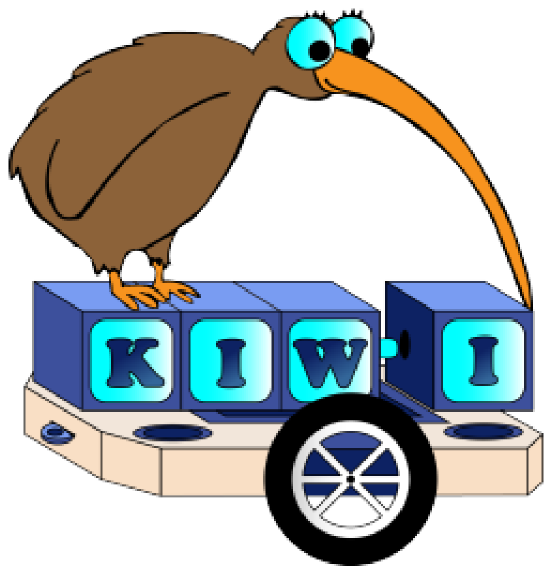
How Things Move:

Exploring Concepts of Motion through Robotics & Programming

An Introductory Curriculum Unit for Pre-K through 2nd Grade



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How Things Move Overview

Introduction to the Curriculum

How Things Move is a robotics and programming curriculum designed to be used with KIWI robotics constructions sets and CHERP programming language. These activities are designed specifically for early childhood classroom use (Pre-K through 2nd grade). Over the course of several weeks, students will work alone or in groups to build and program a robot to demonstrate their understandings and ideas related to the robotics and programming concepts they have mastered. This curriculum also contains foundational physics connections related to motion, light, and friction.

Upon completing the *How Things Move* curriculum, children can move on to *Sensing the World Around Us*, a robotics and programming curriculum that builds on the concepts children have mastered here and focuses sensing. Or, children can complete either the *Dances from Around the World* final project curriculum or one of the culminating projects described at the end of this curriculum.

The Curriculum

Overview: Ready, Set, Roll!

Children explore the concept of **friction** by using LEGO® and art materials (all non-robotic materials) to build non-robotic vehicles that will transport a toy person down series of ramps. The powerful idea in Lesson 1 (building sturdily through use of the **engineering design process**) will prove important to the success of the children's robots in subsequent lessons and should be rearticulated and discussed during each activity.

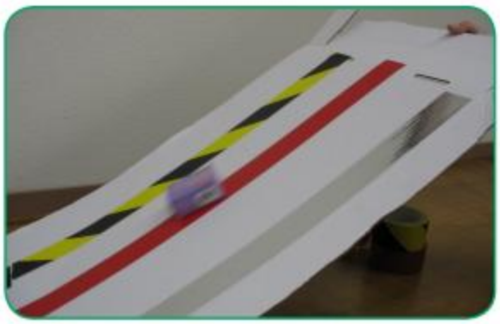


Figure 1. Sample cardboard ramp with different paths made of varying textures to affect friction including: tape, sandpaper, etc.

Prior Knowledge	***Objectives***	
	Students will understand that…	*Students will be able to…*
• None, but prior experience building with LEGO® and crafts or recycled materials is helpful.	• LEGO® bricks and other materials can fit together to form ***sturdy structures***. • The ***engineering design process*** is useful for planning and guiding the creation of artifacts. • There are many different kinds of engineers • Friction can affect movement	• Build sturdy, non-robotic structures • Use the engineering design process to facilitate the creation of their structure.

Materials / resources:

- LEGO® bricks and a variety of crafts and recycled materials for building and decorating
- Poster showing the steps of the engineering design process
- Engineering Design Journals for planning
- Pictures of different types of vehicles
- Cardboard ramp with different surfaces including sandpaper, masking tape, etc. for vehicles to roll or slide down.

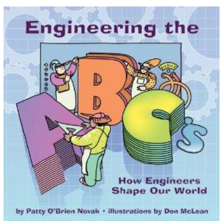
Activity description

Introduce the concepts and the task: "Today we will be building vehicles to transport a toy person down a hill safely. This hill has a bunch of tricky paths and we're going to use a tool (The Engineering Design Process) to help us make sure our vehicles are sturdy and work the way they are supposed to." Discuss what an engineer is and introduce the steps of the engineering design process.

What is an Engineer?

