Using its sensors, a robot must plan its actions according to its programming.

ACT
A robot then must act out its plan.

Today, robotic technology is used in many places: in medicine, in manufacturing, in space programs, and even in military programs. From robots that help assemble new cars to ones that allow surgeons to perform surgery through a tiny hole in a patient's skin, it is clear that robots are playing an increasingly important role in our lives.

DID YOU KNOW

The word *robot* was first used in 1920 in *R.U.R.* (*Rossum's Universal Robots*), a book of science fiction by writer Karel Capek.

Resources

- For a virtual exhibit of robots and robotics history from The Tech Museum in San Jose, CA, go to **www.thetech.org/robotics.**
- Carnegie Mellon's The Robotics Institute has been leading the world in integrating robotic technologies into everyday life. You can learn more at **www.ri.cmu.edu.**

Activity 2: Introduction to LEGO® NXT

Robots can be made from many different kinds of kits. This project uses the LEGO® system, mainly because LEGO® parts are readily available and easy to use. Just like any other technical project, this one has its own special vocabulary. Let's take a moment to be sure that for the rest of this project, we are speaking the same language!

What to Do

Write the letter of the image that matches each part's description.

1. ____ **Studs** are the little bumps on the top of most LEGO® parts. When you press two LEGO® pieces together, the studs are the primary contact points, and the **friction** between the studs and other part causes the pieces to "stick" together.

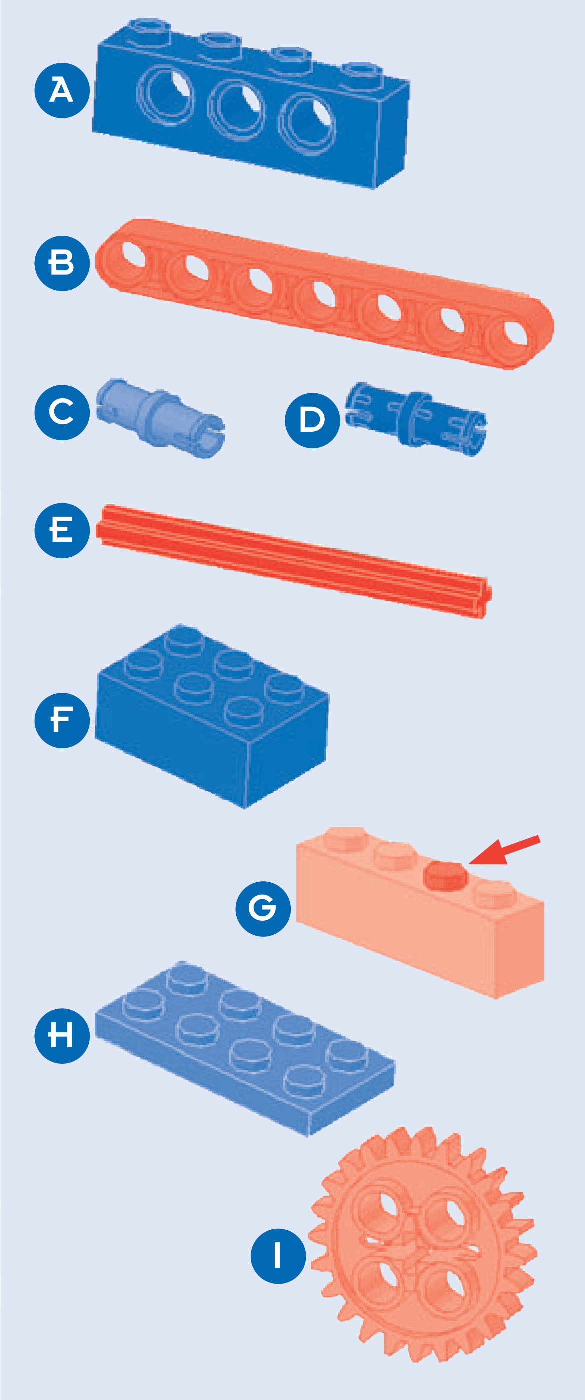
2. ____ **Bricks** are the basic building elements of the LEGO® system. Bricks are measured by the number of studs they have in width and length. For example, this one is called a 2x3 brick since it is 2 studs wide and 3 studs long.

3. ___ A **plate** is a LEGO® element that looks like a short brick. In fact, a plate is exactly one-third the height of a brick. Plates are also classified by their studs. This one is a 2x4 plate.

4. ___ An **axle** is a small rod that is used with a wheel or a **gear** to turn the wheel or the gear. An axle looks like a plus sign (+) from the end. Most axles are black or gray in color. Axles are also measured in stud length. To determine the length of an axle, use a plate or a brick to measure it.

5. ___ Gears are used to transfer movement from one part of a LEGO® model to another part of the model. Gears come in many sizes and are described by the number of "teeth" they have. In your robotics kit, the smallest gear is an 8-tooth and the largest is a 40-tooth gear. This gear is a 24-tooth gear.

6. ___ A **TECHNIC beam** is the basic building element in the NXT robotics kit. A TECHNIC beam has no studs and an odd number (1, 3, 5, 7, etc.) of holes in the side. TECHNIC beams come in various lengths and are measured by the number of holes they have. This TECHNIC beam is a 7.



In case you no longer have the guide to LEGO® NXT parts that came with your kit, a practical, visual guide is located online here: **www.ohio4h.org/robotics**.

7. ___ The **TECHNIC brick** looks just like a standard LEGO® brick except it has an odd number of holes in the side of it. All TECHNIC bricks are only one stud wide. TECHNIC bricks are measured by the number of studs they have. This one is a 4-stud TECHNIC brick.

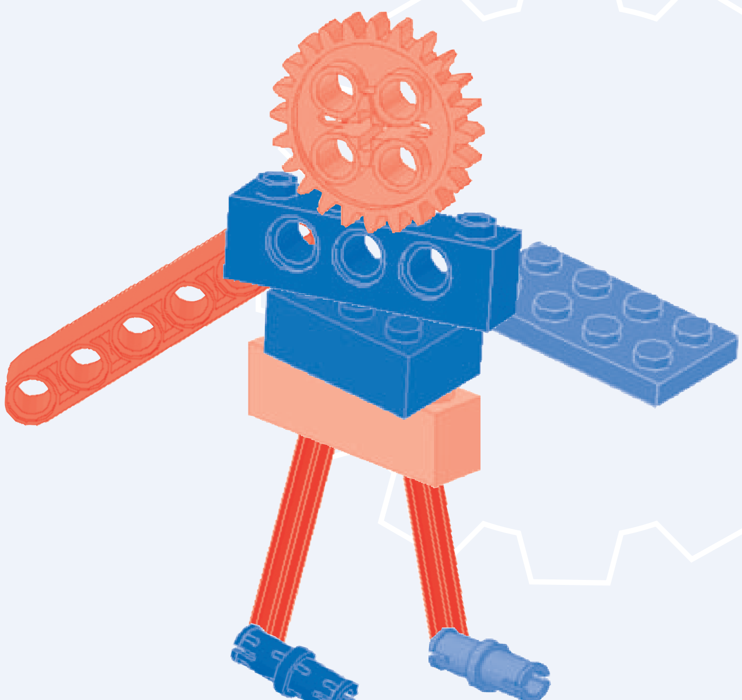
8. ___ This type of **TECHNIC connector peg** is black and has small ribs on it that make it more difficult for the peg to turn inside the hole of a beam due to friction. Connector pegs (also called pins) are used to connect TECHNIC beams and bricks. In the NXT set, most of the structure is held together with these elements.

