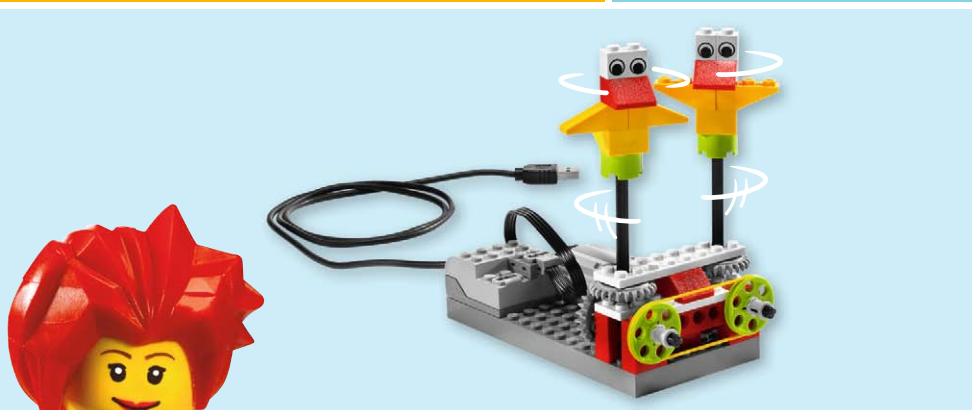
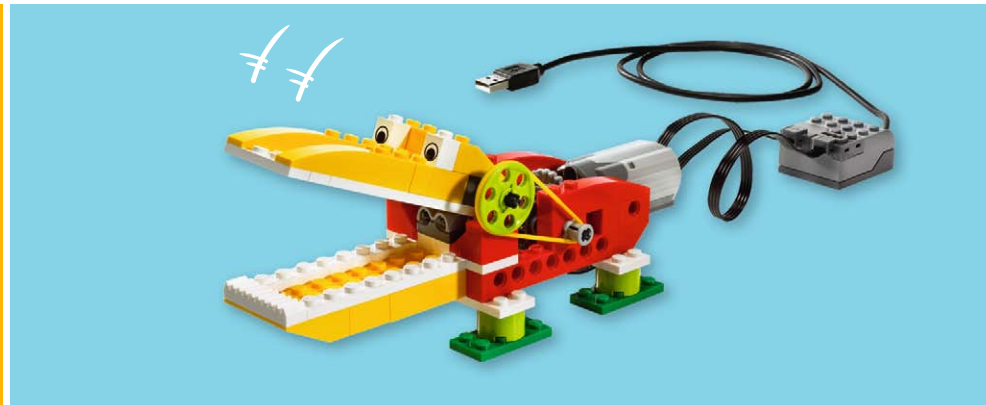


2009580



education



LEGO® Education WeDo™

Teacher's Guide



Table of Contents

Introduction	3
Who is it for?	3
What is it for?	3
What is in the box?	4
The 4C Learning Process	6
Organizing the Classroom	7
Lesson Planning Routes	8
Curriculum	12
Highlights	12
Themes	13
Curriculum Grids	15
LEGO® Education WeDo™ Software	17
Overview	17
Vocabulary List	18
Sound List	21
Background List	22
Shortcut List	23
Getting Started	24
Overview	24
Teacher Notes for Getting Started	
1. Motor and Axle	28
2. Gears	29
3. Idler Gear	30
4. Gearing Down	31
5. Gearing Up	32
6. Tilt Sensor	33
7. Pulleys and Belt	34
8. Crossed Belt	35
9. Decrease Speed	36
10. Increase Speed	37
11. Motion Sensor	38
12. Crown Gear	39
13. Worm Gear	40
14. Cam	41
15. Lever	42
16. Repeat Block	43
17. Add to Display	44
18. Subtract from Display	45
19. Start On Message	46
20. Labeling	47

Teacher Notes for the Activities	48
Overview	48
Amazing Mechanisms	52
1. Dancing Birds	53
2. Smart Spinner	61
3. Drumming Monkey	70
Wild Animals	79
4. Hungry Alligator	80
5. Roaring Lion	88
6. Flying Bird	97
Play Soccer	106
7. Goal Kicker	107
8. Goal Keeper	115
9. Cheerful Fans	124
Adventure Stories	132
10. Airplane Rescue	133
11. Giant Escape	141
12. Sailboat Storm	151
Resources	160
Be Inspired! Programs to Explore	161
Activity Data Tables: Amazing Mechanisms	
1. Dancing Birds	164
2. Smart Spinner	165
3. Drumming Monkey	166
Activity Data Tables: Play Soccer	
7. Goal Kicker	167
8. Goal Keeper	168
9. Cheerful Fans	169
Glossary	170
LEGO® Element Survey for 9580	172



Introduction

LEGO® Education is pleased to introduce the 2009580 LEGO Education WeDo™ Activity Pack which includes this LEGO Education WeDo Teacher's Guide.

Who is it for?

The material is designed for teachers in elementary school, especially second through fourth grade, although it can be used in higher grades as well. Working individually, in pairs or teams, students of any academic background from seven years and up can learn by building and programming the models and by investigating, writing about, and discussing ideas they encounter using the models in these activities.

What is it for?

The WeDo Activity Pack enables students to work as young scientists, engineers, mathematicians and creative writers providing them with the settings, tools and tasks for completing cross-curricular projects.

Using these materials, students are encouraged to build and program a working model and then use the model for different purposes, depending upon the theme of the activity and its focused subject matter in science, technology, mathematics or language.

The WeDo Activity Pack enables teachers to provide learning opportunities for developing these broader learning goals:

- Think creatively to make a working model
- Develop vocabulary and communication skills to explain how the model works
- Establish links between cause and effect
- Reflect on how to find answers and imagine new possibilities
- Brainstorm ideas and endeavor to bring some of them to fruition
- Make fair tests by changing one factor and observing or measuring the effect
- Make systematic observations and measurements
- Display and communicate data using tables
- Follow 2D drawings to build a 3D model
- Think logically and create a program to produce a specific behavior
- Write and present creative stories using models for visual and dramatic effects

See the Curriculum section for an overview of the highlights, a description of the themes around which the activities are organized, and curriculum grids showing how objectives in science, technology, engineering, mathematics and language are met by each activity.

What is in the box?

9580 LEGO® Education WeDo™ Construction Set

The 9580 LEGO® Education WeDo™ Construction Set enables students to build LEGO® models that attach to the LEGO® USB Hub and then control the models using computer programs. The set contains 158 elements including a LEGO Hub, motor, tilt sensor and a motion sensor that add movement and intelligence to the model.



LEGO® USB Hub

The LEGO® USB Hub controls sensors and motors from the 2000095 LEGO® Education WeDo™ Software. Power and data are transmitted from the LEGO motors and sensors to and from the computer using the two LEGO Hub ports. The WeDo Software automatically detects the LEGO Hub and any motors and sensors attached to it. Up to three LEGO Hubs can be attached.

Motor

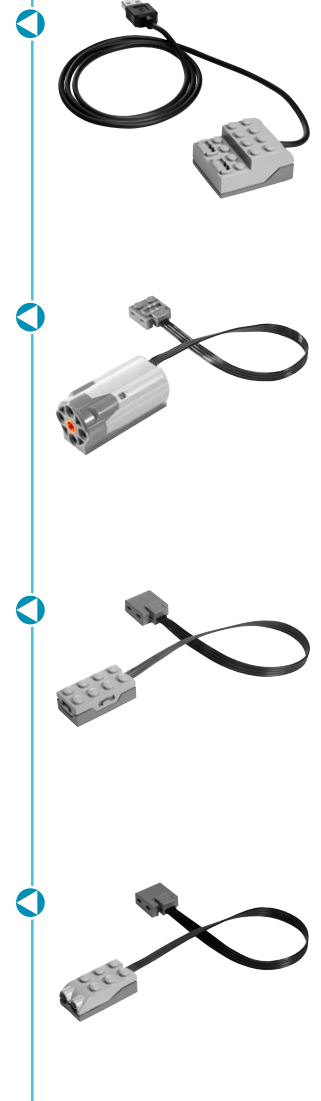
The motor can be programmed to turn this way or that way and to move at different power levels. Power for the motor is supplied through voltage from the computer's USB port (5V). Axles or other LEGO elements can be attached to the motor.

Tilt Sensor

The tilt sensor reports the direction it is tilted. The tilt sensor detects changes within six different positions: Tilt This Way, Tilt That Way, Tilt Up, Tilt Down, No Tilt and Any Tilt.

Motion Sensor

The motion sensor detects objects within a range of 15 centimeters (or about 6 inches) depending on the design of the object.

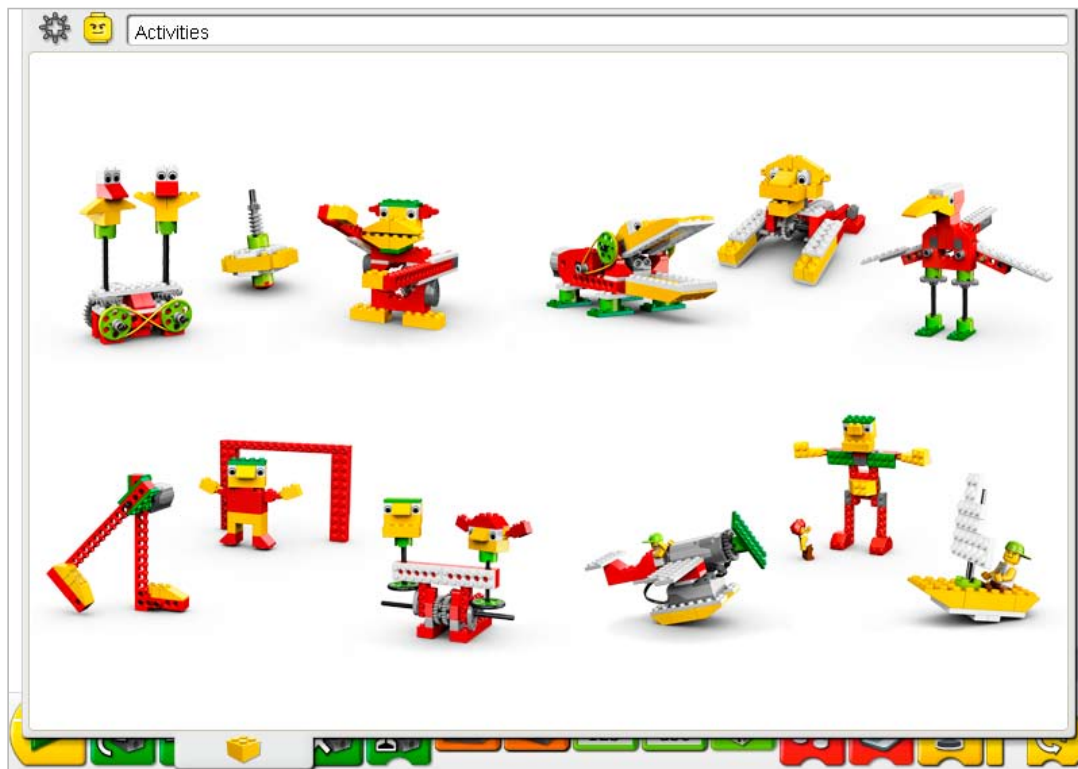


2000095 LEGO® Education WeDo™ Software

The LEGO® Education WeDo™ Software is used to create programs by dragging and dropping Blocks into a sequence on the computer screen or Canvas. Several Blocks control the motor, tilt sensor and motion sensor from the LEGO Education WeDo Construction Set. There are also Blocks that control the computer keyboard, display, microphone and speaker. The WeDo Software automatically detects motors and sensors when they are attached to the LEGO Hub. Getting Started examples in the WeDo Software show LEGO building and programming principles.

2009580 LEGO Education WeDo Activity Pack

The LEGO Education WeDo Activity Pack contains 12 activities that can be installed to run with the WeDo Software. Animations and step-by-step Building Instructions are embedded in the activities. In this Teacher's Guide, Teacher Notes for the activities as well as classroom management ideas, curriculum support, WeDo Software overviews, and Getting Started programming and building examples are also included.



The 4C Learning Process

All LEGO® Education materials support a process of learning that includes four phases: Connect, Construct, Contemplate, and Continue.

Connect

You add to your brain's knowledge when you connect a new learning experience to those you already have or when an initial learning experience is the seed stimulating the growth of new knowledge. Each LEGO Education WeDo™ activity presents an animated situation with minifigures, Mia and Max. Use these animations to illustrate, inspire, and stimulate discussion about the activity topic. Other ways to Connect are also suggested in the Teacher Notes for each activity.

Construct

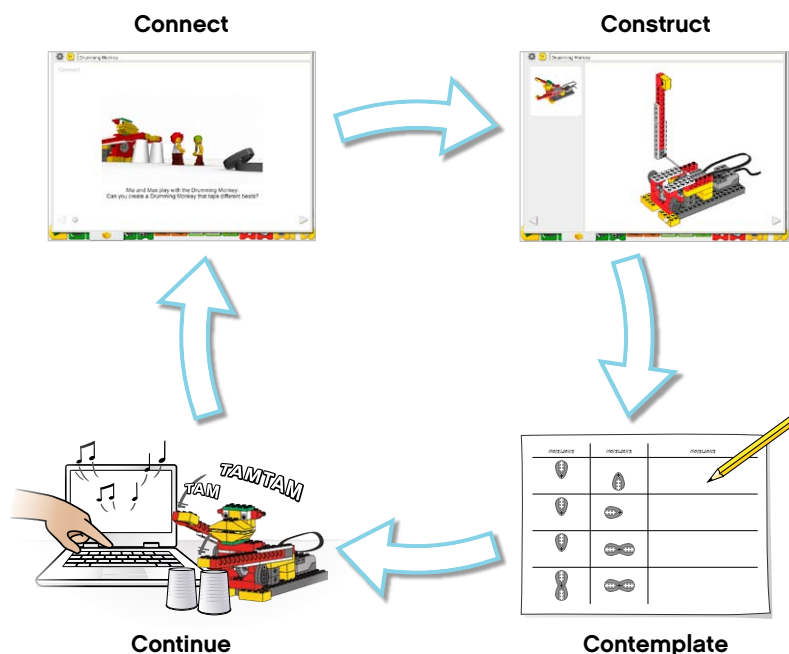
Learning is best when hands and minds are engaged. LEGO Education involves learning by making: the construction of models and of ideas. The WeDo activities include step-by-step instructions embedded directly into the Construct phase. Just click to see the next step. If you prefer, plan time for modifying this model or building and programming something of your own design.

Contemplate

When you contemplate what you have done, you have the opportunity to deepen your understanding. As you reflect, you develop connections between previous knowledge and new experiences. In the Contemplate section, students observe and report how specific changes in the pulleys, gears, or cams affects the movement of the model; they research and make presentations about the behavior of their “animals;” they count, take measurements and rate the performance of their soccer models; and they create different types of stories and act them out using their models for visual and sound effects. This phase offers a good opportunity for evaluating the learning and progress of each student.

Continue

Learning is always more enjoyable and creative when it is adequately challenging. Maintaining this challenge and the pleasure of accomplishment naturally inspires the continuation of more advanced work. The Continue phase of each activity includes a challenge to build and program more behavior or complex interaction with the model.



Organizing the Classroom

Use this checklist to prepare for teaching with the LEGO® Education WeDo™ Activity Pack.

- Install the LEGO Education WeDo Software on each computer or on your network.
- Install the WeDo Activity Pack on each computer or on your network.
- Open each LEGO Education WeDo Construction Set. Store the loose elements in the storage box.
- Arrange the computer and space required for each student or group. For example, place one end of the table near to safe power outlet for the computer. Allow some working space for the storage box and for building models. About 60 centimeters x 40 centimeters (or about 24 inches x 20 inches) next to each computer will do.
- If not already available in your classroom, prepare a box of measuring tools including rulers or measuring tapes and paper for data charts. Stopwatches are optional but useful.
- To become familiar with the materials yourself, set aside an hour and try the Dancing Birds activity as if you were the student. Then read the 1. Dancing Birds Teacher Notes.
- If you have more time, browse Getting Started and try one or more of these: Motor and Axle, Gears, Tilt Sensor, Motion Sensor.

Here are other suggestions recommended by experienced teachers who use LEGO Education materials.

- Place a number on each WeDo Construction Set. That way, you can sign out a numbered kit to each student or team for the term.
- Organize a cupboard, a wheeled cart or storeroom to store the sets between sessions. Unfinished models can be stored in the boxes or on another shelf. If stored separately, put a model in a small box or tray.
- Set aside a resource table or an area that can be used for storing the books related to the current theme topics: e.g., books, photographs, maps and other resources related to the Wild Animals theme.
- For decorating or extending projects, prepare a box of craft materials, e.g., colored paper, card stock, foil, ribbons, and scissors.
- Consider using journals as inventors' notebooks either on paper or online to encourage project organization, note-taking, and reflection throughout the project work.



Lesson Planning Routes

There are many ways to use the LEGO® Education WeDo™ materials in your classroom. Here are two different ways to plan your class schedule.

Each activity can take one or more class periods, depending upon the time spent on discussion, the building and computer skills of your students, and the time you allow for experimentation.

Activities can be completed by an individual or a small team or group, depending upon the number of computers and LEGO Education WeDo Construction Sets available.

Route A: Getting Started Introduction Before Themed Activities

Introduce the building and programming ideas first to help the students become familiar with LEGO building using the WeDo Construction Set and with the LEGO Education WeDo Software. Then start on the themed activities.

You can have the students choose one of the three themed activities for each theme as this chart shows, or if you have more time, you can have the students try all of the activities. Some groups will be faster than others and may be able to complete all three in the same time as others complete one or two.

Extension ideas are suggested in the Teacher Notes for each activity. Some of the activity extensions involve combining models from other projects so extensions are recommended as useful ways to encourage cooperation.

You may wish to organize a class exhibition as a finale for the unit.

Route B: Focus on Themed Activities

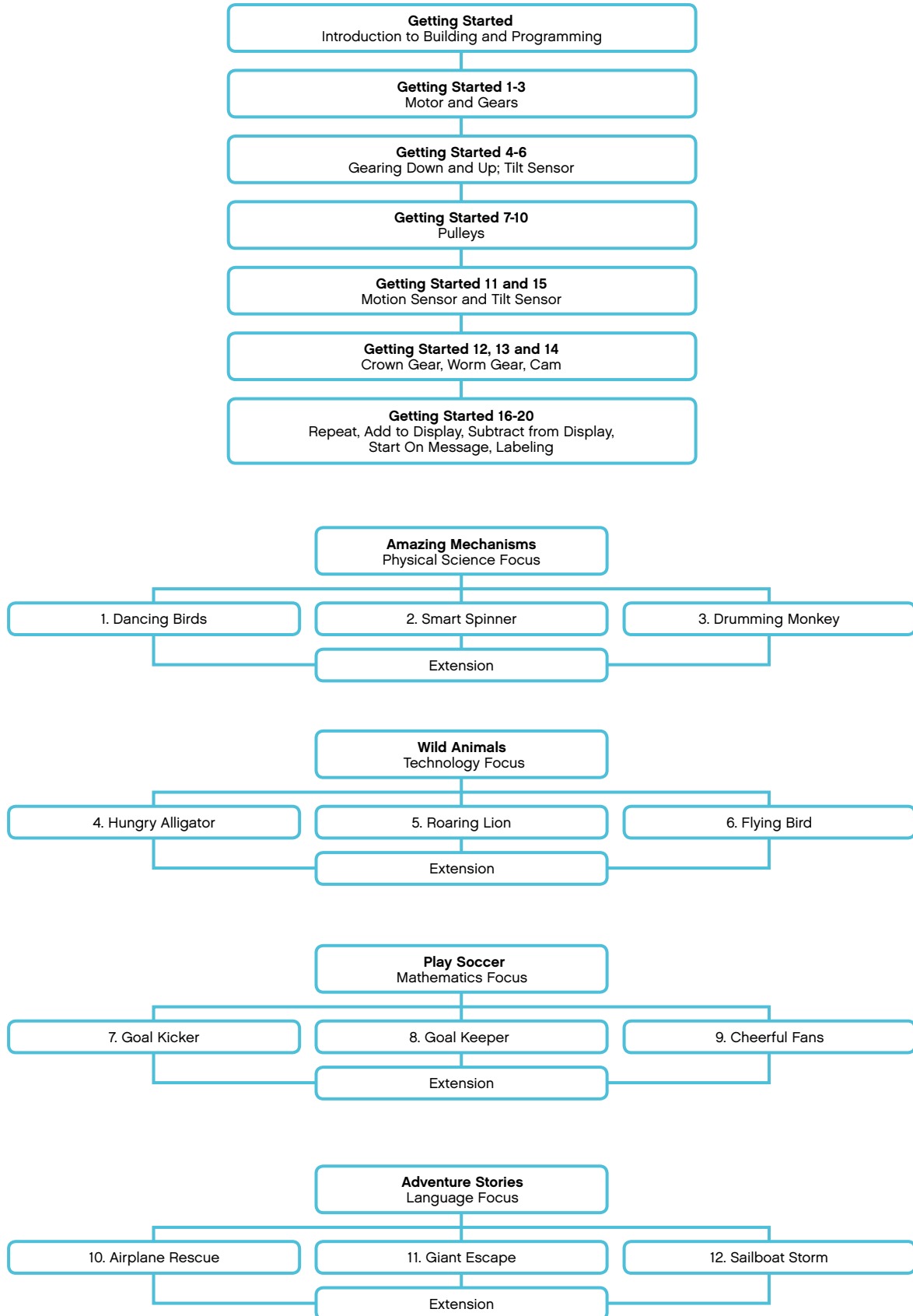
Start with the themed activities, spending more time with them as projects to encourage experimentation.

You can have the students try all of the activities as this chart shows, or if you have less time, you can have the students choose one activity from each theme. Some groups will be faster than others and may be able to complete all three in the same time as others complete one or two.

Use the Getting Started materials as a reference. Extension ideas are suggested in the Teacher Notes for each activity.

You may wish to organize a class exhibition as a finale for the unit.

Route A: Getting Started Introduction Before Themed Activities



Route B: Focus on Themed Activities



Route B: Focus on Themed Activities





Curriculum

Highlights

The process of students actively building, programming, investigating, writing, and communicating benefits their development in numerous ways. The opportunity to integrate subject matter across the curriculum in projects provides a range of contexts for applying concepts, learning new skills, and broadening interests. Specific subject matter is also addressed in the activities. Here are the highlights. For more information, see the Themes and Curriculum Grids sections.

Science

Trace the transmission of motion and transfer of energy through the machine. Identify the simple machines mechanisms at work in the models, including levers, gears, and pulleys. Become familiar with complex motion using a cam, worm gear, and crown gear. Understand that friction can affect the movement of the model. Understand and discuss criteria for a fair test. Consider the needs of living animals.

Technology

Program and create a working model. Interpret 2D and 3D illustrations and models. Understand that animals use parts of their bodies as tools. Compare natural systems with mechanical systems. Use software media to acquire information. Demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build, program, and test the models. Modify a model's behavior by changing the mechanical system or by adding a sensor to provide feedback. Brainstorm to find creative alternative solutions. Learn to share ideas and work together.

Mathematics

Measure time in seconds and tenths of a second. Estimate and measure the distance in centimeters or inches. Understand the concept of randomness. Compare the diameter and rotational speed. Understand and use numbers to represent the type of sounds played and the amount of time the motor turns on. Understand and use the distance between an object and to activate the motion sensor. Understand how the position of the model is measured by the tilt sensor. Understand and use numbers to measure and score qualitative characteristics.

Language

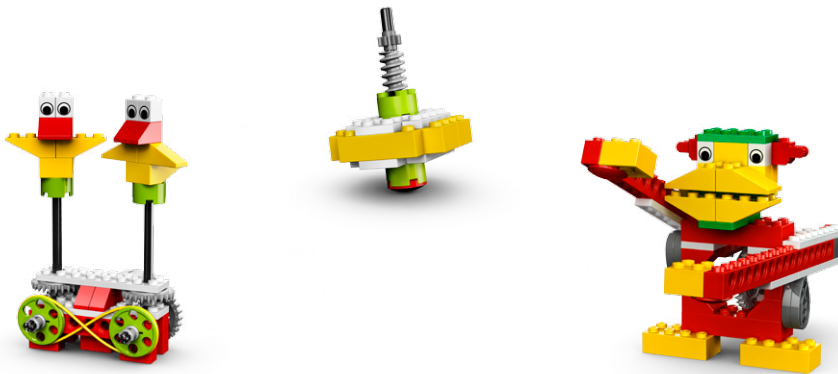
Communicate in spoken or written forms using appropriate vocabulary. Prepare and deliver a demonstration using a model. Use interview questions to find out information and write a story. Write a script with a dialogue. Write a logical sequence of events and create a story including main characters and dramatizing with visual and sound effects. Use technology to create and communicate ideas. Participate as knowledgeable, reflective members of the group and class.

Themes

The 12 activities have been organized around four themes with three activities in each theme. The themes use technology, the building and programming of the model, along with a project-oriented approach to integrate concepts across the curriculum. However, each theme does focus on one subject area more than others.

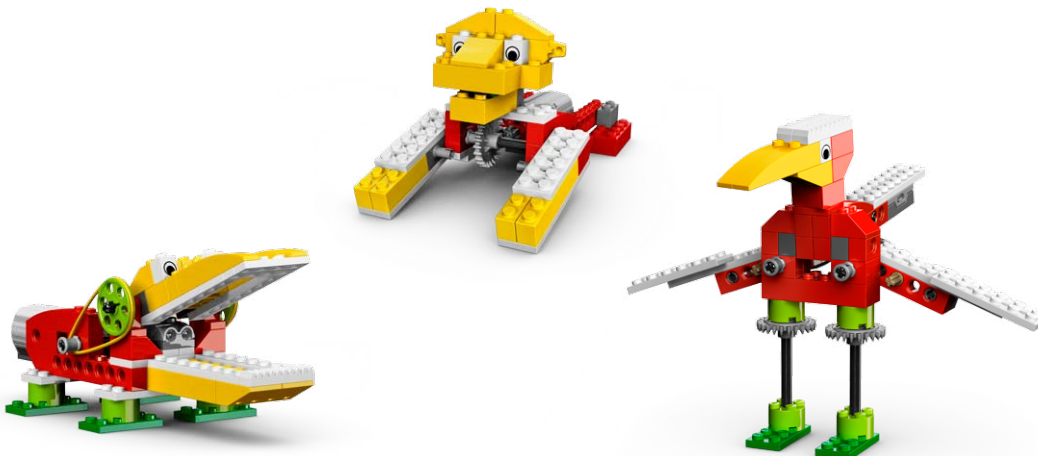
Amazing Mechanisms

The Amazing Mechanisms theme focuses on physical science concepts. In Dancing Birds, students learn about pulleys and belts, experimenting with the size of pulleys and the crossing and uncrossing of the belt. In Smart Spinner, students investigate the effect of smaller and larger gears on a spinning top. In Drumming Monkey, students learn about levers, cams, and patterns of movement. They experiment with the number and position of cams, using them as the effort causing the monkey's arms to drum up and down on a surface at different rates.



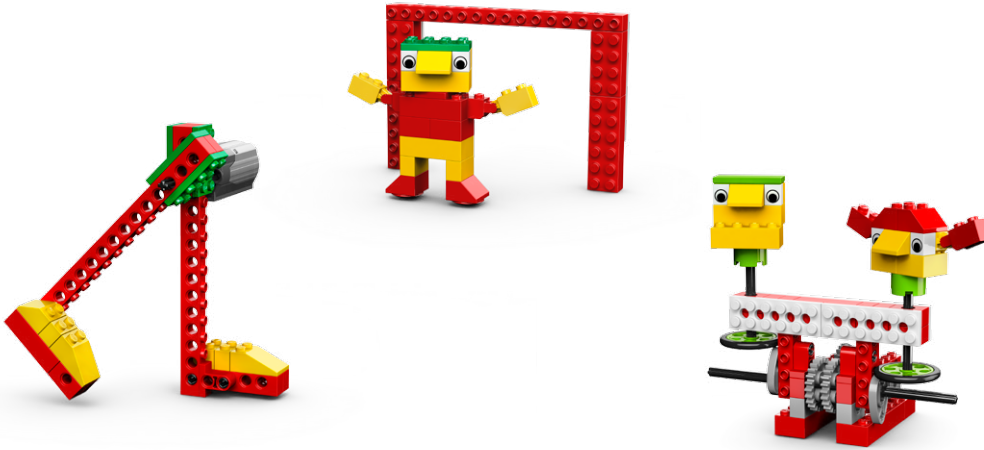
Wild Animals

The Wild Animals theme focuses on technology, emphasizing the concept of sensing and responding to external stimuli. In Hungry Alligator, students program the alligator to snap its jaw shut when the motion sensor sees something near its mouth. In Roaring Lion, students program the lion to sit up and then lie down and roar when it senses a bone. In Flying Bird, students program the tilt sensor to activate a flapping sound as they move the tail up and down, flapping the wings. They also program the motion sensor to activate a tweet sound when the bird tilts down to its feet.



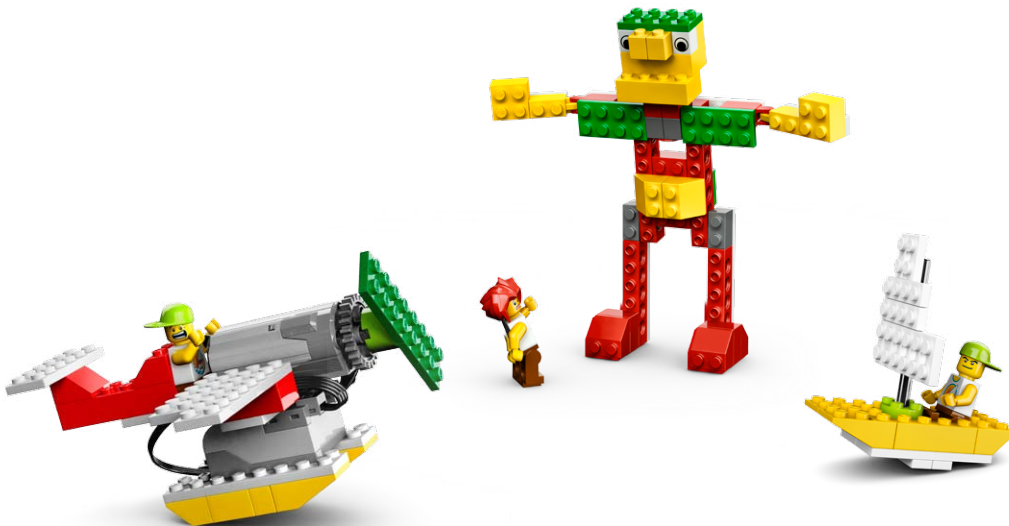
Play Soccer

The Play Soccer theme focuses on mathematics. In Goal Kicker, students measure the distance the kicking leg model kicks paper balls. In Goal Keeper, students calculate the number of blocks, goals, misses as they try to flick paper balls past a mechanical goal keeper. They also learn to program an automatic score keeping system. In Cheerful Fans, students apply a numerical rating system to judging the best performance in three subjective categories.



Adventure Stories

The Adventure Stories theme focuses on language using the model to dramatize events. In Airplane Rescue, students learn important interview questions: Who, What, Where, Why, and How and report a story of Max the LEGO® minifigure's airplane ride. In Giant Escape, students act out the dialogue, role-playing as Mia and Max wake the sleeping giant and must escape the forest. In Sailboat Storm, students describe the sequence of events as Max endures a thunderstorm at sea.



For more details about the specific curriculum objectives covered by each activity, see the Curriculum Grids.

Curriculum Grids

	1. Dancing Birds	2. Smart Spinner	3. Drumming Monkey	4. Hungry Alligator	5. Roaring Lion	6. Flying Bird	7. Goal Kicker	8. Goal Keeper	9. Cheerful Fans	10. Airplane Rescue	11. Giant Escape	12. Sailboat Storm
Science												
Scientific inquiry												
Conduct investigation												
Use tools to gather information												
Communicate investigations and explanations												
Fair testing												
Observation												
Reasoning												
Teamwork												
Transmission of motion												
Transfer of energy												
Lever												
Pulley												
Gear												
Compound gearing												
Friction												
Needs of living animals												
Use evidence to support conclusions												
Technology												
Program and create a working model												
Interpret 2D and 3D illustrations and models												
Compare natural systems with mechanical systems												
Demonstrate the knowledge and operation of digital tools and technological systems												
Use software media to acquire information												
Understand that animals use parts of their bodies as tools												
Use feedback to adjust a programming system output												
Apply principles of motion and other concepts in physical science												

	1. Dancing Birds	2. Smart Spinner	3. Drumming Monkey	4. Hungry Alligator	5. Roaring Lion	6. Flying Bird	7. Goal Kicker	8. Goal Keeper	9. Cheerful Fans	10. Airplane Rescue	11. Giant Escape	12. Sailboat Storm
Engineering												
Build, program and test models												
Modify a model's behavior by changing the mechanical system or by adding a sensor to provide feedback												
Brainstorm to find creative solutions												
Teamwork: Learn to communicate, share ideas and work together												
Mathematics												
Whole number relationships												
Use standard units												
Calculate using numbers with one or two place values												
Estimate												
Count												
Time in seconds and tenths of seconds												
Measure in centimeters or inches												
Measure "soft" qualitative variables												
Use simple counting variables												
Use random numbers between 1 and 10												
Use numbers to represent sounds, displays, distance, tilt value and other data												
Ratio of gear teeth and pulley diameter affects speed												
Cams affect frequency and timing of sound												
Relate numerical values to patterns of movement												
Organize lists or tables of information												
Organize and display data												
Analyze change in many contexts												
Language												
Communicate in spoken form using the appropriate vocabulary												
Use visual props to illustrate and dramatize your presentation												
Communicate in writing to explain information using the appropriate vocabulary												
Use interview questions to find out information												
Write a logical sequence of events												
Organize events to create a story, maintaining a focus on the characters and objects												
Write a script with a dialogue among three characters												
Use technology to create and communicate ideas												
Participate as knowledgeable, reflective members of the group and class												



LEGO® Education WeDo™ Software

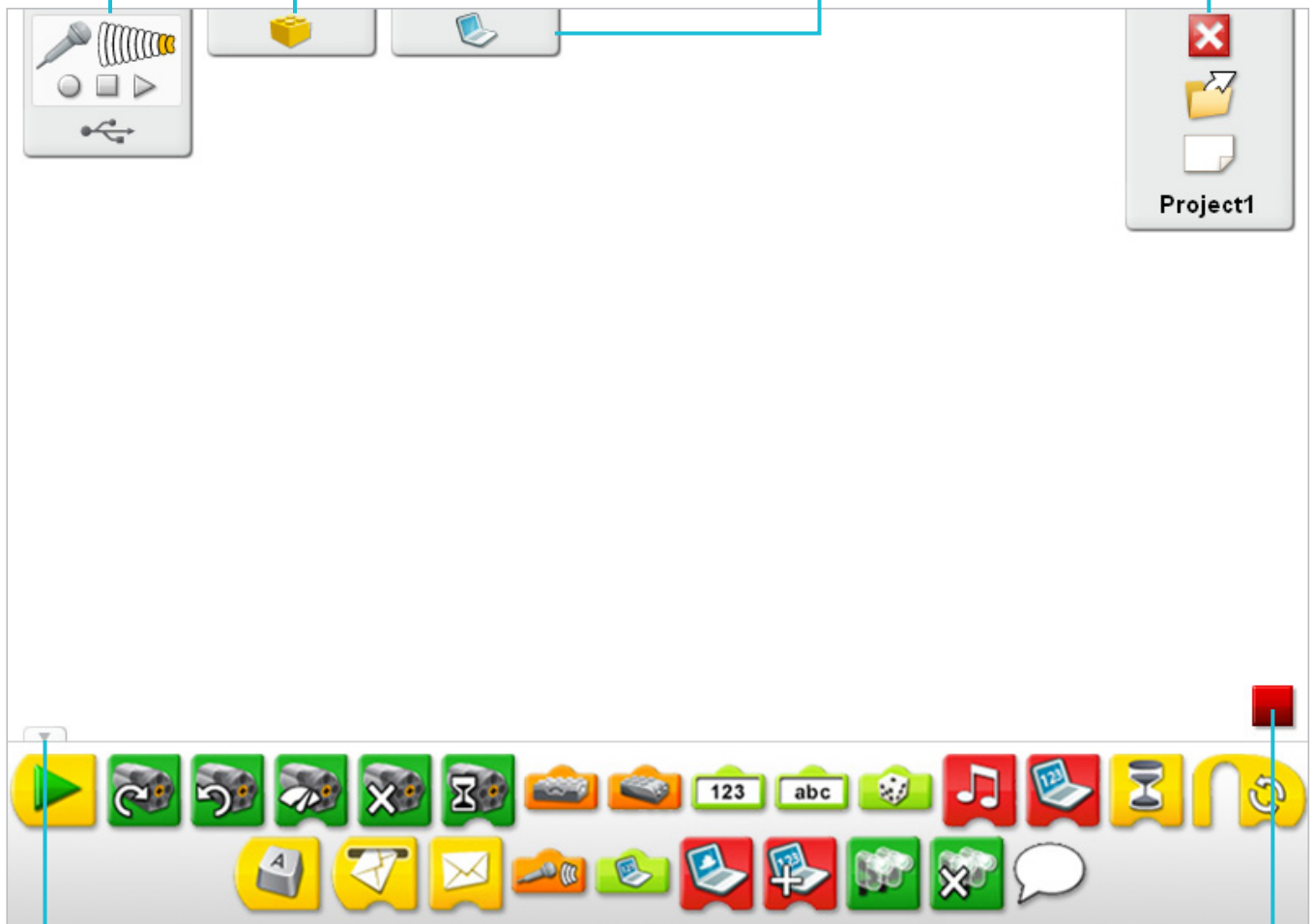
Overview

Connection Tab: Record your own sounds and view any Motors, Tilt Sensors or Motion Sensors.

Project Tab: Click to open the menu showing Exit, Open Project, New Project

Content Tab: Click to find Getting Started, the Activities, and your Browser.

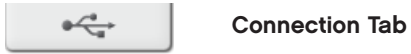
Display Tab: Opens when numbers, letters or backgrounds are programmed in Display Blocks.