An engineer is anyone who invents or improves things (for instance, just about any object you see around you) or processes (such as baking methods) to solve problems or meet needs. Any man-made object you encounter in your daily life was influenced by engineers.

Book Suggestion:



Engineering the ABC's, by Patty O'Brien Novak answers questions about now everyday things work and how engineering relates to so many parts of a child's daily life. In an entertaining way, this book shows how engineers shape our world.

Different Kinds of Engineers

There are many different kinds of engineers including: biomedical engineers, aerospace engineers, computer engineers, and industrial engineers. (For a list and descriptions, check out: http://www.eweek.org/AboutEngineering/TypesEngineering.aspx) Discuss as a class what these different kinds of engineers make and do. What kind of engineer are we going to be when we build our vehicles? (There may be more than one answer!)

Think Like an Engineer

Everyone in the class is going to start thinking like an engineer! That means looking at the purpose of objects and how they function. What are the different parts that make up the whole? What do they do? Why are they important? Let's look at pictures of some different vehicles and ask these engineer's questions.

Ex 1: **Fire engine**- What are the different parts of the fire engine? What function does each part have? Why is each part important?

Ex.2: **Snow Plow**- What function does each part have? What parts are the same as the fire engine? What parts are different? Why?

Jump For Engineers

Look at a series of pictures of naturally occurring and manmade objects. Jump if you think an engineer built it, stay seated if you don't think so. Why or why not? Discuss.

Lesson 1 Vocabulary

Students should become familiar with the following words:

Artifact – something important made by people
Cycle – something that moves in a circle (i.e. the seasons, the Engineering Design Process)
Design – a plan for a building or invention
Engineer – someone who invents or improves things
Friction- what happens when two things rub against each other
Material – something used to build or construct
Structure – a building or object made with different parts

Individual / pair work : Ready, Set, Roll!

Students follow the steps of the engineering design process and use LEGO® and crafts/recycled materials to create a vehicle that can get a toy person safely down each path of a cardboard hill. They may use both structural and aesthetic materials. The criteria for a successful vehicle are that:

- At least one toy person can be attached to the vehicle.
- The toy person remains attached/inside the vehicle when rolling down the ramp
- The vehicle is sturdy and remains intact when being picked up, handled, and when rolling down the ramp

Physics Connection: Friction

What is friction? Friction is what happens when any two things rub against each other. In physics, we might think of friction as a resistance to motion or movement.

What affects friction? The type of surface — is it smooth or rough? Is the object(s) stationary or already moving? Size? Weight?

Try This: Rub your hands together. What do you feel? You are creating friction! 

Sometimes We Need Friction: Friction can slow down or limit the movement of objects, but friction is also a useful tool when we need traction or gripping power. Uses of friction in everyday life can be seen when we walk or ride in a car. Have you slipped in spilled water, or on ice? Have you seen a car spin around on ice because it "lost its friction"? These are examples of where we need friction.

Discuss: How did friction affect our vehicles movement down the different paths on the hill? Did the materials we used to build our vehicles, its size, weight, and other properties change the way it moved down the hill? Why or why not?

Note: Working Individually vs. Working in Pairs

Whether students work in pairs versus individually throughout this lesson is left up to the teachers' discretion based on several factors. Materials may be limited, making pair work necessary. Teachers may also have goals for children's social development that an explicit focus on sharing and teamwork throughout this curriculum can support. On the other hand, teamwork can be challenging at this age, so students may benefit from having their own materials and the option rather than the requirement to collaborate with others when it makes sense.

PTD TEACHING TOOLS:

Expert Badges: Children who finish building their vehicles and master all concepts quickly get to wear a badge that says "Engineering Expert". Engineering Experts walk around and offer help to any classmates experiencing difficulties.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: After finishing, students share their creations. They may do one or more of the following:

a. explain the features of their creation
b. show how their creation moves down the hill
c. describe the features of their final design that make it sturdy
d. talk about what they found easy and difficult, and
e. share anything they changed from their original plan.
f. share their collaboration webs

Free-play:

Provide opportunities for children to build freely with LEGO® and other building materials. After your discussion on friction, allow children to modify their vehicles or build different kinds of structures to roll down the cardboard hill.

<u>Overview</u>: *My Dream Vehicle*

Children share and learn ideas about what robots are. They are introduced to KIWI robotics concepts. Children will think creatively in order to design, build, and test their own robotic vehicles.