9. ___ This type of TECHNIC connector peg is gray, and is smooth so the peg can turn freely inside the hole of a beam to create a movable connection.

Answers are on page 46.

Of course, your kit comes with many more kinds of pieces than the ones shown above. Now that you are familiar with the basics, open your LEGO® NXT kit and sort all of your parts into the compartments. The kit comes with a sorting guide that shows you where each kind of part goes. If you get into the habit of always using this sorting guide, it will be much easier for you to find the parts you are looking for when you need them later in the project.

Record the date you sorted your parts here: ______________



Learning Outcomes

Project Skill: Identifying basic LEGO® NXT parts

Life Skill: Planning and organizing

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 9: Develop an understanding of engineering design

Success Indicator: Matches LEGO® NXT parts with their descriptions

Talking It Over

SHARE How much of this information about LEGO® NXT parts did you already know? How had you learned it?

REFLECT Many people the world over enjoy using LEGO® pieces. What do you think makes the LEGO® system so appealing?

GENERALIZE How will being familiar with LEGO® NXT parts make building a robot easier?

APPLY Name at least one other task that is easier to accomplish with some planning and organizing at the beginning. Include an explanation of the planning and organizing that is required.

More Challenges

Experiment with different ways to connect your LEGO® parts. Then, make sketches or take pictures of your discoveries. Can a TECHNIC beam connect to the studs on a brick?

Background Information

Engineering is a very ancient field of human endeavor. Early humans used their knowledge of the natural world to figure out things like how to irrigate crops and how to build boats that would stay afloat. The term *engineer* comes from the Latin word *ingeniator*, meaning "one with ingenium, the ingenious one." Leonardo da Vinci had the official title of Ingegnere Generale. His notebooks reveal that some Renaissance engineers began to ask systematically what works and why.

Over time, as humans learned more about science and mathematics, engineering became more complex. The field of engineering paved the way for the modern technological society we live in.

As you work through this project, you will explore the field of robotics engineering. As an engineer you must constantly be asking the questions why and how. Why did my robot do that? Why didn't that work like I thought it would? How could this work better? Asking these questions allows you to get the most learning and enjoyment out of your robotics project.

DID YOU KNOW

The name *Mindstorms* comes from the title of a book written in 1980 by Seymour Papert, a computer scientist at the Massachusetts Institute of Technology (MIT). He argued that training in computer programming may be one of the most promising ways to teach children about the nature of problem solving.

To get ready for the next activity, be sure your robot's battery pack is charged.

Resources

- Find out what engineers do and what it takes to become an engineer at **www.futuresinengineering.org.**
- You can learn about engineering and engineering careers at **www.tryengineering.com.**

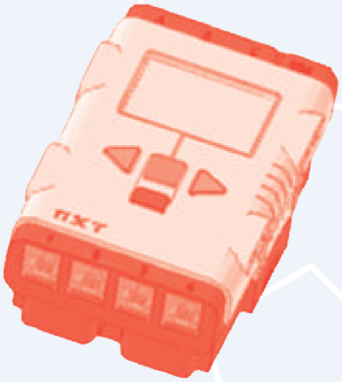
Activity 3: The Intelligent Brick

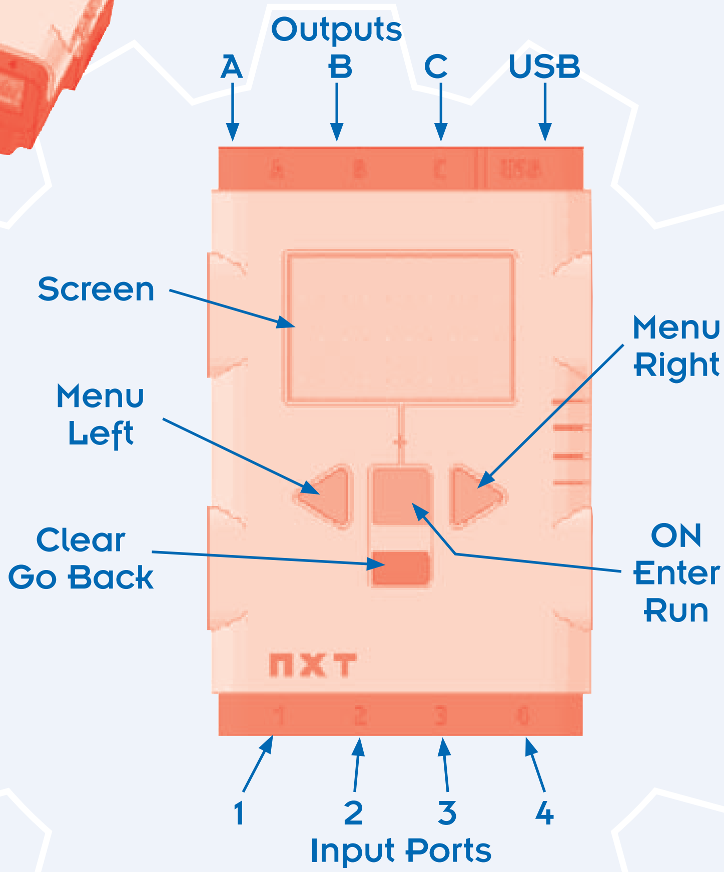
Before you go any further you need to test your NXT intelligent brick by writing, downloading, and running a simple program. The NXT intelligent brick is the large white brick with the screen and buttons. It doesn't really look like a LEGO® brick does it?

What to Do

Using the CD that came in your NXT robotics kit, install the NXT software on your computer. (If you need help with this, ask a parent or adult helper.)

Once the software is installed, go to **www.ohio4h.org/robotics** for a video that shows how to program your brick with sound. View the video and try programming your brick.