Click the **Arrow button** to open the Palette. The Palette shows all of the programming Blocks.

Click the **Stop button** to stop programs and motors.

Vocabulary List



Connection Tab



Content Tab



Display Tab



Project Tab



Exit



Open



New



Stop



Palette [Closed]



Palette [Open]



Program

Vocabulary List



Start Block



Start On Key Press Block



Start On Message Block



Send Message Block



Wait For Block



Repeat Block



Motor This Way Block



Motor That Way Block



Motor Power Block



Motor On For Block



Motor Off Block



Light on



Light off



Play Sound Block



Display Block



Add to Display Block

Vocabulary List



Subtract from Display Block



Multiply by Display Block



Divide by Display Block



Display Background Block



Record Stop Play



Text Input



Number Input



Random Input



Display Input



Motion Sensor Input



Tilt Sensor Input



Tilt Up



Tilt Down



Tilt This Way



Tilt That Way



Any Tilt



Sound Sensor Input



Bubble

Sound List

This list shows the type of sound that is made when you use the Play Sound Block with the Number Input shown. Click the Play Sound Block to hear the sound. See Getting Started 8. Crossed Belts for help recording your own sound.

Hi

Croak

Kiss

Magic

Boing

Bubbles

Spin

Splash

Creak

Thunder

Cheer

Whistle

Zzz

Roar

Motor

Clonk

Crunch

Flap

Tweet

Laser

Background List

This list shows the type of background picture that appears on the LEGO® Education WeDo™ Software Canvas when you use the Display Background Block with the Number Input shown.



Shortcut List

This list shows keyboard shortcuts for working with the LEGO® Education WeDo™ Software.

Press **Escape** to stop motors and programs.

Hold the **Shift** key and left-click on a Block or an Input to label it.

Hold the **Ctrl** key and drag to select and copy Block(s).

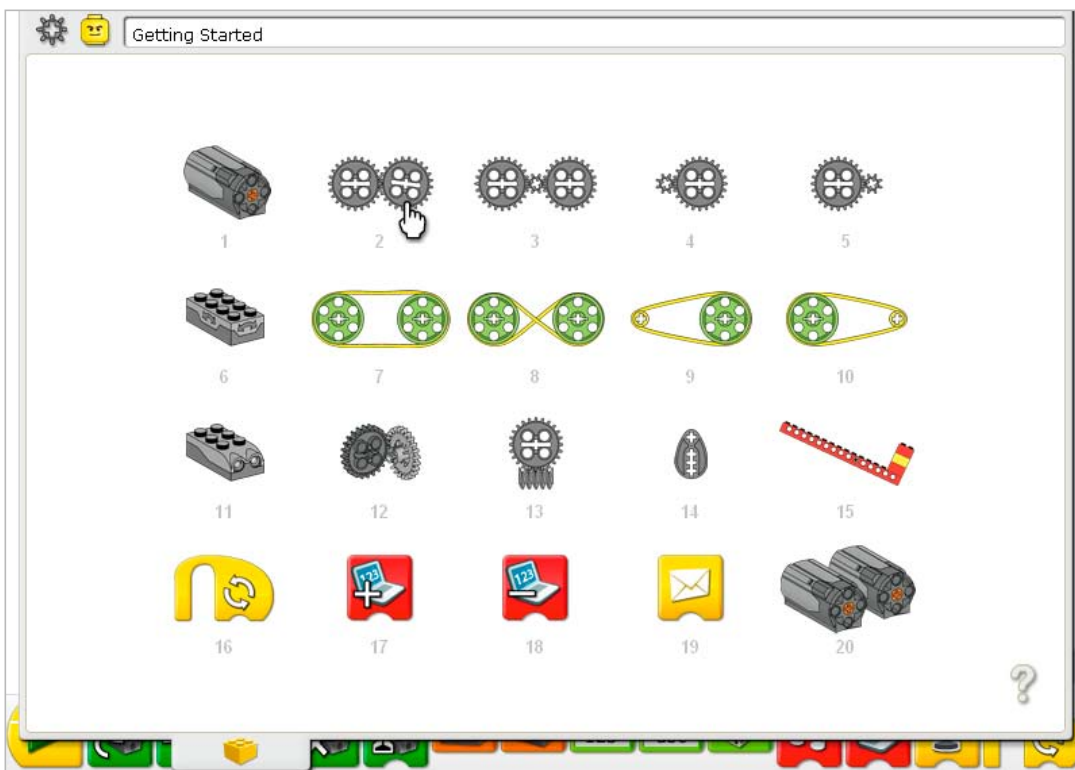


Getting Started

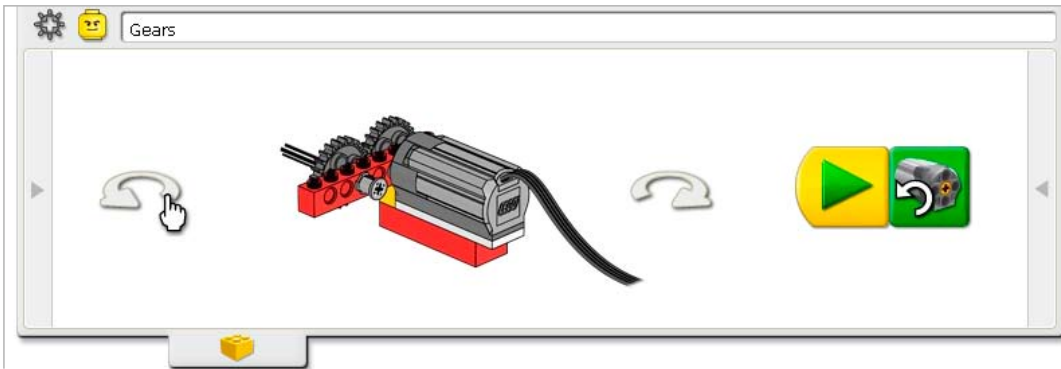
Overview

Getting Started shows fundamental building and programming ideas. These ideas are a useful reference for the themed Activities. Getting Started also provides examples that can be built and programmed as stand-alone lessons to aid students' understanding of science and programming concepts. See the section Lesson Planning Routes for more details about using Getting Started with the themed Activities.

From the LEGO® Education WeDo™ Software, click the Content Tab, then click the Gear button to see the Getting Started menu.

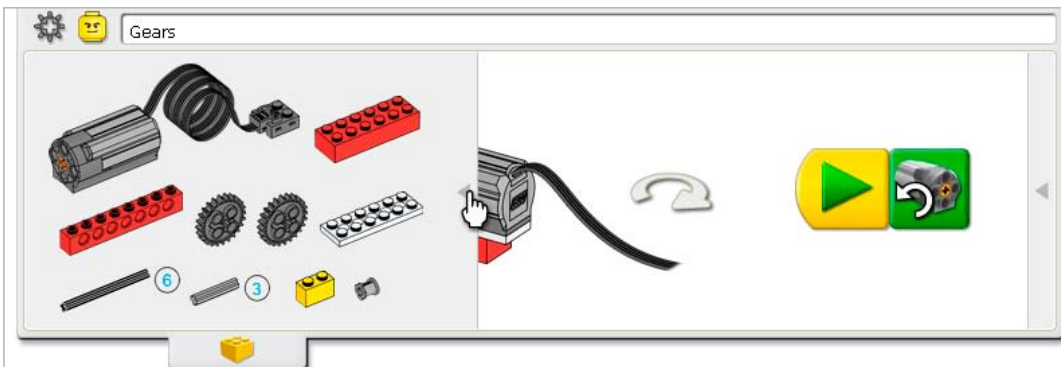


Click on a menu item to select it.

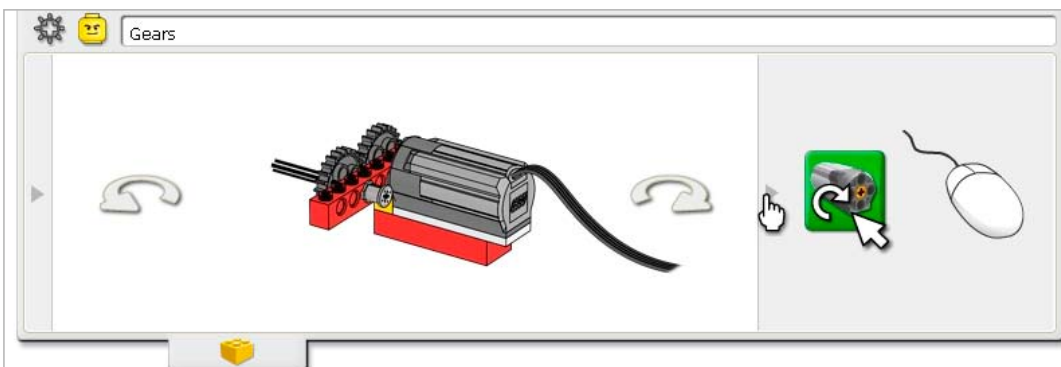


To rotate the model, click the arrows on the right or left.

The Content Tab is open halfway so you can create the program example yourself using the LEGO® Education WeDo™ Software Canvas below.

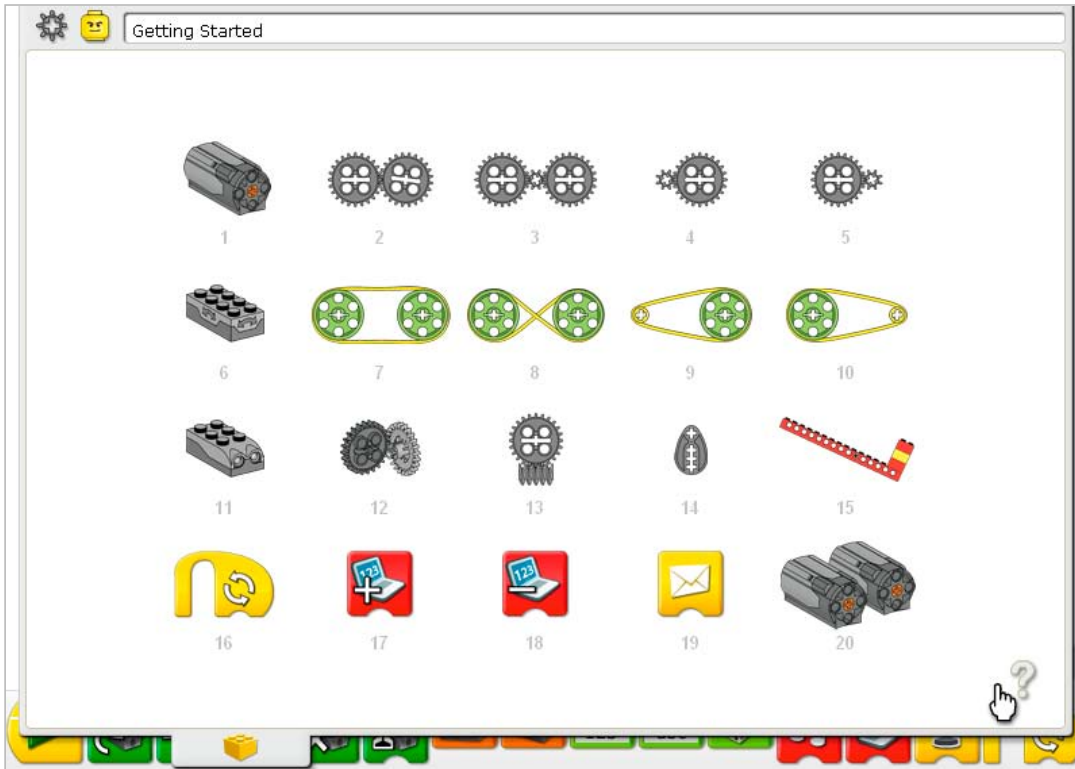


Click on the left side arrow to open the list of LEGO elements you need to build the model.

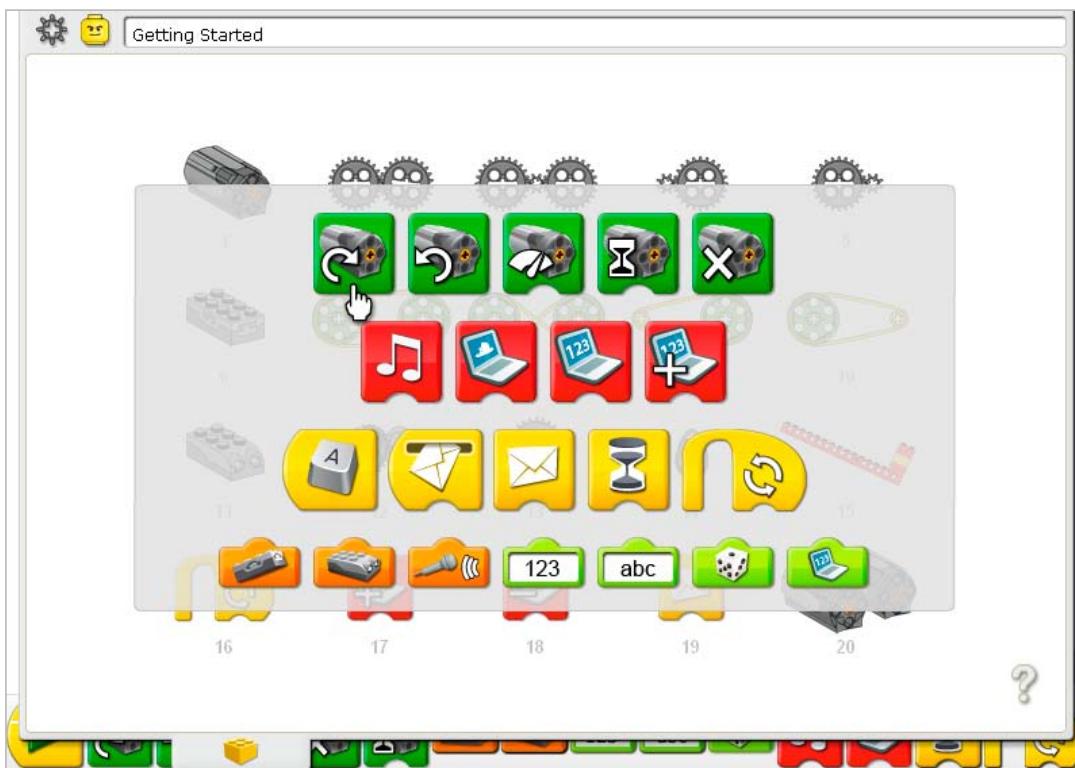


Sometimes a Programming Tip is included. Click on the right side arrow to open the Programming Tip.

Click the Gear button in the top left corner to go back to the Getting Started menu.



To focus on examples related to LEGO® Education WeDo™ Software Blocks, click on the question mark.



Then click on a Block to see in which menu items a Block is used.



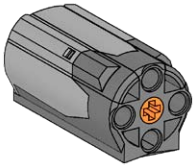
This example shows the menu items that use the Motor This Way Block.

Click to open a highlighted menu item.

Click the question mark to close the window.

See the Teacher Notes following for support using Getting Started in your classroom.

1. Motor and Axle



In Getting Started, click to select Motor and Axle.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor This Way.
- 4) Click the Start Block.
The motor moves. The axle turns.
- 5) To stop the program and turn off the motor, click the Stop button.



Discussion

What does the motor do?

Turns on and makes the axle move.

What does the Start Block do?

The Start Block is the beginning of the program. After you click the Start Block, the program starts running. In this example, the Motor This Way Block runs.

What does the Motor This Way Block do?

The Motor This Way Block turns on the motor in the clockwise direction.

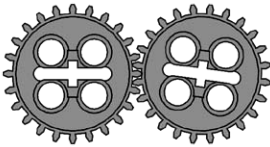
Click the Gear button in the top left corner to go back to Getting Started.

Programming Tip

Use Bubbles to add comments to your program. Click the Arrow button on the Palette to see all of the Blocks. Drag a Bubble from the Palette and drop it on the Canvas. Move the mouse over the Bubble and type your comment.

◀ If nothing happened...
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

2. Gears



In Getting Started, click to select Gears.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor That Way.
- 4) Click the Start Block.
The driver gear turns in the counterclockwise direction. The follower gear turns in the clockwise direction.
- 5) To stop the program and turn off the motor, click the Stop button.



Discussion

What does the motor do?

Turns on and makes the gears move.

What does the Motor That Way Block do?

The Motor That Way Block turns on the motor in the counterclockwise direction.

Move your hand to show the direction the first gear is turning. The first gear is called the driver gear. Why do you think it is called that?

It moves first and drives the ones after it to move also.

Move your other hand to show the direction the second gear is turning. The second gear is called the follower gear. Why do you think it is called that?

It is meshed with the first gear and must move whenever the first gear moves.

What do gears do?

They transmit motion from one gear to another: driver to follower.

Do these gears turn in the same direction or the opposite direction?

Opposite direction to one another. Gears that have teeth meshed together turn in the opposite direction.

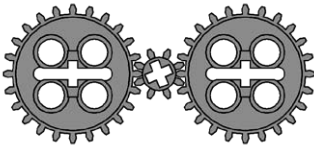
Click the Gear button in the top left corner to go back to Getting Started.

Programming Tip

You can change the Motor That Way Block to a Motor This Way Block by left-clicking on the Block after placing it on the Canvas.

- If nothing happened...**
- Is the motor wire attached to the LEGO Hub?
 - Is the LEGO Hub attached to the computer USB port?
 - Are the Blocks on the Canvas connected?

3. Idler Gear



In Getting Started, click to select Idler Gear.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor That Way.
- 4) Click the Start Block.
The driver gear (first 24-tooth gear) turns in the counterclockwise direction. The smaller, idler gear turns in the clockwise direction. The remaining 24-tooth gear turns in the counterclockwise direction.
- 5) To stop the program and turn off the motor, click the Stop button.



Discussion

Move your hand to show the direction the driver (the first 24-tooth) gear is turning.

It moves counterclockwise.

Look at how the other larger (24-tooth) gear is turning. Use both of your hands to show how the two larger gears are turning. Is it in the same direction?

Yes. The two larger (24-tooth) gears are turning counterclockwise.

Now look at the smaller gear in between. Use both of your hands to show in which direction the driver gear and smaller gear next to it are turning.

The driver gear is turning counterclockwise but the smaller gear is turning clockwise, the opposite direction.

Notice the speed that the three gears are turning. Which ones are turning at the same speed?

The two larger gears are turning at the same speed. The smaller gear turns faster.

The gear in between the two larger gears is acting as an idler gear. Idle means you are not doing productive work. Why do you think it might be called that?

The idler gear is only there to change the direction of the next gear. It is not changing the speed or force of the gears overall.

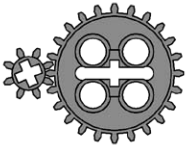
Click the Gear button in the top left corner to go back to Getting Started.

Programming Tip

You can change the Motor That Way Block to a Motor This Way Block by left-clicking on the Block after placing it on the Canvas.

◀ If nothing happened...
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

4. Gearing Down



In Getting Started, click to select Gearing Down.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor On For.
- 4) Click the Start Block.

The smaller, driver gear turns fast in one direction. The larger, follower gear turns more slowly in the other direction. The motor is turned on for one second.



Discussion

The first gear, the driver gear, turns faster than the second gear. Why does the second gear, the follower, turn slower?

The follower gear is larger so it only turns part of one rotation for each rotation of the driver gear.

Gears have teeth that are meshed together. As the driver gear turns, the meshing of the driver gear teeth with the follower gear teeth causes them to turn together. You can think of the gears as moving in “tooth-steps”. The driver gear has how many teeth?

8.

The follower gear has how many teeth?

24.

If the driver gear turns once, how many “tooth-steps” does the follower gear turn?

The follower gear turns only 8 tooth-steps because the gears are meshed together and the driver gear takes only 8 tooth-steps for one turn.

How many turns must the driver gear make in order to turn the follower gear one time?

3.

What do we call it when gears change speed from fast to slow?

Gearing down.

What does the Motor On For Block do?

It turns on a motor attached to the LEGO Hub for one second.

See Gearing Up for more information about gears and speed, and for information on changing the input value of the Motor On For Block.

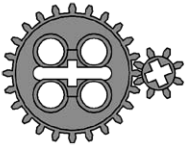
Click the Gear button in the top left corner to go back to Getting Started.

Programming Tip

You can change the input value by moving the mouse pointer over the Number Input and left-clicking to increase the value or right-clicking to decrease the value.

If nothing happened...
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

5. Gearing Up



In Getting Started, click to select Gearing Up.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor On For.
- 4) Move the mouse pointer over the 10 in the Number Input. Type 20.
The 10 changes to 20.
- 5) Click the Start Block. The larger driver gear turns in one direction.
The smaller follower gear turns faster in the other direction. The motor turns on for two seconds then turns off.



Discussion

What does the Motor On For Block 20 do?

The Motor On For Block with an input of 20 turns on the motor, keeps it on for two seconds, then turns it off.

How can you program the motor to turn on for three seconds? Try it!

Change the input to 30. For half of one second? Change the input to 5.

Why does the second gear, the follower, turn faster?

The follower gear is smaller so it must turn more times for each rotation of the driver gear.

Gears move using the meshed teeth. The first gear has how many teeth?

24.

The second gear has how many teeth?

8.

If the first gear turns once, how many “tooth-steps” does it take?

24.

So, how many “tooth-steps” must the second gear take to keep up?

It must take 24 tooth-steps because they are meshed together.

If the first gear turns once, how many turns must the second gear make?

3.

What do we name it when gears change speed from slow to fast?

Gearing up.

How much faster is the second gear “geared up”?

3 times faster.

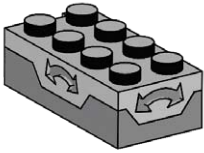
Click the Gear button in the top left corner to go back to Getting Started.

Programming Tip

You can change the Number Input value by moving the mouse pointer over the Input and typing in a new number.

◀ **If nothing happened...**
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

6. Tilt Sensor



In Getting Started, click to select Tilt Sensor.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the tilt sensor wire to the LEGO® Hub. It works on either port.
- 3) Click the Arrow button on the Palette to see all of the Blocks.
- 4) Drag and drop the Blocks from the Palette to the Canvas to build the program shown: Start, Display Background, Wait For, Display Background.
- 5) On the Wait For Block, drag and drop a Tilt Sensor Input on top of the Number Input.
The Tilt Sensor Input replaces the Number Input.
- 6) On the second Display Background Block, move the mouse pointer over the Number Input and type 2.
The Input changes to the number 2.
- 7) Click the Start Block.
The program opens the Display Tab and shows the first background. Then the program waits until you tilt the sensor upward and the Display Tab shows the second background.



Discussion

What does the tilt sensor do?

The tilt sensor tells the computer when it is pointed up, down or in other directions.

Which Blocks did you use to program the tilt sensor?

Wait For with a Tilt Sensor Input.

How does this program work?

The program shows a background in the Display Tab and then waits for someone to tilt the sensor upward. When the tilt sensor tilts upward, the program shows another background.

The tilt sensor can also be pointed in other directions. Click on the Tilt Sensor Input in your program to find out how many ways it can be tilted.

Six ways: Up, Down, This Way, That Way, No Tilt, Any Tilt.

Change your program to use a different Tilt Sensor Input.

Change the Tilt Sensor Input to any of these other options. Then when the program runs again, it will wait for the new tilt input direction before changing to another background.

For other ways to use the Display Block, see ideas in Lever and Motion Sensor.

See the LEGO Education WeDo™ Software section for the Background List showing the Backgrounds that are available.

Click the Gear button in the top left corner to go back to Getting Started.

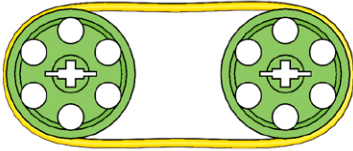
Programming Tip

You can change the Tilt Sensor Input to one of six positions: Up, Down, This Way, That Way, No Tilt, Any Tilt. Left-click on the Tilt Sensor Input to cycle through the six options.

If nothing happened...

- Is the tilt sensor wire attached to the LEGO Hub?
- Is the LEGO Hub attached to the computer USB port?
- Are the Blocks on the Canvas connected?
- Did you tilt the tilt sensor upward?

7. Pulleys and Belt



In Getting Started, click to select Pulleys and Belt.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor Power.
- 4) Move the mouse pointer over the number 10 in the Number Input. Type 5.
The 10 changes to a 5.
- 5) Click the Start Block to run the program.
The motor turns on at half of its normal speed. The power level range is from 0 to 10.
- 6) To stop the program and turn off the motor, click the Stop button.



Discussion

What happens when the motor turns on?

The pulley attached to the motor axle turns. That pulley turns the belt. The belt turns the second pulley. The motor is moving at a slower than normal speed. The normal speed is 10.

The first pulley is the driver pulley. The second pulley is the follower. Why might they be called that?

One pulley turns first in this example. It drives the movement of the second pulley which follows along.

Are the pulleys moving at the same speed or different speeds? Why?

The same speed because they are the same size (diameter). However, the belt drive does allow some slippage so they are not as precise as gears that are meshed together.

Are the pulleys moving the same direction or different directions?

The same direction.

How can you program the motor to turn on at a faster speed? Try it!

Change the 5 to a number between 6 and 10.

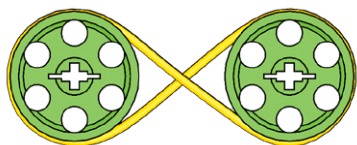
How can you program the motor to turn on at a slower speed? Try it!

Change the 5 to a number between 1 and 4. If you use zero (0) as an Input to Motor Power, the motor does not move.

Click the Gear button in the top left corner to go back to Getting Started.

- ◀ **If nothing happened...**
- Is the motor wire attached to the LEGO Hub?
 - Is the LEGO Hub attached to the computer USB port?
 - Are the Blocks on the Canvas connected?

8. Crossed Belt



In Getting Started, click to select Crossed Belt.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown: Start, Motor Power, Play Sound.
- 4) Move the mouse pointer over the Number Input to Motor Power and type 1.
The 10 changes to 1.
- 5) Click the Start Block to run the program.
The motor turns on at a slow speed and the pulleys turn. Sound 1, the Hi sound plays.
- 6) To stop the program and turn off the motor, click the Stop button.
- 7) Now record your own sound to use in programs. Click Record in Connection Tab.
- 8) Click Stop in the Connection Tab to stop recording. The sound you created is automatically saved as Sound 1, replacing the Hi sound.
- 9) Test the sound by clicking Play.
- 10) Click the Start Block to run the program again.
The motor turns on, the pulleys turn, and Sound 1, your recorded sound, plays.



Discussion

What happens when the motor turns on?

The pulley attached to the motor axle turns. That pulley turns the belt. The belt turns the second pulley.

Are the pulleys moving at the same speed or different speeds? Why?

The same speed because they are the same size (diameter). However, the belt drive does allow some slippage so they are not as precise as gears that are meshed together.

Are the pulleys moving the same direction or different directions?

The opposite direction. Crossing the belt changes the direction of the second pulley.

For how long is the motor on?

The motor turns on and stays on until you click the Stop button.

There are many programmed sounds to choose from. Click on the Number Input of the Play Sound Block and type a number between 1 and 20 to choose a different sound.

The sound changes when the program runs. Some sounds are on longer or shorter than other sounds.

See the LEGO Education WeDo™ Software section for the Sound List showing the sounds that are available.

Compare the pulley movement in this Crossed Belt example to the pulley movement in the Pulleys and Belt activity.

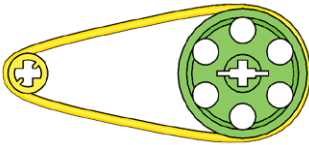
Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

You can record a custom sound in the Connection Tab. Click Record to start recording. Then speak or make a sound. Click Stop to end your recording. Click Play to hear your recording. To include your recording in a program, drag and drop the Play Sound Block and make sure the Number Input is 1.

◀ **If nothing happened...**
Does the microphone appear in the Connection Tab? You must have a microphone to record sound.
Are your speakers turned on? You must have speakers to hear sounds.
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

9. Decrease Speed



In Getting Started, click to select Decrease Speed.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor This Way, Wait For, Motor Off.
- 4) Click the Start Block to run the program.
The motor turns on this way. The program waits for one second then turns off the motor.



Discussion

What happens when the motor turns on?

The first, smaller pulley attached to the motor axle turns. That pulley turns the belt. The belt turns the second, larger pulley.

Are the pulleys moving at the same speed or different speeds? Why?

Different speeds because they are a different size (diameter). The larger pulley turns slower than the smaller pulley.

Are the pulleys moving the same direction or different directions?

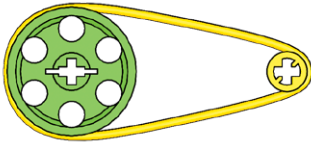
The same direction.

Compare the pulley movement in this example to the pulley movement in the Increase Speed, Pulleys and Belt, and Crossed Belt examples.

Click the Gear in the top left corner to go back to Getting Started.

If nothing happened...
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

10. Increase Speed



In Getting Started, click to select Increase Speed.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor This Way, Play Sound, Motor Off.
- 4) Move the mouse pointer over the Number Input of the Play Sound Block and type 6. The Input changes from 1 to 6.
- 5) Click the Start Block to run the program.

The motor turns on this way, your chosen sound plays then the motor turns off.



Discussion

What happens when the motor turns on?

The larger pulley attached to the motor axle turns. That pulley turns the belt. The belt turns the second, smaller pulley.

Are the pulleys moving at the same speed or different speeds? Why?

Different speeds because they are a different size (diameter). The smaller pulley turns faster than the larger pulley.

Are the pulleys moving the same direction or different directions?

The same direction.

For how long is the motor on?

The motor is on as long as the sound plays. Then it turns off.

Compare the pulley movement in this example to the pulley movement in the Increase Speed, Pulleys and Belt, and Crossed Belt activities.

See how to record your own sound for the Play Sound Block in the Crossed Belt activity.

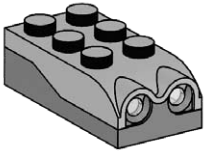
See the LEGO Education WeDo™ Software section for the Sound List showing the sounds that are available.

Click the Gear in the top left corner to go back to Getting Started.

If nothing happened...

Are your speakers turned on? You must have speakers to hear sounds. Is the motor wire attached to the LEGO Hub? Is the LEGO Hub attached to the computer USB port? Are the Blocks on the Canvas connected?

11. Motion Sensor



In Getting Started, click to select Motion Sensor.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motion sensor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown: Start, Wait For, Display.
- 4) Drag and drop a Motion Sensor Input on top of the Number Input that was automatically attached to the Wait For Block. The Motion Sensor Input replaces the Number Input.
- 5) Click the Start Block. Then move your hand in front of the motion sensor.
The program waits to see your hand then displays abc.



Discussion

What does a motion sensor do?

It sees objects or movement and reports to the computer.

What is the Display Block programmed to show?

The Display Block in this program shows the letters abc. It can also be programmed to show other words or numbers. See the Programming Tip.

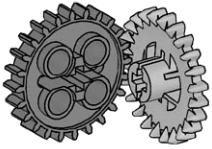
Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

You can change the Text Input contents by moving the mouse pointer over the Input and typing in new text.

◀ If nothing happened...
Is the motion sensor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

12. Crown Gear



In Getting Started, click to select Crown Gear.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Click the Arrow button on the Palette to see all of the Blocks.
- 4) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Motor On For.
- 5) Drag and drop the Sound Sensor Input on top of the Number Input that was automatically attached to the Motor On For Block.
The Sound Sensor Input replaces the Number Input.
- 6) Click the Start Block to run the program.
The motor turns on until you clap your hand or make a loud sound.



Discussion

There are two gears. One has bent teeth and is called a Crown Gear. Why are the teeth bent?

The bent teeth allow the gears to be meshed at a 90° angle.

Are these gears moving at the same speed or different speeds?

The same speed because they are the same size (number of teeth). Each gear has 24 teeth.

What makes the motor turn on and turn off in this program?

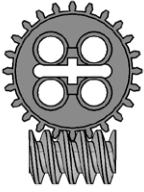
The Motor On For Block turns on the motor and waits for input from the Sound Sensor. The Sound Sensor "listens" for a sound. When it hears a sound, the Motor Block turns off the motor.

Compare the gear movement in this activity to the gear movement in the Gears, Idler Gear, Gearing Up, and Gearing Down activities.

Click the Gear in the top left corner to go back to Getting Started.

◀ If nothing happened...
Does a microphone appear in the Connection Tab? You must have a microphone to use the Sound Sensor Input.
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

13. Worm Gear



In Getting Started, click to select Worm Gear.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Click the Arrow button on the Palette to see all of the Blocks.
- 4) Drag and drop the Blocks from the Palette to the Canvas to build both of the programs shown:
Start On Key Press, Motor This Way, Start On Key Press, Motor That Way.
- 5) Move the mouse pointer over the second Start On Key Press Block and type **B**.
- 6) Press **A** on the keyboard to run one program. Press **B** on the keyboard to run the other.
Pressing A turns on the motor clockwise. Pressing B turns on the motor counterclockwise.
- 7) To stop the program and turn off the motor, click the Stop button.



Discussion

This model combines a 24-tooth gear and a worm gear inside a clear housing. Which gear is moving faster? (You may wish to add a green 2x2 round brick on the end of the worm gear axle to more easily see it turn.)

The worm gear is moving much faster than the 24-tooth gear.

The worm gear is like a 1-tooth gear. For each complete rotation of the worm gear the 24-tooth gear advances by one tooth. How many times must the worm gear rotate in order to make the other gear rotate one time?

The worm gear must rotate 24 times in order to make the 24-tooth gear rotate once.

Notice also that the 24-tooth gear axle is perpendicular to the worm gear axle. So what two changes do the worm gear make in this machine?

The worm gear slows the speed and changes direction of any gear meshed with it.

What controls the motor in this program?

The Start On Key Press Blocks act as Start Blocks that only start a program when a specific key on the keyboard is pressed. The Start On Key Press A Block turns on the motor clockwise when A is pressed. The Start On Key Press B Block turns on the motor counterclockwise when the B key is pressed.

Compare the gear movement in this example to the gear movement in the Gears, Idler Gear, Gearing Up, Gearing Down, and Crown Gear examples.

Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

You can change the character used with the Start On Key Press Block. Move the mouse pointer over the Start On Key Press Block and type the character you want to use. Number keys and arrow keys can also be used.

◀ **If nothing happened...**
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

14. Cam



In Getting Started, click to select Cam.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor wire to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Repeat, Motor Power, Motor On For.
The Repeat Block automatically expands to fit the Motor Power and Motor On For Blocks.
- 4) Drag and drop a Random Input on top of the Number Input that was automatically attached to the Motor Power Block.
The Random Input replaces the Number Input.
- 5) Click the Start Block to run the program.
The motor turns at a random power level between 1 and 10 for one second. Then it repeats and the power level changes again.
- 6) To stop the program and turn off the motor, click the Stop button.



Discussion

This model and program show two ways to design surprising behavior. First, the model uses a cam. The cam is not round — it is shaped like an egg (an ellipse). Look at the model as it moves. What happens to the wheel on top of the cam each time the cam rotates?

As the cam turns, the wheel that is resting on top of it moves up and down following the cam's shape. So the cam creates a bobbing movement up and down in the other wheel and axle as the cam turns.

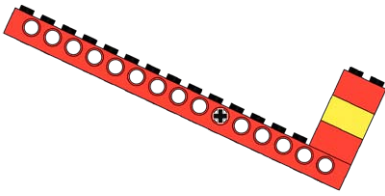
A second surprising behavior can be programmed. Random Input varies from one to ten. How is the Random Input used to program your model?

The program changes the power level of the motor using the Random Input. So the motor speed goes up and down based on a random number between 1 and 10. The change in speed causes the cam movement to speed up or slow down every second.

Click the Gear in the top left corner to go back to Getting Started.

If nothing happened...
Is the motor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

15. Lever



In Getting Started, click to select Lever.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the tilt sensor to the LEGO® Hub. It works on either port.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Repeat, Display.
- 4) Drag and drop a Tilt Sensor Input on top of the Number Input that was automatically attached to the Display Block.
The Tilt Sensor Input replaces the Number Input.
- 5) Click the Start Block and move the arm of the lever by pressing down on the green brick.
The Display Tab shows a numeric value equal to the position of the tilt sensor. As you move the lever arm, the numeric value of the tilt sensor changes in the Display Tab.
- 6) To stop the program, click the Stop button.



Discussion

The lever is a simple machine. The main parts are the effort arm (the place at which you press down), the load or resistance (what is being lifted), and the pivot point (the point at which the effort and load spin around). Show these parts on your model.

The effort arm is the end with the green brick. The load arm is the end with the three bricks stacked up. The bricks are the load. The pivot point is at the axle.

Change the position of the pivot point so the effort arm is shorter. Is the load easier or harder to lift?

Harder. The shorter the effort arm, the harder a load is to lift.

Change the position of the pivot point so the effort arm is longer. Is the load easier or harder to lift?

Easier. The longer the effort arm, the easier a load is to lift.

How does this program work?

The program shows the input from the tilt sensor in the Display Tab. The program repeats, constantly updating the numeric value displayed as the tilt sensor changes position.

Click the Gear in the top left corner to go back to Getting Started.

To see more ideas for programming with the Tilt Sensor and Display Tab, see Tilt Sensor in Getting Started.

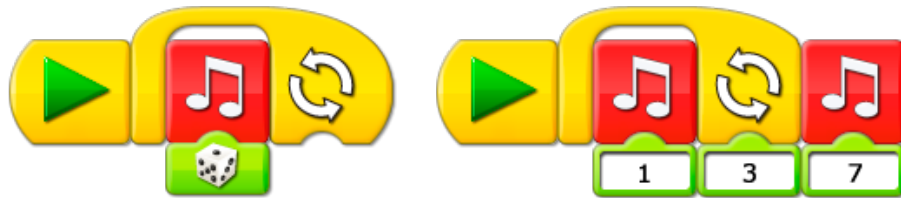
If nothing happened...
Is the tilt sensor wire attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?

16. Repeat Block



In Getting Started, click to select Repeat Block.