Prior Knowledge	***Objectives***	
	Students will understand that…	*Students will be able to…*
• LEGO® bricks and other materials can fit together to form sturdy structures. • The engineering design process is useful for planning and guiding the creation of artifacts. • Symbols (pictures, icons, words, etc.) can represent ideas or things. • Some ability to recognize letters or to read is helpful, but not required.	• Robots need moving parts, such as motors, to be able to perform behaviors specified by a program. • The robotic 'brain' has the programmed instructions that make the robot perform its behaviors. • The computer must communicate with the motors for the motors to function.	• Describe the components of a KIWI robot. • Upload a program to a robot via the tangible blocks or graphical icons • Build sturdy, robotic vehicles that move.

Materials / resources:

- Pictures of different robots and non-robots
- Large icons for games and reference displays
- Computers with CHERP software
- One set of KIWI robotic parts for each student or group of students
- A variety of crafts and recycled materials for building and decorating
- Some partially built vehicles (or pictures of them) to show possible attachments

> **Note:**
> *It is important to establish rules or expectations for how students should treat each other's materials, programs, and robots. Find a time for students to generate these group expectations. Students may be better able to imagine reasonable expectations after using the robots or programming interface once.*

<u>Activity description</u>

<u>*Warm up activities*</u>:

1) *Jump for the robots!* Children will be shown about 10 different images of robots and non-robots. They jump up and down if they think the picture shown is of a robot. Later, make an "Is It a Robot?"

chart putting these images in one of three categories: Robots, Maybe or Sort of Robots, and Not Robots. *(See Materials in Appendix H for sample pictures)*

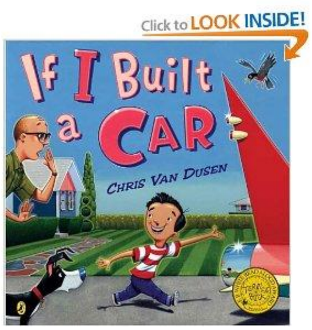
2) *Yes or No*? Students jump up (or make another movement) for statements they think are true and sit down for statements they think are false.

3) *Discussion: What is a robot?* As a class, children discuss what they think a robot is and examples of robots they know of. Children and teachers can bring in pictures of these objects later and put them on the "Is It a Robot?" chart. The teacher shows a pre-built KIWI vehicle and a non-robotic vehicle. The class identifies that you have to push the non-robot to make it move. You can also push the robot, but (as the teacher shows) but you can also give it instructions and push a button to make it follow them. Why can the robot do this? It has special parts, which the teacher overviews.
4) *Watch video clips of different robots in action!*

Building and Programming a KIWI Robot

Introducing the concepts and task: Build robotic vehicles that are programmed to move

Book Suggestion:



In *If I Built a Car* by Chris Van Dussen, Jack has designed the ultimate fantasy car inspired by zeppelins and trains, Cadillacs and old planes, with brilliant colors and lots of shiny chrome. Get kids to start thinking creatively about the features of their dream robotic vehicle, and emphasize the importance of the imagine and design phases of the engineering design process, by reading this book as an introduction!

1. Introduce the robot's key parts and their functions.
2. *Communication with a robot:* Explain that we can tell a robot what to do, as long as we use a language it understands. Encourage the students to offer examples of how people communicate (speaking, writing, drawing, facial expressions, etc.) and other languages they (or people they know) can speak. Discuss the idea of translating between languages, and the need to translate what we want a robot to do into the robot's language. A *program* is another word for instructions we give the robot.
3. Show how to use the programming interface on the computer. Briefly describe the icons (children will learn more about programming in the next lesson). In this lesson, children will solely concentrate on programming their motors to move in order to test their robotic creations.

Individual/pair work: My Dream Vehicle

Students will design and build their own robotic vehicles. Allow the students to design creatively and build how they see fit, but remind them that a working robot must have a computer 'brain', motors, and properly connected wires. When they think they have a working robot, they bring it to a testing station where they upload the program "Begin, Forward, End" with the help of a teacher and run it. This test is to ensure that their robot follows the instruction properly and that it is sturdy.