Project Area: The Basics

Learning Outcomes

Project Skill: Following directions for a basic program

Life Skill: Mastering technology

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of and be able to select and use information and communication technologies

Success Indicator: Programs a LEGO® NXT intelligent brick

Talking It Over

SHARE Was it easy or hard to program your intelligent brick? Explain.

____

____

____

REFLECT Now that you've written this simple program, what general statement can you make about computer programming? ____________________

____

____

GENERALIZE When you are learning something new, is it easiest for you to imitate what you see in a demonstration (like the video) or would you rather experiment on your own and discover an answer through trial and error? ____________________

____

____

APPLY What is a simple task that you think you could program your robot to do? ____________________

____

____

More Challenges

To learn more about inputs and outputs, search for Intel's publication *The Journey Inside* on the Internet. Explore the seven lessons in the chapter called "Introduction to Computers."

Background Information

The LEGO® NXT intelligent brick is no ordinary LEGO®. It is the microprocessor, or rather the "brain" of your robot. It is actually a very small computer. It has a screen so you can see what is going on, and it has buttons you can use to give instructions. This is really what makes your kit a robot rather than a machine.

Think about how the program, input, and output are used by a digital video recorder (DVR) to record a television show.

Program

The program (also known as the "algorithm") is the robot's set of instructions. In this case, you are programming (or instructing) the DVR to record your favorite television show for one hour.

Input

When you use the remote control to program your DVR, you send input via infrared signals that tell the DVR it's time to take a particular action.

Output

Finally, look at the output, which means the action you want the robot to take. Here, the action is to turn the DVR on at the start of the hour, and off at the end of the hour. You can see certain lights come on to indicate that the DVR is taking action. The control loop is complete as the DVR records your favorite show.

DID YOU KNOW

The first general digital computer was completed in 1945 and was called ENIAC. It filled an entire room and weighed more than 60,000 pounds.

Resources

Here's Intel's handy collection of 35 interactive, online lessons for learning about technology, computers, and society: **http://educate.intel.com/en/TheJourneyInside**.

Project Area: Building Your First Robot

Activity 4: Start with Something Simple

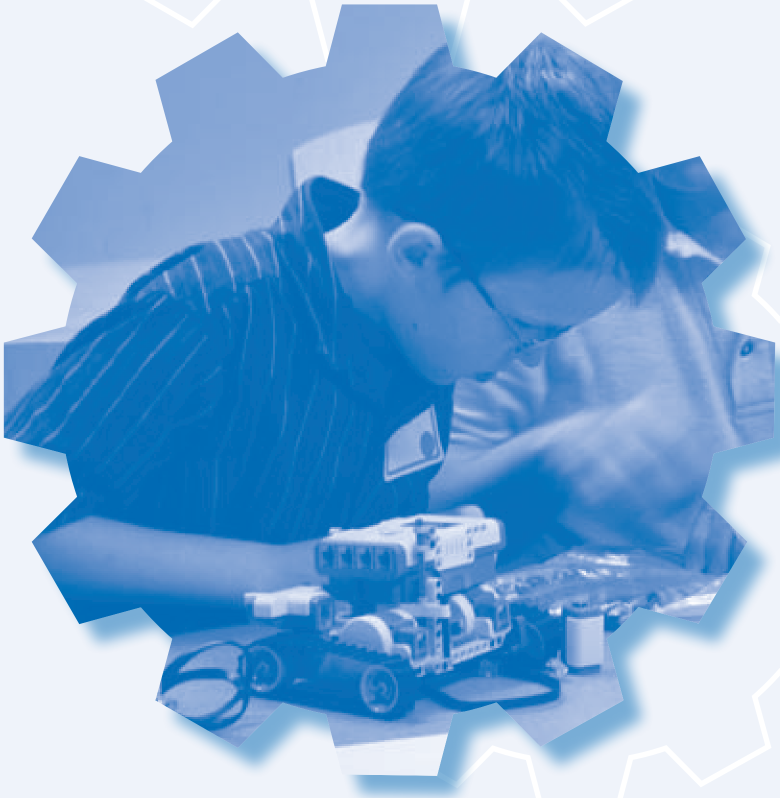
Now you are ready to build your first robot! To make the building process a little simpler for your first robot, your kit includes detailed building instructions. Once you have completed this project book, you can find many building guides and design tips online by searching the Internet.

At this point, learning how to build a robot from the parts included in your basic NXT kit can be a challenge, so this project requires you to build the robot described in the directions. Once you complete this first robot, you can begin to experiment with different designs and configurations.

What to Do

Let's keep this easy by simply following the directions. Printed step-by-step instructions for building the **driving base** are included with LEGO® Education Kit 9797 (through page 23), or you can view them online here: **www.ohio4h.org/robotics.** See Activity 4—Your First NXT Robot Building Instructions.

Record the date you built the driving base here: ____________________



LEGO® also makes its instructions available online, which is helpful if you ever misplace your hard copy or if it is ever changed. Do a search for *NXT school technical support downloads.*

Learning Outcomes

Project Skill: Building a simple robot

Life Skill: Following directions

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of and be able to select and use transportation technologies

Success Indicator: Builds the driving base for a LEGO® NXT robot

Talking It Over

SHARE What was the hardest part about building the driving base? What was the easiest part? ___

REFLECT How did having your parts organized help you follow the directions? ___

GENERALIZE Give at least one example of things people keep organized so that they can find them when needed. ___

APPLY Following instructions, especially technical ones, can be difficult. What advice would you give to someone who is about to build his or her first robot? ___

More Challenges

Your robot needs to move around to perform its functions. This type of robot is often referred to as a "rover." Rovers are often designed to operate on specific types of surfaces. Some are designed for sandy surfaces while others are designed for rocky, muddy, or smooth surfaces. On which surfaces do you think your robot design would work best? On which surfaces would your robot have problems driving? Can you modify the design of your robot to operate on a different type of surface?

Background Information

Because it is difficult to build a stable, two-wheeled robot, your robot has a small wheel on the back for balance. Commonly called a **caster**, the purpose of the caster is to stop the robot from tipping while not affecting the steering. Unlike the drive wheels that move in only one direction, a caster can turn in any direction. Upside-down ball rollers are perfectly suited for this task. The use of skids is also a good solution if the floor is smooth and slippery. But LEGO® does not make ball rollers, and skids are not always appropriate. So, you are using a swivel caster.

A swivel caster has one or more wheels attached to a pivoting horn. The horn is bent to offset the wheel axle. This offset makes the caster self-aligning. When your robot changes direction, the caster automatically turns to the new heading. If the caster is pointed in the direction of travel, the force causes the caster to roll. However, if the caster is not pointing in the direction of travel, it generates a turning force (torque) which turns or pivots the caster to the correct direction. This pivoting causes the robot to turn slightly before it takes off in the direction it was programmed to go. This slight turn is called **caster steer** and can really mess up your plan!