- 1) Build the first program shown. Drag and drop the Blocks from the Palette to the Canvas: Start, Repeat, Play Sound.
- 2) Drag and drop a Random Input on to the top of the Number Input that was automatically attached to the Play Sound Block.
The Random Input replaces the Number Input.
- 3) Click the Start Block to run the first program.
The program plays a random sound between 1 and 10. Then it repeats.
- 4) To stop the program, click the Stop button.
- 5) Build the second program shown. Drag and drop the Blocks from the Palette to the Canvas: Start, Repeat, Play Sound, and Play Sound again.
- 6) Drag and drop a Number Input to the end of the Repeat Block.
The Repeat Block changes shape.
- 7) Move the mouse pointer over the Number Input and type 3.
- 8) On the Play Sound Block after the Repeat Block, move the mouse pointer over the Number Input and type 7.
- 9) Click the Start Block to run the second program.
The program plays Sound 1, the Hi sound, repeating it three times. Then the program plays Sound 7, the Spin sound.



Discussion

What is the difference between a Repeat Block without an input and a Repeat Block with an input?

A Repeat Block without an input repeats forever. You must use the Stop button to stop the program. A Repeat Block with an input repeats only the number of times specified then continues the program.

How does Random Input change the sounds that are played?

The Play Sound Block plays sounds programmed in the LEGO® Education WeDo™ Software. Sounds are identified by a number. Using Random Input, you can play any sound between 1 and 10.

Note: there are more than 10 sounds that can be programmed using Play Sound; however, Random Input only handles a range between 1 and 10.

See the LEGO Education WeDo Software section for the Sound List showing the sounds that are available.

Click the Gear in the top left corner to go back to Getting Started.

If nothing happened...
Are your speakers turned on? You must have speakers on to hear sounds.
Are the Blocks on the Canvas connected?

17. Add to Display



In Getting Started, click to select Add to Display.

- 1) Click the Arrow button on the Palette to see all of the Blocks.
- 2) Drag and drop the Blocks from the Palette to the Canvas to build the program shown:
Start, Display, Repeat, Wait For, Add to Display.
- 3) Click the Start Block to run the program.
The program resets the Display to 0. The program waits for 1 second. Then the Add to Display Block adds 1 to the Display. The program repeats, adding 1 to the Display each time it repeats.
- 4) To stop the program, click the Stop button.



Discussion

This program counts up by 1s. How can you program it to count up by 2s? Or 5s? Or 10s? Try it!
Change the Add to Display Input from 1 to 2, or 5, or 10.

What does the Display Block with the Number Input 0 do? What happens if you don't have it in the program?

When you run the program, it resets the Display to 0. If it is not in the program, the counting will never restart at 0.

Why does the program need to repeat in order to count up?

Each time the program repeats, it adds 1 to the Display. If it doesn't repeat, the count stays at 1.

What are some ways to use a counting program?

E.g., a scoreboard for a game, a tally for people entering a door.

Note: You can set the program to repeat a specific number of times. See Getting Started Repeat Block for an example.

Click the Gear in the top left corner to go back to Getting Started.

If nothing happened...
Are the Blocks on the Canvas connected?
Is the Display Block with zero input outside the Repeat Block?

18. Subtract from Display



In Getting Started, click to select Subtract from Display.

- 1) Click the Arrow button on the Palette to see all of the Blocks.
- 2) Drag and drop the Blocks from the Palette to the Canvas to build both of the programs shown: Start On Key Press, Add to Display, Motor Power, Start On Key Press, Add to Display, Motor Power.
- 3) On the second program, move the mouse pointer over the Start On Key Press Block and press **B** on the keyboard.
The Start On Key Press Block changes from A to B.
- 4) On the second program, left-click on the Add to Display Block to change it to Subtract from Display.
The Input to Subtract from Display is 1 so this Block will now take 1 away from the value in the Display Tab instead of adding 1.
- 5) For both programs, drag and drop the Display Input onto the Number Inputs that were automatically attached to the Motor Power Blocks.
The Inputs for both Motor Power Blocks are set to become whatever number is in the Display Tab.
- 6) Press **A** on the keyboard to run the first program. Press **B** on the keyboard to run the second.
The first program adds 1 to the Display Tab. The second program subtracts 1 from the Display Tab. The Motor Power Block turns on the motor at the power level equal to value in the Display Tab each time A or B is pressed.
- 7) To stop the programs and turn off the motor, click the Stop button.



Discussion

This program counts up and down by 1s. How can you program it to count up or down by 2s? Or 5s? Or 10s? Try it!

Change the Subtract from Display Input from 1 to 2, or 5, or 10.

Why do the programs need to repeat in order to add or subtract?

Each time one of the programs repeats, it adds or subtracts 1 from the Display Tab count. If the program doesn't repeat, then each program will only run once and you cannot add or subtract more than 1.

What are some ways to use a counting program?

E.g., countdown for a rocket launch, count down for a Top Ten list.

Note: You can set the program to repeat a specific number of times. See Getting Started Repeat Block for an example.

Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

You can change Add to Display to Subtract from Display, Multiply by Display, or Divide by Display. Place an Add to Display Block on the Canvas. Left-click on the Block to cycle through the four options.

If nothing happened...

- Is the motor wire attached to the LEGO® Hub?
- Is the LEGO Hub attached to the computer USB port?
- Are the Blocks on the Canvas connected?

19. Start On Message



In Getting Started, click to select Start On Message.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the motor to the LEGO® Hub. It works on either port.
- 3) Click the Arrow button on the Palette to see all of the Blocks.
- 4) Drag and drop the Blocks from the Palette to the Canvas to build both of the programs shown: Start, Send Message, Play Sound, Start On Message, Motor On For.
- 5) On the Motor On For Block, move the mouse pointer over the Number Input and type 20.
The input changes from 10 to 20.
- 6) On the Play Sound Block, move the mouse pointer over the Number Input and type 14, the Roar sound.
The input changes from 1 to 14.
- 7) Click the Start Block to run the first program.
The first program sends the message abc and plays a sound. The second program receives the message abc and turns on the motor for two seconds.



Discussion

Why is Start On Message useful?

Start On Message can be used as a “remote” start for another program. It can also be used to run several different programs at the same time.

What can be sent as a message? Try some ideas!

Both numbers and letters can be included in the message sent.

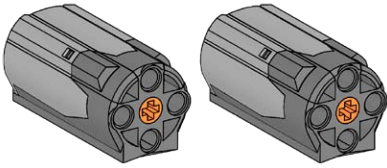
Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

You can also send messages from your computer to other computers. On your computer, use the Send Message Block to send a message. Make sure the other computers have Start On Message Blocks programmed to receive the same message.

If nothing happened...
Are the motor wires attached to the LEGO Hub?
Is the LEGO Hub attached to the computer USB port?
Are the Blocks on the Canvas connected?
Is your Send Message the same as your Receive Message?

20. Labeling



In Getting Started, click to select Labeling.

- 1) Build the model shown. Click the arrows on the right or left to rotate it.
- 2) Attach the two motor wires to the two ports on the LEGO® Hub.

Notice that both of the motors can be seen in the Connection Tab. One of the motors is shown with one dot indicating that it was the first motor attached. The other motor is shown with two dots indicating it was the second motor attached.
- 3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown: Start, Motor On For, Motor On For, Motor On For.
- 4) Label the first Motor On For Block. Press and hold the keyboard Shift key and left-click on the Block.

A dot appears above the first Motor On For Block showing that only the first motor attached to the LEGO Hub will turn on.
- 5) Label the second Motor On For Block. Press and hold the keyboard Shift key and left-click twice on the Block.

Two dots appear above the second Motor On For Block showing that only the second motor attached to the LEGO Hub will turn on.
- 6) Leave the third Motor On For Block without a label.

No dots appear over the third Motor On For Block showing that both motors will turn on.
- 7) Click the Start Block to run the program.

The first motor turns on for one second. The second motor turns on for one second. Then both motors turn on for one second.



Discussion

Why is Labeling useful?

Using Labeling, two motors or two of the same sensors can be attached to the LEGO Hub but can be programmed separately.

Click the Gear in the top left corner to go back to Getting Started.

Programming Tip

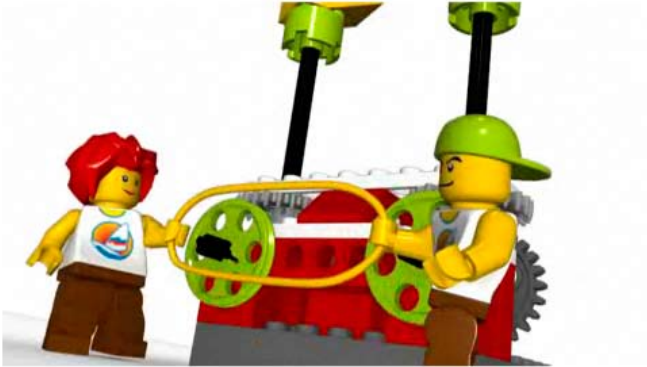
You can label Motor Blocks and Sensor Inputs. To label a Block or an Input, press and hold the keyboard Shift key while left-clicking. Click once to label with 1 dot. Click again to label with 2 to 6 dots and click again to remove the label.

If a Motor Block is not labeled, it affects all connected motors. If a Sensor Input is not labeled, it waits for one of the connected sensors or outputs the sum of all the Sensor Inputs. You can use a maximum of three LEGO Hubs (6 motors or sensors) at the same time.

If nothing happened...
 Are the motor wires attached to the LEGO Hub on separate ports?
 Is the LEGO Hub attached to the computer USB port?
 Are the Blocks on the Canvas connected?

⚙️ 😊 Dancing Birds

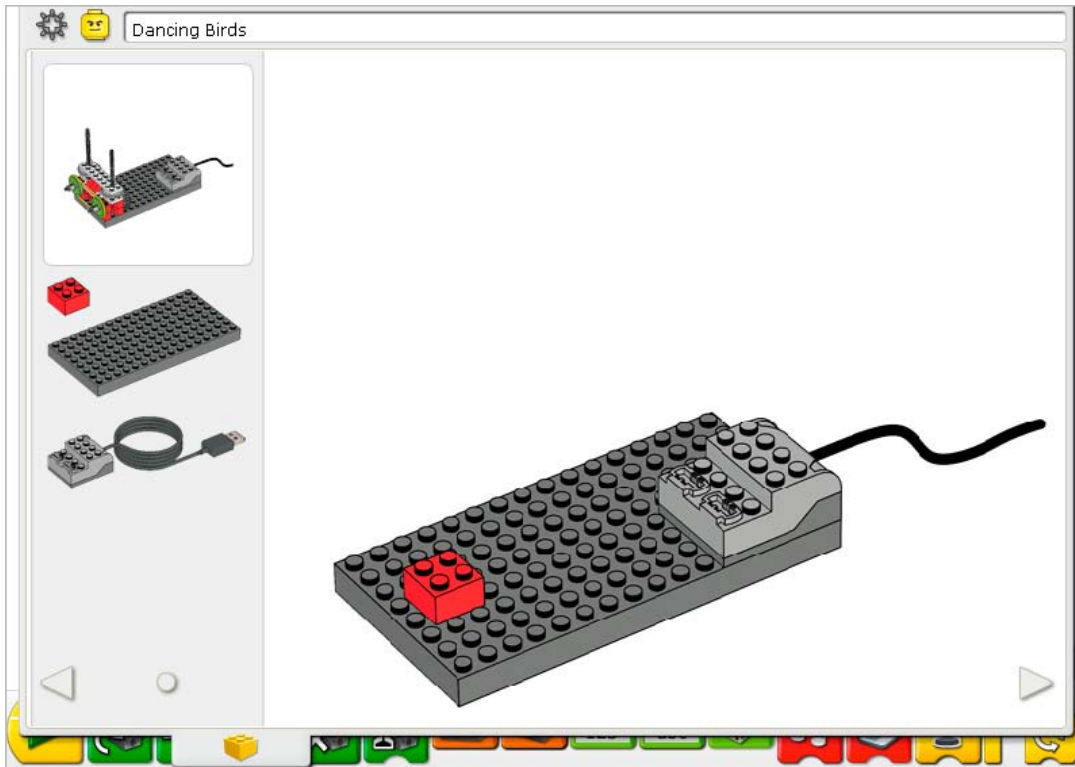
Connect



Mia and Max play with the dancing birds.
Can you create dancing birds that spin in different ways?

◀️ ● ▶️

The movie starts automatically. Click on the movie to see it again.
Click the right arrow to go to the next step.



On the building instructions pages, the elements you need for each step are shown on the left.

Click the right arrow to go to the next step. Click the left arrow to go the previous step. You can also click and drag the ball to move more quickly to a page.



Teacher Notes for the Activities: Amazing Mechanisms





1. Dancing Birds Teacher Notes

Students will build and program two mechanical birds that make sounds and are motorized to dance using a pulley and belt drive system.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine. Identify the pulleys and belt drive mechanism, and the effect changing the belt has on the direction and speed of the dancing birds' movement.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the dancing birds' movement.

Modify the dancing behavior by changing the pulleys and belt to affect the speed and direction of motion.

Mathematics

Understand how the diameter of the pulleys affects the speed of the dancing birds' movement.

Compare the diameter and rotational speed as a ratio.

Understand and use numbers to represent the amount of time the motor is turned on in seconds and in tenths of seconds.

Language

Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

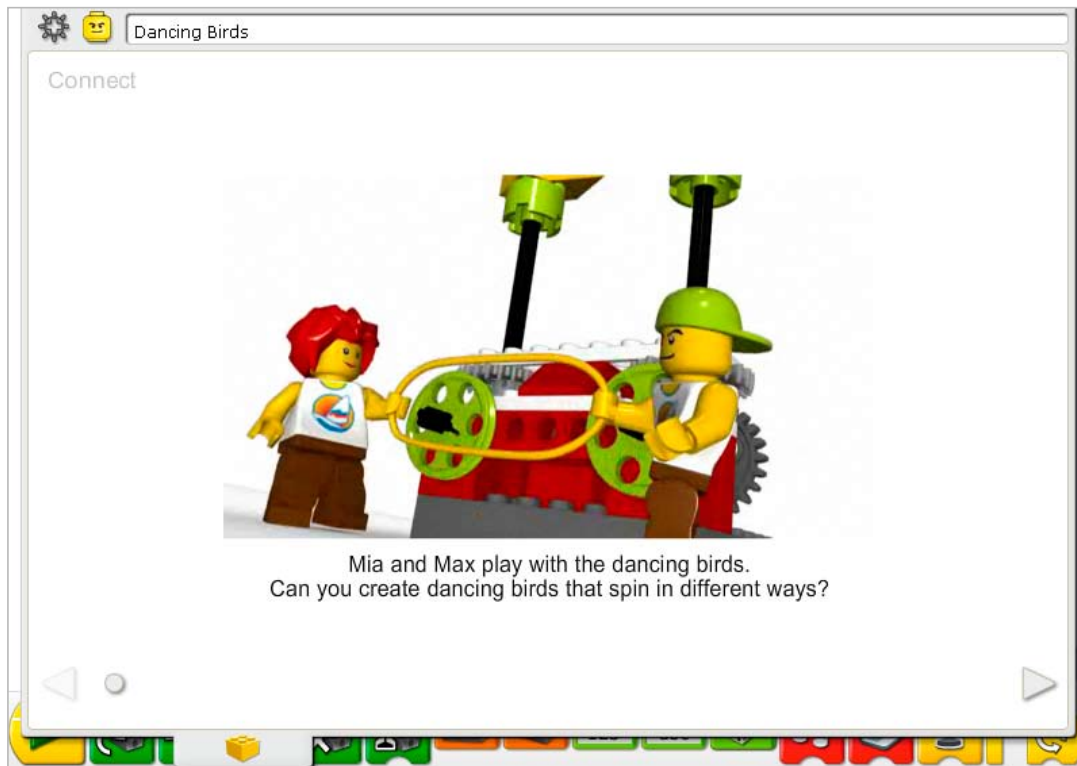
Belt, pulley, and random. Blocks: Motor Power, Motor This Way, Motor That Way, Random Input, Play Sound, Repeat, Start, and Wait For.



Connect

Review the Connect animation and discuss:

What do Mia and Max see when they look at the birds turning?
Can the birds go in the same direction? Opposite directions?
What is making the birds move?



Here are other ways of connecting:

Split into teams of three. Place two students inside a hula hoop or in a long rope tied together to form a circle. Hold onto the hoop or rope. The third student pushes the hoop or one of the students inside the circle to make them turn. What happens to the other student inside the hoop? That student turns the same direction.

Did you know...

The dancing birds are moving because they are connected with pulleys and a belt? See the models in Getting Started:

7. Pulleys and Belt
8. Crossed Belt
9. Decrease Speed
10. Increase Speed

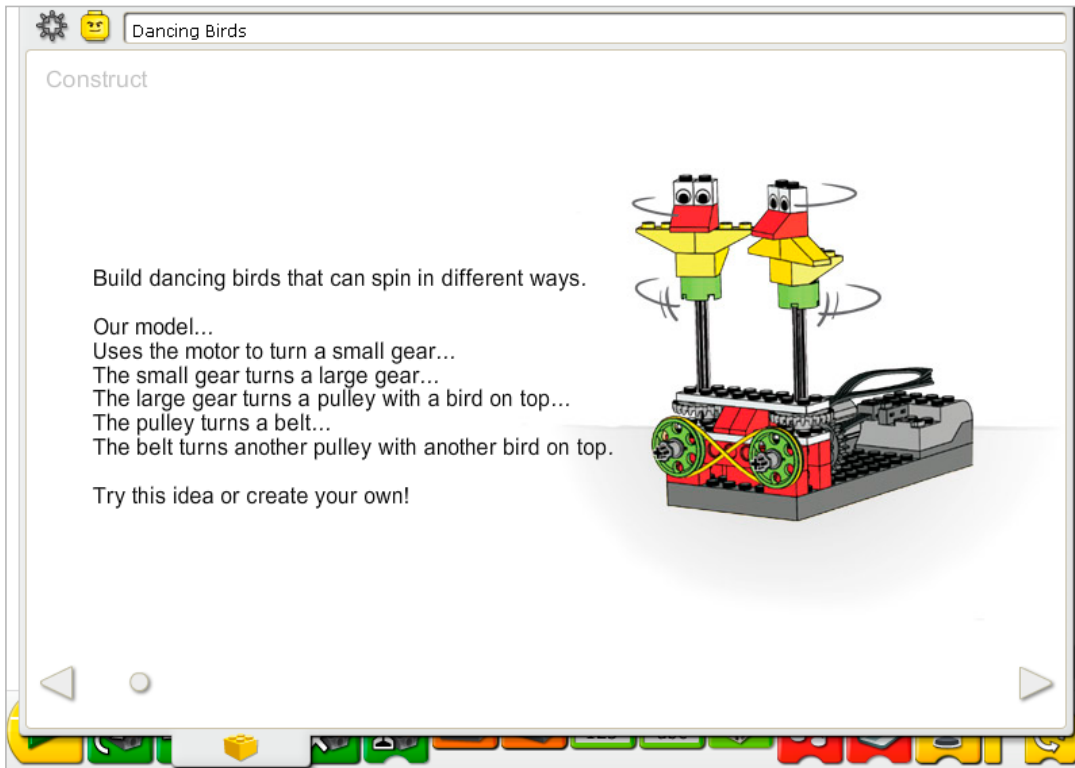
How can you reverse the direction of one of the pulleys?

Cross the belt.

How do you make one pulley spin faster than the other?

Change one pulley to a pulley with a smaller diameter.

Construct



Construct

Build dancing birds that can spin in different ways.

Our model...

- Uses the motor to turn a small gear...
- The small gear turns a large gear...
- The large gear turns a pulley with a bird on top...
- The pulley turns a belt...
- The belt turns another pulley with another bird on top.

Try this idea or create your own!

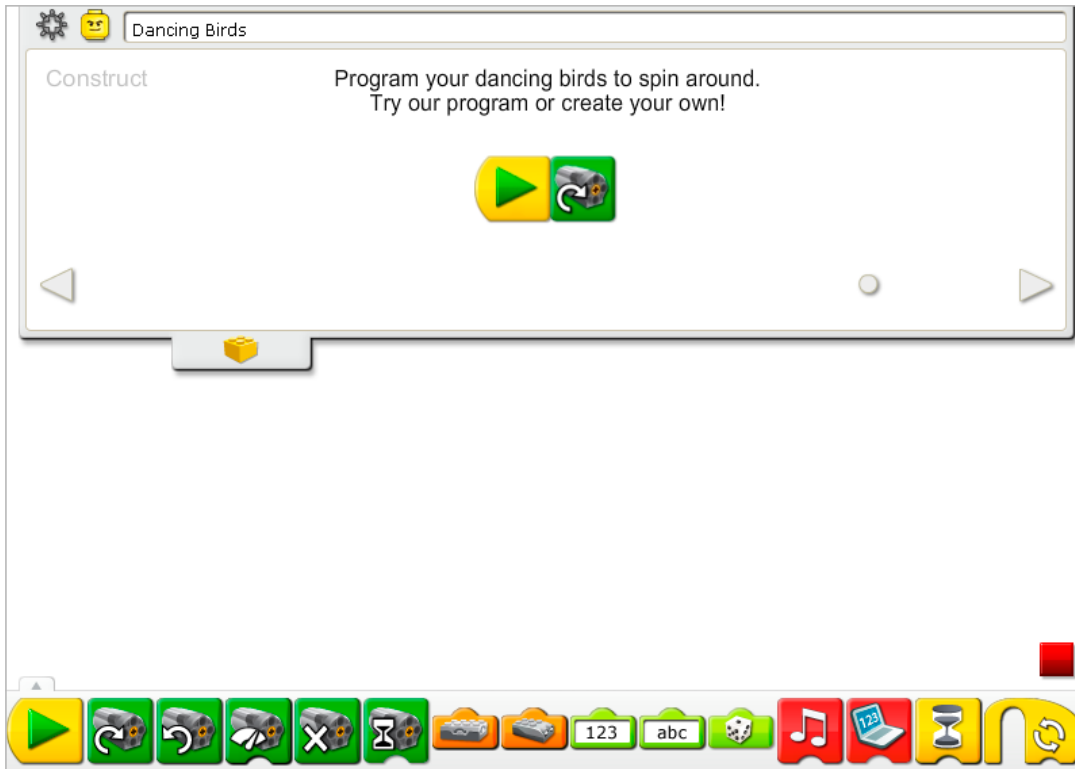
The screenshot shows a software window titled "Dancing Birds" with a "Construct" tab. It features a 3D model of a LEGO robot with two dancing birds on top. The birds are yellow and red, and they are spinning. The robot has a motor and gears. The text in the window provides instructions for building the model and explains the mechanism. The window also has a toolbar at the bottom with various icons.

Build the model following step-by-step instructions or create your own dancing birds. If you create your own, you may need to change the example program.

To operate the dancing birds best, make sure the pulleys and belt on the front of the model can move freely.

The energy transfers from the computer powering the motor to the small gear. The small gear turns a large gear. The large gear is connected on the same axle as a pulley so the pulley turns also. The pulley has a bird mechanism on top that turns as the pulley turns. Also connected to the pulley is a belt. As the pulley turns, the belt turns. The belt then turns another pulley with another bird on top. The speed of the birds can be changed by shifting the belt from the larger pulley to the smaller pulley on one side or the other. The direction of the birds can be changed by crossing or uncrossing the belt.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, pulleys and belts, and axles).



The dancing birds program uses the Start and the Motor This Way Blocks to turn on the motor.

The power level can be changed using the Motor Power Block if desired. More complex programs are shown in the Continue section of this activity.

See Getting Started for more examples with the Start and Motor This Way Blocks.

Contemplate

Contemplate

You can change the way your birds move by changing the belt and the pulleys on the model.

Try the following ideas and record what happens in your notebook.

Try some other changes to the model and the program. What other dances can you make the birds do?

Set up enough space to experiment with the pulleys and belt and make notes of your observations.

Draw a data table on a separate sheet of paper.

Use the data table to record the changes in the pulley and belt positions and the effect on the speed and direction of the dancing birds.

After investigating the pulleys and belt, discuss conclusions to the data tables.

Use your hands to show how the birds move when the large pulleys are connected and the belt is not crossed as shown in the first line of the chart.

The birds turn the same direction and move the same speed.

What happens when you move the belt from one large pulley to the smaller pulley as shown in the second line of the chart?

The speed of the smaller pulley increases and so does the speed of the dancing bird connected to the smaller pulley.

What happens when you cross the belt so that it looks like a sideways figure 8 around the two pulleys as shown in the third line of the chart?

The pulleys and the two birds connected to the pulleys spin in opposite directions.

Alternative ideas...

How much faster do the birds dance when they are on the small pulley compared to the large pulley? Work in pairs so that one person counts the rotations of one bird and the other person counts the rotations of the other bird. How much faster is the bird on the smaller pulley?

About 3-4 times faster. You can also measure the diameter of the pulleys. The ratio of the small to large pulley is about 1:3.8.

Continue

Continue

Program your birds to dance to music. Try our solution or create your own!

Our solution uses the model with different pulley and belt combinations.

FLAP TWEET BOING

There are no building instruction changes required in this activity. Change the pulleys and belt to create a dancing pattern you prefer.



The Dancing Birds program is modified to change the power level of the motor randomly, play a sound, wait, change the motor direction and play two more sounds with a pause in between. The program repeats.

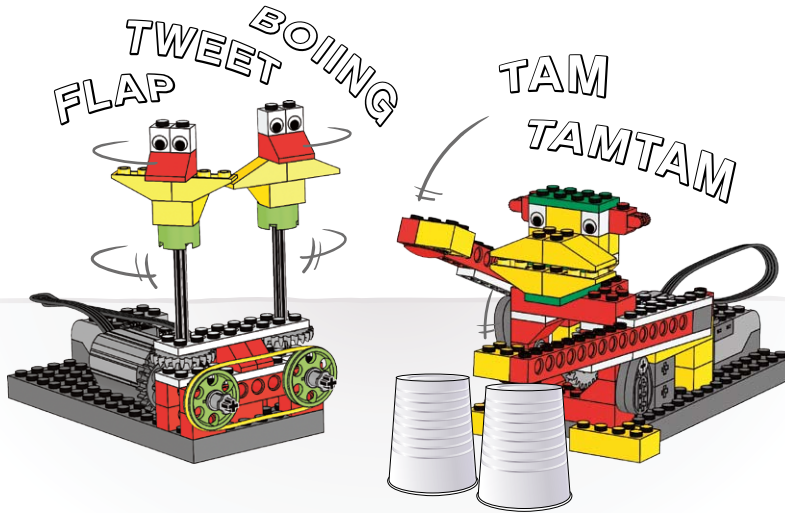
See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motor Power, Motor This Way, Motor That Way, Play Sound, Random Input, Repeat and Wait For.

1. Dancing Birds Teacher Notes

Extension

Join with another team that has a drumming monkey model. Program the monkey and the dancing birds to play and dance together.





2. Smart Spinner Teacher Notes

Students will build and program a spinner mechanism that is motorized to spin a top and release it and that uses a motion sensor to turn off the motor when the top is released.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the gear mechanism and the effect of the gears on the length of time the top can spin.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the spinner movement.
Modify the spinning behavior by changing the gears to affect the speed of the top and the length of time it spins.

Mathematics

Understand how the number of teeth and diameter of the gears affect the speed of the movement.

Compare the ratio of the smaller and larger gears.

Language

Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

Gears, rotation, and speed. Blocks: Add to Display, Display, Motion Sensor Input, Motor Off, Motor This Way, Number Input, Play Sound, Repeat, and Wait For.



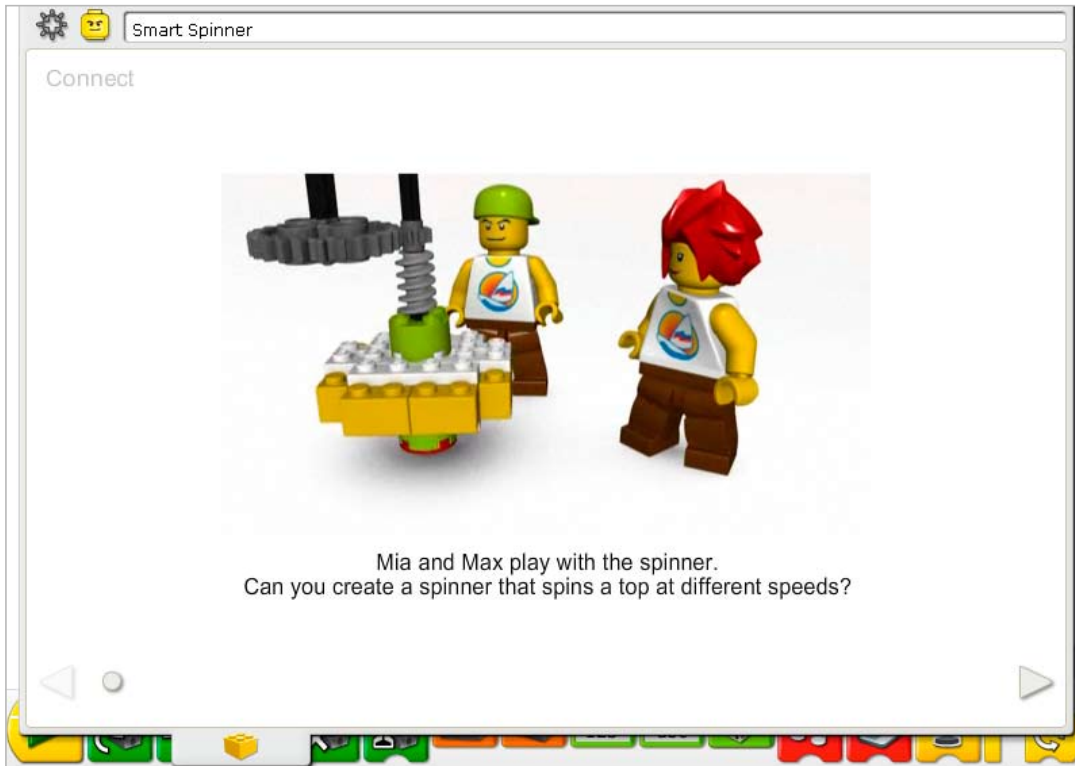
Connect

Review the Connect animation and discuss:

What do Mia and Max see?

What are they doing when they set up the top?

What happens after they set up the top?



Here are some other ways of connecting:

Take a coin, a pen, or other objects and try to spin it on your table or desk. How can you spin it? How long does it spin?

Most objects are not stable enough to spin for long and quickly fall down. The friction of the table or other surface slows and stops the movement. To keep the object spinning, the spinning force must be applied evenly to the center of the object; otherwise, the object will not be balanced and will not spin but move off in another direction.

Pretend you are a top and spin in place. What do you do with your body to spin a long time? What do you do to try to spin faster?

You can stand tall and hold your arms to stabilize your body as you spin. Keep your feet together as much as possible to have a "point" in the center of the spinning movement.

Did you know...

Gears can speed up and slow down motion?

See the models in Getting Started:

4. Gearing Down

5. Gearing Up

How do the gears work?

They mesh which means they fit their teeth together so as one moves, the other also moves.

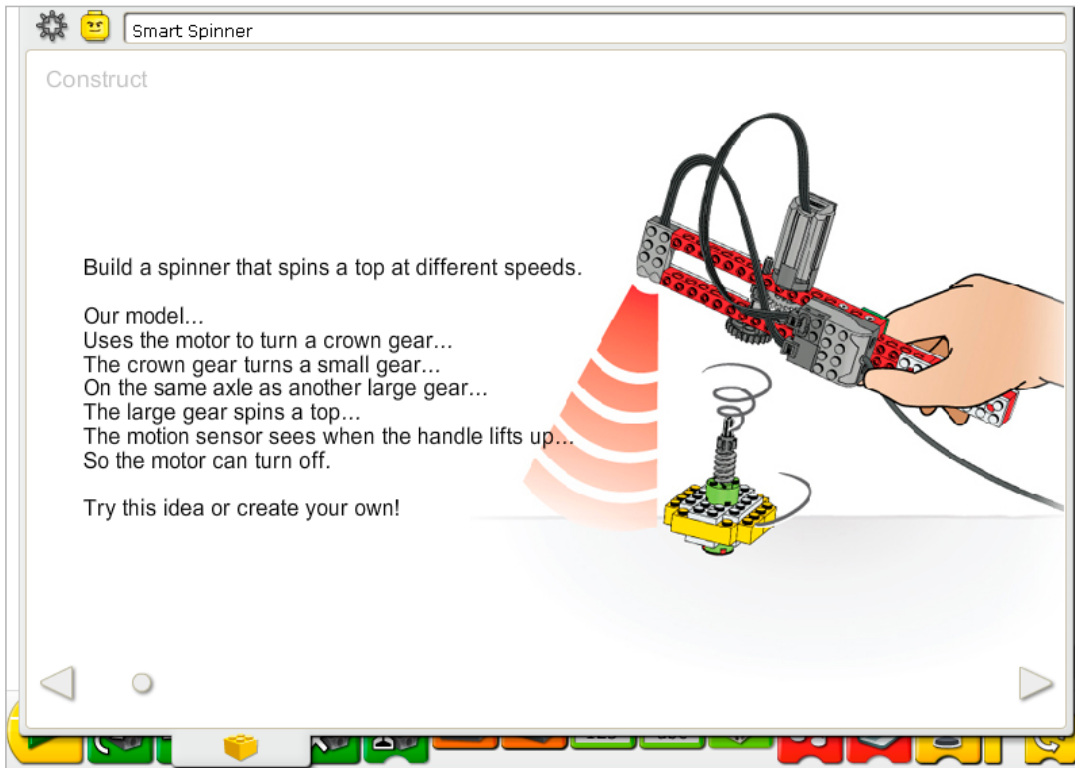
How do you make something move slower using gears?

Make sure the movement is transferred from a smaller gear to a larger gear. Motion transmitted from a smaller (8-tooth) gear to a larger (24-tooth) gear is called gearing down because speed is reduced.

How do you make something move faster using gears?

Make sure the movement is transferred from a larger gear to a smaller gear. Motion transmitted from a larger (24-tooth) gear to a smaller (8-tooth) gear is called gearing up because speed is increased.

Construct



Build a spinner that spins a top at different speeds.

Our model...

- Uses the motor to turn a crown gear...
- The crown gear turns a small gear...
- On the same axle as another large gear...
- The large gear spins a top...
- The motion sensor sees when the handle lifts up...
- So the motor can turn off.

Try this idea or create your own!

Build the model following step-by-step instructions or create your own spinner handle and top. If you create your own, you may need to change the example program.

To operate the spinner best, make sure the gear train of the handle meshes with the gear of the top when the top is inserted. Do not press the spinner top hard against the surface but let it spin freely before releasing.

The energy transfers from the computer powering the motor to the crown gear. The crown gear turns the small gear that is meshed with it. On the same axle as the small gear is a large gear, so the large gear also turns. The spinner top is inserted into the handle. On the spinner top is a small gear. When the top is inserted and the handle motor is turned on, the handle spins the top. When the top is released from the handle, the top keeps spinning. The combination of gears is called a gear train.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, spinning the top).



The program turns on the motor, plays Sound 15, the Motor sound, then waits for the motion sensor to see that you have lifted the spinner handle to release the top. Once the handle is released, the program turns off the motor.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motion Sensor Input, Motor Off, Motor This Way, Play Sound, and Wait For Blocks.

Contemplate

Set up enough space to experiment with the gears and make notes of your observations.

Draw a data table on a separate sheet of paper.

Use the data table to record the changes in the gear positions and the length of time in seconds the top spins with each gear combination.

After investigating the gears, discuss conclusions to the data tables.

For how long did your top spin when the handle had a 24-tooth gear and the top had an 8-tooth gear as shown in the first line of the chart?

Answers will vary. This combination is very fast and stable so most should run for several seconds. Collect the answers to summarize a range for the class.

When you changed the top from 8 to 24-tooth gear as shown in the second line of the chart, did it spin slower or faster? For a longer time or shorter time?

Usually this combination spins slower than the combination above because the speed of the top has been reduced. When the top spins slower it tends to spin for a shorter period of time.

When you changed to the 8-tooth gear on the handle and the 24-tooth gear on the top as shown in the third line of the chart, did the top spin fastest or slowest? Did it spin for the longest time or the shortest time compared to the previous combinations?

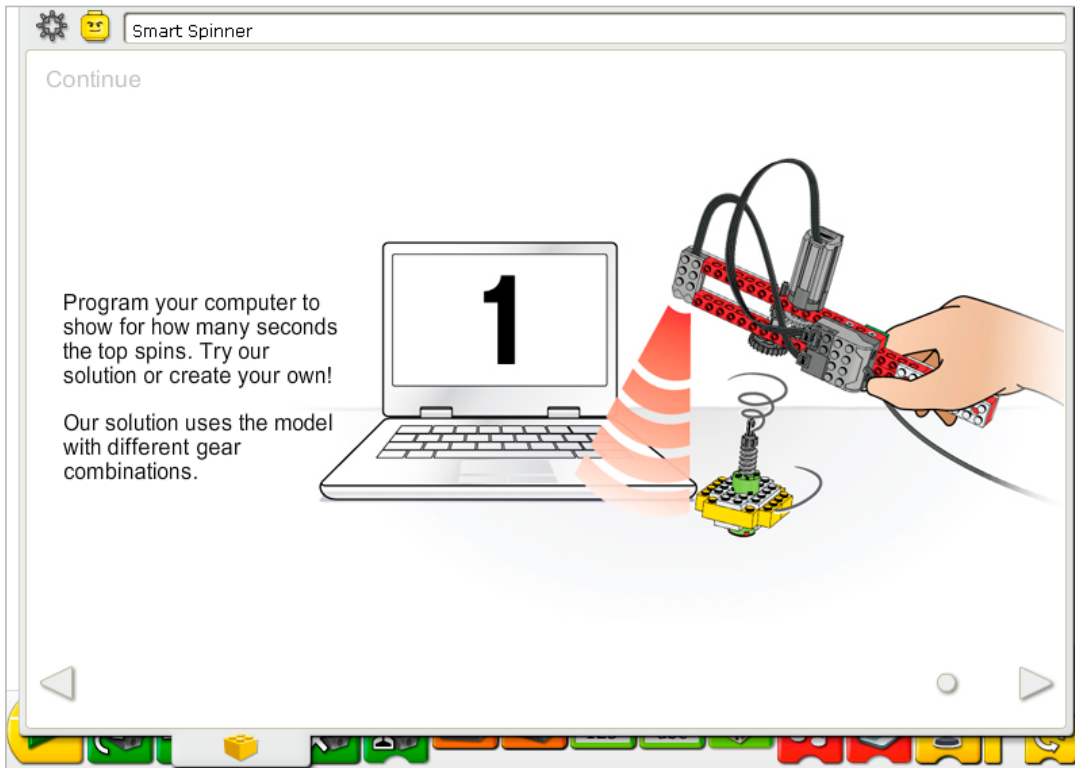
Usually this is the slowest spinning top with the shortest spinning time.