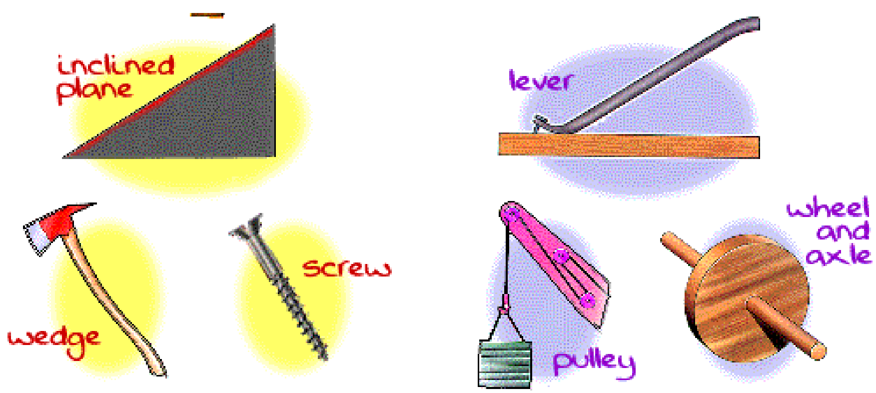
Lesson 2 Vocabulary:

Students should become familiar with the following words:

***Automatic* –** by itself, without help from a person
Computer – a machine that gives a robot its program or instructions
Function – the reason a machine or robot was built
Motor – the part of a robot that makes it move
Robot – a machine that can be programmed to do different things
USB Cable- Connects robot to the computer so the program can be sent
Micrcontroller- the computer "brain"

Physics Connection: Simple Machines- The Wheel

A **machine** is a tool used to make work easier**. Simple machines** are simple tools used to make work easier. They have few or no moving parts. There are 6 simple machines: **Inclined Plane, Wedge, Screw, Lever, Wheel and Axle, and Pulley**.



Most of you used **wheels** to help your robotic vehicle move today. The **wheel & axle** is a type of **simple machine**. As you saw with your robotic vehicles, the wheel and axle can move objects across distances.

The **wheel** (the round end) turns the **axle** (the cylindrical post) causing movement!

Discuss: How did wheels help your robot to move? How did motors interact with the wheels in order to create movement? Did your robot use any other simple machines?

Language Arts Connection: *How-To Guide*

You need to explain to someone how to build robotic vehicle the way you did. In your Engineering Design Journals, create a series of drawings showing all the different robotic and non-robotic parts you used. Try to use the new vocabulary words you've learned to label the different parts, or dictate to a teacher who can write the labels down for you.

PTD TEACHING TOOLS (refer back to Lesson 1 for descriptions): Expert Badges, Collaboration Web, Technology Circle.

Free-play:

Provide opportunities for children to build freely with KIWI parts and other building materials. After your discussion on friction, allow children to modify their vehicles OR try building something that isn't a vehicle- how else can you connect the motor? What else can you attach to spin besides wheels?

Overview: The Hokey-Pokey

Children learn the importance of sequence as they program their robots to dance the Hokey-Pokey.

What Is a Program?

A program is a sequence of instructions that the robot acts out in order. Each instruction has a specific meaning, and the order of the instructions affects the robot's overall actions.

Prior Knowledge	***Objectives***	
	Students will understand that…	*Students will be able to…*
• A robot is a machine that can act on its own once it receives proper instructions.	• Each icon or "block" corresponds to a specific instruction • A program is a sequence of instructions that is followed by a robot • The order of the instructions dictates the order in which the robot executes the instructions	• Point out or select the appropriate block corresponding to a planned robot action • Connect a series of blocks on the computer • Transmit a program to a robot

Materials / resources:

- Large icons for games and reference displays
- Robotic and non-robotic building materials
- Computers with CHERP software

Activity description

Warm-Up: Play *Simon Says* or another game to learn/review each of the CHERP programming icons and what each icon represents.

Introduce the concepts and task. Show an example robot and have the class name it. "Today we will give instructions, or *programs*, to our robots so they will do the Hokey-Pokey." The whole class sings and dances the Hokey Pokey to make sure everyone remembers it. Conclude with a "robot verse":

You put your robot in, you put your robot out,
You put your robot in, and you shake it all about.
You do the Hokey Pokey, and you turn yourself around.
And that's what it's all about. (Clap, clap.)