Caster steer is something you may have experienced with a shopping cart. It is the tendency of the casters (on the front of the shopping cart) to steer the front end of the cart when going forward after completing a turn, usually most noticeable after a sharp turn or reversing direction. Although it is not a huge problem when shopping, caster steer can be a real issue in a robot. It can make your robot hard to control, and it creates errors in distance and steering measurements. Before running your program, be sure the caster is pointed in the direction your robot is heading.

DID YOU KNOW

Each LEGO® brick must be manufactured within one-thousandth of a millimeter of the designed specifications or the bricks will not stay firmly connected.

Activity 5: Giving Your Robot a "Brain"

Now that you have built your robot, you have to program it. A robot is a combination of hardware (the parts) and software (the program). Hardware and software are important and must work together for the robot to function. If you are good at designing and building but you do not understand programming, your new robot won't be much fun. To be a successful robotics expert, you have to understand both pieces of the robotic puzzle.

What to Do

Go to **www.ohio4h.org/robotics** and watch the video titled Activity 5—Program 1 to learn how to create a basic NXT program for your new robot. After you run your first program, change the settings for the move icon as indicated below and answer the questions.

Turn motor "C" back off.

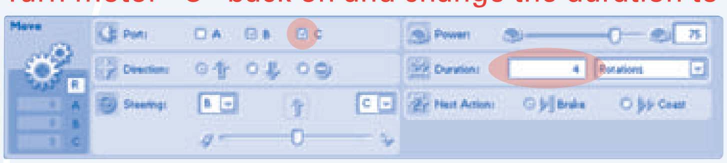
What do you think will happen when you push the run button? ________

____

Try it! What happened? ______________________________

____

Turn motor "C" back on and change the duration to "4."



What do you think will happen when you push the run button? ________

____

Try it! What happened? ______________________________

____

Project Area: Building Your First Robot

Learning Outcomes

Project Skill: Experimenting with computer programming

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard A: Science as Inquiry (Grades 5–8), Abilities Necessary to Scientific Inquiry; Standards for Technological Literacy 1: Develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

Success Indicator: Creates and changes a basic LEGO® NXT program

Change the duration from “Rotations” to “Seconds.”

What do you think will happen when you push the run button? ________

____

Try it! What happened? ________________________________

____

Change the duration back to “2” and “Rotations,” and slide the steering all the way to the right.

What do you think will happen when you push the run button? ________

____

Try it! What happened? ________________________________

____

Talking It Over

SHARE Did the robot usually operate as you expected after you changed the program? Explain why or why not.________________

____

____

REFLECT When a robot behaves in an unexpected way, what has really happened? ________________________________

____

____

GENERALIZE Do you agree with the statement, *Computers do only what people tell them to do*? Explain. ________________________

____

____

APPLY What are some other factors that might affect how a robot performs? ____________________

____

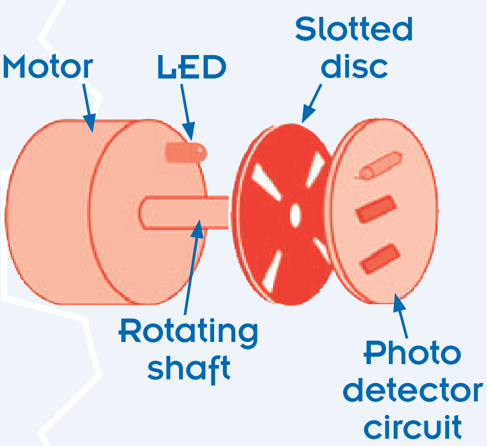
____

More Challenges

Experiment with moving the steering control to the left or right. Create some notes so that you know what each position of the slider makes the robot do.

Background Information

In the program, you specified to have the motor turn for a certain number of rotations. So how does the robot "know" how far the motor has turned? This is done with a device called an **encoder**. The most common encoder is called an optical encoder. Inside the NXT motor housing are three basic components: a light source (usually a light emitting diode or LED), a slotted disc, and a photo detector circuit. A single encoder is shown in the diagram to the left.



As the motor turns the slotted disc, the light from the LED shines through the slots in the disc. The photo detector circuit picks up the light and sends a signal to the NXT robot so that it can keep track of the rotations of the motor.

Resources

Learn more about NXT motors at **www.philohome.com/nxtmotor/nxtmotor.htm.**

DID YOU KNOW

LEGO® NXT motor encoders read to an accuracy of one degree of rotation; this is called the **resolution** of the encoder. For example, you cannot tell the motor to rotate 66.5 degrees.

Project Area: Building Your First Robot

Activity 6: One Step at a Time

You have built a robot and have learned how to program it to go forward. Now that your robot is mobile, it must be able to follow a route or a path. This is done by writing multiple, **sequential** commands that the robot follows. The process is kind of like baking a cake. If you give the robot the wrong instructions or if the instructions are in the wrong order, the robot does not perform as expected.

What to Do

Go to **www.ohio4h.org/robotics**, and watch the video titled Activity 6—Program 2 to learn how to create a simple route program for your robot.

Run the new program. Did your robot do what you expected? __________

____

____

Change the duration of the turn in the program (the second move block) to "0.5." Download the program to your robot and run this new program. What does your robot do now? ____________________________

____

____

Using your new skills, create a short course in your house for your robot and create a program that drives your robot through it. For example, guide your robot from one room to another or around two table legs.

How long did it take to get the program to work? ____________________

____

____

If you run the program four times in a row, does the robot always end in exactly the same spot? Why do you think this happens? ______________

____

____

Learning Outcomes

Project Skill: Creating a simple route program

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristic and scope of technology

Success Indicator: Programs a LEGO® NXT robot to follow a path

Talking It Over

SHARE What surprised you about your robot's behavior? ______________

REFLECT Once you have a route or a path program in place, you can count on your robot to run it successfully. Do you agree with this statement? Why or why not? ______________

GENERALIZE What other things would you like your robot to do? Can you use the basic programming you've learned, or do you need to know more? Explain. ______________

APPLY Name another task (besides baking a cake) in which the order of the tasks is extremely important. Now, name one in which the order of the tasks is not important. ______________

More Challenges

Program your robot to follow a course that another member of your family defines. Is it easier to program your own path or to program one that someone else gives you?

Background Information

With patience and determination, you should have been able to get your robot through the course you made. It isn't as easy as it looks, is it? Your robot probably didn't end at the same spot every time. Why didn't it?