Alternative ideas...

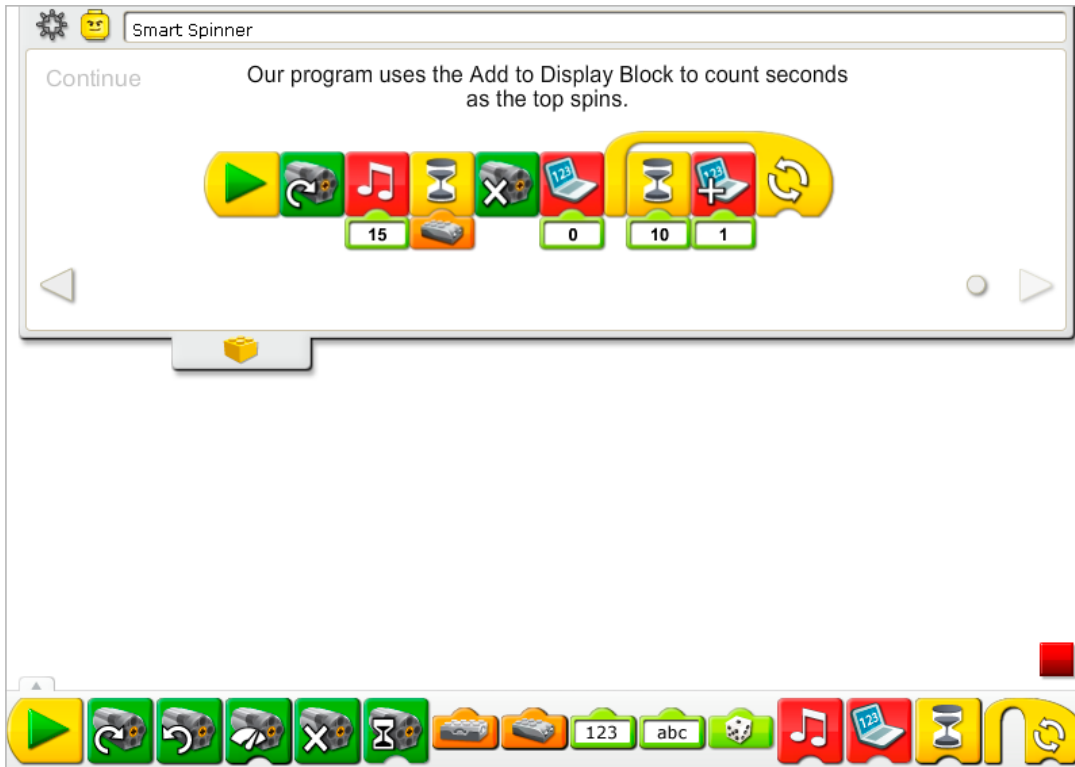
Try some other designs for the top. Does the design of a top affect the length of time it spins? Is it more or less stable? Does it spin for a longer or shorter time?

Answers will vary but very stable tops can spin many seconds with some spinning over a minute.

Continue



There are no building instruction changes required in this activity. Change the gears to spin the top at the speed you prefer.



The Smart Spinner program is modified to use the Display Tab as a clock. After the spinner handle is released and the top is spinning, the program waits for one second, adds one to the Display Tab and then repeats. The Display Tab “clock” repeats counting each second until you click Stop.

See Getting Started for more examples with Add to Display, Display, Motion Sensor Input, Motor Off, Motor This Way, Play Sound, Repeat, and Wait For.

Extension

Have a contest for the longest spinning top. Create the master program on one computer that sends a message to start several spinners running on other computers. Make sure everyone participating changes the Start Block of their spinner programs to Start On Message Blocks. When the program runs and the sound has finished playing, everyone should lift their handles to let the tops spin.

See Getting Started 19. Start On Message for help. Send Message programs work among computers on the same network as long as the receiving computers have the correct Start On Message program running.





3. Drumming Monkey Teacher Notes

Students will build and program a mechanical monkey with motorized arms that tap up and down drumming on a surface.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine. Identify the lever mechanism and the effect of the cams on the rhythm or timing of the lever arm movement.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the drumming monkey movement. Modify the drumming behavior by changing the cams to affect the pattern of tapping and program sound effects to make the patterns more interesting.

Mathematics

Understand how the number and position of the cams affects the frequency and timing of the beat pattern (rhythm). Understand and use numbers to represent the type of sounds played and the amount of time the motor turns on.

Language

Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

Cam, crown gear, lever, pattern. Blocks: Motor This Way, Number Input, Play Sound, Start, and Start On Key Press.

Other Materials

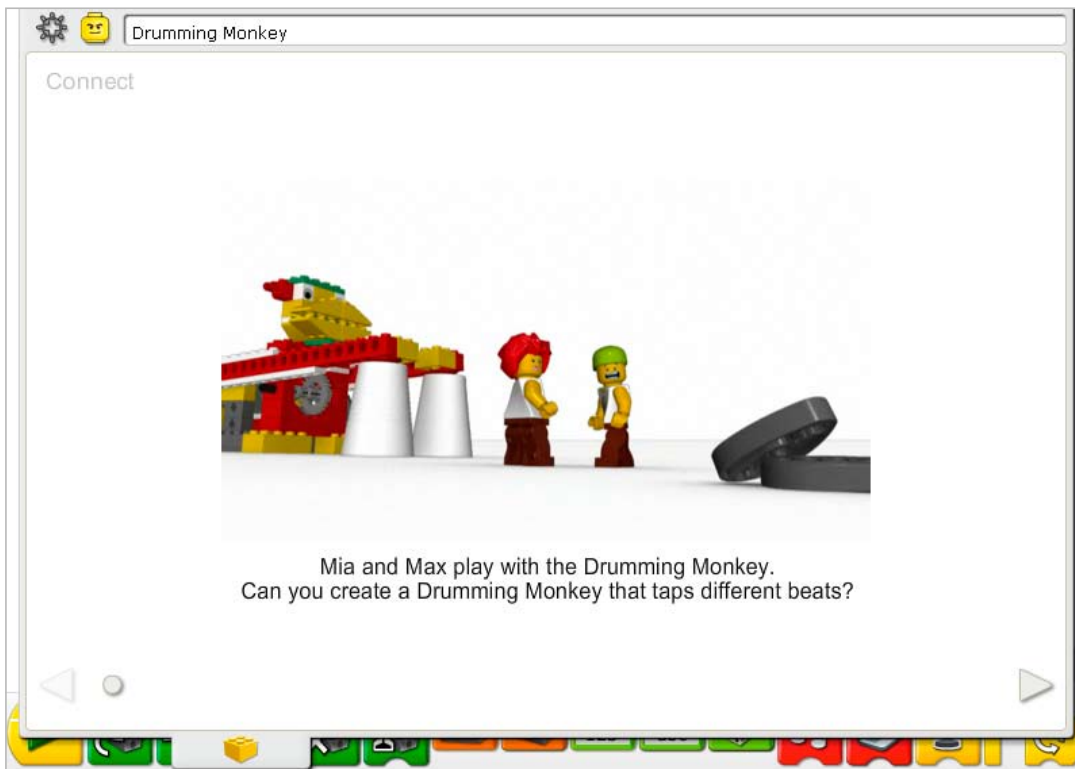
Drumming surfaces such as cardboard, plastic or metal containers.



Connect

Review the Connect animation and discuss:

What do Mia and Max notice about the monkey?
Have you used a drum? How did it work?
Have you seen or played with mechanical drumming toys such as the monkey?
What is making the monkey move?
What is making the tapping sound?



Here are other ways of connecting:

Tap up and down on your desk. Can you create a nice pattern of beats? How are your arms moving? What is creating the sound?

Arms moving up and down striking the surface of the desk creates the sound.

Does anyone play an instrument? How do you create sounds?

Answers can vary. Some may have wind instruments and blow through them. Others may have a piano or string instrument or drums. These are percussion instruments that create sounds by striking or bowing a string or surface so it vibrates.

Watch the movement of one of the monkey arms in the animation. What other machines can we think of that move up and down like that? E.g.,

Pump handle, railroad crossing bar, an arm when it hammers a nail.

Did you know...

The drummer's arms are levers? They move up and down around a fulcrum. The drumming monkey moves the arms up and down to create a pattern or rhythm. You can use levers to move up and down and cams to create surprising movement.

See the models in Getting Started:

14. Cam

15. Lever

How can you change the lever arm to make the load arm shorter? Or longer?

Adjust the position of the fulcrum by moving the axle into another beam hole.

How does a cam work?

The cam is shaped like an egg so as it turns, it creates a bobbing movement when something is attached or on top of it.

Construct

Construct

Build a Drumming Monkey that can tap different beats.

Our model...
Uses the motor to turn a small gear...
The small gear turns a crown gear...
The crown gear turns the cams...
The cams push on the lever "arms".

Try this idea or create your own!

Build the model following step-by-step instructions or create your own drumming monkey. If you create your own, you may need to change the example program.

To operate the drumming monkey best, make sure the pair of lever arms that are resting on top of the cams can move up and down freely on each side of the model. Position a drumming surface, such as the LEGO® Education WeDo™ storage box, underneath the tapping arms. To accommodate other drumming surfaces, adjust the height of the drummer by adding bricks at the bottom of the large grey 8x16 brick.

The energy transfers from the computer powering the motor, to the small gear, then at a 90° angle to the crown gear. That gear turns the cams on the same axle. The cams push up on the lever arms, raising and lowering the arms as the cams turn.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, cams, and lever arms).

Contemplate

Drumming Monkey

Contemplate

Create different beat patterns or rhythms with the Drumming Monkey by changing the way the cams push on the lever arms.

Are the left and right arms moving at the same time or not?
Is the tapping sound the same or different?

Set up enough space to experiment with the cams and make notes of your observations.

Draw a data table on a separate sheet of paper.

Use the data table to record the changes in the cam positions and the type of tapping pattern created by each cam combination.

After investigating the cams, discuss conclusions to the data table.

Can you describe what you see or hear with one cam up and one cam down as shown in the first line of the chart?

The arms go up and down at opposite times. There is a regular tap, tap sound at about two beats per second.

What happens when you change the position of the cam on the right as shown in the second line of the chart?

Each arm still goes up and down at different times but the beat pattern changes to a quick tap-tap, pause. There are still about two beats per second but each tap is faster before the "rest" or pause.

What do you see or hear when you add another cam on the right as shown in the third line of the chart?

The right side moves twice as fast and taps twice as often as the left side. The beat pattern is faster now at about three beats per second with a tap-tap-tap-pause sound.

What do you see or hear when you add another cam on the left as well?

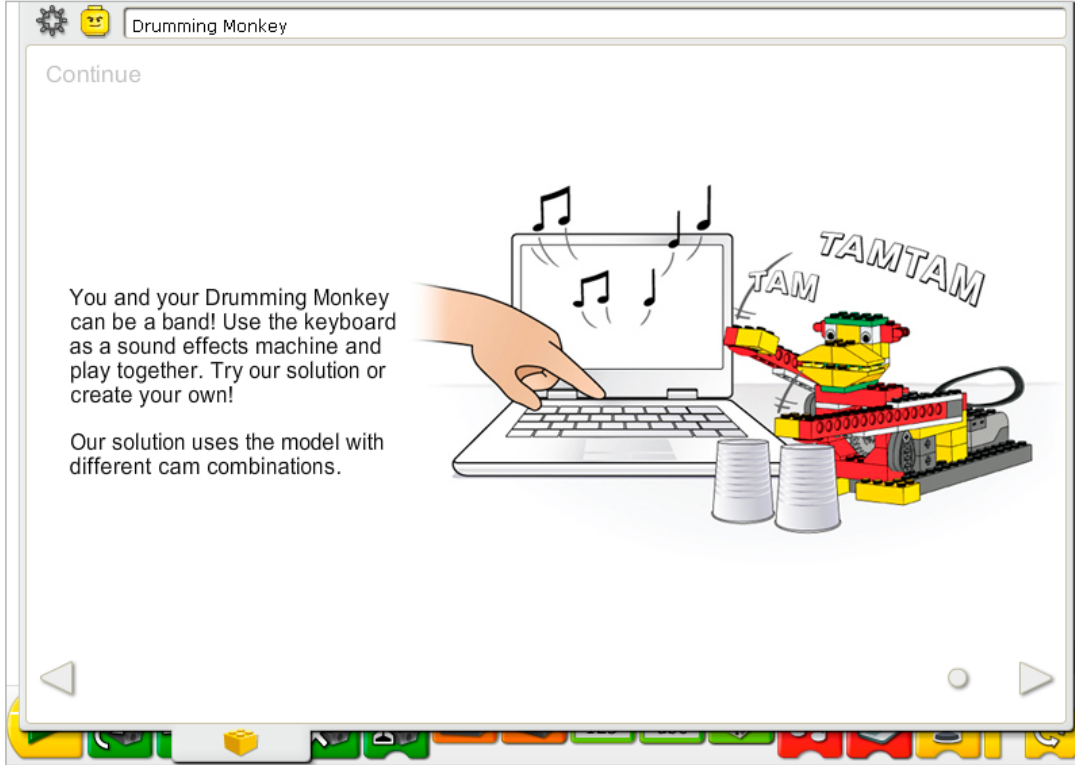
The arms are back to moving up and down at opposite times but twice as fast as the first example. There is a regular tap-tap-tap-tap at about four beats per second now.

Alternative ideas...

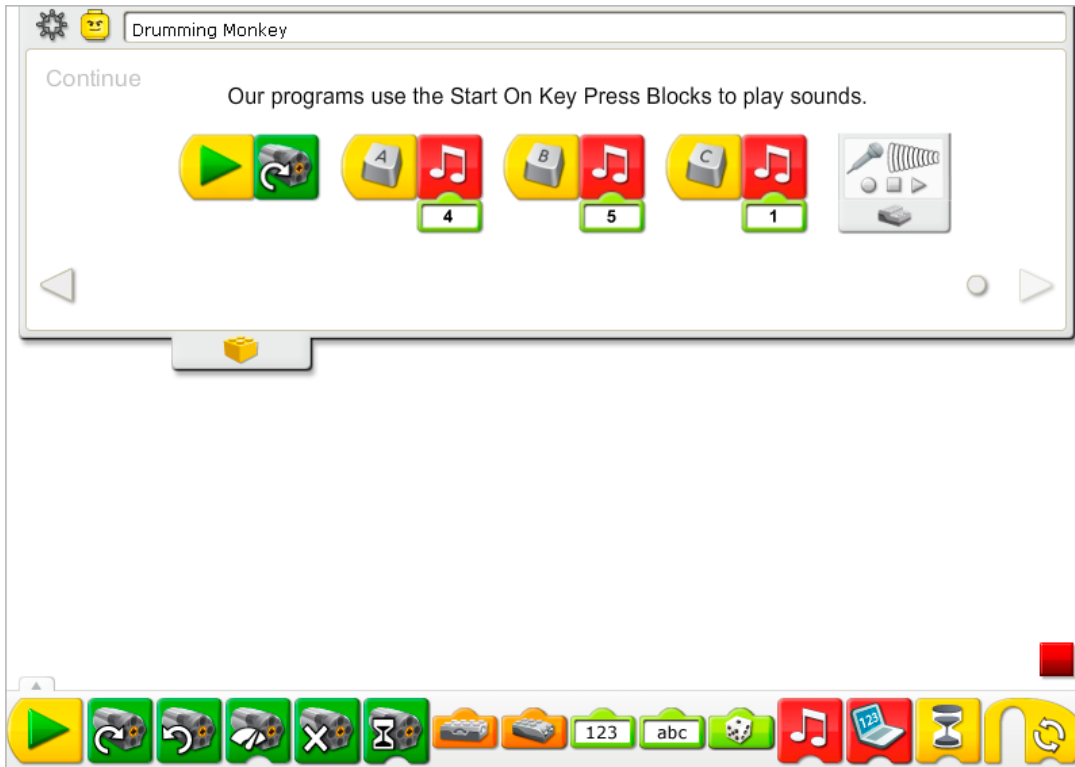
Place the pivot point of the arms in another hole position to change the length of the effort arm and the height at which the arm lifts up.

The result is an audible change in the force at which the tapping ends (load of the lever) strike the surface.

Continue



There are no building instruction changes that are required in this activity. Change the cams to create the tapping pattern you prefer.



The Drumming Monkey program is modified to add three separate sound effect programs. Start On Key Press Blocks are programmed to wait for keyboard key presses to initiate the sounds. The first program waits for you to press the **A** key on the keyboard then plays Sound 4, the Magic sound. The second program waits for you to press the **B** key on the keyboard then plays Sound 5, the Boing sound. The third program waits for you to press the **C** key on the keyboard then plays Sound 1, the Hi sound. If your computer supports a microphone, record your own sound in the Play Sound Block with the Number Input set to 1. The Hi sound will be replaced with your sound when the Play Sound Block using Number Input 1 is used for any program created in this LEGO® Education WeDo™ project file.

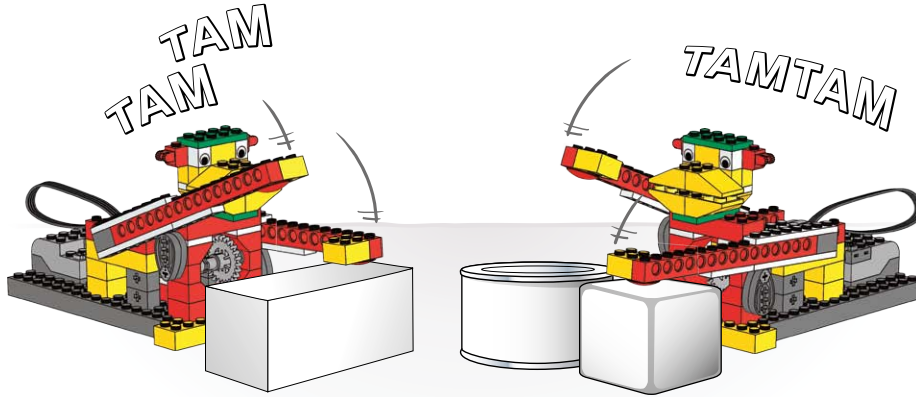
See the LEGO Education WeDo Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motor This Way, Play Sound, Number Input, and Start On Key Press. See Getting Started 8. Crossed Belt for an example showing how to record your own sound.

3. Drumming Monkey Teacher Notes

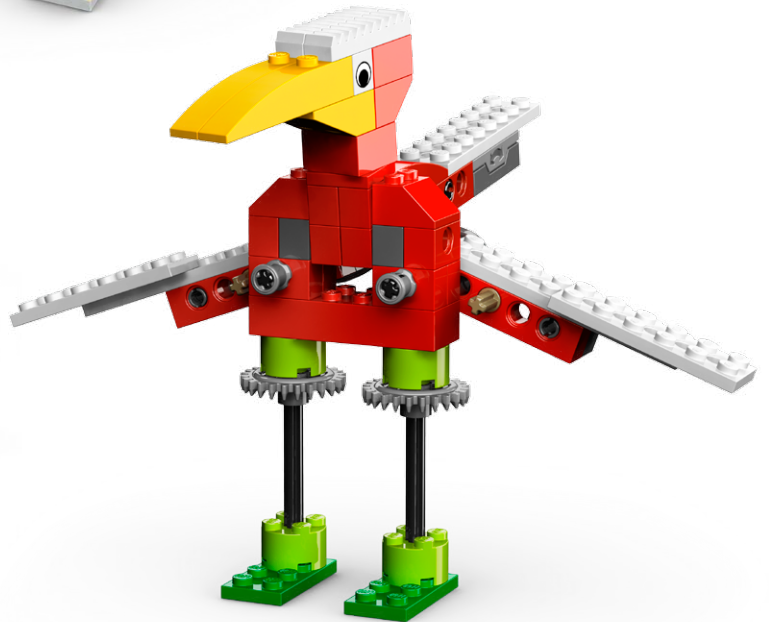
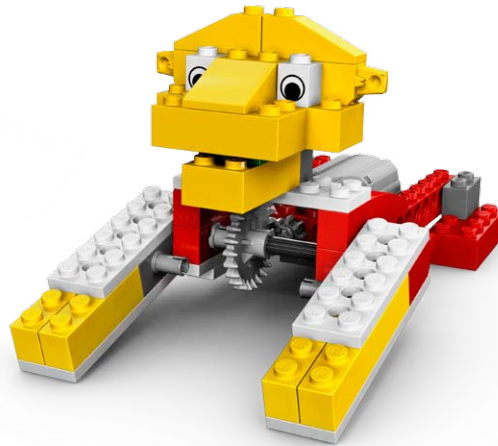
Extension

Join with others in the class to create a drum band with several of the drumming monkey models. Arrange for certain models to play specific patterns. Find other safe but interesting surfaces on which the models can tap, e.g., metal bowls or cardboard boxes to create different sounds.





Teacher Notes for the Activities: Wild Animals





4. Hungry Alligator Teacher Notes

Students will build and program a mechanical alligator that makes sounds and is motorized to open and close its jaw.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the pulleys and belts and the slowing down mechanism at work in the model.
Consider the needs of living animals.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the alligator's movement.
Improve the alligator's behavior by adding the motion sensor and programming sounds to coordinate with the movement.

Mathematics

Understand how the distance between an object and the motion sensor is important to how the sensor functions.
Understand and use numbers to represent the type of sounds played and the amount of time the motor turns on.

Language

Prepare and deliver a demonstration about alligators using the alligator model.
Use technology to create and communicate ideas.
Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

Belts, motion sensor, and pulley. Blocks: Motion Sensor Input, Motor On For, Motor This Way, Motor That Way, Number Input, Play Sound, Repeat, Start On Key Press and Wait For.

Other Materials

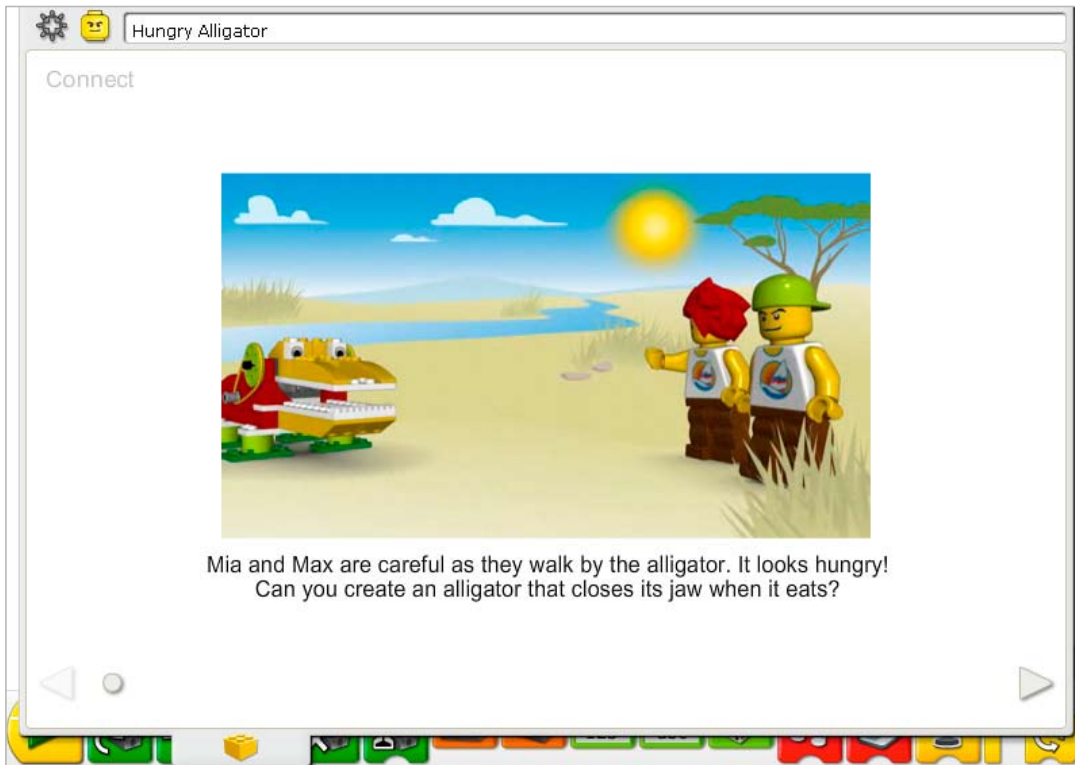
Optional for Extension: Construction paper, cardboard, grass, rocks.



Connect

Review the Connect animation and discuss:

- What was the alligator doing when Mia and Max saw it?
- What happened as they stood near the alligator?
- Do alligators really eat caps?
- Why does an alligator have a large jaw?
- What kind of food does an alligator eat?
- Would you pet an alligator? Why or why not?



Here are other ways of connecting:

Pretend you are an alligator. How does an alligator walk? Use your arms to show how the alligator opens and closes its jaw.

Have you seen a real alligator in person or on television? What did it do?

Is an alligator like a dinosaur? Why or why not?

Alligators lived as far back as some dinosaurs. However, dinosaurs are extinct, alligators are not. Alligators are reptiles: they lay eggs, have scales on their skin, and are cold-blooded. Cold-blooded means they must use the sun and means outside their body to stay warm. Dinosaurs seemed to have had these traits also.

Did you know...

You can use belts and pulleys to slow down the motor speed?

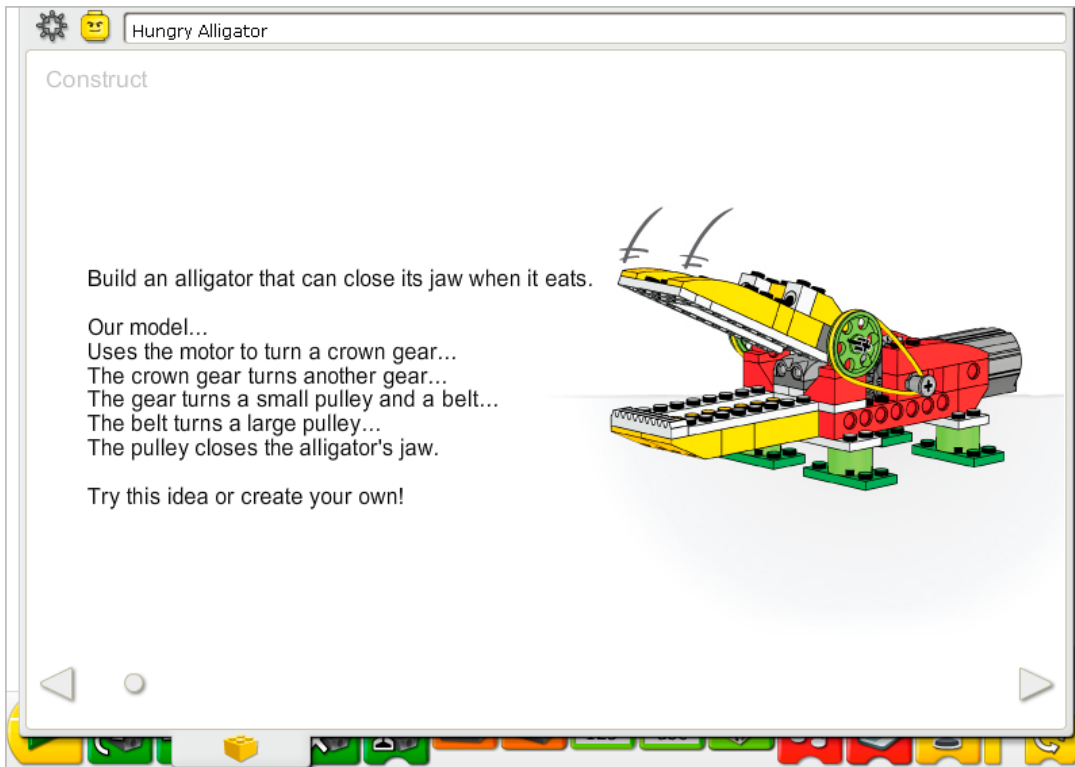
See the model in Getting Started:

9. Decrease Speed.

How much slower is the large pulley than the small pulley?

The large pulley turns only one time for every three times the small pulley turns. The large pulley is three times slower than the small pulley

Construct



The screenshot shows a software window titled "Hungry Alligator" with a "Construct" tab. The text in the window reads: "Build an alligator that can close its jaw when it eats. Our model... Uses the motor to turn a crown gear... The crown gear turns another gear... The gear turns a small pulley and a belt... The belt turns a large pulley... The pulley closes the alligator's jaw. Try this idea or create your own!" To the right of the text is a 3D model of a LEGO-based alligator jaw mechanism. The model features a red motor at the back, connected to a green crown gear. This gear is mounted on an axle that also holds a smaller green gear. A yellow rubber band (belt) is stretched between the smaller gear and a larger green pulley. The pulley is connected to a yellow jaw mechanism that can open and close. The entire assembly is built on a base of yellow and red LEGO bricks.

Build the model following step-by-step instructions or create your own alligator. If you create your own, you may need to change the example program.

To operate the alligator best, make sure the jaw opens and closes easily. To do that, loosen the pulleys and bushings to reduce friction. If the belts have been used a lot, wipe them clean to improve performance.

The energy transfers from the computer powering the motor, to the crown gear at a 90° angle to the next gear. That gear turns a small pulley and a belt that are on the same axle as the gear. The belt connects the small pulley to the large pulley. Moving the large pulley opens and closes the alligator's jaw.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, belts and the jaw mechanism).



The Hungry Alligator program uses the keyboard controls to start the movement. The Start On Key Press Block waits for you to press the **A** key on the keyboard. Then it turns on the Motor That Way (counterclockwise) to close the jaw. Next, the program runs Play Sound 17, the Crunch sound. Then it turns on the Motor This Way to open the jaw. The motor runs for seven-tenths of one second and turns off.

To change the Start On Key Press letter, place the mouse over the Block and type a different letter key. You can also type a number key or one of the four arrow direction keys.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with Motor On For, Motor This Way, Motor That Way, Play Sound and Start On Key Press.

Contemplate

Hungry Alligator

Contemplate

Find out more about alligators and what they eat. Share what you learn about alligator behavior. Use your model and program to demonstrate.

What other things might an alligator eat? Why does an alligator need a big jaw and teeth?

Set up enough space for books, paper, scissors and other materials and for demonstrating your model.

Gather some books or search internet sources for information about other sources of food for alligators. Choose a type of food. Then draw it and cut it out or make it. Prepare an information sheet, digital slides, or notes for your demonstration.

You are demonstrating alligator behavior: the motion sensor feedback allows the alligator model to react to the food. You may wish to adjust the input numbers to the Play Sound and to the Motor On For timing to suit your demonstration better.

Practice presenting your information about alligators and timing the demonstration.

After the alligator presentations, discuss these ideas.

How is the alligator program like a real alligator's brain?

The program is like a brain because it makes decisions and causes movement to respond to the environment.

How is the alligator program different from a real alligator brain?

A real alligator brain is capable of more sophisticated and varied responses. It is 'programmed' to respond to much more than a simple showing of food.

Is this an alligator or crocodile?

It is more like an alligator because they have U-shaped jaws. Crocodiles have more pointed and narrow jaws.

Alternative ideas...

Describe a day in the life of your alligator by drawing a series of pictures. When is the alligator awake? When is it eating?

Continue

Continue

CRUNCH

Program your alligator to sense food so it behaves more like a real alligator.
Try our solution or create your own!

Our solution uses the motion sensor in the alligator's mouth.

In the Continue phase of this activity, you are adding more intelligence to the alligator behavior.

Use the sensor that is already built into the model. The motion sensor and motor can work in either LEGO® Hub port.

The motion sensor must be positioned as shown in the building instructions or it will not work according to the example program. The mouth must open wide when it is waiting to be “fed” so the motion sensor can see the food, not its own jaw. The motion sensor can see large and small objects within a range of about 15 cm.



The Hungry Alligator program is modified to change the Start On Key Press to a Start Block and to add the motion sensor input. After you click the Start Block, the program waits for the motion sensor to see something. Then it turns on the Motor That Way to close the jaw and plays Sound 17, the Crunch sound. Then the motor turns on this way to open the jaw. The motor runs for seven-tenths of one second and turns off. The program repeats.

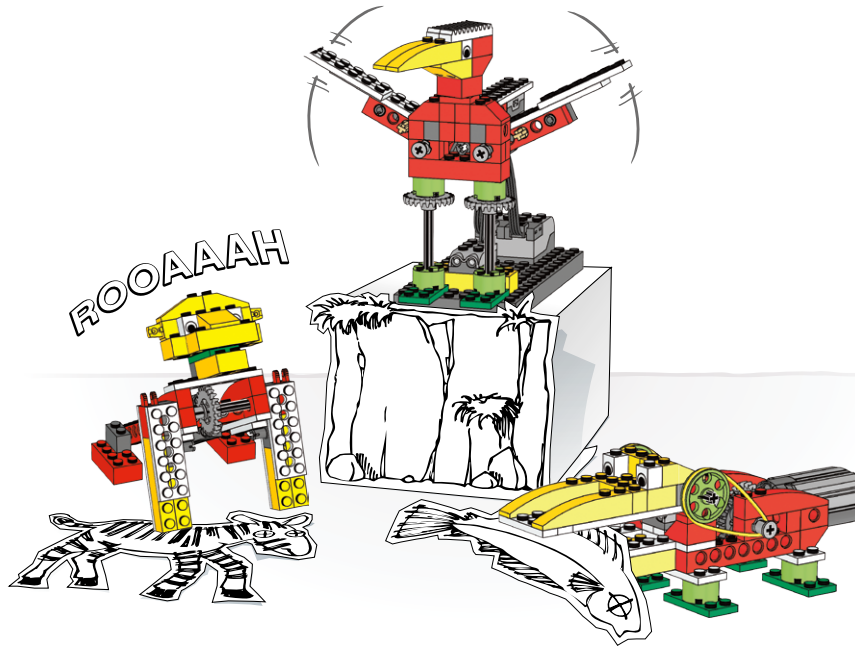
To repeat the program a specific number of times, add a number and text input to the Repeat Block.

See Getting Started for more examples with the Motion Sensor, Motor On For, Motor This Way, Motor That Way, Play Sound, Repeat, and Wait For.

4. Hungry Alligator Teacher Notes

Extension

Join with all of the other groups in your class to create a Wild Animal Park. Use construction paper, cardboard, grass, rocks and other materials to create an appropriate habitat for each animal. Design a tour of the Park and allow each group to present their animal. Invite other students to tour the Wild Animal Park.





5. Roaring Lion Teacher Notes

Students will build and program a mechanical lion that makes sounds and is motorized to lift and lower its front legs as if it is sitting up and lying down.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the crown gear at work in the model.
Consider the needs of living animals.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the lion's movement.
Improve the lion's behavior by adding the tilt sensor and programming sounds to coordinate with the movement.

Mathematics

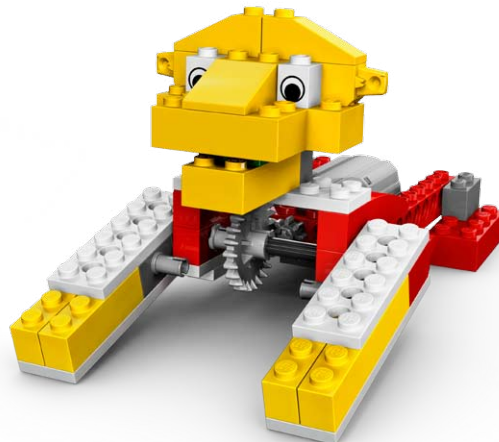
Understand how the gears used affect the angle of movement.
Understand and use numbers to represent the type of sounds played and the amount of time the motor turns on.

Language

Prepare and deliver a demonstration about lions using the lion model.
Use technology to create and communicate ideas.
Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

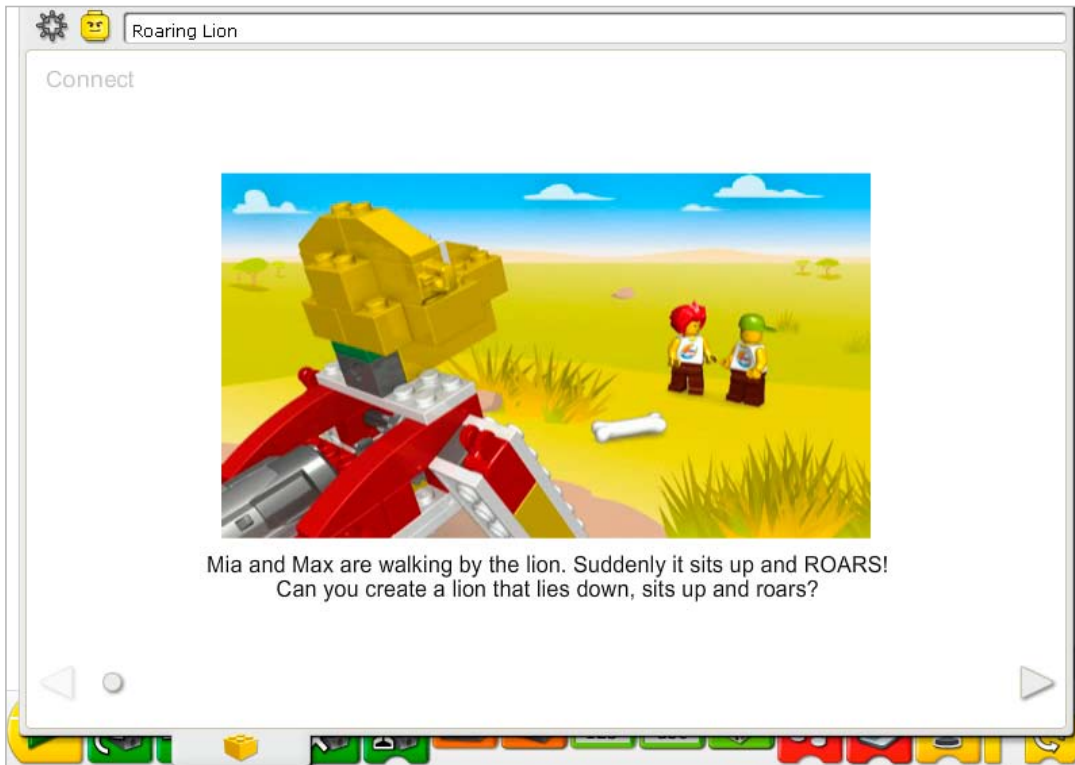
Climate, crown gear, mammal, and pride (lion). Blocks: Motor On For, Motor Power, Motor This Way, Motor That Way, Number Input, Play Sound, Start On Key Press, Tilt Sensor Input and Wait For.