Activity: Individually or in groups, students program their robot to do the Hokey Pokey dance. When all groups are done, everyone does the Hokey Pokey with the robots!

Math Connection: *Counting and Labeling*
If students modify their vehicles, have them write or draw what robotic, recycled, and other craft pieces they use and:

1) *Label the pieces by shape*
2) *Count how many of each shape they used*
3) *Teacher can add individual student results to a classroom chart.*

Lesson 3 Vocabulary:

Instruction – a direction that a robot will listen to
Keyboard – the part of a computer used to type letters, numbers, symbols, and commands
Order – parts of a group arranged to make sense
Program – a set of instructions for a robot
Sequence – the order of instructions that a robot will follow exactly
Variable – something in a program that can change

Language Arts Connection: *Program Charades*

Children will pair up. One child will make up a program using the CHERP icons and act it out while the other partner guesses what the programming instructions are. Switch roles. Come up with a program together that you will "write" out (using stickers or cutouts of the CHERP instructions) to act out for the class.

PTD TEACHING TOOLS (refer back to Lesson 1 for descriptions): Expert Badges, Collaboration Web, Technology Circle.

<u>Free-play</u>:

Provide opportunities for children to build freely with KIWI parts and other building materials. After your discussion on friction, allow children to modify their vehicles OR try building something that isn't a vehicle- how else can you connect the motor? What else can you attach to spin besides wheels?

Overview: Driving Around the Block

Students will learn about a new instruction that makes the robot repeat other instructions infinitely or a given number of times. They use these new instructions to program robotic vehicles to "drive around the block" a particular number of times.

Prior Knowledge	***Objectives***	
	Students will understand that…	*Students will be able to…*
• Arranging instructions in a different order will result in a different program.	• An instruction or sequence of instructions may be modified to repeat. • Some programming instructions, like 'Repeat,' can be qualified with additional information.	• Recognize a situation that requires a looped program. • Make a program that loops. • Use number parameters to modify the number of times a loop runs.

Materials / resources:

- Large icons for games and reference displays
- Robotic and non-robotic building materials
- Computers with CHERP software

Activity description: Individually or in groups, children use their already built vehicles and modify their programs to utilize Repeats.

Warm-Up: Game or song that uses repetition.

Introduce the concepts: Repeats

1. Discuss what it means for something to repeat. How does this relate to similar concepts like patterns?
2. Introduce the "Repeat" programming icon. Show the different ways you can program a Repeat.
3. Using a sample robot and program, demonstrate a robot acting out a pattern by repeating certain actions multiple times.

Lesson 4 Vocabulary:

Loop – something that repeats over and over again
Parameter – a limit that a robot will follow
Pattern – a design or sequence that repeats
Repeat – to do something more than once

Math Connection: *Patterns & Counting*

After showing a robot acting out a sample program that is a pattern, children will identify the repeating unit, count how many times it repeats, and (as a class) change the program so that it uses a repeat to accomplish the same outcome.

The task: Driving Around the Block

Imagine you need to drive around the block several times until you can find a parking space. Children will use repeats correctly to make their vehicles move around "the block" (i.e. in a square, this could be made of masking tape on the floor as part of a large community map) 4 times. One full drive around the block is considered moving in one full square.

Simple Version: Try an L shaped map on the floor instead of a full square

Extension: Once this is mastered, use repeats to create a more complex repeating pattern (i.e. create a program that has two things that repeat or create a more complex floor map to navigate).

Language Arts Connection: *Toothbrush Exercise*

Think about the way your brush your teeth- this is a task that requires some repeating motions (like moving your toothbrush from left to right) and other motions that only happen once (like squeezing out toothpaste). Pretend YOU are a robot that needs a program to brush your teeth. Using CHERP programming instructions (and made up instructions like "spit" and "rinse"). Make up a program that uses repeats and act it out for a partner. Did you have the same program or different programs?

PTD TEACHING TOOLS (refer back to Lesson 1 for descriptions): Expert Badges, Collaboration Web, Technology Circle.

Free-play:

Provide opportunities for children to program freely with CHERP.

Lesson 5 Powerful Idea:

What are Sensors? *Sensors*

Overview: The Robot Relay!

Your robots will run in the Robot Relay Race! Each robot will run one leg of a relay race and use a distance sensor to stop when their part of the race is done and it reaches its teammate.