There are two possible reasons for this. First, if you don't start the robot in exactly the same place at the beginning of each run, it does not end up in the same spot either. The second reason is friction. As the robot moves, the parts move; anytime something moves, there is friction. *Friction* is the scientific term for two things rubbing against each other. This "rubbing" or "friction" causes the robot to move a little differently every time it is run.

DID YOU KNOW

There is a hidden reset button on the NXT brick! If the running icon stops spinning, the NXT has frozen and you must reset it. Follow these steps to reset the NXT:

1. Make sure the NXT is turned on.
2. Press the reset button that is located on the back of your NXT, in the LEGO® TECHNIC hole in the upper left corner. Use an unfolded paper clip to press the button.
3. If you press the reset button for more than 4 seconds, you will need to update the firmware.

Resources

The online LEGO® NXT community is a large one, and many people and organizations produce their own troubleshooting guides. You might be able to find an online guide that you will like to use as a resource.

Activity 7:
Seeing, Feeling, and Hearing

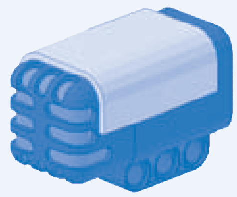
To help your robot overcome the challenges of starting in different places and encountering friction, you can add sensors. Sensors give your robot a way to "sense" its environment. Just as your five senses give you the ability to make adjustments to your actions, sensors allow your robot to do the same.

What to Do

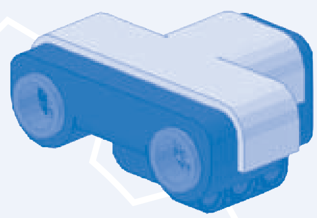
Identify the sensors in your kit. Write the letter of the image that matches each sensor's description.

1. ___ With the light sensor, your robot can tell the difference between light and dark. With this sensor, you can also program your robot to determine the light intensity in a room, or the darkness of different colors.
2. ___ The touch sensor gives your robot the ability to "feel" its way through its environment. By creating attachments for your robot's touch sensor, you can make your robot react when it runs into obstacles.
3. ___ The sound sensor gives your robot "ears." With this sensor, your robot can react to noise. The robot cannot understand what you are saying, but it can hear noise as well as changes in volume.
4. ___ The ultrasonic or distance sensor gives your robot depth perception, or the ability to judge the distance of objects.

A



B



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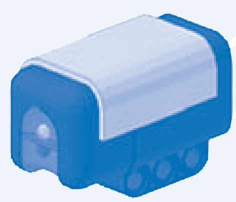
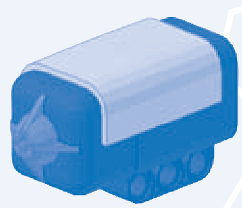


D



Answers are on page 46.

Now that you know what each sensor does, attach the touch sensor to your robot. You can find out how with the printed instructions that came with LEGO® Education Kit 9797 (pages 40–45), or you can view them online here: **www.ohio4h.org/robotics**. See Activity 7—Touch Sensor Building Instructions.

Learning Outcomes

Project Skill: Identifying LEGO® NXT sensors

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology

Success Indicator: Matches LEGO® NXT sensors with their descriptions

Talking It Over

SHARE Use your own words to describe how the mechanics or hardware of the LEGO® NXT touch sensor works. ______________________

____

____

REFLECT Your robot now has the parts to sense touch. What's missing?

____

____

____

GENERALIZE In what ways are the sensors on your robot similar to your own senses? In what ways are they different? ______________________

____

____

APPLY How will sensors add to the tasks that your robot is capable of doing? Give some examples. ______________________

____

____

More Challenges

Make a sketch of a robot that you might want to invent someday. Label all of the sensors that your robot will need, and write a paragraph describing how your robot will work.

Background Information

Now your robot has a touch sensor! OK, so what do you use it for? Touch sensors are often used in robotics to help robots know when they're running into something. In robotics, it is very important that your robot and everyone around it is safe. Let's say you have a robotic lawn mower. While your robot is mowing, your dog decides to take a nap in the middle of the yard. When your handy little mowing robot runs into the dog, it has to "know" to change direction; otherwise, your dog might get an unwanted haircut! A touch sensor, sometimes called a bump sensor, allows the robot to know that something is in the way. In robotics, this is called **obstacle detection**. To avoid accidents, all robots that drive around in crowded places must have some type of obstacle detection system.

DID YOU KNOW

The word ***automaton*** means "self-operating machine." The word is sometimes used to describe a robot. But more often, it refers to a machine that looks and moves like living things. In the mid-1700s, French engineer Jacques de Vaucanson invented a mechanical duck that ate and "digested" food!

Resources

The Carnegie Mellon Robotics Academy has links to building plans and to a LEGO® NXT "Constructopedia," courtesy of Tufts University. Check out what's available at **www.education.rec.ri.cmu.edu/content/lego/building**.

Project Area: Sensors

Activity 8: Avoiding Obstacles

Now that the sensor is attached, your robot needs a program so that it knows how to use the sensor and knows how to react to its surroundings.

What to Do

Go to **www.ohio4h.org/robotics**, and watch the video titled Activity 8—Touch Sensor Program to create your new program.

Run your new program. Describe what your robot did when you ran the program.

Talking It Over

SHARE Was programming your robot easy or difficult? Explain.

REFLECT Now you have touch sensor hardware in place and the software to run it. What would happen if either component wasn't working properly?

GENERALIZE What are some other things that might keep your touch sensor from working as planned?

APPLY Describe another program you could write that uses the touch sensor.

Learning Outcomes

Project Skill: Creating a program for the LEGO® NXT touch sensor

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology

Success Indicator: Creates a LEGO® NXT program that uses the LEGO® NXT touch sensor

More Challenges

Create a new program using the touch sensor so that your NXT robot drives around your kitchen one time.

Background Information

Now you really have a robot. It can sense its surroundings with the touch sensor, plan what its response will be when it runs into an object, turn around, and drive in a different direction to avoid it.

The next step for developing your robot is to learn how the other sensors in your kit can be used to give your robot more ability to sense. The more "senses" your robot has, the better decisions it can make. Think of it this way: When you walk into a dark room, what is the first thing you do? You probably look for the light switch. Why is that? Well, your light sensors (your eyes) need a certain amount of light to work properly. Without light, you are not able to use your eyes to make decisions about your surroundings.

When you lose one of your senses, you have less ability to make decisions about your surroundings. The less "input" you have, the harder it is to make a good plan for your actions. Your robot is the same. If you can give your robot access to more sensors, you can create more complex programs and have your robot complete more complex tasks.

DID YOU KNOW

A touch sensor is basically an electric switch. Just like a light switch in your house, it can either be on (pushed) or off (released).

Resources

To learn more about your sensor, go to **www.ehow.com** and read the article, "How Does a Momentary Switch Work?"