Connect

Review the Connect animation and discuss:

What did the lion do?
How did Mia and Max react?
What does the lion want?
Do you act that way when you want something, such as food?
Is a lion a vegetarian?
What does it eat?



Here are other ways of connecting:

Does anyone have a cat as a pet? How is a cat similar to a lion? How does a cat sound? How does a lion sound?

Let's pretend we are on the savanna and move around like lions. How do we walk, lie down, and sit up. What do we eat?

Did you know...

The lion's legs, in a similar way to our legs and arms, can move in many ways at different angles? See the model in Getting Started:

12. Crown Gear.

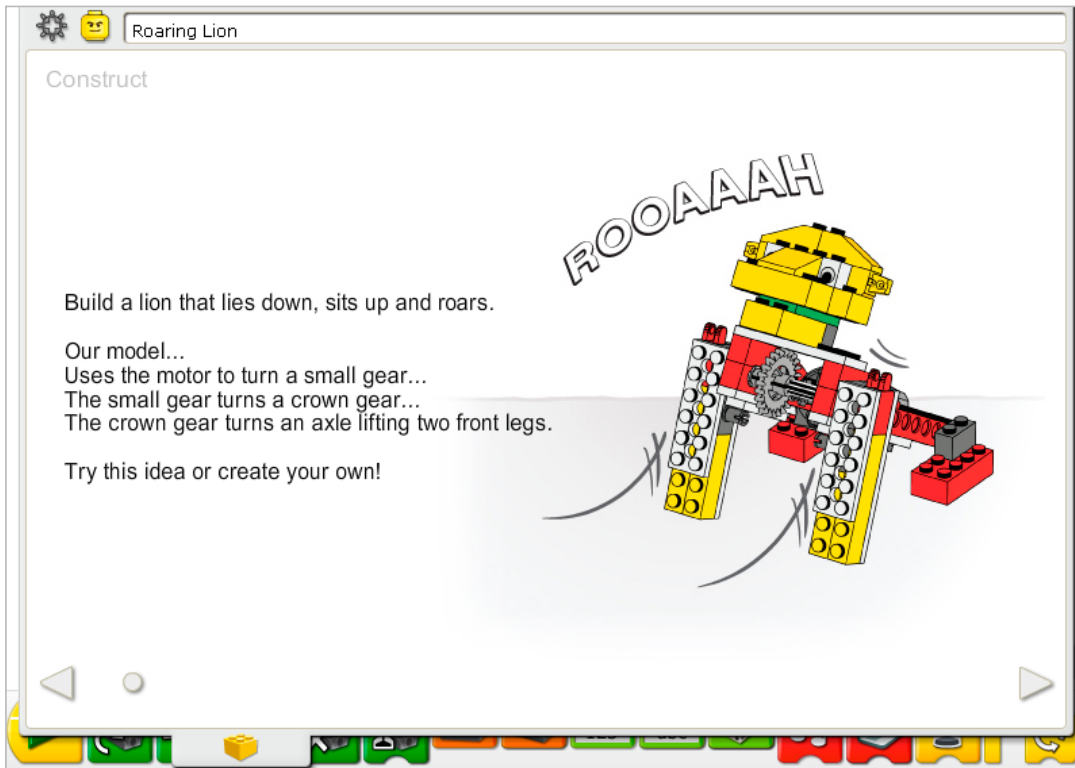
Look at the small gear and crown gear. Are they in a straight line or meshed at an angle?

At an angle.

At what angle does the small gear and crown gear transmit motion?

At a 90° angle (or if you do not want to introduce degrees of measure, just call it a right angle).

Construct



The screenshot shows a software window titled "Roaring Lion" with a "Construct" tab. The text inside the window reads: "Build a lion that lies down, sits up and roars. Our model... Uses the motor to turn a small gear... The small gear turns a crown gear... The crown gear turns an axle lifting two front legs. Try this idea or create your own!". To the right of the text is a 3D model of a lion's head and front legs, constructed from yellow, red, and white LEGO bricks. The lion's mouth is open, and the word "ROOAAAHH" is written in a stylized font above it. The model is shown in a dynamic state, with curved lines indicating the movement of the front legs. At the bottom of the window, there is a toolbar with various icons for navigation and editing.

Build the model following step-by-step instructions or create your own lion. If you create your own, you may need to change the example program.

To operate the lion best, make sure the small gear is meshing with the crown gear.

The energy transfers from the computer powering the motor to a small gear. The small gear turns the crown gear. The bent teeth of the crown gear change the angle of motion by 90°. The crown gear turns an axle which is locked into the two front legs of the lion's body, lifting the lion so it sits up.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears and the axle).



The Roaring Lion programs use the keyboard controls to start the movement. The first program waits for you to press the **A** key on the keyboard. Then it turns on the Motor This Way (clockwise) at medium power (6) so the lion sits up and plays Sound 14, the Roar sound. The second program waits for you to press the **B** key on the keyboard. Then it turns on the Motor That Way (counterclockwise) at a lower power (4) so the lion lies down and plays Sound 13, the Zzz sound.

To change the Start On Key Press letter, place the mouse over the Block and type a different letter key. You can also type a number key or one of the four arrow direction keys.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with Motor On For, Motor Power, Motor This Way, Motor That Way, Number Input, Play Sound, and Start On Key Press.

Contemplate

Roaring Lion

Contemplate

Explain how your lion is programmed.
Show how it sits up and lies down.
Share some information about real lions.

Mia and Max found this information about lions.

Mammal
Lives in a warm, dry climate.
Lives in a big group called a pride.
Eats large animals such as zebras, giraffes, and even young elephants!

ROOAAAHH

Set up enough space for books, other materials and for demonstrating your model.

Mia and Max provide some information about lions. Gather other books or search internet sources for information about lions. Use your own notebook to keep track of the background information.

You are demonstrating lion behavior: the keyboard commands allow the lion model to respond. You may wish to adjust the input numbers to the Play Sound, Motor Power, and Motor On For timing to suit your demonstration better.

Practice presenting your information about lions and timing the demonstration.

After the lion presentations, discuss these ideas.

What is a mammal? Are you a mammal? Name other animals that are mammals.

They are warm-blooded, give birth live to their young, provide milk to their young. E.g, Dog, cat, horse, mouse, human being.

The crown gear changes the movement of the motor to the legs of the model by 90° or at a right angle. Compare the movement of the lion to your legs and arms. What do you notice?

Human arms and legs can move many more directions and angles than the lion. Our legs and arms can rotate and move up and down. The lion can only lift up and lower down.

Notice that the lion needs more power to move up than down. Why is that? How does the program provide the intelligence to control the lion movement?

Gravity pulls down on the lion so it needs more energy to move up and less to move down. When you jump up, you come down. That is the effect of gravity. The program changes the power level of the motor to provide more power when the lion is sitting up and acting against gravity and to provide less power when the lion is lying down and acting with gravity.

Alternative ideas...

Program the lion to show its behavior as a wild animal. Then pretend it is a domestic cat instead. Then change the program to make it act and sound like a domestic cat. You can record your own sound in the Play Sound Block using Number Input 1, replacing the Hi sound. How are the lion and cat alike? How are they different?

Continue

Roaring Lion

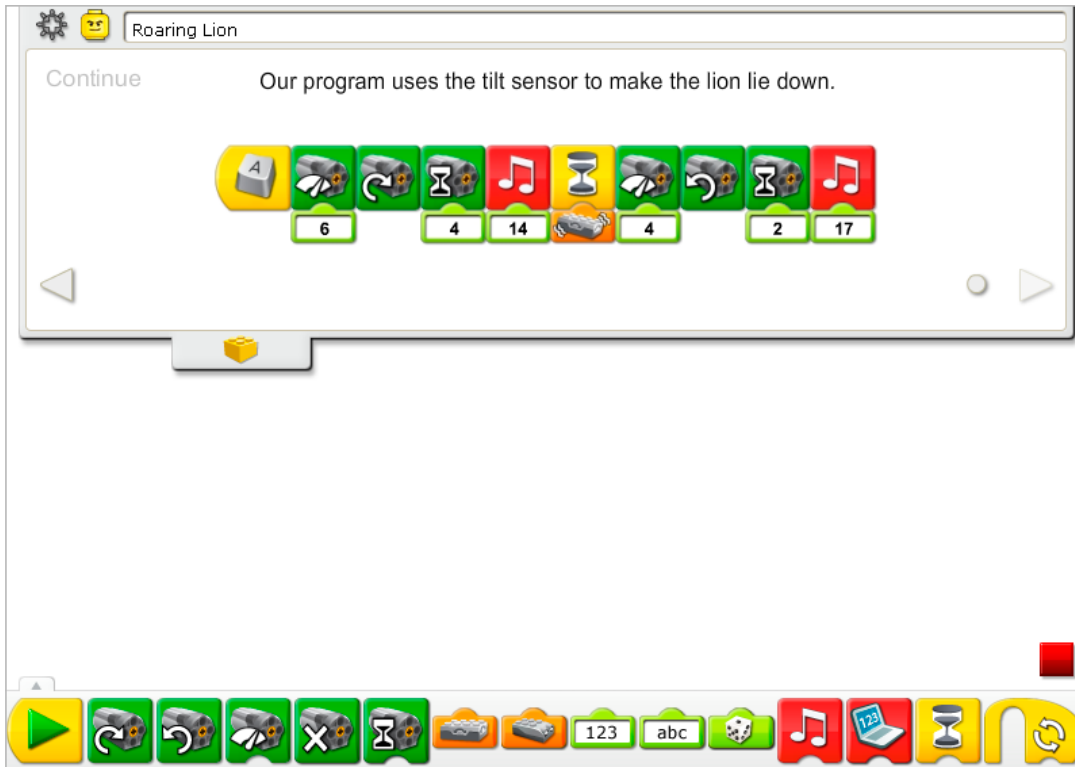
Continue

The lion is hungry! Program your lion to lie down and eat when you throw it a bone. Try our solution or create your own!

Our solution uses a bone with a tilt sensor in it.

In the Continue phase of this activity, you are adding more behaviors to the lion.

Follow the step-by-step instructions to build the bone with the tilt sensor. The tilt sensor and motor can work in either LEGO® Hub port.



The Roaring Lion program is modified to combine behaviors and add the tilt sensor input. After you press the **A** key on the keyboard, the motor turns on the Motor This Way, at a power level 6, for four-tenths of one second and plays Sound 14, the Roar sound. The program waits for you to tilt the bone in any direction then it lowers the motor power to level 4, reverses the Motor That Way, turns on the motor for two-tenths of one second, and plays Sound 17, the Crunch sound.

See Getting Started for more examples with the Motor On For, Motor Power, Motor This Way, Motor That Way, Play Sound, Tilt Sensor Input, and Wait For.

Extension

Work with another student or group so that you can have two lions programmed together. One lion model is the mother lion and the other lion model is a cub. Create each of the programs below on different computers. The first program is for the mother lion. It plays a sound and calls to the cub using the Send Message Block. The second program is for the lion cub. The cub program responds to the mother lion by making a sound when it receives the message using the Start On Message Block.

See Getting Started 19. Start On Message for help. Send Message programs work between computers on the same network as long as the receiving computer has the correct Start On Message program running.





6. Flying Bird Teacher Notes

Students will build and program a mechanical bird that makes sounds which are activated by manually tilting the bird up and down to lift and lower its head and flap its wings.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the lever mechanisms at work in the model.
Consider the needs of living animals.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the bird's movement.
Improve the bird's behavior by adding the motion sensor and programming sounds to coordinate with the movement.

Mathematics

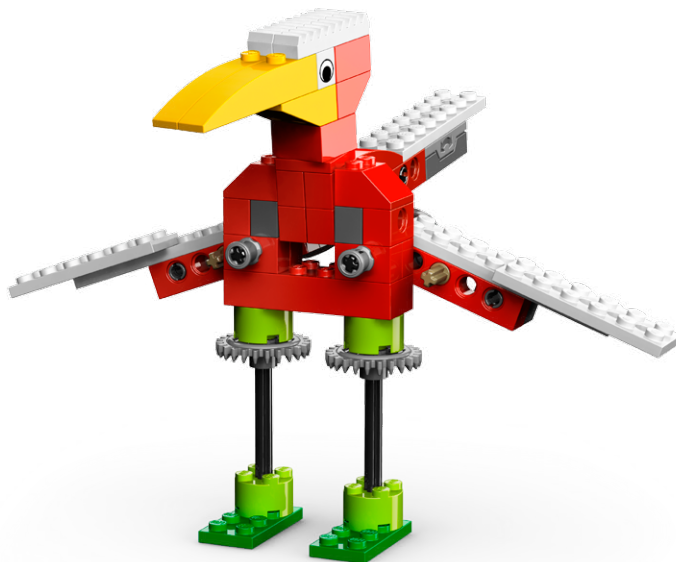
Understand how the bird's head and tail change their angle position as the bird pivots.
Understand and use numbers to represent the type of sounds played and the amount of time in tenths of one second.

Language

Prepare and deliver a demonstration about birds using the bird model.
Use technology to create and communicate ideas.
Communicate in spoken or written forms using the appropriate vocabulary.

Vocabulary

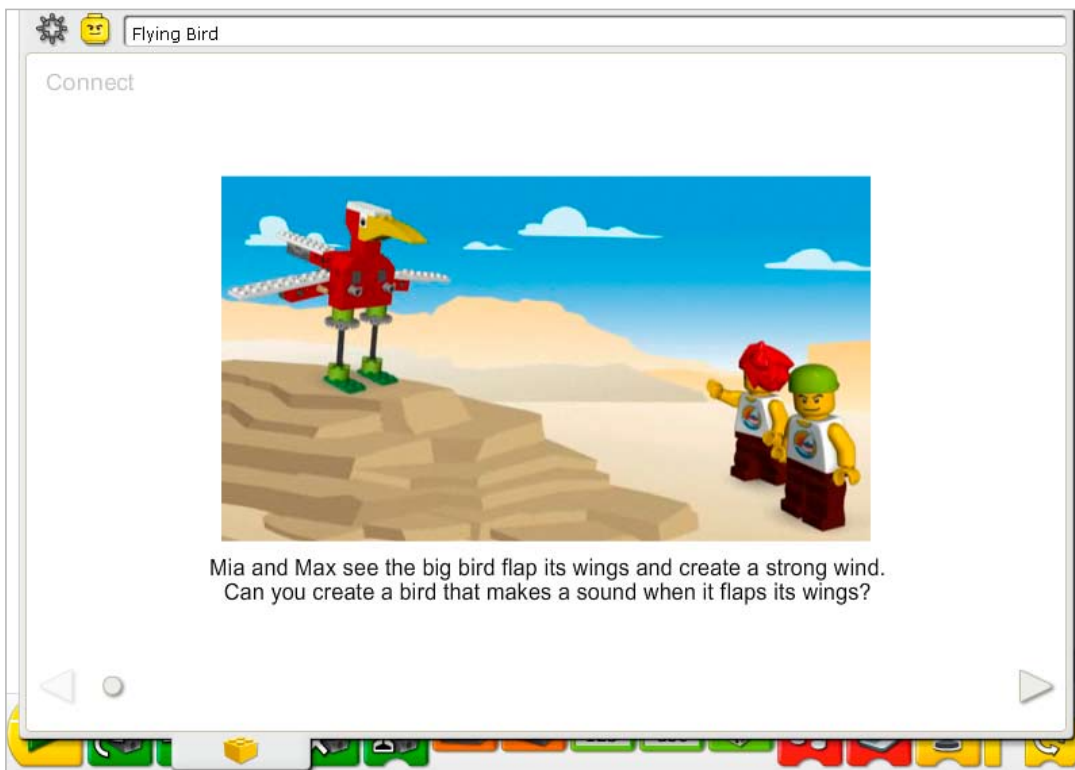
Motion sensor, tilt sensor, and wingspan. Blocks: Motion Sensor Input, Play Sound, Repeat, Tilt Sensor Input, and Wait For.



Connect

Review the Connect animation and discuss:

What do Mia and Max see the bird doing?
What does a bird have that you don't?



Here are other ways of connecting:

There are many sizes of birds. What sort of birds have you seen? How big were they? What was the largest bird you have seen in person or on television? What is the smallest bird you have seen?

Pretend you are a hawk or an eagle. Act out the way the bird moves. Hawks and eagles hold their wings out and glide along the air currents. Pretend you are a hummingbird. They are tiny birds that flap their wings so fast we can see only a blur. Show how a hummingbird flies.

Did you know...

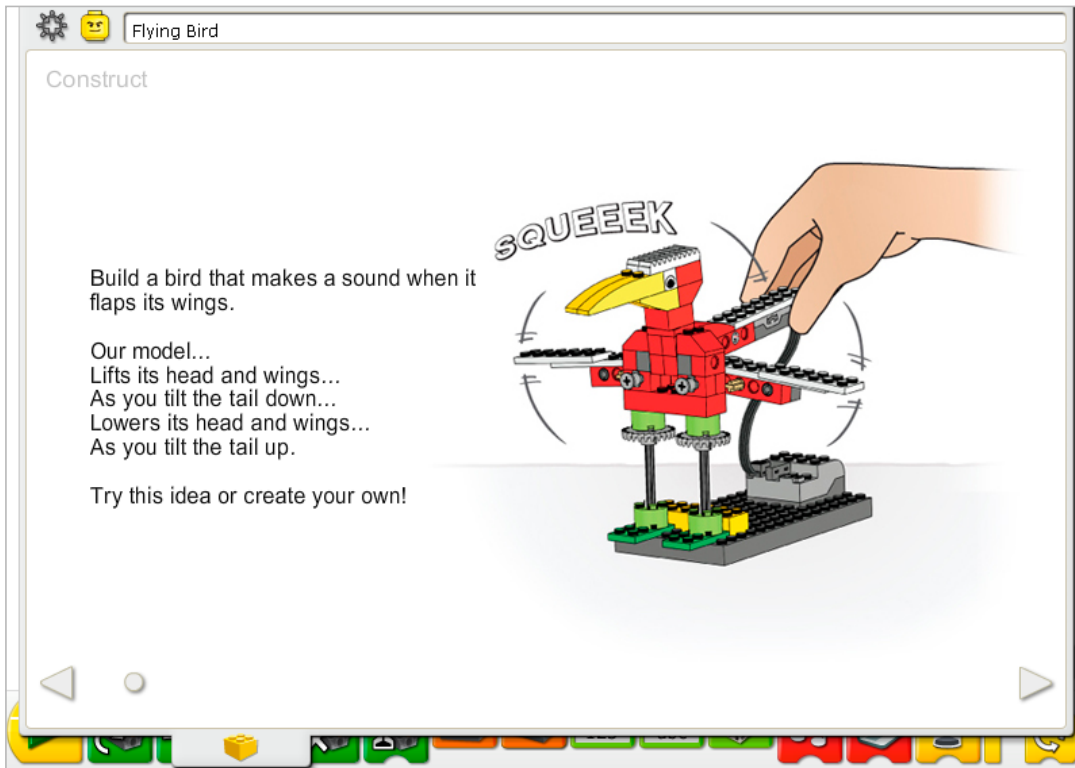
Many birds have specific songs they repeat to communicate with other birds?
To see an example of how to create a program that repeats sounds, see Getting Started:
16. Repeat

What do birds sound like when they sing or call? Can anyone sing or call like a bird?
Answers will vary but a rooster or chicken sound can be used if bird songs are not known. Bird songs are usually repetitive and can involve a call and response.

A bird wing is a kind of lever?
See the model in Getting Started:
15. Lever

If a bird wing is a lever, what pushes on the wing to move it?
Inside the bird's body, muscles and ligaments move the wing up and down. Move your own arm up and down and feel your muscles and ligaments.

Construct



Build a bird that makes a sound when it flaps its wings.

Our model...

- Lifts its head and wings...
- As you tilt the tail down...
- Lowers its head and wings...
- As you tilt the tail up.

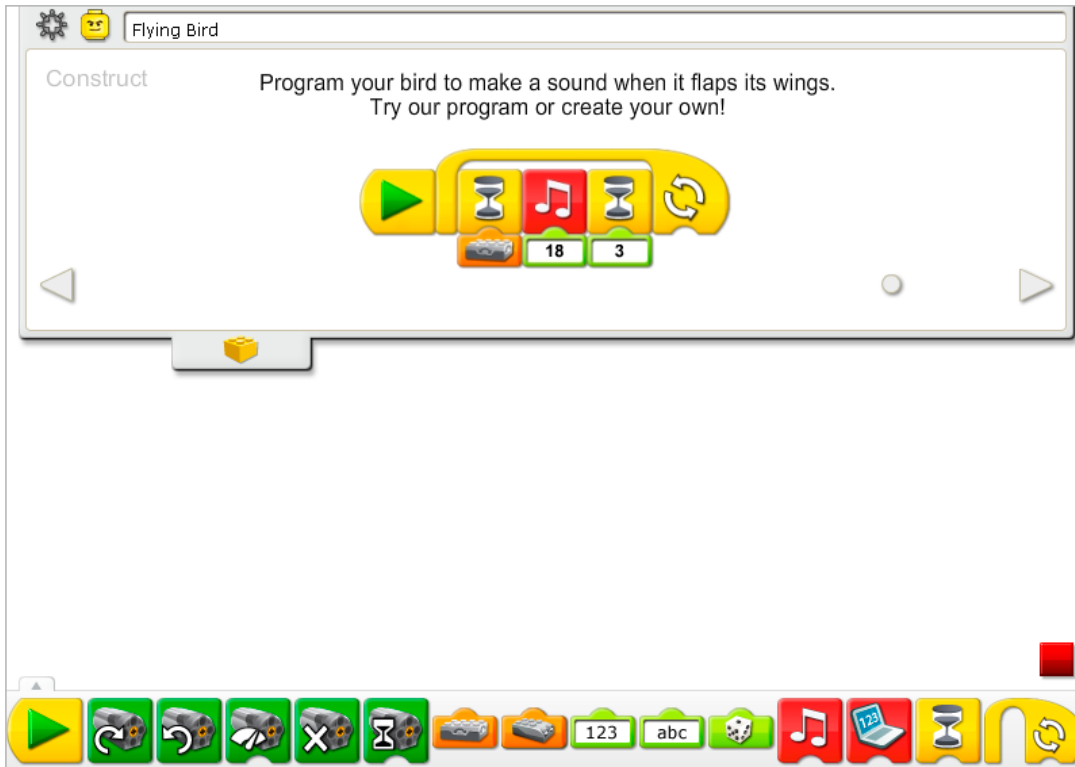
Try this idea or create your own!

Build the model following step-by-step instructions or create your own bird. If you create your own, you may need to change the example program.

To operate the bird best, make sure the cams are positioned as shown in the building instructions so the tail mechanism presses down on them evenly as it moves. Notice that this model is not motorized but uses both the tilt sensor and motion sensor.

The energy transfers from you to the model. The head and wings lift up as you tilt the tail down. The head and wings lower down as you lift the tail up.

The energy changes from kinetic (you pushing down on the tail) to mechanical (physical movement of the bird's tail, head and wing mechanisms).



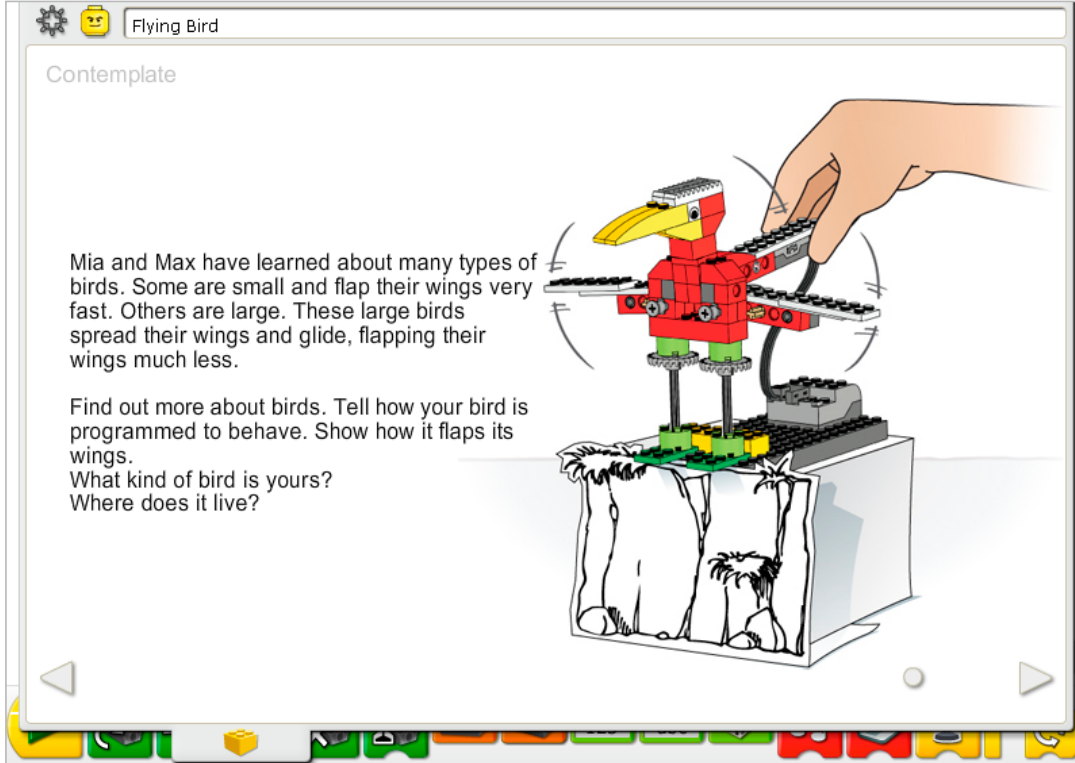
The Flying Bird program waits for the tilt sensor to be level (No Tilt), then plays Sound 18, the Flap sound, waits for three-tenths of one second and repeats.

To repeat the program a specific number of times, add a number and text input to the Repeat Block.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with Play Sound, Repeat, Tilt Sensor Input, and Wait For.

Contemplate



Flying Bird

Contemplate

Mia and Max have learned about many types of birds. Some are small and flap their wings very fast. Others are large. These large birds spread their wings and glide, flapping their wings much less.

Find out more about birds. Tell how your bird is programmed to behave. Show how it flaps its wings.
What kind of bird is yours?
Where does it live?

Set up enough space for books, note paper, and other materials, and for demonstrating your model.

Gather some books or search internet sources for information about other birds. Look at three sources and choose a bird that you like. What does it look like? Does it have small wings? Big wings? In between? What about the beak? What does it eat? Where does it live? Prepare an information sheet, digital slides, or notes for your demonstration.

You are demonstrating the behavior and flapping motion of the bird. The bird body flaps the wings faster or slower depending on the speed at which you move the tail up and down. The tilt sensor can tell when something is tipped or not. You may wish to adjust the input numbers to Play Sound and Wait For to suit your demonstration better.

Practice presenting your information about birds and timing the demonstration.

After the bird presentations, discuss these ideas.

How is the bird's body like a lever?

The main body of the bird, the head and tail, pivot up and down around axles in the center. A second set of levers moves along with the up and down motion of the tail: as the tail moves up and down, the effort from that movement forces each wing to pivot around an axle. So, each wing is a lever also.

The bird's tail lifts up and down at different angles. Describe or show some of the different angles the bird tail moves as it pivots. Show the tail at 45°? 90°? 180°?

The tail can lift up to 90° and pivot down to -90° or 270°.

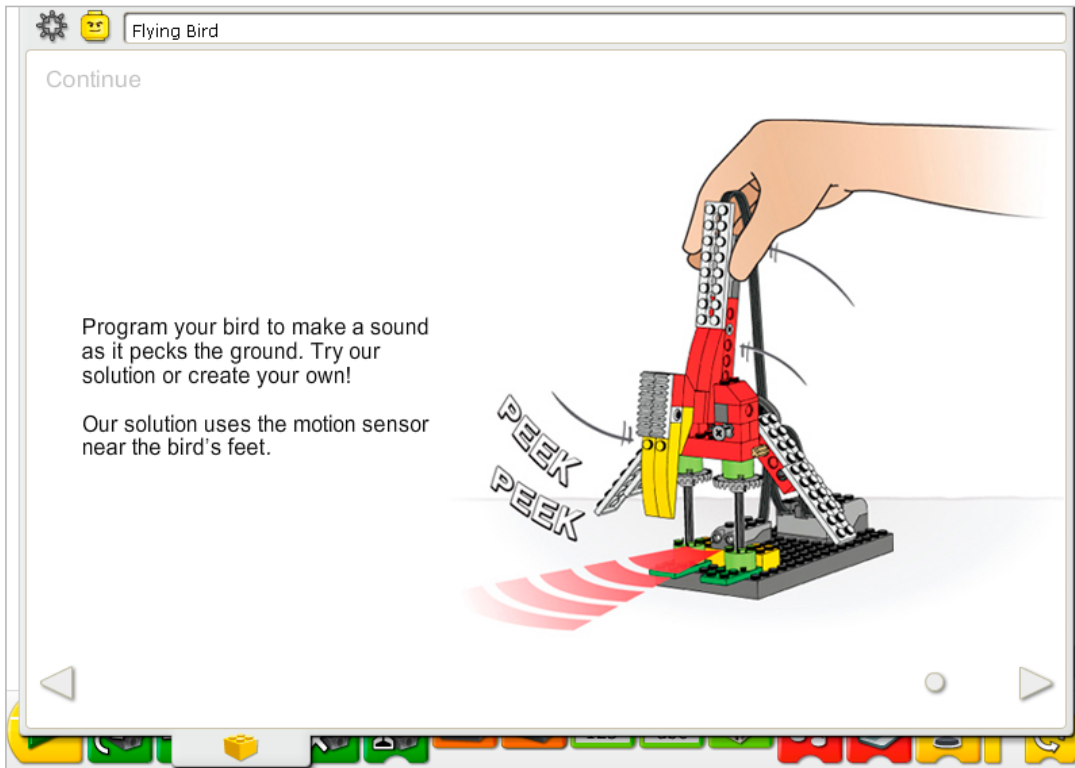
What other senses might you program in the bird?

Answers to this will vary. The motion sensor has been built into the model near the birds' feet. The Continue activity shows how to use it.

Alternative ideas...

The bird can fly over land and see the world from a different point of view. Consider the type of bird you have. Draw a picture from the bird's perspective. What does it see? What type of land is below? Is there salt or fresh water nearby?

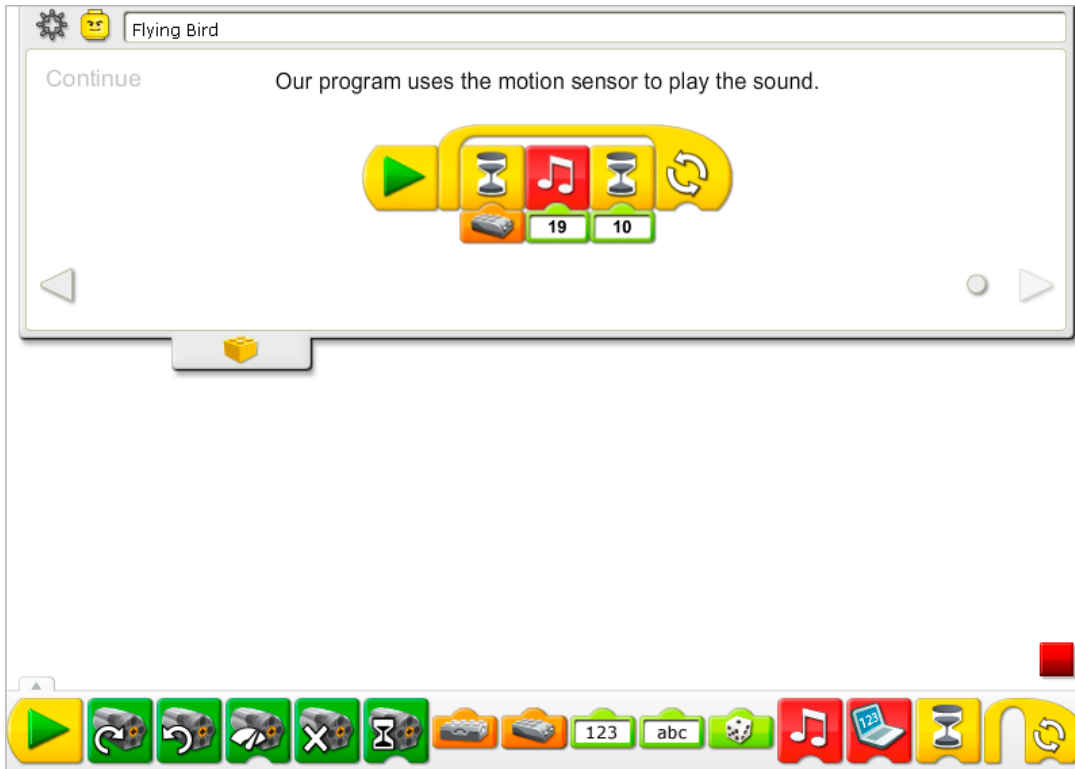
Continue



In the Continue phase of this activity, you are adding more intelligence to the bird behavior.

Use the sensor that is already built into the model. The motion sensor and tilt sensor can work in either LEGO® Hub port.

The motion sensor must be positioned as shown in the building instructions and the bird needs to tilt all the way down in order to activate the motion sensor.

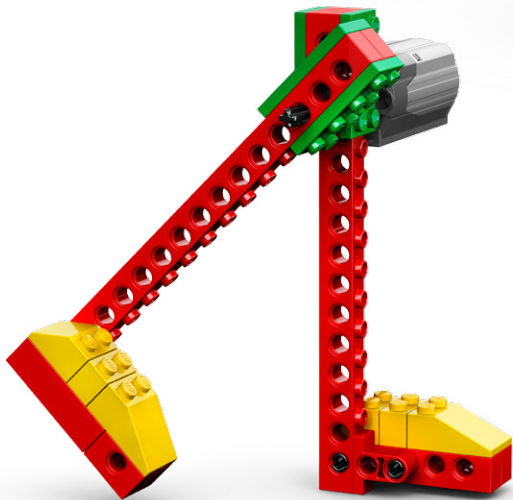


The Flying Bird program is not modified but a program using the motion sensor is added. The new program waits for the bird's beak to activate the motion sensor then it plays Sound 19, the Tweet sound and waits for one second. The program repeats. Both programs in the Construct and Continue examples can run at the same time.

See Getting Started for more examples with the Motion Sensor, Play Sound, Repeat, and Wait For.



Teacher Notes for the Activities:
Play Soccer





7. Goal Kicker Teacher Notes

Students will build and program a mechanical leg that is motorized to swing and kick a paper ball.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the lever at work in the model.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the goal kicker.
Improve the goal kicker by adding a motion sensor.

Mathematics

Estimate and measure the distance in centimeters or inches that paper balls are kicked.
Understand and use numbers in programming operations to control the timing of the motor.

Language

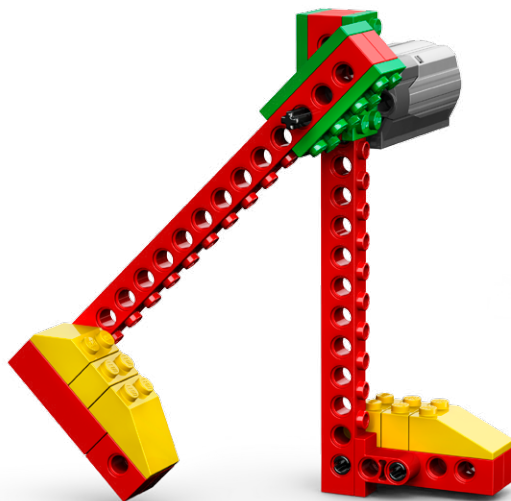
Communicate in spoken and written form using the appropriate vocabulary.
Participate as knowledgeable, reflective members of the group and class.

Vocabulary

Centimeter or inches, lever, measure, and motion sensor. Blocks: Motion Sensor Input, Motor On For, Motor This Way, Motor That Way, Start, and Wait For.

Other Materials

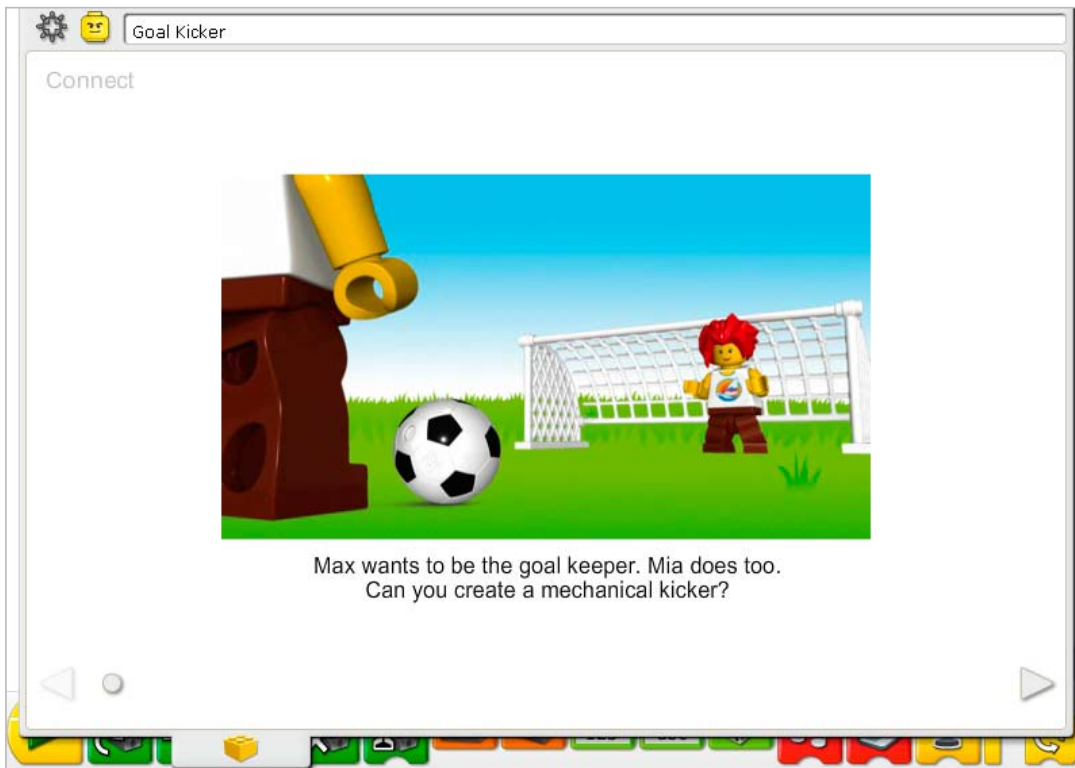
Wads of paper, rulers. Optional for Extension: target.