<table>
<tr><td rowspan="2">Prior Knowledge</td><td colspan="2">Objectives</td></tr>
<tr><td>Students will understand that…</td><td>Students will be able to…</td></tr>
<tr><td>• Examples of human or animal sense organs and that people and animals use information provided by their senses to help make decisions.</td><td>• A robot can feel and see its surroundings with a sensor.
• A robot can react to collected data by changing its behavior.
• Certain instructions (like “Repeat”) can be modified with sensor data.</td><td>• To use a distance sensor with KIWI
• Compare and contrast human sense and robot sensors</td></tr>
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Materials / resources:

- Large icons for games and reference displays
- One working robot, build in previous lessons, for each child or pair
- Computers with CHERP software
- KIWI Distance Sensor

Activity description

Warm-Up: Game or song that uses the 5 human senses.

Introduce the concepts: Sensors and Sensor Parameters:

1. Discuss examples of human senses and how these senses let us gather information about what’s going on around us, so that we can make decisions based on this information.
2. We need programming instructions to tell the robot what to do with the information from its sensors. Show the Repeat blocks, which are now familiar, and the new Until Near/ Until Far blocks. Create an example program together.
3. Run the program, and have students discuss what the robot is doing.
4. Display the reference program visibly in the room.

Science Connection: Sensors in the World

Sensors are all around us, making life easier and more convenient. How many sensors can you think of? Here are some examples of commonplace sensors we might take for granted:

Automatic Faucets: http://www.youtube.com/watch?v=QkCDg9GFOMg

Elevator Doors: http://www.youtube.com/watch?v=tvVCEMriHtE

Lights: http://www.youtube.com/watch?v=X_fkbI4xm6Y

The task: Robot Relay

1. The students add a distance sensor to their robot. Students must also build a "wall" on their robot that is big enough for their partner's robot to sense. (These can be made out of paper and taped to the KIWI robot like a flag, or to show team colors, etc.) *Note: Refer to your KIWI manual for more information on triggering the different sensors.*
2. Children program their robots to repeat moving forward along the "race track" (A masking tape line on the floor) and until it senses it is near something (it's partner's robot).

Lesson 5 Vocabulary:

Direction – the way something is pointing
Distance-
Sensor – a machine that can tell something that is happening around it
Vision – the sense used by the eyes

Language Arts Connections: *Sensor Walk*

Divide the class into two groups: Humans and Robots. Take the class for a walk around the school or neighborhood. As a class, keep a list of all the different things the humans and robots can sense and what part they used to sense it. For example, the human group may sense the sunlight with their eyes while students in the robot group would sense this with their light sensors. Children in the robot group do not need to be limited CHERP sensors, but can think creatively about all kinds of sensors a robot might have. Upon returning to the classroom, compare and contrast the Human and Robot lists. Are there some things humans can sense but robots cannot? What about vice versa?

Physics Connection:

You've already learned how different surfaces can create different amounts of **friction** with your robots wheels. Try using a KIWI sensor to program your robot to avoid the types of terrain you don't think it can handle!

PTD TEACHING TOOLS (refer back to Lesson 1 for descriptions): Expert Badges, Collaboration Web, Technology Circle.

Free-play:

Provide opportunities for children to program freely with CHERP.

Overview: Driving After Dark

Robots do different activities based on the state of a light sensor. On a map on the floor, robots drive to school if it is light and back home if it is dark.

Prior Knowledge	***Objectives***	
	Students will understand that…	*Students will be able to…*
• Some instructions can be qualified with additional information. • A robot can feel and see its surroundings with a sensor. • A robot can react to information it collects by changing its behavior.	• A robot can 'choose' between two sequences of instructions depending on the state of a sensor.	• Connect a light sensor to the robot. • Identify a situation that needs a branched program. • Make a program that uses a branch.

Materials / resources:

- Large icons for games and reference displays
- One working robot, built in Lesson 2, for each child or pair
- Light sensor
- Computers with CHERP software
- "Home" and destination icons or models placed on the floor, tape roads

Activity description

If Statements

Think about the different routines that happen around the community, like garbage pickup, mail delivery, etc. What are some things that only happen rarely around the community (e.g. snowplows in the winter). As a class, put up a calendar for display including as many of these community routines as you can. Then, work together to come up with a list of "if statements" about these different routines (e.g. if it is Monday-Saturday, then the mailperson comes, if it is Sunday then the mailperson does not come, etc.)