Project Area: Sensors

Activity 9: Sounds Like a Plan

In this activity, your robot gains the ability to hear sounds. As with other components, hardware and software must work together if your robot is going to respond to its environment as you would like.

What to Do

Build the sound sensor attachment by following the printed instructions that came with LEGO® Education Kit 9797 (pages 24–27). You also can view them online here: **www.ohio4h.org/robotics**. See Activity 9—Sound Sensor Construction.

Also at **www.ohio4h.org/robotics**, follow the programming instructions in Activity 9—Sound Sensor Programming. Once you are familiar with its operation, answer the following questions.

Why isn't a single "Wait for Sound" block good enough to make your robot recognize a sound for this activity? ______________________________

____

____

What does the threshold for the sound sensor do? ____________________

____

____

Try setting the threshold higher and lower. What happens? ____________

____

____

Try triggering the robot with different sounds (e.g., whisper, stomp your feet, and whistle). Did they work? Why or why not? ____________________

____

____

Learning Outcomes

Project Skill: Creating a program for the LEGO® NXT sound sensor

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology

Success Indicator: Creates a LEGO® NXT program that uses the LEGO® NXT sound sensor

Talking It Over

SHARE Does the sound sensor work as well as you had hoped? Better perhaps? Explain. ______________________________

REFLECT Under what circumstances would you modify the way your robot responds to sound? ______________________________

GENERALIZE What new tasks is your robot able to do? ______________________________

APPLY Name at least two other devices that recognize and respond to sound. ______________________________

More Challenges

Using your new knowledge, create a program to run your robot down the hall and into your room by clapping your hands.

Background Information

The sound sensor in your NXT kit is basically a **microphone**. A microphone is a device that converts acoustic waves (sound) into electrical signals. Every microphone has a diaphragm or some part that vibrates when it is "hit" by sound waves. You can "feel" sound by placing your hand close to your mouth when you talk. Your hand can "sense" the vibrations produced by your vocal chords, and you can feel the sound. As the diaphragm vibrates to the sound wave, a device in the microphone converts these vibrations into electrical signals. These signals are then interpreted by the robot as "sound." The greater the vibrations, the more electrical signal produced by the sound sensor.

DID YOU KNOW

The LEGO® sound sensor can recognize sounds from about 50 decibels (the volume of average rainfall or of a dishwasher) to about 90 decibels (the volume of a gasoline lawn mower).

Resources

Use this chart to learn more about decibel levels of common sounds: **http://downloads.cas.psu.edu/4H/SoundDecibelChart.pdf.**

Activity 10: Seeing Is Believing

In Activity 6, you programmed your robot to follow a course in your home. It probably took many attempts to finally get the robot to go where you wanted it to go. Most likely, your robot wouldn't even run the exact same course each time. For robots to do useful work, they have to be reliable. When a program is run, the user or the operator has to know that the same thing will happen every time. This is called **repeatability**.

What to Do

Build the light sensor attachment by following the printed instructions that came with LEGO® Education Kit 9797 (pages 32–35). You also can view them online here: **www.ohio4h.org/robotics**. See Activity 10—Light Sensor Construction.

Also at **www.ohio4h.org/robotics**, follow the programming instructions in Activity 10—Light Sensor Programming. Once you are familiar with its operation, answer the following questions.

What does the threshold for the light sensor do? ____________________

____

____

Try setting the threshold higher and lower. What happens? ___________

____

____

What if your robot needed to follow a white line on a black surface? Would your current program work for that? If not, how would you need to change it? ____

____

____

Project Area: Sensors

Learning Outcomes

Project Skill: Creating a program for the LEGO® NXT light sensor

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology

Success Indicator: Creates a LEGO® NXT program that uses the LEGO® NXT light sensor

Talking It Over

SHARE At least to a small extent, your robot can now touch, hear, and see. What two human senses does it lack? ______________________________

____

____

REFLECT Why do you think using a path or a line for your robot to follow is better than using motor rotations to guide it? ______________________

____

____

GENERALIZE How do a robot's sensors contribute to its ability to complete complex tasks? ______________________________

____

____

APPLY Give at least two examples of common but complex computer programs. Are these examples robots? Explain. ______________________

____

____

More Challenges

Think of other uses for the light sensor besides following a line. List your ideas, pick one, and see if you can design a program that demonstrates your idea.

Background Information

Repeatability is the ability of a robot to conduct itself in the same manner every time a program is run. This repeated movement is measured over a period of time. Repeatability is an important element of robotic performance. Nearly every application requires good repeatability—from spot welding and plasma cutting to material handling. Repeatability is especially important when it comes to industries whose products require high accuracy. Some very expensive robots have a much higher repeatability than your little NXT robot. Industrial robots such as the Motoman K6 can repeat movements over and over within one-tenth of a millimeter. Wow!

Because your robot does not have great repeatability, you can use sensors instead of motor rotations to keep track of where your robot is going. Your robot can make adjustments as it goes through a program if you build it with sensors to follow a path instead of relying on it to make repeated turns.

DID YOU KNOW

The light sensor reads only reflected light. It cannot tell what color it "sees." Instead, it interprets all colors as a percentage of gray. Yes, your current robot is color-blind!

Activity 11: Ultra Robotics

One of the most exciting improvements when the LEGO® NXT was developed was the addition of a new powerful sensor, the ultrasonic sensor. The ultrasonic sensor works by using the same scientific principle as bats: it measures distance by calculating the time it takes for a sound wave to hit an object and return, just like an echo.

The ability of the ultrasonic sensor to measure distance is pretty accurate, at least for a toy. But how accurate is it? To answer that question, you need to understand tolerance.

What to Do

In engineering, **tolerance** is the permissible variation of a characteristic or response. Another word for tolerance is allowance—it's the range of something that is acceptable. Think of the tolerance as the goal posts in a football game. If the kick is perfect it is right down the middle. However, any kick within the goal posts is acceptable.

Use the Internet or ask an adult to identify four examples of engineering tolerances. List them here:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Attach and program the ultrasonic sensor by following the instructions at **www.ohio4h.org/robotics**.

Talking It Over

SHARE What new abilities does the ultrasonic sensor allow you to program? ______________________________

____

____

REFLECT How does the sensor's tolerance affect what your robot is capable of doing? ______________________________

____

____

Learning Outcomes

Project Skill: Creating a LEGO® NXT program that uses the ultrasonic sensor

Life Skill: Understanding systems

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5-8), Abilities of Technological Design; Standards for Technological Literacy 9: Develop an understanding of engineering design

Success Indicator: Creates a LEGO® NXT program that uses the ultrasonic sensor

GENERALIZE What are some other things that limit what your robot can do? ____

____

____

APPLY Can you think of other examples of engineering tolerance that would be very small? ____

____

____

More Challenges

Using the ultrasonic sensor, program your robot to avoid objects in its path.