Connect

Review the Connect animation and discuss:

What are Mia and Max doing?
Have you played soccer before?
How are Mia and Max feeling?



Here are other ways of connecting:

Stand with your hand on your hip and kick your leg. Can you feel the kicking motion? What part of your body is moving? What part is still? Show what a hard kick and a soft kick look like. How is the movement different?

Watch or play a soccer game. Notice how players kick. What does the leg do when the kick is hard? How is a soft kick different? Can you show a hard and soft kick with your fingers?

Did you know...

Your leg is like a machine? It acts like a lever.

See the model in Getting Started:

15. Lever.

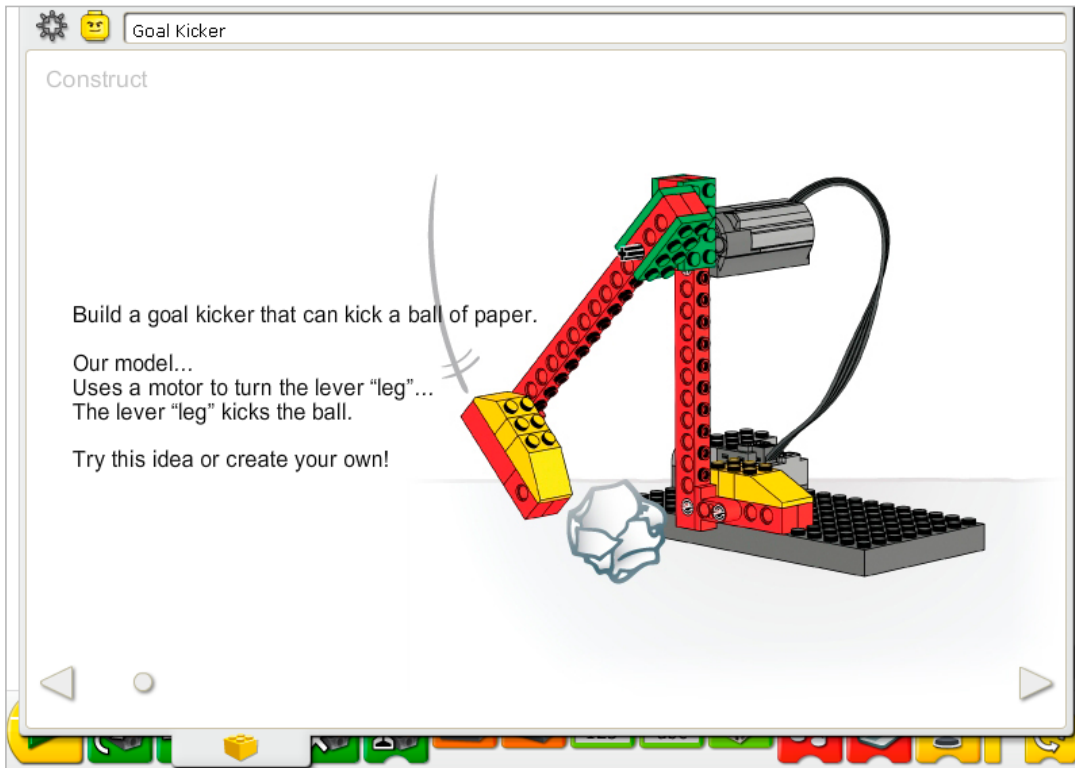
How is this like your leg kicking a soccer ball? What part of the lever model is like your hip?

The movement of the beam around the axle is like your hip rotating your leg.

What part of the model is like the soccer ball?

The three LEGO® bricks on the end are moved when the beam moves so the bricks move like the soccer ball when it is kicked by your foot.

Construct

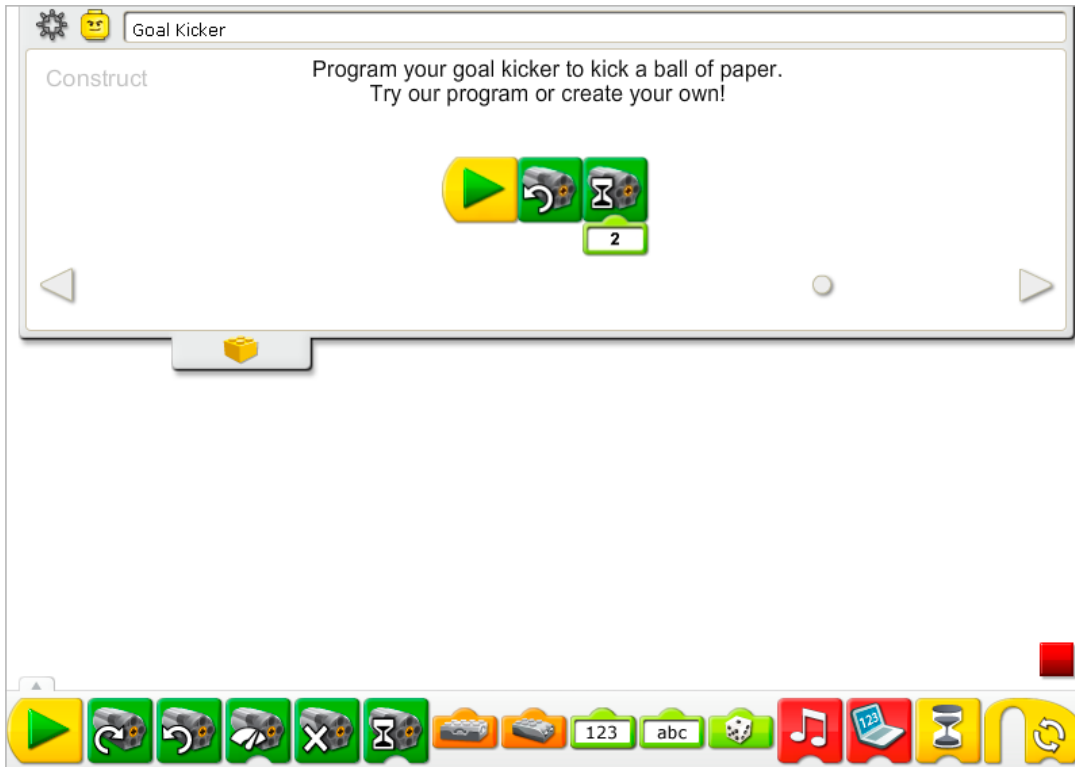


Build the model following step-by-step instructions or create your own goal kicker. If you create your own, you may need to change the example program.

To operate the goal kicker best, move the leg back manually to a higher position. Then place the paper ball next to the standing leg before running the program.

The energy transfers from the computer powering the motor through the leg. The leg is like a lever: the motor is the "effort" pushing on the axle (the pivot point). The axle turns, lifting the leg (the load). When the paper ball is in place, the energy moving the leg transfers to the ball.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the leg and ball).



The Goal Kicker program turns on the Motor That Way (counterclockwise) and runs it for two-tenths of one second. Then the motor turns off.

Left-click on the Motor That Way Block to change it to a Motor This Way Block. The motor then moves the opposite direction (clockwise).

To change the Number Input to Motor On For, mouse over the Input Block and type a new number or change it by pressing the up or down arrow keys.

See Getting Started for more examples with Motor This Way, Motor That Way, and Motor On For.

Contemplate

Goal Kicker

Contemplate

How far can your model kick?

1. Predict the distance.
2. Run the program to kick the ball.
3. Measure the distance.

Repeat steps 1, 2, and 3 again.