Introduce the concept: "If"

1. In the programs so far, the robot has only one choice of what instructions to do next. Today we will learn an instruction that give the robot two choices, and the robot uses a sensor to know which set of instructions to follow each time the program is run. Solicit examples of times we rely on sensors to help us make decisions. (If I feel something prickly, I'll move away from it. Or, if I see it's rainy out, I'll bring an umbrella; if not, I'll leave the umbrella at home.)

2. Play “Simon Says” to help the students gain familiarity with the thought process behind branches. For example, “Simon says, ‘If the lights are on, jump twice, (if not, stand on one foot).”
3. Introduce If, End-If blocks and light/dark and pushed / released parameters. Make and act out a model program together. Upload it to a robot to see how it works. It is best to start out with a program that uses only “If” and to save the “If Not” segment for an extension if students are ready for it. Students will have a much better understanding of how “If” gives the robot choices once they have run the program themselves in both sensor conditions.
4. Once the students run the program, use the reference icons to post the program in the room.

<u>The task</u>: The Robot Chooses a Program

The challenge:

1. On a T shaped map on the floor, students will program their robot to drive home if it is dark and go to school if it is light.

Physics Connection: What Is Light?

Our robots have been sensing whether it is light or dark. But what exactly is “light”? Light is everywhere in our world. We need it to see: it carries information from the world to our eyes and brains. Seeing colors and shapes is second nature to us, yet light is a perplexing phenomenon when we study it more closely.

Here are some things to think about:

- Our brains and eyes act together to make extraordinary things happen in perception. Movies are sequences of still pictures. Magazine pictures are arrays of dots.
- Light acts like particles—little light bullets—that stream from the source. This explains how shadows work.
- Light also acts like waves—ripples in space—instead of bullets. This explains how rainbows work. In fact, light is both. This "wave-particle duality" is one of the most confusing—and wonderful—principles of physics.

Math Connection: *Red Light, Green Light*

In small groups, have students take turns being the “Traffic cop.” The Traffic cop gives out orders to the group such as “If green, go jump 3 times. If red, sit down.” The Traffic cop then holds up either a red or a green piece of paper, and the other students in the group must complete the instructions accordingly. Try the game as a class first, and once the children feel comfortable with it, allow them to break into smaller groups and try being the Traffic cop themselves.

Literacy Connection: *If Worksheet*

Students will complete a worksheet about their daily and weekly schedules. They will fill in the second half of an "If, then" statement such as "If it is Saturday, _________" in any way they want and draw a picture of the activity they're describing.

PTD TEACHING TOOLS (refer back to Lesson 1 for descriptions): Expert Badges, Collaboration Web, Technology Circle.

Free-play:

Provide opportunities for children to program freely with CHERP.

Lesson 7: Culmination of the *How Things Move* Curriculum

Complete one of the following culminating exercises before moving on to the next curricular unit:

1) **The Iditarod Race**
   Apply the knowledge you've learned about movement and friction to the Iditarod sled-dog race. Create a real map on the floor to represent Alaska and have each robot complete one leg of the journey. Integrate social studies, geography, and history by learning about the original Iditarod.

2) **A Compound Machine:**
   You have learned about how some basic simple machines can help your robot move. A **Compound Machine** is a machine that consists of two or more simple machines. Some everyday items that we might not think of as compound machines (but they are) imclude: scissors, pencil sharpener, and can opener. Others that we might readily think of are: bicycle, lawn mower, bulldozers. Modify your robot so that it is a compound machine utilizing as many simple machines as possible (your robot may already be a compound machine, can you identify how?).

3) **Robot Obstacle Course/Extended Robot Olympics**
   You have explored concepts of motion including simple machines, friction, gravity, and more. Test your skills as a physicist and engineer by designing, building, and programming a robot capable of going through an obstacle course with all different kinds of terrain that may affect your robot's movement (carpet, tile, sandpaper, pebbles, etc.) and hills/ramps of varying steepness. Create attachments or use different wheels to increase/decrease friction as needed. Or, use advanced commands like Ifs and Sensors to avoid dangerous terrain your robot can't handle.

4) **Come up with your own culminating project!**

After completing a short culminating activity like the ones listed above, students will be ready to move on to the Sensing curriculum.