Background Information

The ultrasonic sensor works by using the same scientific principle as bats: it measures distance by calculating the time it takes for a sound wave to hit an object and return, just like an echo. It measures distance in centimeters or inches and is able to measure distances from 0 to 255 centimeters within 3 cm. That is, it measures distance with a tolerance of 3 cm—the measurement might be 3 cm less than or greater than the actual measurement.

Practically speaking, a tolerance of +/– 3 cm means that if the distance is set to 40 cm, the sensor sees anywhere from 37 to 43 cm as the 40 cm target. Large objects with hard surfaces return the best readings. Objects made of soft fabric, curved objects (like balls), thin, or small objects are more difficult for the sensor to detect since the sound waves may not bounce back directly.

The concept of tolerances in engineering and robotics is very important. In mechanical engineering, parts have to fit together, whether the parts are for a bridge, a building, or a rocket. You can imagine that robots assembling cars or assisting in surgery must be very precise.

DID YOU KNOW

If a sensor on your robot is not accurate enough to stay within your acceptable tolerances, you may need to redesign or reprogram your robot.

Project Area: What Do You Want Your Robot to Do?

Activity 12: Small Tasks, Big Accomplishments

When completing a 4-H robotics project, you assume the role of a robotics engineer. As an engineer, you need to follow an "engineering process." According to The Princeton Review, **robotics engineers** "design robots, maintain them, develop new applications for them, and conduct research to expand their potential."

What to Do

Finish building your robot by completing the remainder of the instruction booklet. Now, let's see if you can expand your robot's potential. You know it's capable of many things, but sometimes the hard part is deciding what, exactly, those things are. To build your knowledge of robotics and to prepare yourself for competition, see if you can program your robot to do the following tasks. Use the table to indicate your success.

Task	My robot can do this. Indicate "yes" or "no."
Stay within an area defined by tape, fencing, or some other boundary	
"Park" in a garage, then exit, turn around, and park again	
"See" and "kick" a table tennis ball	
Move from point A to point B while avoiding different kinds of obstacles	
Pick up, move, and drop a small object	
Push and pull a wagon or other object with wheels	
Open and close a gate	
Respond to a sound, such as a bell or clapping, by turning in circles	
Locate and pass through a doorway	
Any other defined task you can think of. Describe it here: ______________________________ ______________________________ ______________________________	

Learning Outcomes

Project Skill: Using the engineering or design process

Life Skill: Practicing creativity

Educational Standard: National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 9: Develop an understanding of engineering design

Success Indicator: Creates programs for various tasks

Talking It Over

SHARE Which of the tasks on page 40 were difficult to program? Which were easy? ______________________________

REFLECT As you become more experienced at programming, what new possibilities do you see for your robot? ______________________________

GENERALIZE Do you consider programming your robot to be a creative process? Why or why not? ______________________________

APPLY Give your own example of a complicated task that is easy to accomplish when broken down into simple tasks. ______________________________

More Challenges

People often combine simple tasks to accomplish more complicated ones. Program your robot to complete a series of chores around a house, a farm, or a work site that you create. Then, give a demonstration to your project helper.

Background Information

Do you remember learning about the scientific method? There are several versions, but it basically contains these steps:

- Ask a question.
- Do background research.
- Construct a hypothesis.
- Test your hypothesis by doing an experiment.
- Analyze your data and draw a conclusion.
- Communicate your results.

The engineering process has similar steps.

Step 1: Define a problem or a need.

The engineering process begins when a need or a problem is realized. Many times this is found by the engineer while he or she works through daily life. Successful engineers are constantly looking for problems that need a solution. You want to state clearly the problem you are trying to solve with your robot. This problem could be a simulation such as "I need to build a robot that takes my dog for a walk." Or, it could be a set of criteria from a robotics competition such as the National Robotics Challenge or the FIRST LEGO® League. Either way, you should know what problem you are trying to solve with your robot.

Step 2: Gather background information.

Research, research, research! Once you know what problem you need to solve, you need to research what has been done in the field before. A solution might already exist, or someone might have already patented a solution to your problem. You also might find a few ideas to help jump-start your design, or you might eliminate designs that others have tried with no success.

Step 3: Establish criteria for success.

Before you begin your actual design work, define what a successful solution to the problem looks like. This is usually created as a **design brief**. The design brief lists all of the features that must be included in a final solution.

Step 4: Prepare preliminary designs and create a prototype.

Using your design brief as a guide, you need to brainstorm a large number of possible solutions. These different ideas should be written down or sketched on paper. From this list of solutions, you will select a design with which to begin building your prototype. The prototype is your original robotic design. Your prototype will be refined and redesigned as you move closer and closer to a robot that does what you want it to do.

Step 5: Test the prototype and analyze the results.

All prototypes must be tested to see if the design meets all of the criteria you outlined in the design brief. If the robotic prototype does not meet the criteria, you have to go back to the first step of the process since you now have a new problem.

Step 6: Communicate the results.

Once you have a successful design and prototype, you will bring your robot—along with all of your documentation—to the fair to be judged. A great robotics project will not only solve the stated problem from the design brief, it will also have a detailed portfolio that shows how you followed each of the steps in the engineering process.

DID YOU KNOW

The National Robotics Challenge began and is held each year in Marion, Ohio. Learn more at **www.nationalroboticschallenge.org**.

Resources

- Here's a great source that describes the engineering process in similar terms: **www.sciencebuddies.com/science-fair-projects/project_engineering.shtml**.
- Browse the web site of the FIRST LEGO® League, a global program created to get youth excited about science and technology: **www.firstlegoleague.org**.