Mark your Best Distance!
Mark your Best Prediction!

~~~~~	~~~~~	~~~~~
~~~~~		
~~~~~		
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Set up enough space so that the model can kick balls of paper.

Make paper balls: About 3 centimeters (or a bit larger than an inch) in diameter works well.

Draw a data table on a separate sheet of paper. Use the data table to record the distance the paper ball moves after each kick.

After running the activity, discuss conclusions to the data tables.

What was your best distance as shown in the Actual Distance column of the chart?

Answers will vary based on individual data. A typical answer is in a range of 30 centimeters or 12 inches.

What was your best prediction as shown in the Predicted Distance column of the chart?

Answers will vary.

Discuss other questions related to collecting data on the kicking distance.

Were your best distance and best prediction the same?

Answers will vary.

How can you make the tests fair?

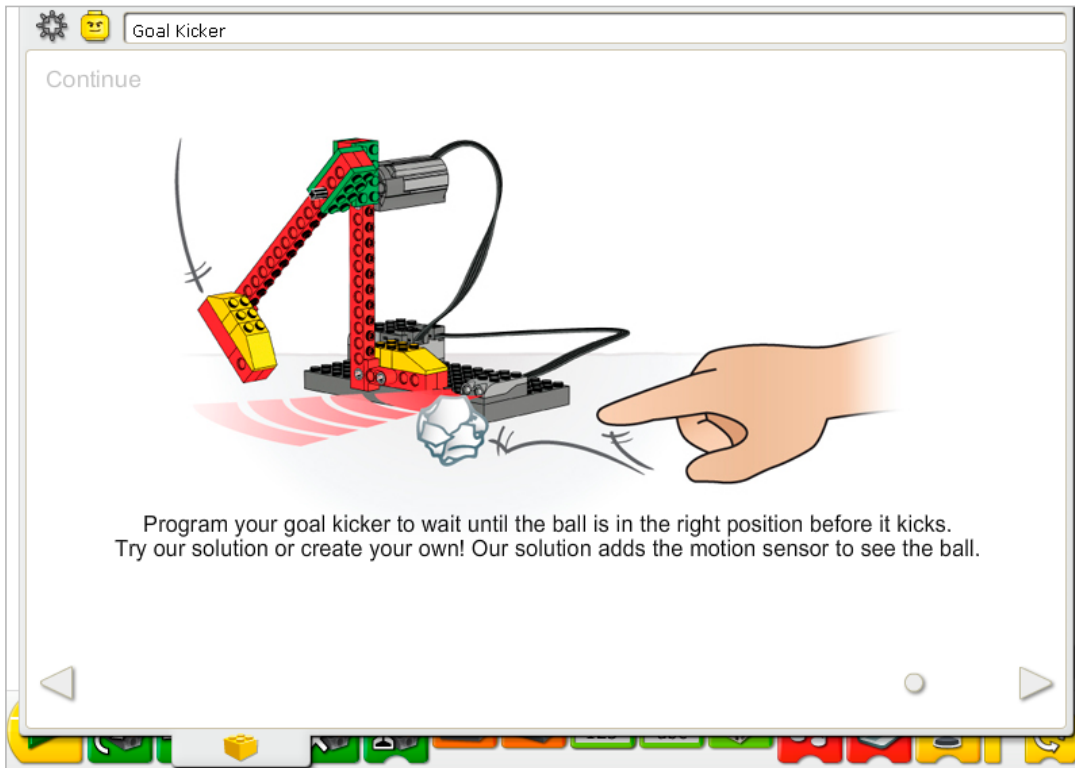
E.g., Run at least three trials; start with the leg in the same position each time; use paper balls of the same size; measure the distance the ball moved using the same method each time.

Alternative ideas...

Calculate the average distance the ball travels.

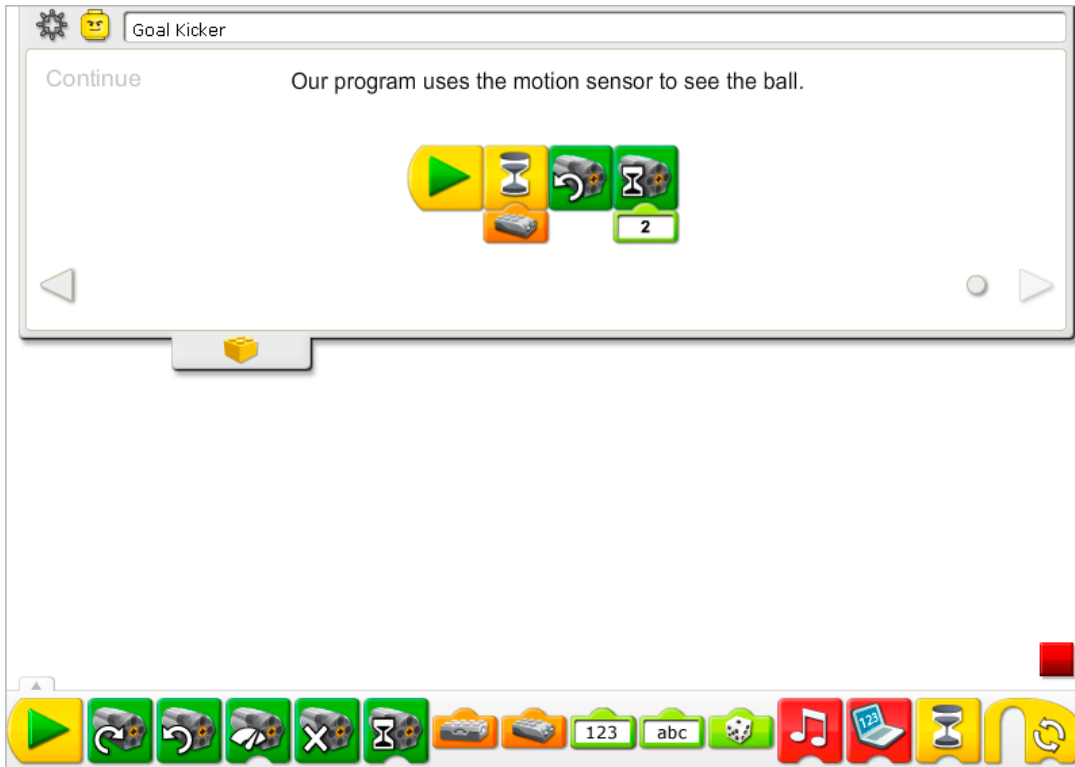
Try using different types of balls, e.g., bigger, smaller, heavier, lighter.

Continue



Follow the step-by-step instructions to add the motion sensor. The motion sensor and motor can work in either LEGO® Hub port.

The paper ball must be in range of the motion sensor to detect it. The best position of the paper ball is at the motion sensor position.

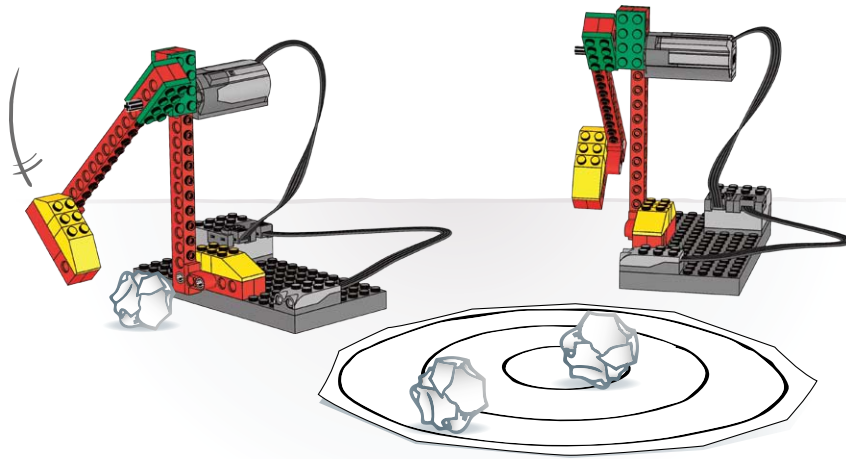


The Goal Kicker program is modified to add a Wait For Motion Input into the program. After the motion sensor is activated by the paper ball, the program is the same as before: It turns on the Motor That Way (counterclockwise) and runs for two-tenths of one second. Then the motor turns off.

See Getting Started for more examples with the Motion Sensor Input, Motor On For, Motor That Way, and Wait For.

Extension

Design a target-kicking competition for your own goal kicker or for several goal kickers. How close to the bulls-eye can you kick a ball?





8. Goal Keeper Teacher Notes

Students will build and program a mechanical goal keeper that is motorized to move back and forth to block a paper ball from a goal.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the pulleys and belts at work in the model.
Understand that friction can affect the movement of the model.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the goal keeper.
Use random input as feedback.
Improve the goal keeper by adding a motion sensor and an automatic scoring system program.

Mathematics

Count blocks, misses, and goals.
Measure time in seconds and tenths of a second.
Understand the concept of randomness and use it in a programming operation.
Understand and use numbers in programming operations to create an automatic scoring system.

Language

Communicate in spoken and written form using the appropriate vocabulary.
Participate as knowledgeable, reflective members of the group and class.

Vocabulary

Random and score. Blocks: Add to Display, Display, Motion Sensor, Motor On For, Motor This Way, Motor That Way, Random Input, Repeat, Start, and Wait For.

Other Materials

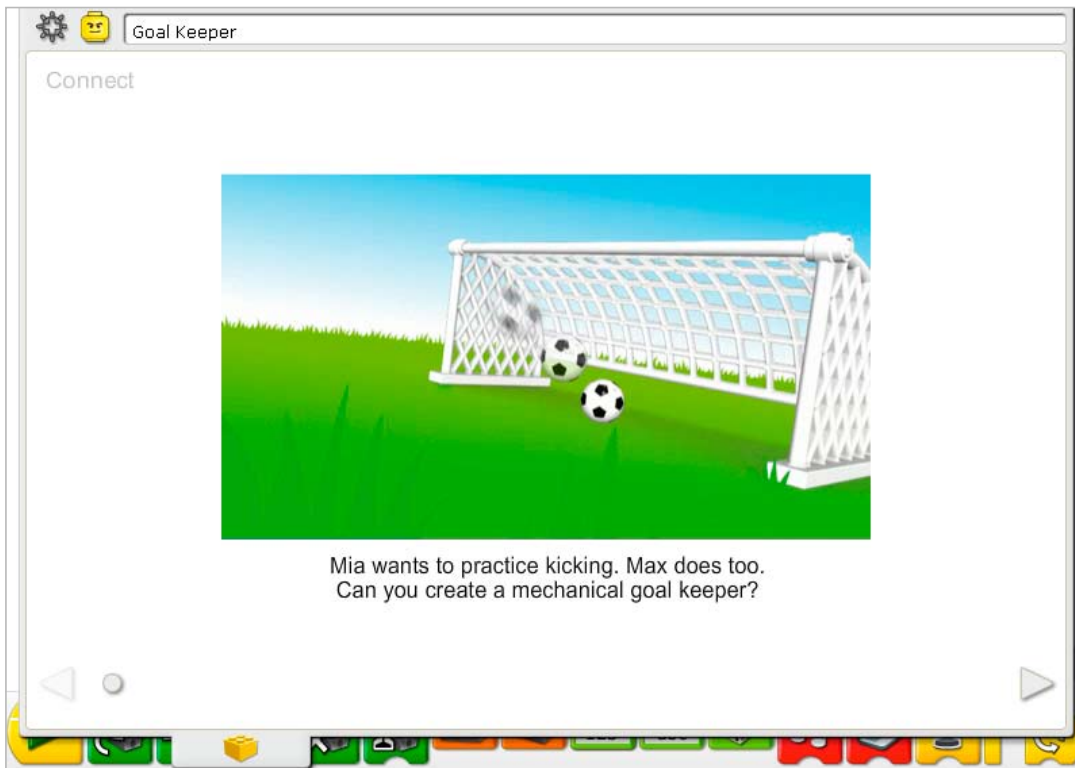
Wads of paper.



Connect

Review the Connect animation and discuss these questions:

What does the goal keeper do?
Is being the goal keeper easy? Why or why not?
Why do Mia and Max not want to be the goal keeper?



Here are other ways of connecting:

Stand up and raise your arms over your head. Lower your arms slowly. How big an area can you block by stretching your arms? Put your arms down and lift a leg. Now imagine you are a goal keeper? Can you stand at the goal and just block the ball with your body? What do you have to do to block the ball?

You must also move around.

Create a soccer goal and use balloons instead of soccer balls. Who can block the most balloons from the goal? Pretend you are a fantastic goal keeper and replay part of a game in slow motion. Can you save the game by blocking the ball?

Did you know...

Sports and games are unpredictable and that is one reason they are so interesting? Using a computer, unpredictability can be added into a program.

See the Random Input example in Getting Started:

16. Repeat Block.

Do you know who will win a game or how and by how much? Have you seen something random or unpredictable happen in a game? Was it a good surprise or a bad surprise?

Answers will vary according to experiences.

Construct

Build a goal keeper that blocks paper balls from the goal.

Our model...
 Uses a motor to turn a small pulley and belt...
 The belt turns the large pulley...
 The large pulley turns a lever arm...
 The lever arm moves the goal keeper.

Try this idea or create your own!

Build the model following step-by-step instructions or create your own goal keeper. If you create your own, you may need to change the example program.

To operate the goal keeper best, make sure the model can move freely back and forth. Otherwise, friction will interfere with the performance.

The energy transfers from the computer powering the motor, to the small pulley, then to the larger pulley, slowing the motion down. The rotating motion of the large pulley produces a back and forth motion in the beams connected to it. The back and forth motion of the beam transfers to the goal keeper as it slides back and forth on the rounded skid plate elements mounted on its feet. The rounded skid plate helps reduce friction because less of the LEGO® element is touching the surface.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the pulleys, belt, beams, and the goal keeper figure built from LEGO elements).

You can change the length of the lever arm by changing the hole in which it is attached to the pulley.



The Goal Keeper program turns on the Motor This Way, runs it for a random amount of time between one-tenth of one second and one full second then reverses the Motor That Way and runs it for a random amount of time between one-tenth of one second and one full second. The program repeats. Stop the program by clicking the Stop button.

See Getting Started for more examples with Motor On For, Motor This Way, Motor That Way, Random Input, and Repeat.

Contemplate

The screenshot shows a digital interface titled "Goal Keeper" with a "Contemplate" section. The text includes two questions: "How many balls can the goal keeper block?" and "How many goals can you score?". It lists two steps: "1) Flick paper balls at the goal keeper 10 times." and "2) Count the number of blocks, goals, and misses." It then says "Repeat steps 1 and 2 to play and count again!" and "Mark the goal keeper's best number of blocks. Mark your best number of goals." Finally, it asks "Did you or the goal keeper improve your scores?". To the right of the text is a hand-drawn data table with 4 columns and 4 rows. The top row has wavy lines in each cell. A yellow pencil is pointing to the top-right cell. The interface also has a settings gear icon, a smiley face icon, and navigation arrows at the bottom.

Set up enough space so you can flick paper balls toward the model and it can move back and forth to block them.

Make paper balls: About 3 centimeters (or a bit larger than an inch) diameter works well.

Draw a data table on a separate sheet of paper. Use the data table to record the attempts, blocks, goals, and misses. The data table should be large enough to record three sets of 10 attempts.

After running the activity, discuss conclusions to the data tables.

What was the goal keeper's highest number of blocks as shown in the Blocks column of the chart?

Answers will vary based on the individual data.

What was your best score as shown in the Goals column of the chart?

Answers will vary.

Did you or your goal keeper improve your scores as you compare results in the Blocks column of the chart for the goal keeper and the Goals column of the chart for yourself?

Answers will vary; however, if more goals (for you) or blocks (for the goal keeper) are made on the last test than the first or second, the response is yes.

Discuss other questions related to collecting data with the goal keeper.

From how far away were you when you flicked the paper balls?

Answers will vary but generally 15 to 30 centimeters or 6 to 12 inches is a good distance.

Do you think that your scores would improve if you moved closer or farther away? What do you predict?

Answers will vary. It is likely that the closer to the goal, the more goals are scored and fewer missed or blocked.

Alternative ideas...

Test your prediction. Did you score more goals when you were closer or farther away? Was your prediction correct or not?

Collect the data on the number of blocks, goals and misses. What is the average number of blocks per attempt (total of blocks, goals and misses) by the goal keeper? Which goal keeper in class has the best average?

Continue

Continue

Program your goal keeper to keep score. Try our solution or create your own!

Our solution adds the motion sensor to the goal to see the ball.

There are no building instruction changes required in this activity.

Use the motion sensor that is already built into the model. The motion sensor and motor can work in either LEGO® Hub port.



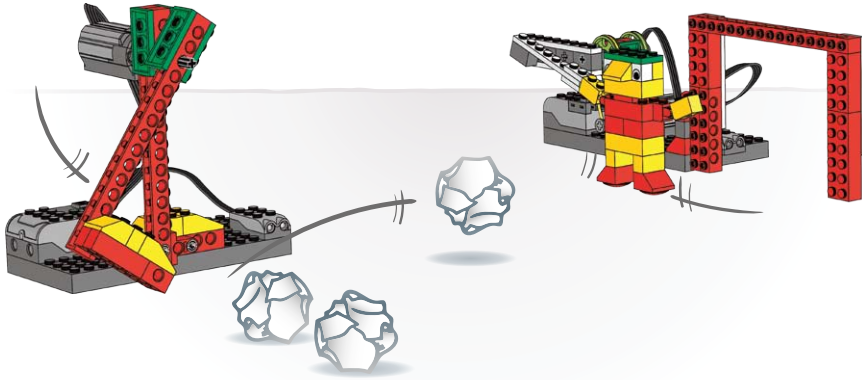
The Goal Keeper program is modified to add a new program that can run at the same time as the Construct program example.

The new program counts goals automatically. First, the Display Tab is reset. Then the program waits for the motion sensor to see something. When the motion sensor sees something, the Display adds one. The program pauses for half of a second (five-tenths of one second). The program repeats but only those Blocks checking for goals and displaying the score. The program does not reset the Display again.

See Getting Started for more examples with Add to Display, Display, Motion Sensor Input, Repeat, and Wait For.

Extension

Work with another group that has a kicker model and play a game of one-on-one soccer. Switch roles after a couple of minutes. Who has the most goals?





9. Cheerful Fans Teacher Notes

Students will build and program mechanical soccer fans that make cheering sounds and are motorized to jump up and down.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the cams at work in the model.
Understand and discuss criteria for a fair test.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the cheerful fans.
Improve the cheerful fans by adding a motion sensor.

Mathematics

Measure time in seconds and tenths of a second.
Understand and use numbers to measure and score qualitative characteristics.

Language

Communicate in spoken and written form using the appropriate vocabulary.
Participate as knowledgeable, reflective members of the group and class.

Vocabulary

Cam, crown gear, motion sensor, and performance. Blocks: Motion Sensor Input, Motor Off, Motor This Way, Play Sound, Start, and Wait For.

Other Materials

Optional for Extension: paper, yarn, pom-poms.



Connect

Review the Connect animation and discuss these questions.

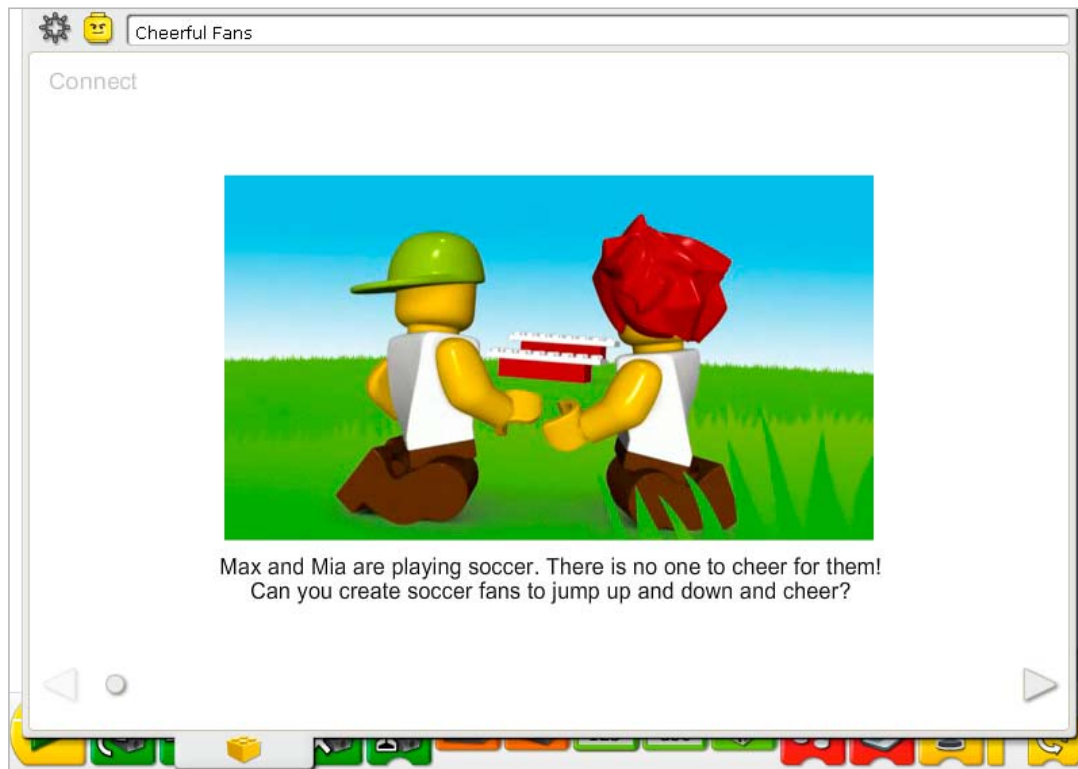
What are Mia and Max doing?

Mia and Max looked like they were having fun. Why are they not so cheerful at the end?

What might help them maintain their energy and excitement?

Have you ever been to a soccer game or seen one on television?

What do the fans do when the team scores?



Here are other ways of connecting:

Do you have a favorite sports team?

What do you do as a fan to support your team?

Who can sing the song or lead us in the cheer for a sports team?

Let's make up a cheer.

Give me an L...Give me an E...Give me a G...Give me an O. What does it spell? LEGO!

Did you know...

Fans who are watching the game are standing up and sitting down all the time as they try to follow the plays all over the field? To make mechanisms move up and down at various times, cams are used.

See the model in Getting Started: 14. Cam.

How does the cam create an up and down movement?

The egg shape of the cam lifts and lowers whatever is on the cam as it rotates around.

Construct

⚙️
😊
Cheerful Fans

Construct

Build soccer fans that move up and down and make sounds..

Our model...
 Uses a motor to turn a crown gear...
 The crown gear turns a small gear...
 The small gear turns other large gears and two cams...
 The two cams push the soccer fans up and down.

Try this idea or create your own!

◀
▶

Build the model following step-by-step instructions or create your own cheerful fans. If you create your own, you may need to change the example program.

To operate the cheerful fan model best, make sure each cam is positioned underneath the tire of the wheel and axle to lift, lower, and rotate the wheel and axle mechanism on each rotation.

The energy transfers from the computer powering the motor, to the crown gear, to a smaller gear, back to a pair of larger gears, to a pair of cams mounted on the same axle. The cams rotate, lifting and lowering two “heads” mounted on axles on a wheel base. The wheels provide a surface for lifting and lowering the heads of the cheerful fans.

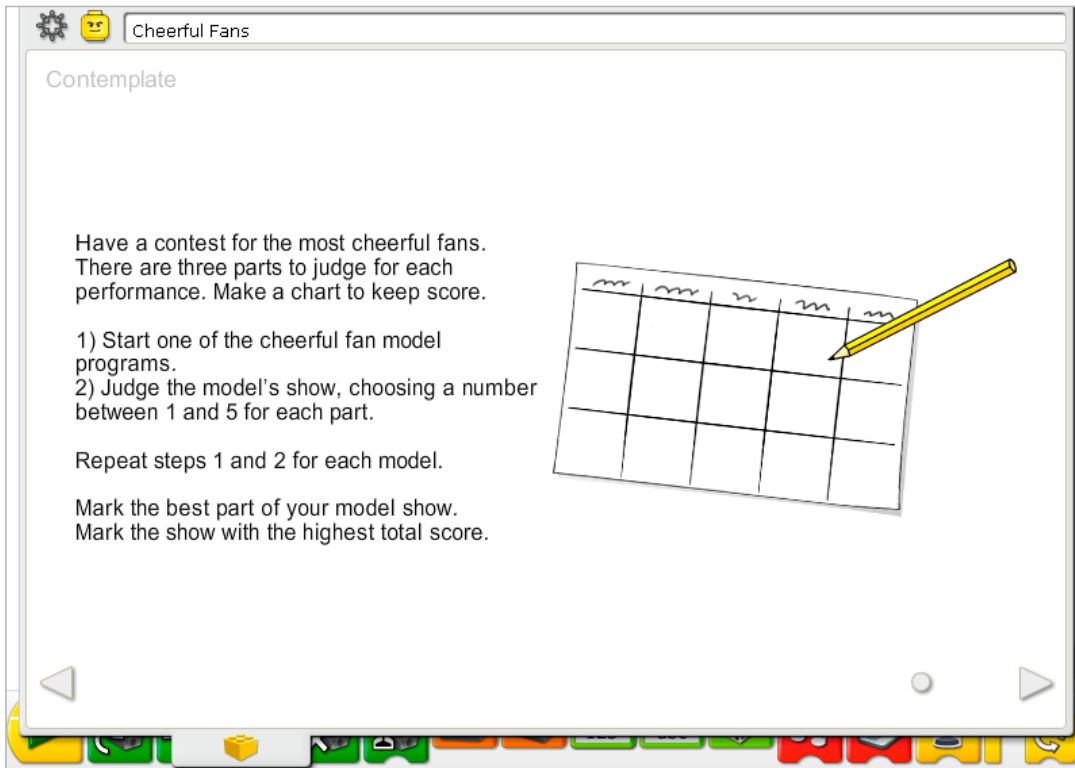
The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, cams, and heads of the soccer fans built from LEGO® elements).



The Cheerful Fans program turns on the Motor This Way, plays Sound 11, the Cheer sound, waits for two seconds, plays Sound 12, the Whistle sound, waits for one second, then turns off the motor.

See Getting Started for more examples with Motor Off, Motor This Way, Play Sound, and Wait For.

Contemplate



Cheerful Fans

Contemplate

Have a contest for the most cheerful fans. There are three parts to judge for each performance. Make a chart to keep score.

- 1) Start one of the cheerful fan model programs.
- 2) Judge the model's show, choosing a number between 1 and 5 for each part.

Repeat steps 1 and 2 for each model.

Mark the best part of your model show.
Mark the show with the highest total score.

The image shows a 3x5 grid chart with a yellow pencil pointing to the top-right cell. The top row of the grid has wavy lines above each column, representing categories for judging.

Set up enough space so you arrange the cheerful fans models and have a contest to judge the best performance.

Draw a chart on a separate sheet of paper. Use the chart to record the scores for all three categories: Looks, Sounds, and Moves. Include a line for each model so you can mark scores for each performance.

After running the activity, discuss conclusions to the data tables.

What was the best part of your own model's show?

Answers will vary based on the individual data.

Which model had the best performance over all?

Answers will vary.

Discuss other questions related to collecting data on the performances.

How can we have a fair test for the models judged?

Run each program for same length of time, have multiple people judging, give each contestant more than one try.

Is it fair to judge our own models?

Self-assessment can be appropriate but often we prefer our own ideas to others. On the other hand, sometimes we are harder on ourselves or fear that others will think we are biased so we judge ourselves more harshly.

How else might we judge?

Invite others from another class to judge; Include other categories, e.g., Most decorated, Best team effort; Include more than five levels? Fewer?

Alternative ideas...

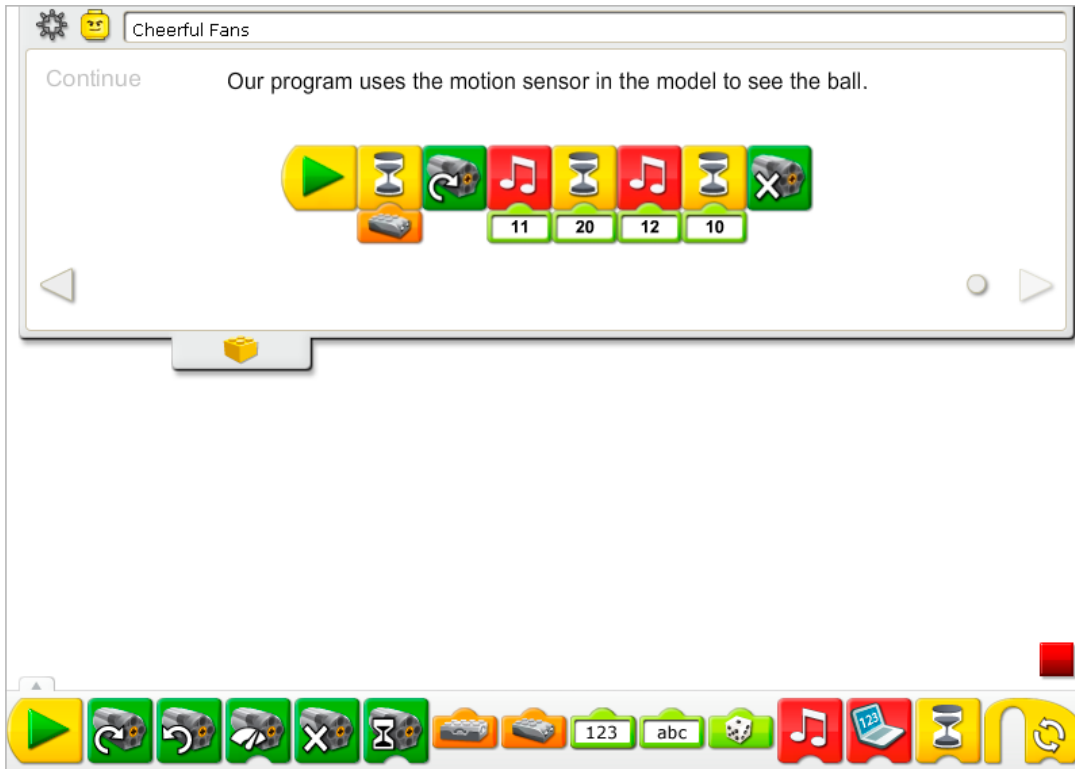
Write your own cheer and program the cheerful fans to synchronize their movement and sounds along with you.

Continue

The screenshot shows the LEGO Mindstorms software interface for a project named "Cheerful Fans". The window title is "Cheerful Fans" and the main content area is titled "Continue". The text in the window reads: "Program your soccer fans to jump up and down and cheer when the ball passes by. Try our solution or create your own!" and "Our solution uses the motion sensor in the model to see the ball." To the right of the text is an illustration of a LEGO robot with two fans on top. One fan is yellow and the other is red. The yellow fan has "UUUUHH" written above it, and the red fan has "WHAAA" written above it. A hand is shown pointing at a soccer ball on the ground, with red wavy lines indicating the ball's path. The bottom of the window shows a toolbar with various LEGO parts and icons.

There are no building instruction changes required in this activity.

Use the motion sensor that is already built into the model. The motion sensor and motor can work in either LEGO® Hub port.



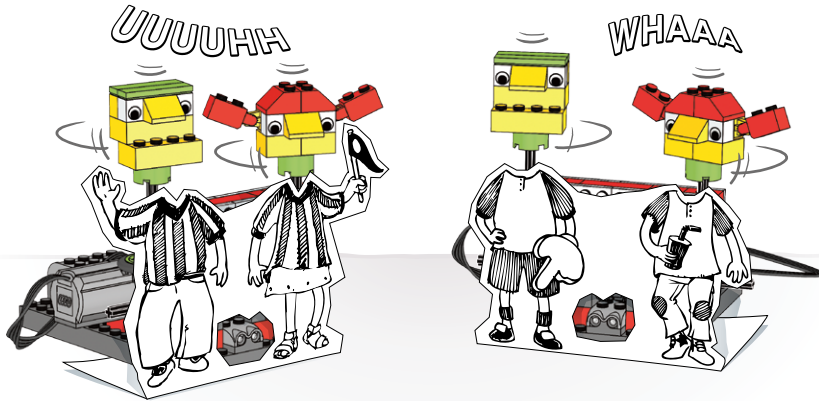
The Cheerful Fans program is modified to wait for the motion sensor to see the ball. When the motion sensor sees the ball, it turns on the Motor This Way, plays Sound 11, the Cheer sound, waits for two seconds, plays Sound 12, the Whistle sound, waits for one second then turns off the motor.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motion Sensor Input, Motor Off, Motor This Way, Play Sound and Wait For.

Extension

Create a half-time show with several cheerful fans models. Create a song and program the models to “sing” together. Use the sensors to time the performances. Use other materials such as paper, yarn, and pom-poms to decorate the models.





Teacher Notes for the Activities: Adventure Stories





10. Airplane Rescue Teacher Notes

Students will build and program a mechanical airplane that is motorized to change propeller speed as it climbs up and dives down.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the airplane's power level and movement.

Improve the airplane by programming sounds to coordinate with the feedback from the tilt sensor.

Mathematics

Understand and use tilt sensor values to control the timing of the motor and the type of sounds played.

Language

Use interview questions to find out information.

Organize that information to write a story, maintaining a focus on the events.

Use technology to create and communicate ideas.

Communicate in spoken and written forms using the appropriate vocabulary.

Vocabulary

Propeller. Blocks: Motor Power, Play Sound, Random Input, Repeat, Start On Key Press, Tilt Sensor Input and Wait For.

Other Materials

Stopwatches or clock with second hand.

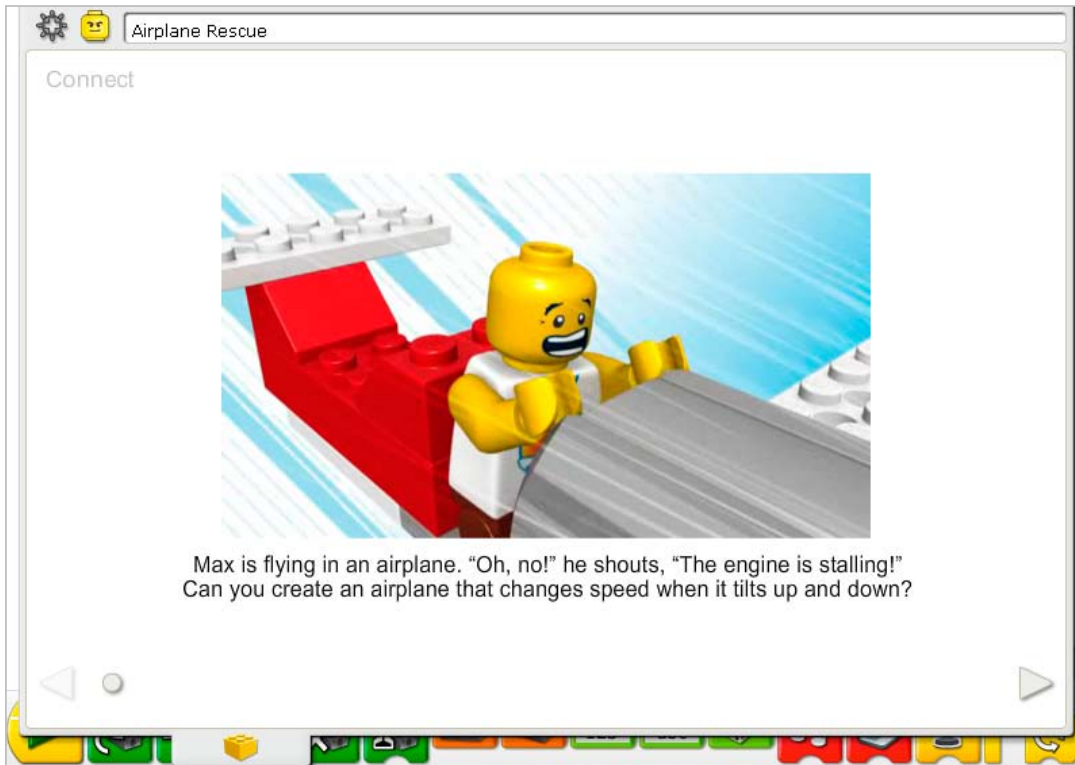
Optional for Extension: Sheets of card, scissors, tape, string, marker pens, brushes and paint.



Connect

Review the Connect animation and discuss these questions.

What happened to Max as he was flying along?
What did the plane do when the engine stopped?
What did the plane do when the engine started again?
Where do you think Max was going?



Here are other ways of connecting:

Look at a map or a globe. Find your location. Choose another location far away. Pretend you are on an airplane flying from one location to another. As you take your journey, what are you flying over? What might you see if you could look out the window of the airplane? Are there mountains? Farms? Rivers? Oceans?

Why do we have airplanes to go from one place to another?

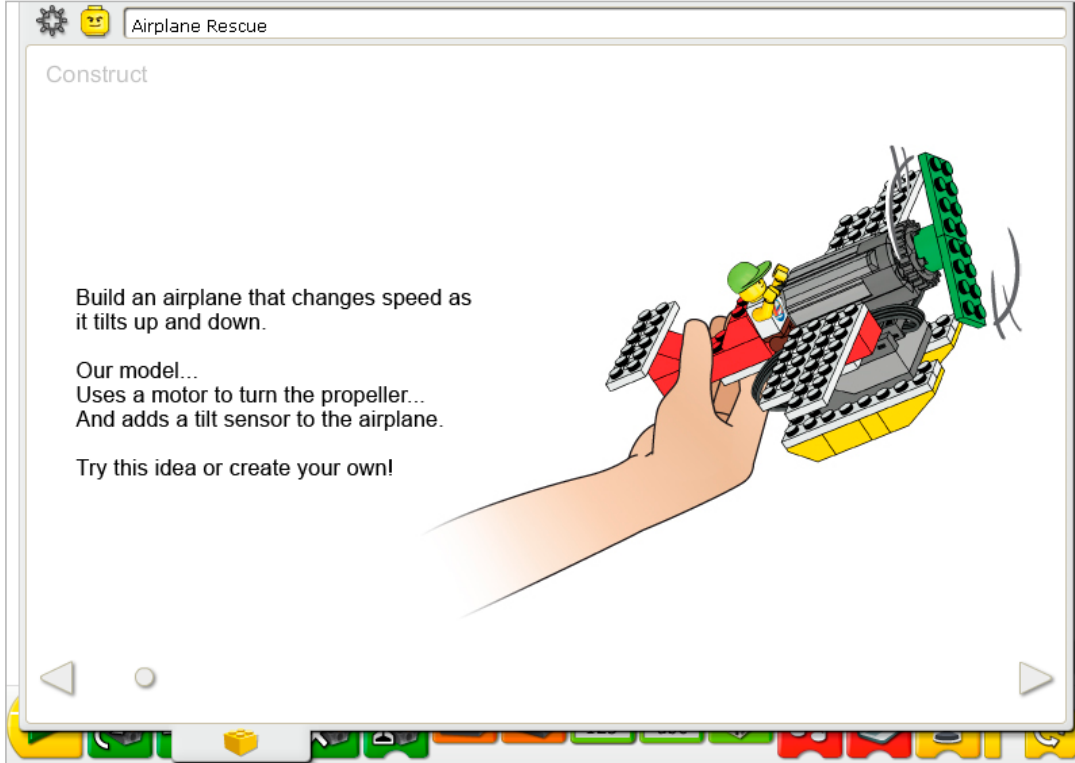
Did you know...

To fly properly, a pilot needs to know the position of the airplane in the air. Is it tilted up, tilted down, or in some other direction?
See the model in Getting Started: 6. Tilt Sensor.

How many different ways does the tilt sensor report its position?

The tilt sensor can report its position in six ways: Up, Down, This Way, That Way, No Tilt, Any Tilt.

Construct



The screenshot shows a software window titled "Airplane Rescue" with a "Construct" tab. The window contains the following text:

Build an airplane that changes speed as it tilts up and down.

Our model...
Uses a motor to turn the propeller...
And adds a tilt sensor to the airplane.

Try this idea or create your own!

The window also features a 3D illustration of a hand holding a LEGO airplane model. The model is built using various colored bricks (red, white, grey, yellow, green) and includes a motor and a propeller. The window has a standard toolbar at the bottom with navigation arrows and a search icon.

Build the model following step-by-step instructions or create your own airplane. If you create your own, you may need to change the example program.

To operate the airplane best, make sure the wires are positioned away from the propeller as shown in the building instructions. The tilt sensor, the motor, and the LEGO® Hub are mounted on the airplane so you can move the model around more easily.

The energy transfers from the computer powering the motor to the axle turning the propeller blades.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the motor axle and propeller).



There are two airplane programs. Both of these programs start when you press the **A** key on the keyboard. The first program waits for the airplane to tilt up then turns on the motor at power level 10. The program repeats. The second program waits for the airplane to tilt down then turns on the motor at a random speed between 1 and 10. The program repeats. To stop the programs, click the Stop button.

Running two or more programs at the same time is called multitasking but this term is not introduced directly to the students.

See Getting Started for more examples with the Motor Power, Random Input, Repeat, Start On Key Press, Tilt Sensor Input, and Wait For.

Contemplate

Airplane Rescue

Contemplate

You are a reporter interviewing Max after his journey. You ask questions to find out:

Who is Max?
Where did he go?
Why did he go there?
What happened on his trip?
How did he get back safely?

Act out the story of the trip. Use the airplane to help you! Work with a friend so that one of you is Max and the other is the interviewer.

Set up enough space so you can run the airplane program and act out your story.

Develop responses to the interview questions as if you are journalist interviewing Max. Write a story of Max's journey based on these interview responses. Then read through the story using a stopwatch.

You may wish to adjust the airplane program to suit your story better.

Practice reading your airplane story, dramatizing important moments with the airplane movement.

After acting out your story, discuss these ideas.

Did the responses to your interview questions give details that make the story interesting?

Answers will vary. If the class hears each presentation, a class evaluation or informal feedback may help here.

Did your use of the airplane add drama to the story?

Self-evaluation and class evaluations may be useful here as well.

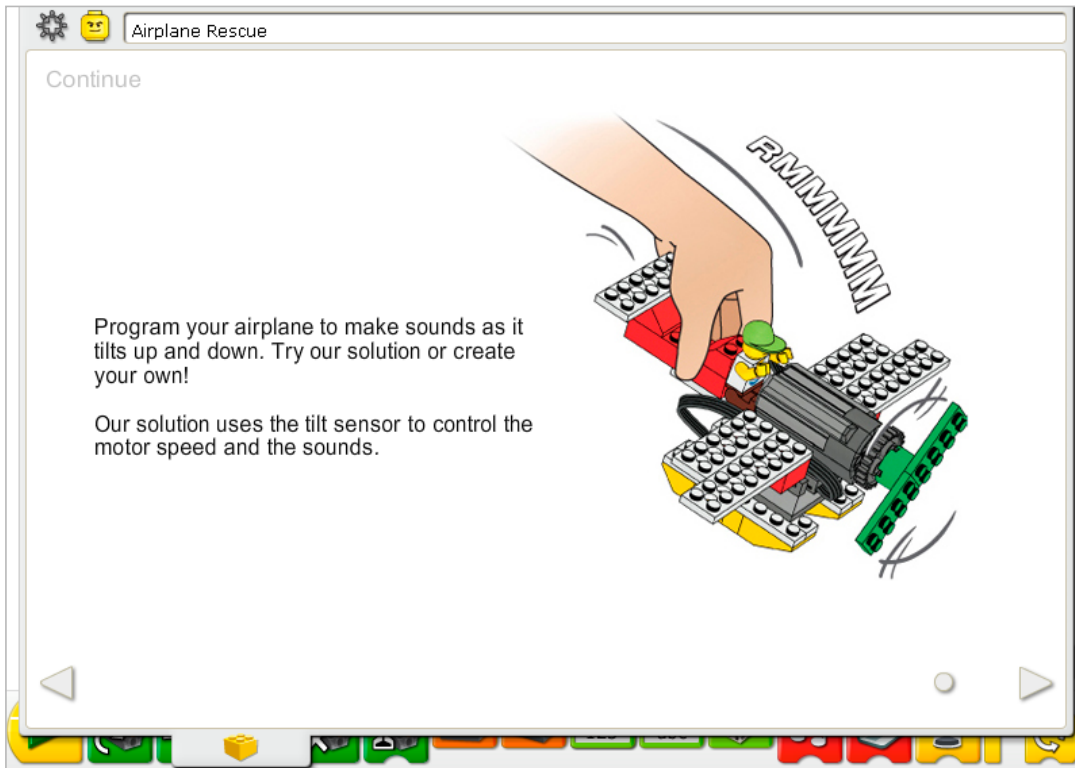
What other features of the story or program might you want to add next time?

Answers will vary. Possible answers could include other sound effects, a bigger plane with more people in the story, sending Max somewhere else.

Alternative ideas...

Create a map with a dotted line to show Max's journey. Fly the plane over the map and tell a story about his journey following the map.

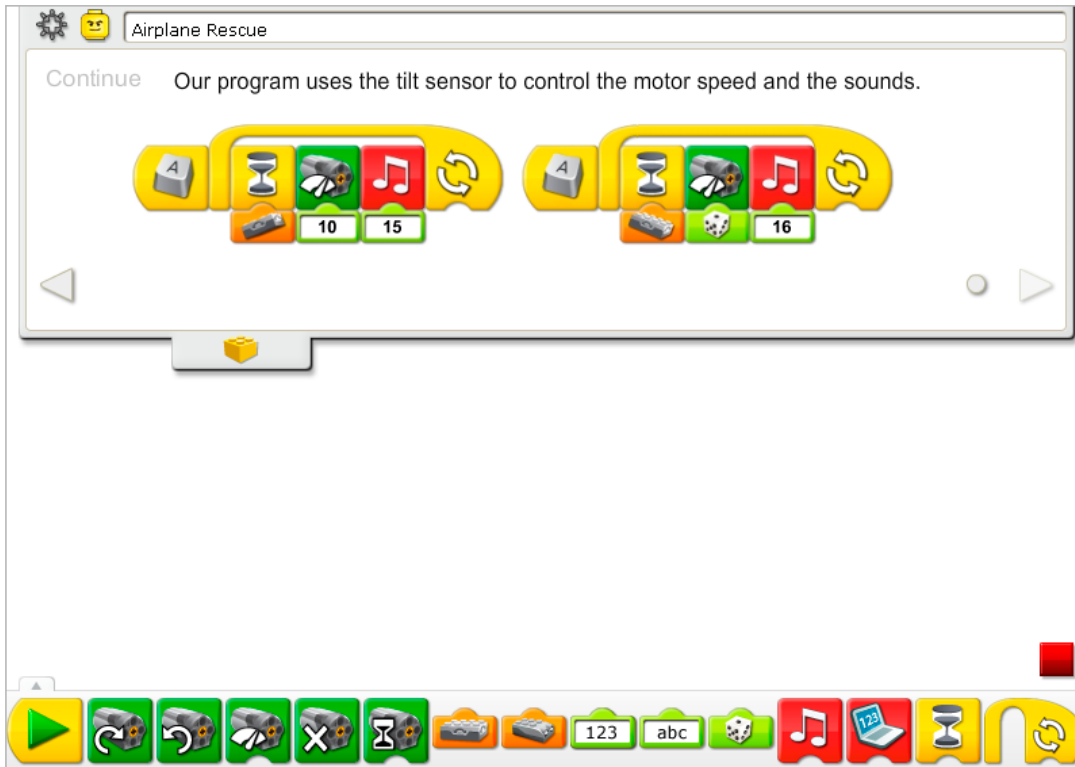
Continue



The screenshot shows a software window titled "Airplane Rescue" with a "Continue" screen. The text on the screen reads: "Program your airplane to make sounds as it tilts up and down. Try our solution or create your own!" and "Our solution uses the tilt sensor to control the motor speed and the sounds." To the right, an illustration shows a hand tilting a LEGO airplane model. The model is built with red, yellow, and grey bricks, featuring a motor and a green propeller. The word "RMMMMM" is written in a curved, stylized font above the model, indicating sound. The interface includes a settings icon, a smiley face icon, and navigation arrows at the bottom.

There are no building instruction changes required in this activity.

The tilt sensor is already part of the model. The tilt sensor and motor can work in either LEGO® Hub port.



The Airplane Rescue program is modified to add the sounds. Sounds are added in each program after the Wait For Tilt Sensor Input. The first program waits for the plane to be tilted up, then changes the motor power to level 10 and plays Sound 15, the Motor sound. The second program waits for the tilt sensor to be tilted down, then changes the power to a random level between 1 and 10 and plays Sound 16, the Clonk sound. Both programs repeat.

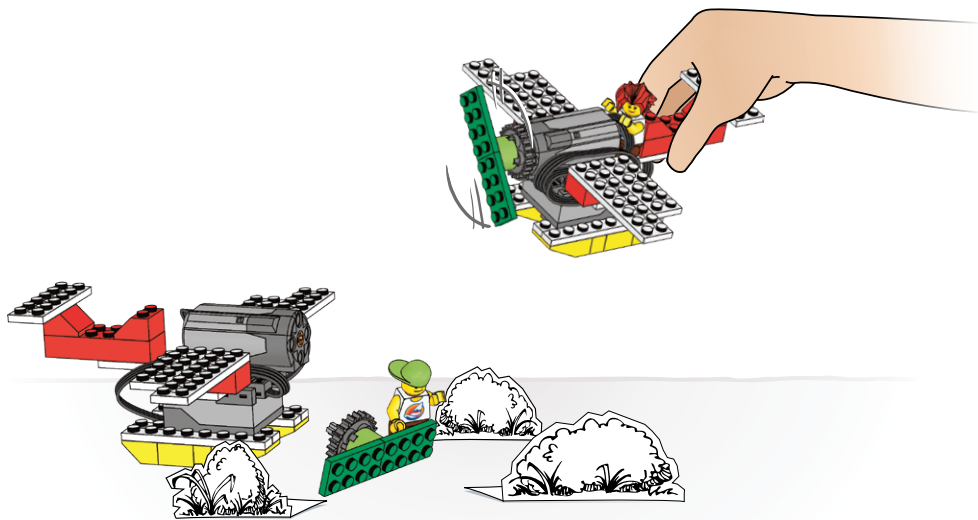
Run both program by pressing the **A** key on the keyboard. The two programs can run at the same time without conflicting because they are waiting for the tilt sensor to be moved into different positions.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motor Power, Play Sound, Random Input, Repeat, Start On Key Press, Tilt Sensor Input and Wait For.

Extension

Cooperate with another group in the class to create a rescue story. Max's airplane has run out of fuel and has landed hard, damaging the airplane, somewhere in a remote part of the world. Mia and her rescue team are searching for him. Ask the interview questions to develop the story. Then create an airplane or another vehicle to rescue Max. Act out your story for the rest of the class.





11. Giant Escape Teacher Notes

Students will build and program a mechanical giant that makes sounds and is motorized to lift up as if it is waking from sleep and standing up.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the range of motion as well as the pulley and gears at work in the model.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the giant's movement.