Glossary

automaton. A self-directed machine, usually one that looks and moves like a living thing.

axle. A small rod that is used with a wheel or a gear to turn the wheel or the gear. An axle looks like a plus sign (+) from the end. Most axles are black or gray in color. Axles are also measured in stud length. To determine the length of an axle, use a plate or a brick to measure it.

bricks. The basic building elements of the LEGO® system. Bricks are measured by the number of studs they have in width and length.

caster (also called caster wheel). A small wheel that provides balance and turns in any direction.

caster steer. A slight, unintentional turn that occurs when a caster wheel is not set in the direction an object is headed.

design brief. In its simplest form, a list of all the features that must be included in a final solution; design briefs often include the need for a particular device, an assessment of existing similar devices, costs, etc.

driving base. The part of the robot to which other components are attached.

encoder. A device that measures and communicates a robot's experience.

friction. The scientific term for two things rubbing together.

gear. Used to transfer movement from one part of a LEGO® model to another part of the model. Gears come in many sizes and are described by the number of "teeth" they have. In your robotics kit, the smallest gear is an 8-tooth and the largest is a 40-tooth gear.

microphone. A device that converts acoustical waves (sound) into electrical signals.

obstacle detection. The ability to know when something is in the way.

plate. A LEGO® element that looks like a short brick. A plate is exactly one-third the height of a brick. Plates are also classified by their studs.

repeatability. The ability of a robot to conduct itself in the same manner every time a program is run.

resolution. The degree to which an encoder can measure.

robot. A machine that (1) is programmable, (2) is automatic, (3) has multiple uses, and (4) is able to sense its surroundings.

robotics. The science or technology of designing, building, and using robots.

robotics engineers. People who design robots, maintain them, develop new applications for them, and conduct research to expand their potential.

sensors. Mechanisms that allow a robot to sense its surroundings. Sensors can detect light, touch, and sound.

sequential. In a specific order.

studs. Little bumps on the top of most LEGO® parts. When you press two LEGO® pieces together, the studs are the primary contact points, and the friction between the studs and other part causes the pieces to "stick" together.

TECHNIC beam. The basic building element in the NXT robotics kit. A TECHNIC beam has no studs and an odd number (1, 3, 5, 7, etc.) of holes in the side. TECHNIC beams come in various lengths and are measured by the number of holes they have.

TECHNIC brick. Looks just like a standard LEGO® brick except it has an odd number of holes in the side of it. All TECHNIC bricks are only one stud wide. TECHNIC bricks are measured by the number of studs they have.

TECHNIC connector peg (also called pin). Used to connect TECHNIC beams and bricks. In the NXT set, most of the structure is held together with these elements. Comes in two colors, black and gray. A black connector peg has small ribs on it that make it more difficult for the peg to turn inside the hole of a beam due to friction. A gray connector peg is smooth so the peg can turn freely inside the hole of a beam to create a movable connection.

tolerance. In engineering, the permissible variation of a characteristic or response.

Answer Key

Activity 1

(This activity implies that there are right or wrong answers, but people often have differing opinions.)

Gas Pump

- [x] Programmable
- [x] Automatic
- [ ] Multi-use
- [x] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Computer

- [x] Programmable
- [x] Automatic
- [x] Multi-use
- [ ] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Car

- [x] Programmable
- [x] Automatic
- [ ] Multi-use
- [ ] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Washing Machine

- [x] Programmable
- [x] Automatic
- [ ] Multi-use
- [x] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Blender

- [ ] Programmable
- [ ] Automatic
- [x] Multi-use
- [ ] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Light Switch

- [ ] Programmable
- [ ] Automatic
- [ ] Multi-use
- [ ] Senses surroundings

Is it a robot?

- [ ] Yes
- [x] No

Activity 2

1. G
2. F
3. H
4. E
5. I
6. B
7. A
8. D
9. C

Activity 7

1. C
2. D
3. A
4. B

Summary of Learning Outcomes

Activity	Project Skill	Life Skill	Educational Standard*	Success Indicator
The Basics				
1. What Is a Robot?	Understanding what a robot is	Thinking critically	National Science Education Content Standard F: Science in Personal and Social Perspectives (Grades 5–8), Science and Technology in Society; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology	Identifies robots in everyday life
2. Introduction to LEGO® NXT	Identifying basic LEGO® NXT parts	Planning and organizing	National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 9: Develop an understanding of engineering design	Matches LEGO® NXT parts with their descriptions
3. The Intelligent Brick	Following directions for a basic program	Mastering technology	National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of and be able to select and use information and communication technologies	Programs a LEGO® NXT intelligent brick
Building Your First Robot				
4. Start with Something Simple	Building a simple robot	Following directions	National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of and be able to select and use transportation technologies	Builds the driving base for a LEGO® NXT robot
5. Giving Your Robot a "Brain"	Experimenting with computer programming	Understanding systems	National Science Education Content Standard A: Science as Inquiry (Grades 5–8), Abilities Necessary to Scientific Inquiry; Standards for Technological Literacy 1: Develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving	Creates and changes a basic LEGO® NXT program
6. One Step at a Time	Creating a simple route program	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristic and scope of technology	Programs a LEGO® NXT robot to follow a path
Sensors				
7. Seeing, Feeling, and Hearing	Identifying LEGO® NXT sensors	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology	Matches LEGO® NXT sensors with their descriptions

Activity	Project Skill	Life Skill	Educational Standard*	Success Indicator
8. Avoiding Obstacles	Creating a program for the LEGO® NXT touch sensor	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology	Creates a LEGO® NXT program that uses the LEGO® NXT touch sensor
9. Sounds Like a Plan	Creating a program for the LEGO® NXT sound sensor	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5–8), Understandings about Science and Technology; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology	Creates a LEGO® NXT program that uses the LEGO® NXT sound sensor
10. Seeing Is Believing	Creating a program for the LEGO® NXT light sensor	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 1: Develop an understanding of the characteristics and scope of technology	Creates a LEGO® NXT program that uses the LEGO® NXT light sensor
11. Ultra Robotics	Creating a LEGO® NXT program that uses the ultrasonic sensor	Understanding systems	National Science Education Content Standard E: Science and Technology (Grades 5-8), Abilities of Technological Design; Standards for Technological Literacy 9: Develop an understanding of engineering design	Creates a LEGO® NXT program that uses the ultrasonic sensor
What Do You Want Your Robot To Do?				
12. Small Tasks, Big Accom-plishments	Using the engineering or design process	Practicing creativity	National Science Education Content Standard E: Science and Technology (Grades 5–8), Abilities of Technological Design; Standards for Technological Literacy 9: Develop an understanding of engineering design	Creates programs for various tasks

* The educational standards cited here are from two sources: the National Science Teachers Association's National Science Education Standards, which are available in their entirety at **www.nsta.org/publications/nses.aspx**, and the International Technology and Engineering Educators Association's Technological Literacy Standards, which are available in their entirety at **www.iteaconnect.org**.

PHOTO Page

Your project documentation can take many forms. Begin with this book, but keep in mind that you can take video along the way and then create a DVD of highlights. You can take pictures and then create a slideshow presentation or a scrapbook. You could create a journal and write a daily log of your progress. There really is no “correct way” to document your work. The important thing is for you to have a record of what worked well and what didn’t. For project judging, you’ll need a way of proving that you did the work on your project. For a start, use this page to document your work.

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I pledge

My head to clearer thinking,

My heart to greater loyalty,

My hands to larger service, and

My health to better living,

For my club, my community, my country, and my world.

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