Improve the giant by adding the motion sensor and programming the giant to respond when someone comes near.

Mathematics

Understand that numbers control the timing of the motor and the type of sounds played.

Language

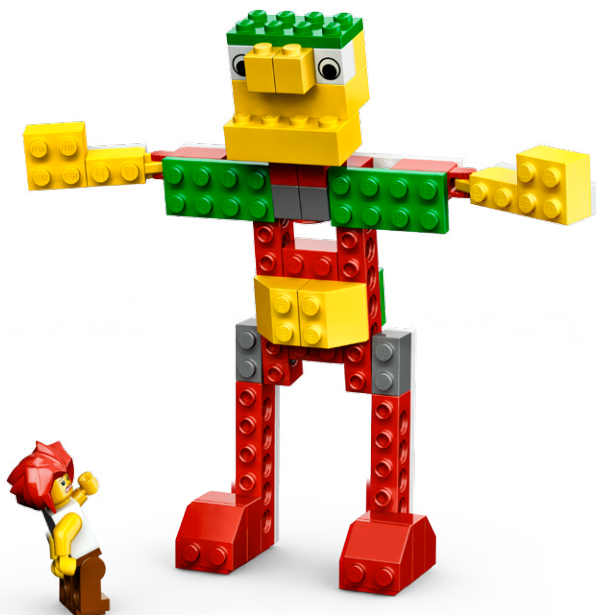
Write a script with a dialogue among the three characters: Mia, Max, and the giant.
Use technology to create and communicate ideas.
Communicate in spoken and written forms using the appropriate vocabulary.

Vocabulary

Gear, lever, motion sensor, program, pulley, and script, worm gear. Blocks: Motion Sensor Input, Motor Off, Motor That Way, Play Sound, Repeat, Start and Wait For.

Other Materials

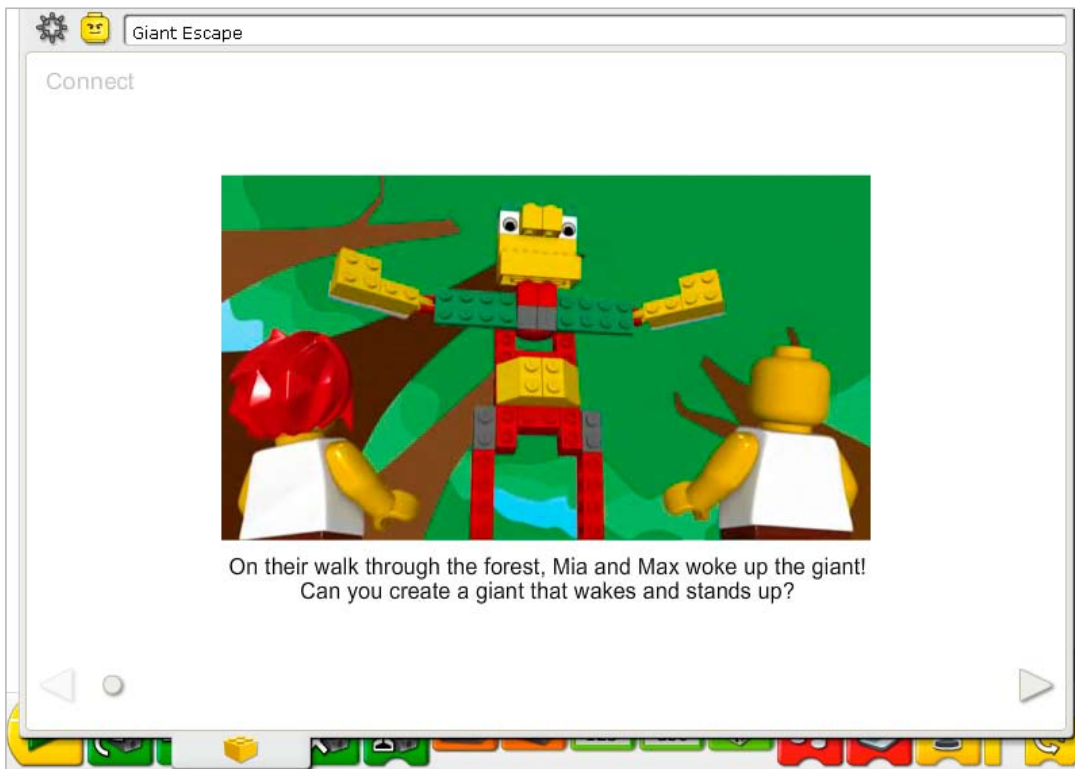
Stopwatches or clock with second hand.



Connect

Review the Connect animation and discuss these questions.

- What will the giant do when it wakes up?
- Is it an angry giant or a friendly giant?
- What will Max and Mia do?
- What would you do?
- What sounds will the giant make?



Here is another way of connecting:

Have someone lie down on the floor and pretend to be the sleeping giant. Ask two others in the classroom to sneak up on the sleeping giant. How close can they get? Can the giant jump up before they are within $\frac{1}{2}$ meter (about $\frac{1}{2}$ a yard)?

Did you know...

Gears and pulleys can be used to move and lift heavy objects?
See the model in Getting Started:
13. Worm Gear.

What is a worm gear and why is it useful?

A worm gear slows down the motor speed and increases the force possible to lift heavier objects. A worm gear turns only in one direction, serving as a "lock" for gear trains

Construct

⚙️
😊
Giant Escape

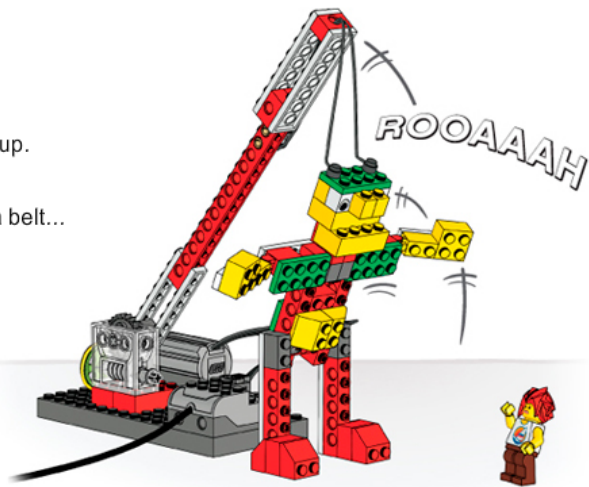
Construct

Build a giant that wakes and stands up.

Our model...

- Uses a motor to move a pulley and a belt...
- The belt moves another pulley...
- The pulley turns a worm gear...
- The worm gear turns a large gear...
- The large gear lifts the lever arm...
- The lever arm lifts the string...
- The string lifts the giant!

Try this idea or create your own!



◀
▶

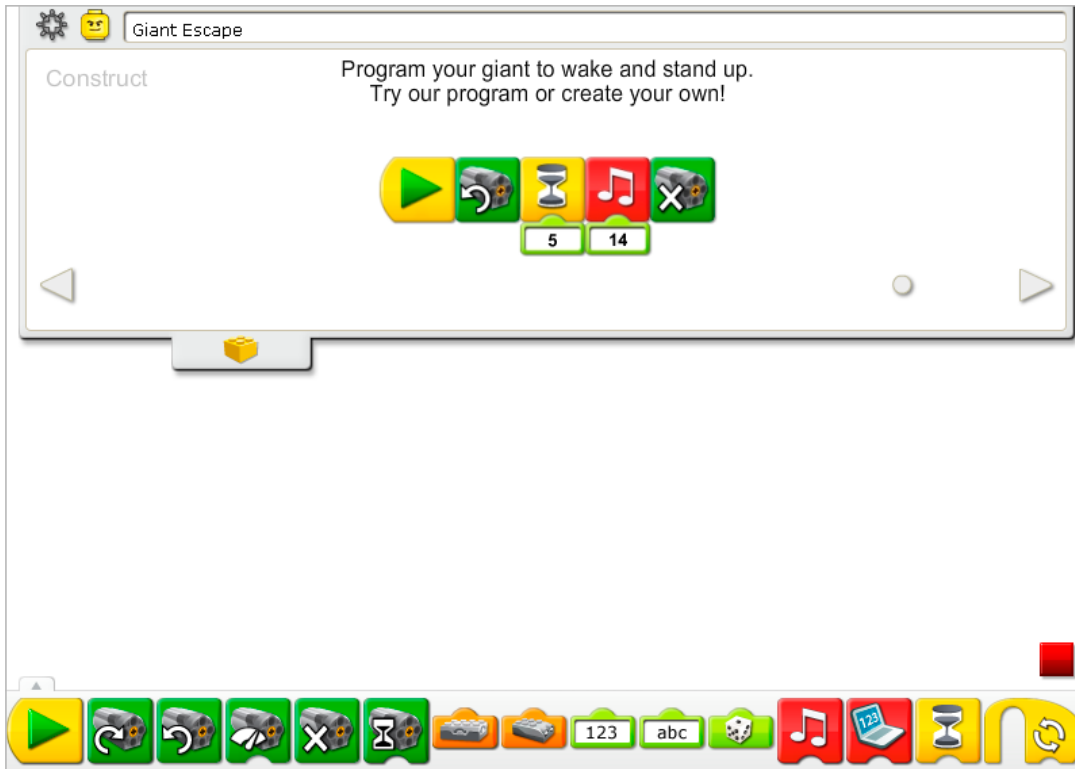
Build the model following step-by-step instructions or create your own giant. If you create your own, you may need to change the example program.

The energy transfers from the computer powering the motor, to the pulley and the belt. The belt moves another pulley, turning the worm gear and larger gear, slowing the motion down and providing more force to raise the lever arm and string, lifting the giant.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the pulleys and belt, gears, lever arm, string, and the giant figure built from LEGO® elements).



To operate the giant best, lay it down and test the motor direction to make sure the pulley and gears are lifting and lowering the giant properly. Here are two test programs to raise and lower the giant. The programs start when you press the arrow up key or arrow down key on the keyboard.



The Giant Escape program turns on the Motor That Way, leaves it on for five-tenths of one second, plays Sound 14, the Roar sound, and turns off the motor.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with Motor Off, Motor That Way, Play Sound and Wait For.

Contemplate

Contemplate

A script tells a story as a play or movie. It tells the actors what to say and do. Write a script to tell what happened when the giant woke up.

Giant: Who woke me up? ROAR! I want to eat now!
 Mia: Oh, Mr. Giant, we don't taste very good.
 Max: I'll run home and find something very good to eat.

How do Mia and Max save themselves from the giant?
 Act out your script with the giant model!

Set up enough space so you can run the giant program and act out your story.

Gather paper, work with a partner and start writing your script. After writing a draft, read through the script using a stopwatch. Have your partner mark the time that has passed for each line to be read and add comments in for the movements of the model and the Max and Mia minifigures.

You may wish to adjust the giant program including the input numbers for Wait For and Play Sound to suit your story better.

Practice reading through your story script, dramatizing it at important moments with the giant movements.

After acting out your story, discuss these ideas.

What happened when the giant woke up?

Answers will vary based on each story script.

How did Mia and Max save themselves from the giant?

Answers will vary based on each story script.

Discuss other questions related to the giant story.

What type of characters are Mia and Max? Are they young, old, brave, cowardly, smart?

Answers will vary based on each story script; however, you may want to focus on specific words or actions in each script and relate them to character traits.

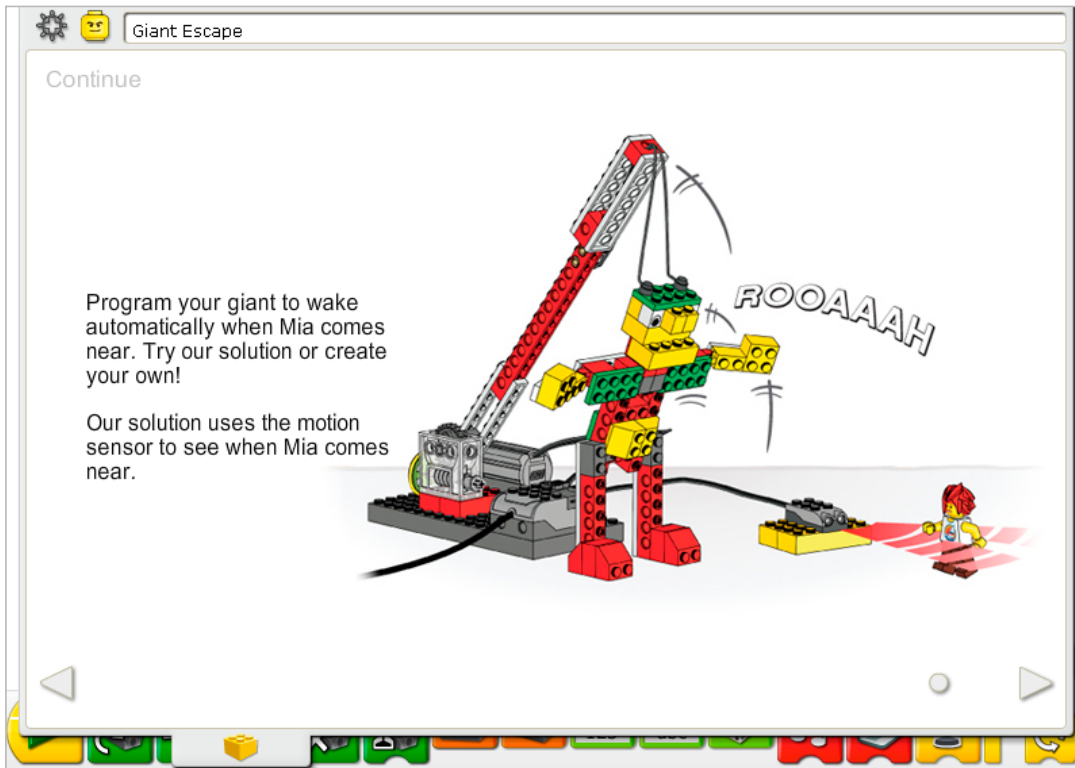
Adventure stories usually have a great deal of action and an exotic location. Is your story an adventure story? If so, what are the actions in the story? What is the location? If not, what actions could you add? In what location would you place your story?

Answers will vary based on each story script.

Alternative ideas...

Act out the story using gestures and facial expressions rather than words. Are you able to convey the same thoughts and feelings? Why or why not?

Continue



Continue

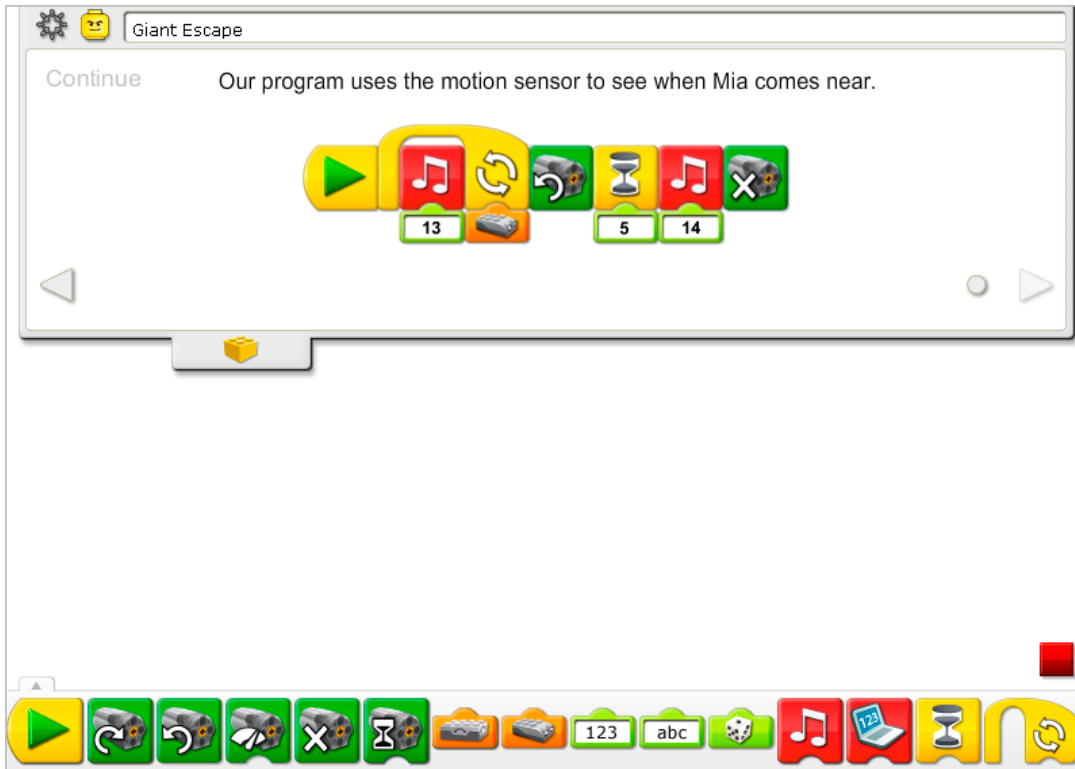
Program your giant to wake automatically when Mia comes near. Try our solution or create your own!

Our solution uses the motion sensor to see when Mia comes near.

ROOAAAH

Follow the step-by-step instructions to add the motion sensor. The motion sensor and motor can work in either LEGO® Hub port.

You can activate the motion sensor with your hand or with a Max or Mia minifigure. Make sure to hold your hand or the minifigure in front of the motion sensor so the sensor has enough time to see it.



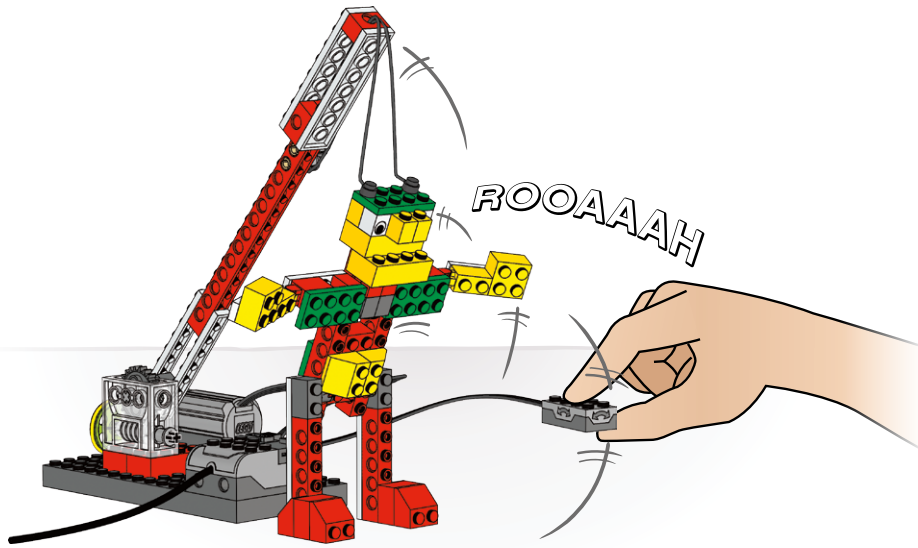
The Giant Escape program is modified to add the Motion Sensor Input and more sounds. To start, Sound 13, the Zzz sound plays and the program repeats until the motion sensor sees something. Then it turns on the Motor That Way, for five-tenths of one second, plays Sound 14, the Roar sound, and turns off the motor.

See Getting Started for more examples with Motion Sensor Input, Motor Off, Motor That Way, Play Sound, Repeat, and Wait For.

Extension

Change story to suit a new situation. Mia has found a magic wand in the forest! Create a magic wand using the tilt sensor. Put the giant back to sleep after waving the magic wand. No spell is necessary but you can make up your own!

See Getting Started Tilt Sensor for programming ideas.





12. Sailboat Storm Teacher Notes

Students will build and program a mechanical sailboat that makes sounds and is motorized to rock back and forth as if it is sailing on the sea.

Objectives

Science

Trace the transmission of motion and transfer of energy through the machine.
Identify the range of motion as well as the gears and the gearing down at work in the model.

Technology

Create a programmable model to demonstrate the knowledge and operation of digital tools and technological systems.

Engineering

Build and test the sailboat's power level and movement.
Improve the sailboat by adding the tilt sensor and programming sounds to coordinate with the movement.

Mathematics

Understand how the speed of the motor and the timing of the sounds relate to the rocking pattern of sailboat.
Understand and use tilt sensor values to control the timing of the motor and the type of sounds played.

Language

Write a logical sequence of events.
Organize those events to create a story, maintaining a focus on the characters and objects.
Use technology to create and communicate ideas.
Communicate in spoken and written forms using the appropriate vocabulary.

Vocabulary

Gears, lever, random, ship's log, and tilt sensor. Blocks: Motor Power, Play Sound, Random Input, Repeat, Start, Tilt Sensor Input and Wait For.



Connect

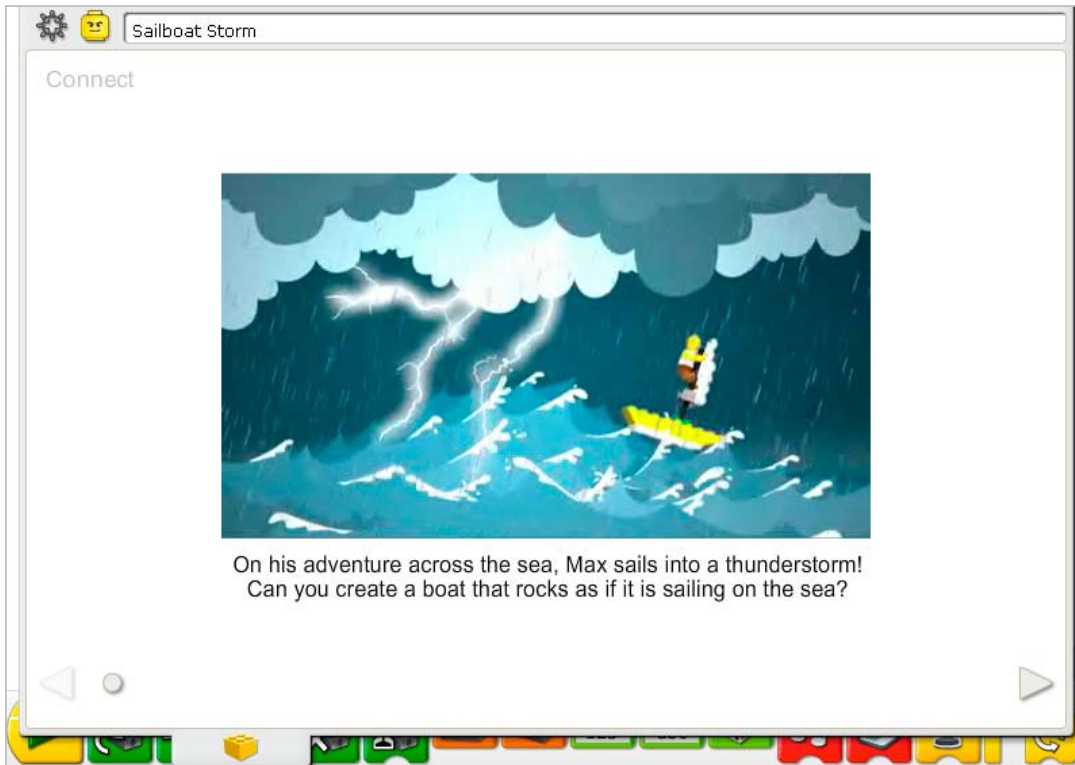
Review the Connect animation and discuss these questions.

What is Max doing?

What was the weather like when he started his journey?

What happened while he was out at sea?

Was Max able to finish his journey?



Here are other ways of connecting:

Pretend you onboard the sailboat with Max. Show us what happens when the storm comes.

Pretend you are the captain of a large ship. Are you an explorer, or a pirate, or do you just enjoy sailing? Sing a sea shanty!

Did you know...

You can show a value for the position of the tilt sensor when the boat rocks back and forth?

See the model in Getting Started:

15. Lever.

What tilt sensor values are shown when the lever moves up and moves down?

The tilt sensor value is 8 when it moves This Way and 6 when it moves That Way. When the tilt sensor is level (No Tilt), it measures 0. Although not used in this model, Tilt Up and Tilt Down also show values. The Tilt Up value is 4 and the Tilt Down value is 10.

Construct

⚙️
😊
Sailboat Storm

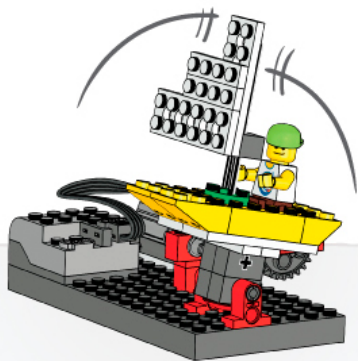
Construct

Build a boat that rocks as if it is sailing on the sea.

Our model...

- Uses a motor to turn a small gear...
- The small gear turns a large gear...
- The large gear moves a lever arm...
- The lever arm moves the boat...
- The boat is mounted on an axle...
- So it rocks back and forth.

Try this idea or create your own!



◀
▶

Build the model following step-by-step instructions or create your own sailboat. If you create your own, you may need to change the example program.

To operate the sailboat best, use a gearing down combination like the one shown in the building instructions so the sailboat moves more slowly.

The energy transfers from the computer powering the motor, to the small gear, then to the larger gear, slowing the motion down. The rotating motion of the large gear produces a back and forth motion in the lever arm beam because it is fixed to the outer edge of the gear. The back and forth motion of the lever arm transfers to the sailboat which is mounted on an axle mechanism.

The energy changes from electrical (the computer and motor) to mechanical (physical movement of the gears, lever arm, and sailboat).



The Sailboat Storm program repeats a series of actions controlling the motor. First, the motor is set to power level 2. Then the computer waits for a random amount of time between one-tenth of one second and one full second. Then the motor power increases to power level 6 and waits for random amount of time.

The Motor Power Block can use a number between 0 and 10. If the power level is 0, the motor is off.

To repeat the program a specific number of times, add an input to the Repeat Block.

See Getting Started for more examples with Motor Power, Repeat, Random Input and Wait For.

Contemplate

Sailboat Storm

Contemplate

A ship's log is a record of what happens on a journey. Write an exciting ship's log to describe what happens on Max's journey.

9:00 I left on a calm sea.
 1:00 Thunder sounds and waves are high.
 3:00 The lightening scares me!
 7:00 I landed safely. Where am I?

Act out the events from your ship's log with your model.

What does the storm do to the boat?
 What does Max see?
 Does Max's boat survive?

Set up enough space so you can run the sailboat program and act out your story.

Draw a chart for your ship's log on a sheet of paper. Use the chart to organize the sequence of events that you imagine for Max's journey. Order the events according to the time of day.

You may wish to adjust the input numbers to the Motor Power level and Wait For timing to suit your sequence better, including changing the Random Input to a Number Input.

Practice reading through your ship's log and dramatizing it at important moments with the sailboat movements.

After acting out your story, discuss these ideas.

What does the storm do to the boat?

Answers will vary based on each story. There are no right or wrong answers; however, you may wish to compare the ship's log entries with the stories as they are written and presented to focus on developing logical sequences.

What does Max see?

Answers will vary based on each story.

Does Max's boat survive?

Answers will vary based on each story.

Discuss other questions related to the sailboat story.

How can you add details to improve the story?

Answers will vary, e.g., tell more details about Max's character; tell more about the plot such as where Max is going and why; describe what Max sees.

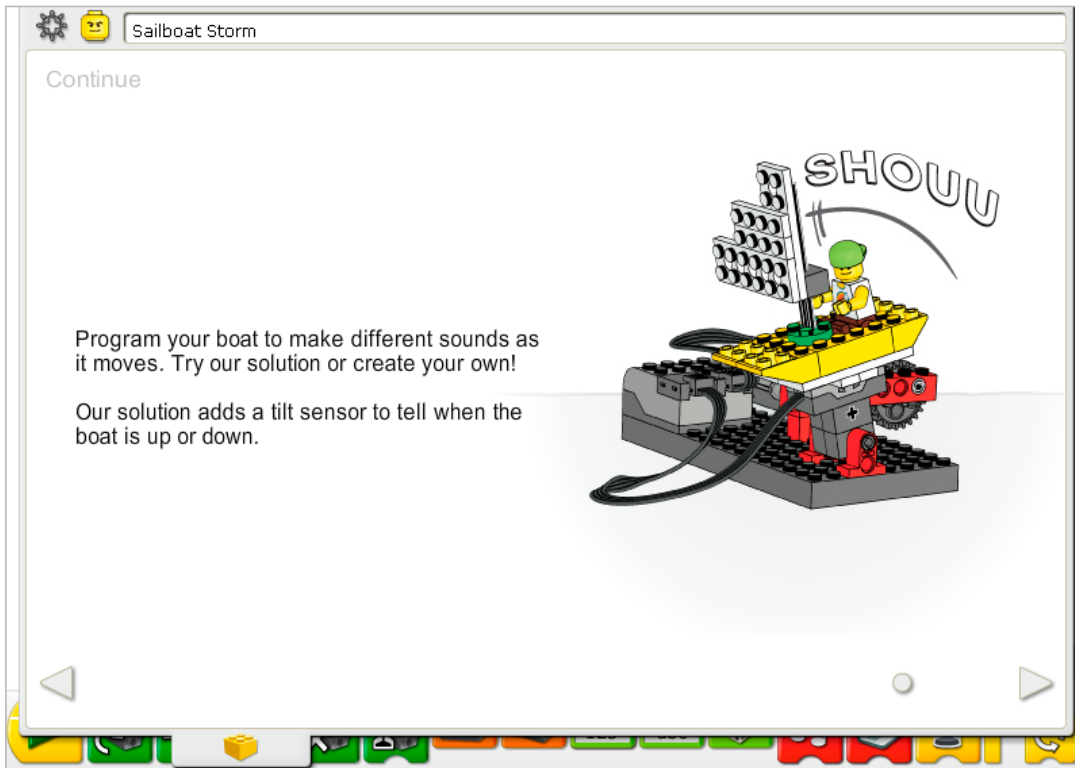
How can you make the plot more interesting?

Answers will vary. Create some tension in the story to add excitement. For example, create a time constraint so Max has only a small amount of time to fix something or get somewhere. You can also create an exciting plot twist. For example, introduce another character such as Mia and have her rescue Max using a plane or another sailboat.

Alternative ideas...

Create a storyboard to show a visual sequence of events illustrating your ship's log.

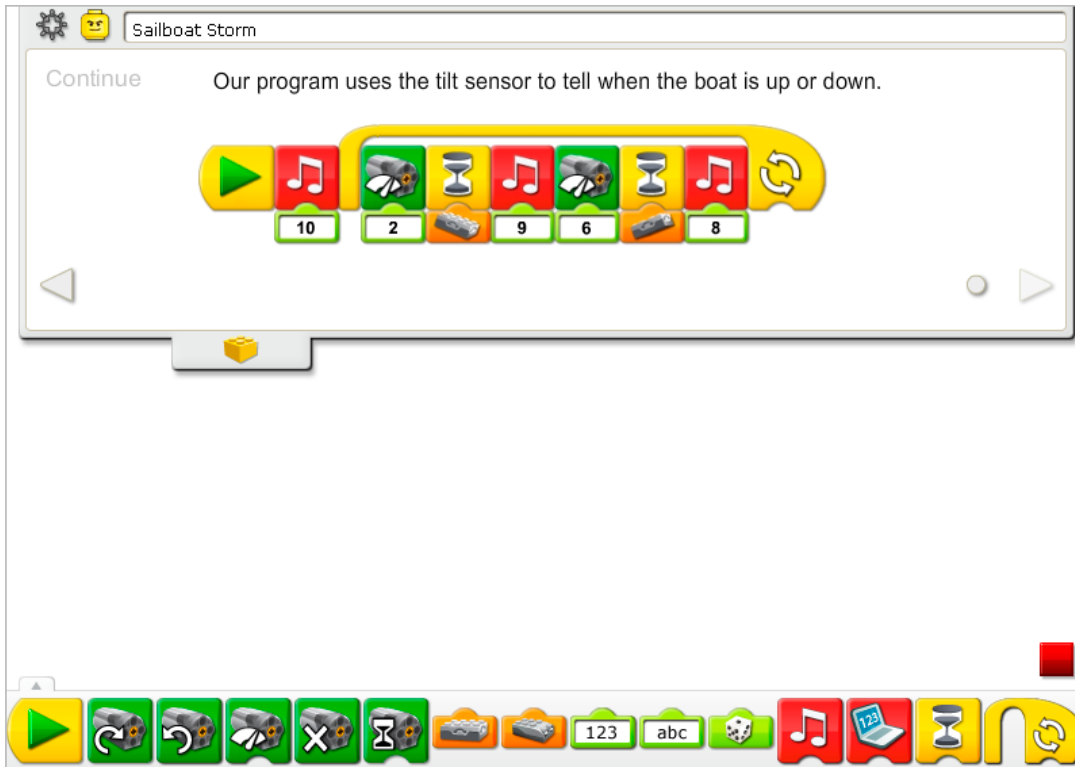
Continue



The screenshot shows a software window titled "Sailboat Storm" with a gear icon and a smiley face icon. The window contains the text "Continue" at the top. Below this, there is a paragraph of text: "Program your boat to make different sounds as it moves. Try our solution or create your own!" followed by another paragraph: "Our solution adds a tilt sensor to tell when the boat is up or down." To the right of the text is an illustration of a LEGO boat with a yellow hull and a grey motor. A tilt sensor is mounted on the boat's deck. The word "SHOUU" is written in a stylized font above the boat, with a curved arrow indicating the boat's movement. At the bottom of the window, there is a toolbar with various icons, including a left arrow, a play button, and a right arrow.

Follow the step-by-step instructions to add the tilt sensor. The tilt sensor and motor can work in either LEGO® Hub port.

The tilt sensor must be positioned as shown in the building instructions or it will not work according to the example program.



The Sailboat Storm program is modified to add the tilt sensor. The Wait For Random Input is changed to Tilt Sensor Input. Sounds are added in three places: in beginning of the program, after the tilt sensor tilts up, and after the tilt sensor tilts down. First, the program plays Sound 10, the Thunder sound. Next, the motor power is set to level 2 and the program waits for the tilt sensor to move down. Then Sound 9, the Creak sound plays, the motor power is set to a level 6 and the program waits for the tilt sensor to move up. When the tilt sensor moves up, Sound 8, the Splash sound plays. The program repeats.

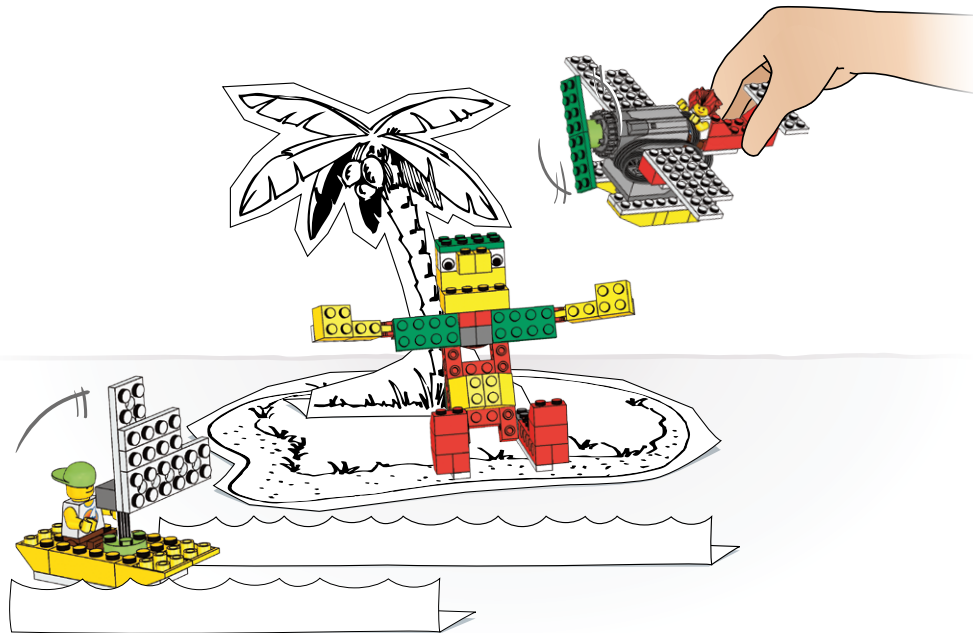
Click on the Tilt Input to cycle through the six possible settings: Tilt Up, Tilt Down, Tilt This Way, Tilt That Way, No Tilt, and Any Tilt.

See the LEGO® Education WeDo™ Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

See Getting Started for more examples with the Motor Power, Play Sound, Repeat, Tilt Sensor Input, and Wait For.

Extension

Work with other groups that have the airplane model and the giant model from these Adventure Stories activities. Create a story that combines all three models. For example, create a story in which Mia flies in on her seaplane and rescues Max whose sailboat is drifting too close to the giant sea creature!





Resources

This section includes print or copymasters for inspirational programs, data tables needed in the Amazing Mechanisms and Play Soccer activities, glossary of important terms, and LEGO® elements included in the LEGO Education WeDo™ Construction Set.

These materials are provided for supporting the WeDo projects in your classroom.

Be Inspired! Programs to Explore

Try the programs shown here to explore the LEGO® Education WeDo™ Software. Some behaviors are more advanced and may require experimentation and repetition. What kind of model can you create for these programs?

1. Super Random Wait

How long does it take for the sound to play?



2. Lottery

Run the programs to see who wins the lottery.



3. Keyboard Control

With the arrow keys, you are in control of the motor power.



4. Voice Control

Speak and then watch what happens to the motor power.



5. Joystick Control

Move the tilt sensor up or down and watch what happens to the motor direction.



6. Tilt Power

Tilt the sensor and watch what happens to the motor power.



7. Sound Shuffle

Play sounds 1-10 randomly.



8. Background Shuffle

Display backgrounds 1-10 randomly.



9. Sound Blaster

Play all the sounds.



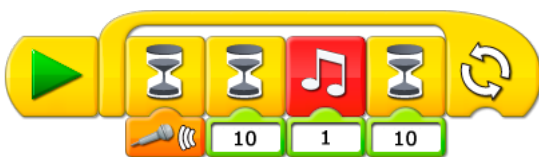
10. Background Blaster

Display all the backgrounds.



11. Parrot

Speak and then listen for a reaction.



12. Count Down

Start the program and watch what happens when the count reaches 0.



13. Whistle Motor

For how long can you whistle the same note?



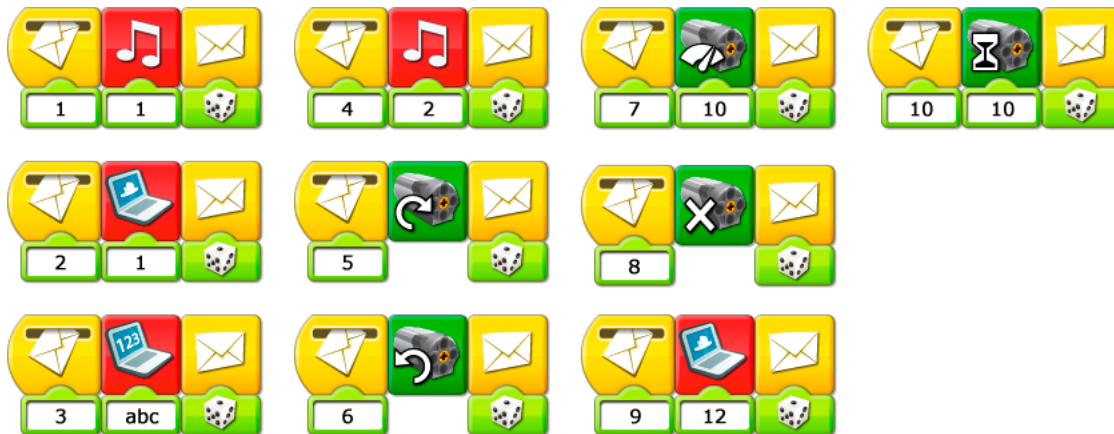
14. Vault

Start the program and type in your secret code. Can you unlock the vault?



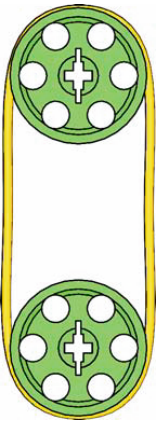
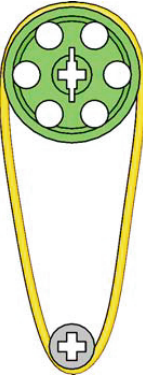
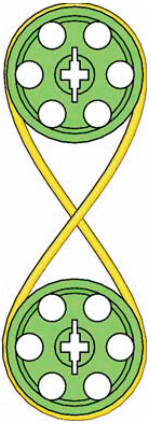
15. Random Chain Reaction

Right-click any program to start and watch what happens.


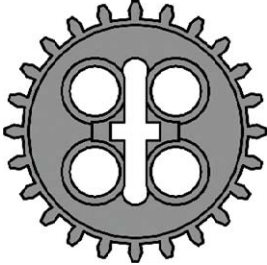
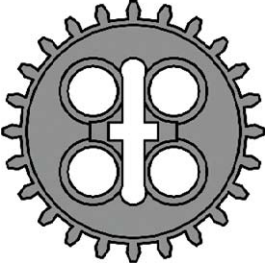
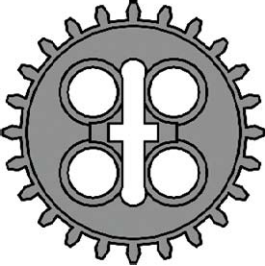
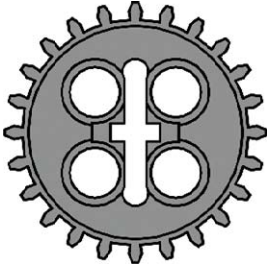



Activity Data Tables





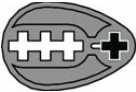
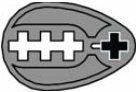
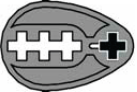
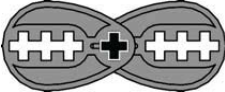
Amazing Mechanisms: 1. Dancing Birds

<p>How Bird 2 Turns</p>			
<p>How Bird 1 Turns</p>			
<p>Belt</p>			

Amazing Mechanisms: 2. Smart Spinner

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Top spins this long</p>			
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Top</p>			
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Handle</p>			

Amazing Mechanisms: 3. Drumming Monkey

<p>What I see or hear</p>				
<p>Right Cam</p>				
<p>Left Cam</p>				

Play Soccer: 7. Goal Kicker

Actual Distance			
Predicted Distance			
Kicker	Test 1	Test 2	Test 3

Play Soccer: 8. Goal Keeper

Misses				
Goals				
Blocks				
Attempts	10	10	10	

Play Soccer: 9. Cheerful Fans

Total				
Moves				
Sounds				
Looks				
Names				

Glossary

The Glossary includes specific terms from student pages in the Activities that may require definition. See the LEGO® Education WeDo™ Software Vocabulary List for names of the Blocks. See the LEGO Element Survey for the names elements in the LEGO Education WeDo Construction Set. An explanation of the motors and sensors can be found in the **What is in the box?** section.

Belt	A continuous band stretched around two pulleys so that one pulley can turn the other.
Cam	A non-circular, egg-shaped wheel that rotates and converts circular motion into reciprocating (repeating up and down) or oscillating (repeating a path such as backward and forward) motion by the follower.
Centimeter	A unit of length in the metric system equal to 0.01 or one hundredth of one meter.
Climate	A region of Earth having particular temperature, humidity, air pressure, and other conditions.
Gear	A toothed wheel or cog. The teeth of the gears mesh together to transmit movement. Often called a spur gear.
Gear, crown	A toothed wheel that has teeth out to one side looking like a crown. When meshed with a regular gear, a crown gear transfers the motion through a 90° angle, or perpendicular to the original direction of motion.
Gear, worm	A gear with one spiral tooth resembling a screw. When meshed with a regular gear, the worm gear acts as a one-tooth gear, reducing speed and increasing force.
Inch	A unit of measure from the US Customary and British Imperial systems equal to 1/12 of one foot.
Lever	A bar that pivots about a fixed point when an effort is applied to it.
Mammal	Animals with backbones (vertebrates) who have hair or fur, give birth to live young, and feed the young milk through mammary glands.
Measure	<ol style="list-style-type: none"> 1. A unit or standard of measurement such as weight, distance, volume, area. 2. The act of gathering the dimensions or quantity of something.
Pattern	A repeatable sequence.

Performance	Entertainment presented before an audience.
Pride	A group of lions living together.
Program	A set of instructions created on a computer.
Propeller	A rotating hub with blades for causing an airplane, boat or other device to move.
Pulley	A wheel with a grooved rim used with a belt, chain, or rope.
Random	Choosing or occurring without a specific reason or pattern. Equally likely to be chosen or having the same probability of occurrence.
Rotation	Turning on an axis.
Score	The record of points in a game.
Script	The text of a play, film, video, or radio or television broadcast.
Ship's log	The record of events during a ship's journey.
Speed	The distance traveled within a specific amount of time. Rotational speed is described in rotations per minute or RPM. The speed of other objects is described in distance over time, e.g., kilometers per hour, miles per hour, or centimeters per second.
Wingspan	The distance from one wingtip on a bird to the other wingtip when the wings are fully extended.

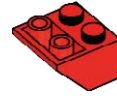
LEGO® Element Survey for 9580



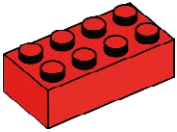
2x
Brick, 2x2, red
300321



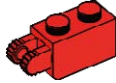
6x
Studded beam, 1x2, red
370021



2x
Roof brick, 2x2/45°, inverted, red
366021



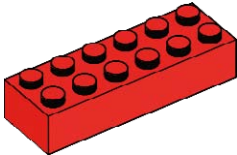
2x
Brick, 2x4, red
300121



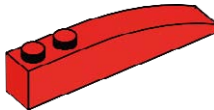
2x
Hinge, 1x2, red
4173322



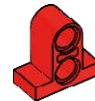
2x
Roof brick, 1x2/45°, inverted, red
366521



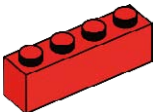
2x
Brick, 2x6, red
4181138



2x
Brick, 1x6 curved, red
4160390



2x
Beam with plate, 2-module, red
4207715



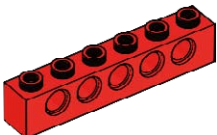
2x
Brick, 1x4, red
301021



2x
Roof brick, 2x2/45°, red
303921



1x
Turntable, 2x2, red
368021 + 4540203



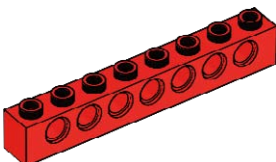
2x
Studded beam, 1x6, red
389421



2x
Roof brick, 1x2/45°, red
4121934



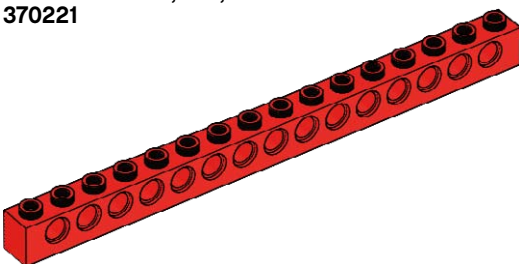
2x
Skid plate, red
4278275



2x
Studded beam, 1x8, red
370221



4x
Brick, 1x2 with connector peg,
dark grey
4211087



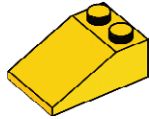
2x
Studded beam, 1x16, red
370321



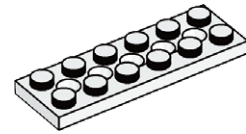
4x
Studded beam, 1x2 with crosshole,
dark grey
4210935



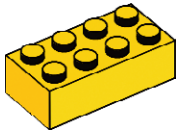
2x
Brick, 2x2, yellow
300324



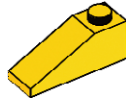
2x
Roof brick, 2x3/25°, yellow
329824



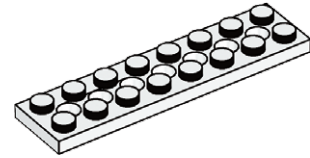
4x
Plate with holes, 2x6, white
4527947



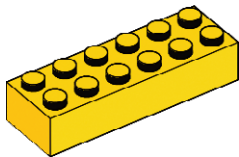
2x
Brick, 2x4, yellow
300124



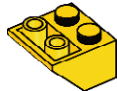
2x
Roof brick, 1x3/25°, yellow
428624



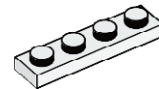
4x
Plate with holes, 2x8, white
4527945



2x
Brick, 2x6, yellow
4181143



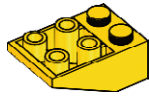
2x
Roof Brick, 2x2/45°, inverted, yellow
366024



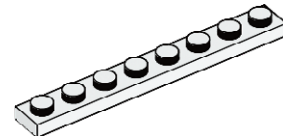
4x
Plate, 1x4, white
371001



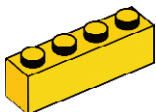
2x
Brick, 1x2, yellow
300424



2x
Roof brick, 2x3/25°, inverted, yellow
374724



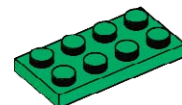
4x
Plate, 1x8, white
346001



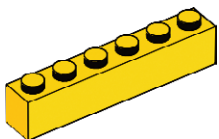
2x
Brick, 1x4, yellow
301024



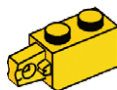
2x
Roof brick, 1x3/25°, inverted, yellow
428724



4x
Plate, 2x4, green
302028



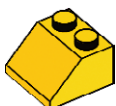
2x
Brick, 1x6, yellow
300924



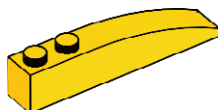
2x
Hinge, 1x2, yellow
4220284



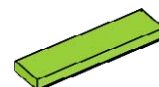
4x
Brick, 2x2 round, lime green
4527943



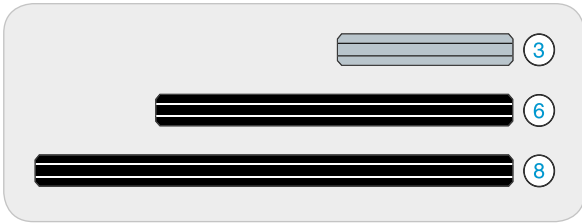
2x
Roof brick, 2x2/45°, yellow
303924



2x
Brick, 1x6 curved, yellow
4160392



2x
Tile, 1x4, lime green
4164021



1x
Minifigure, cap, lime green
4527944



6x
Bushing, grey
4211622



2x
Gear, 8-tooth, dark grey
4514559



2x
Gear, 24-tooth, dark grey
4514558



1x
Minifigure, wig, red
4292017



6x
Connector peg with friction, black
4121715



2x
Gear, 24-tooth crown, grey
4211434



1x
Minifigure, head, yellow
4506830



4x
Connector peg with axle, beige
4186017



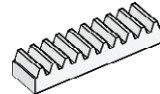
1x
Worm gear, grey
4211510



1x
Minifigure, head, yellow
4506812



2x
Axle, 3-module, grey
4211815



2x
Gear, 10-tooth rack, white
4250465



1x
Minifigure, body, white with surfer
4275606



2x
Axle, 6-module, black
370626



4x
Cam wheel, dark grey
4210759



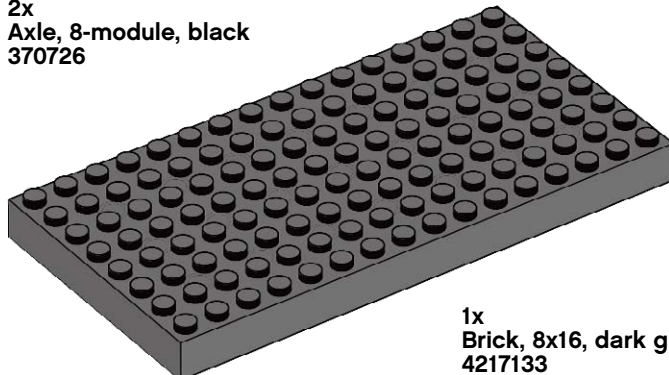
1x
Minifigure, legs, brown
4221886



2x
Axle, 8-module, black
370726



4x
Brick, 1x1 with eye, white
4140002



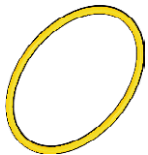
1x
Brick, 8x16, dark grey
4217133



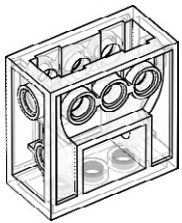
2x
Tire, 30, 4x4, black
281526



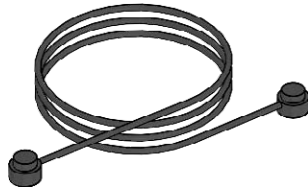
2x
Hub, 24x4, lime green
4494219



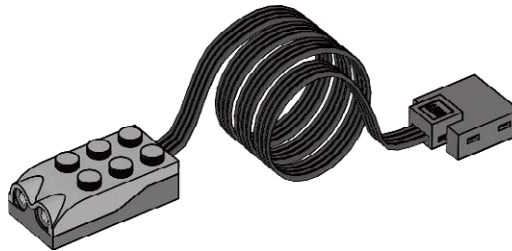
2x
Belt, 33mm, yellow
4544151



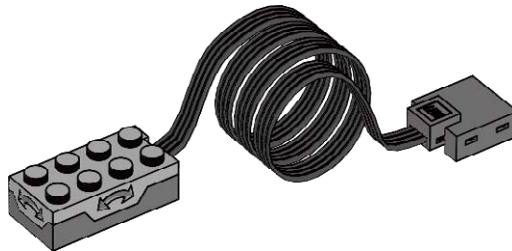
1x
Gear block, transparent
4142824



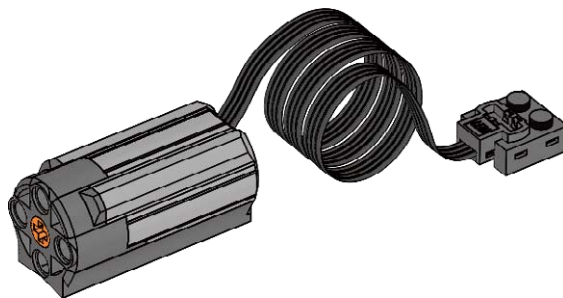
1x
String, 30-module with knobs, black
4528334



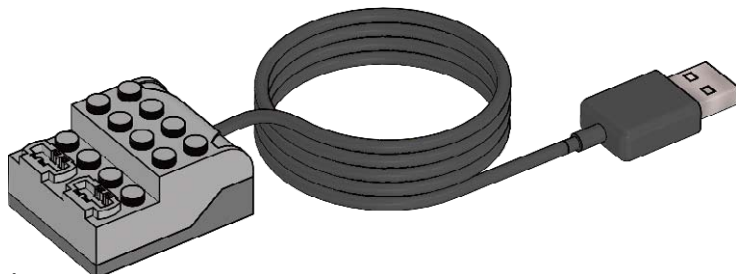
1x
Motion Sensor, grey
4535734



1x
Tilt Sensor, grey
4535729



1x
Motor, grey
4506083



1x
LEGO® USB Hub, grey
4535710

